Training for the mining and metallurgical industry based on electronic educational technologies

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Abstract. Improving the quality of the equipment use for its intended purpose largely depends on the proficiency of the drivers and maintenance personnel. With the excavator’s highly skilled control, the change in load over time is stationary in nature, with a mathematical expectation within the nominal values. At the same time, when a driver with low qualification is working, the loading of the main drives is strongly marked, unstable, and oscillatory in nature and increases sharply over a very short period of time, reaching values close to stop, which adversely affects the operation of the main excavator components, especially in poorly trained faces and in cold climates. The work defines the possibility of using electronic educational technologies, in accordance with the main structural components of educational and cognitive activities; the didactic components of the developed educational system include: meaningful component, operational-active and evaluative-effective components.

1. Introduction
To date, the bulk of works on the rock mass excavation in open cast mining is performed by single-bucket caterpillar crawler excavators of cyclic action, so the implementation of mining plans is largely determined by the productive and reliable operation of these machines.

In the process of studies, some indicators that affect the high-performance and effective operation of the ECC are not allocated, or insufficient attention is paid to their accounting. These indicators include: non-compliance with the rules of technical operation; low level of design, construction and manufacturing of machines, components and parts; lack of spare parts and their limited supplies; qualification of excavators’ drivers and of repairmen, etc.

In their works the Russian scientists N.V. Melnikov, R.Yu. Poderny point out that the indicators affecting ECC performance include the excavator driver’s qualification, which includes a set of skills and working techniques during excavation that allow him to control the excavator without shock loads and overload mechanisms.

Until the end of the 80s of the XX century, in Russia there was a fairly well-organized system of training, retraining and advanced training of workers, specialists and managers. Then, in connection with a sharp drop in production output, the need for training workers, engineering and technical workers fell sharply.

The system liquidation of the branch ministries entailed the entire network destruction of branch institutes of advanced training and their territorial branches, the actual liquidation of most of them. At industrial enterprises, there was a decrease in the need for educational services. The enormous economic difficulties faced by most enterprises have led to the fact that work on training personnel at enterprises,
and, consequently, the number of employees of factory technical training services, have been minimized [1-3].

2. Methodology
The rapid range growth of mining equipment and the complexity of the studied material led to the fact that the traditional training system has become insufficiently effective and requires innovative technologies based on the use of information and computer technology. Effective personnel management, including training and retraining of the personnel at industrial enterprises, is currently impossible without the use of modern computer technologies, which are intensively implemented in all areas of management. Fulfillment of the social order for highly effective technologies for training and retraining of personnel required the creation of a steadily developing system of continuous advanced professional training, ensuring a new quality of educational activity.

One of the main tasks of the personnel training and retraining system is to assess the compliance of the staff with job responsibilities, which requires constant determination of the employees’ level of knowledge and skills, which can be realized only through the comprehensive use of computer test control procedures that provide dynamic identification of staff training using a single educational information environment.

At present, there are a large number of systems for implementing distance learning and test control. Moodle (Modular Object-Oriented Dynamic Learning Environment - a modular object-oriented dynamic learning environment) is a software package distributed according to the Open Source principle (open source code, free use). Moodle is a free Learning Management System (LMS). The Moodle system is a modular interactive system that allows you to organize the interaction of subjects of the educational process through the use of a set of modules. One of the important features of Moodle is its versatility; it can be installed on almost any platform, running any of the currently common operating systems.

One of the most important system modules is the Test module. Testing in the Moodle system is a tool that minimizes the time spent on testing knowledge and at the same time allows you to process and store the accumulated test results [6-8].

The Test module, being an element of the course, has a large number of parameters discussed below.

Name - sets the name of the test and is displayed in the link to the test.
Introduction - is a brief instruction and is displayed before presenting questions.
Start of testing / End of testing - sets the date and time when this test becomes or ceases to be available.
Test time (minutes) - sets a time limit for the execution of one attempt.
Displaying questions on one page - sets the maximum number of questions that are placed on one page (for the training mode, the parameter is set - Unlimited, but for the final test - 1).
Random order of questions - when this option is enabled, questions will be automatically displayed in random order each time a student tries to pass the test.
Individual setting of a random order of answers - when this option is enabled, answer options will be automatically displayed in random order each time you try to pass the test (only for questions of the "multiple choice" type).
The number of attempts - for the final testing - 1, if the test is used as a training tool, then the number of attempts can be arbitrary.
Each attempt is based on the previous one - in each new attempt to pass the test, the answers selected in the previous attempt will be displayed.
Training mode - if the answer is incorrect, it will be allowed to correct the answer, but at the same time the points assigned in the option are removed - a fine. In the training mode, an additional Submit button is displayed for each question. When you click this button, the answer is checked and the result is displayed. After that, you can change your answer and check it again.
Assessment method is a method of calculating the grade for a test (Best Score, Average Rating, First Try, Last Try).
Accrue fines - the calculation of the penalty works only in the training mode and with several attempts to pass the test.

Number of decimal places is the number of decimal places that will be displayed to the student when viewing test results.

Viewing parameters - specify the parameters for viewing results after a test attempt, at the time of testing and immediately after testing. During the final testing, it is impossible to set the parameter - the correct answers and it is necessary to remove all the parameters in the option - immediately after the attempt.

Display test in a “protected” window - testing takes place in full-screen mode without the ability to minimize / close the window. Until testing is complete, the hot keys (Win, Ctrl + Alt + Del, Alt + F4, F1, Ctrl + P, PrtScr) and the context menu do not work.

Password is required in order to protect the test; you must enter a password before testing.

Network address required – it allows computers with specific IP addresses to access the test.

General module settings - sets such parameters as working with a group (group method), course access (show or hide it), determination of the course identification number.

Commentary on the test - defines comments on the test depending on the percentage of completed tasks or the number of points scored.

The Test module consists of two components: a test and a question base. Various types of questions are added to the test, which are stored in the question base of the system. The question base of the Moodle system is formed from various types of test questions. Questions are compiled in accordance with the structure of the discipline or in accordance with the topics of the course. The question may have comments explaining the correct choice of answer. The question base is preceded by the creation of categories in accordance with the structure of the discipline or the topics of the course.

3. Implementation

In order to adapt electronic educational technologies, we carried out studies on the establishment of seniority groups, the level of education of technological personnel (excavator drivers) for mining enterprises in the South Urals, which are shown in figure 1–4 [4-6].

![Figure 1. Distribution of technological personnel by experience groups at JSC UMPP.](image1)

![Figure 2. Distribution of technological personnel by experience groups at PJSC MMK Group.](image2)
Based on the presented statistical data, it was established that there is a need for advanced training of workers, since at the present stage of mining equipment development, the complexity of its operation and management, and also the level of education of technological personnel is clearly insufficient.

In this regard, we have created test systems for the main special disciplines, knowledge of which is included in the basic level of theoretical knowledge of the excavator driver (figure 6). In the future, it is planned to develop a test base on the fundamentals of the operation of the excavator, maintenance and repair of the machine, electrical safety and labor protection.

In this study, we developed the structure of a training system for training excavator drivers, which includes blocks of content for educational material and the ability to test knowledge through testing.

In accordance with the basic structural components of educational and cognitive activities, the didactic components of the training system are: meaningful, operational-active and evaluative and effective.

Given the specifics of the excavator drivers’ training, we will describe the structure of the future system. Using the projected training system, the excavator driver must master both the theoretical foundations of working with the machine and practical skills, be able to pass testing on the material embedded in the system [5, 6].

The following requirements were imposed on the software simulator: speed; visualization (a property expressing the degree of accessibility and comprehensibility of images of objects of cognition for a cognizing subject).

The following bookmarks are highlighted in the software simulator: menu, simulator, help, and exit.

Development environment. Microsoft Visual Studio is a line of Microsoft products, including an integrated software development environment and a number of other tools. These products allow you to develop both console applications and applications with a graphical interface, including those that support Windows Forms technology, as well as websites, web applications for all platforms supported by Microsoft Windows, Windows Mobile and others.
Visual Studio includes a source code editor that supports IntelliSense technology and the ability to easily refactor code. The built-in debugger can work as a source level debugger, or as a machine level debugger. Other built-in tools include a form editor to simplify GUI application creation, a web editor, a class designer, and a database schema designer. Visual Studio allows you to create and connect third-party add-ons (plugins) to expand functionality at almost every level, including adding support for source control version control systems, adding new toolkits (for example, for editing and visual designing code in subject-oriented programming languages) or tools for other aspects of the software development process.

Visual Studio includes one or more of the following components: Visual Basic .NET, and before it appears, Visual Basic; Visual C++; Visual C#; Visual F# (included since Visual Studio 2010).

C# is an object-oriented programming language. It was developed in 1998-2001 by a group of engineers led by Anders Halesberg at Microsoft as an application development language for the Microsoft .NET Framework and was subsequently standardized as ECMA-334 and ISO / IEC 23270.

C# belongs to a family of languages with C-like syntax, of which its syntax is closest to C++ and Java. The language has static typing, supports polymorphism, operator overloading (including explicit and implicit type conversion operators), delegates, attributes, events, properties, generalized types and methods, iterators, anonymous functions with support for closures, LINQ, exceptions, comments in the format XML.

The Microsoft Visual Studio 2010 development environment was used to develop the software product. Unlike its predecessors, this environment has several advantages, namely:

Visual enhancements. The integrated development environment has been redesigned to improve readability. The unnecessary lines and color transitions are deleted to reduce congestion.

Support for multiple monitors. Document windows, such as the code editor and the design view, can now be placed outside the IDE window. For example, you can drag the code editor outside of the IDE so that you can see it next to the design view.

Code editor. The new code editor makes it easier to read code. You can scale the text by pressing the CTRL key and rotating the mouse wheel. In addition, if you click a character in Visual C# or Visual Basic, all instances of that character are automatically selected.

Search as you type. The new Go to feature provides as-you-type search support for files, types, and items. For example, you can use the abbreviation "AOH" to search for "AddOrderHeader".

System requirements. Minimum system requirements: Pentium III processor and higher; RAM capacity - 256 MB and above; the amount of available free space on the hard drive - 50 MB; operating system Windows XP and higher; Screen resolution 1024x780 and higher. To install the simulator on the user's computer, you must log in to MS Windows with administrator rights.

The software simulator consists only of a control panel. The control panel is designed to implement common actions when working with the simulator. The panel contains four tabs: "Menu", "Simulator", "Help" and "Exit". Consider working with each of these parts individually.

The "Menu" tab includes two buttons: "Start Test" and "Start Demo". When you click on the "Start Test" button, the user is invited to independently pass the test, which consists of 20 questions, without access to theoretical material in 30 minutes. Information about whether he made the right choice will be available only after passing the test to the end. The answers are mixed up, which eliminates the need to remember the number of the correct answer, and in order to correctly answer the question, it is necessary to know the text of the correct answer. The testing block contains questions on the following areas of knowledge: mechanical equipment of an excavator; excavator hydraulic equipment; excavator electrical equipment.

Test questions are divided into five types: "Selecting one answer option"; "The choice of several answer options"; "Setting compliance"; "Enter response from the keyboard"; "The arrangement in the right order."

After passing the test, a report is generated on the number of correct and incorrect answers, on the basis of which the program gives the user a recommended rating. In addition, it is possible in the viewing mode to return to incorrectly answered questions.
When you click on the “Start Demo” button, the user is prompted to view a video tutorial consisting of three main technological operations of an excavator: development of rock mass and soil; moving the excavator during operation; loading of minerals and rocks into motor vehicles.

The tab "Simulator" allows the user to solve targets, because all actions are carried out on a specially-developed virtual remote control, exactly repeating the real control panel of the excavator. The main objective of this bookmark is to develop user action scenarios. The tab has two buttons: “Study of the virtual excavator console”, “Study of technological operations”. By clicking on the first button, the driver solves the simple tasks of manipulating the working bodies and moving the excavator. Thus, preparations are underway for a more complex section, in which the driver will have to perform real tasks that are possible at mining enterprises, according to one of the target scenarios.

Scenario list: development of rock mass and soil; the movement of fuel and various materials in warehouses, vehicles, dump; layout of the face, upper and lower platforms of the ledge; moving the excavator during operation; ensuring technically correct development of the face and efficient use of the excavator; layered excavation; loading of minerals and rocks into trains; loading useful and digging and rock into vehicles; rock laying in the developed space and on the dump; production of selective mining of the face; excavator track profiling; providing excavation of rock mass by grades; cleaning the bucket of adhering soil; routine inspection and participation in the repair of the excavator.

Scenarios should provide for the exact sequence of actions of the excavator driver, and the program logic should take into account both critical and non-critical errors. Critical errors will include overloading the bucket, and non-critical, it’s obvious under loading, which will increase the operation time.

On the screen, the user sees the control panel with a view from the cab, and at the top of the screen is a 3D model of the excavator from the side. Any action of the excavator will be displayed immediately in two forms, which will greatly simplify the user's addiction to the system and facilitate the execution of tasks. All levers and buttons in the cockpit are interactive.

This simulator has several advantages: the study of complex technological equipment; understanding of the essence of ongoing processes through simulation experiments; visual representation of educational material by means of computer graphics; active form of training, increasing the efficiency of the educational process; improving the perception of educational material; strengthening learning motivation through the game effect.

The Help tab is used to access the help system. The aforementioned tab describes the specifics of training of excavator drivers, which can be accessed using the following path: Help - Contents - The specifics of training of excavator drivers.

When you click on the “Exit” tab, the program closes, and the work with the simulator ends.

The most important advantage of the developed software product is the fact that the system can be constantly and quickly improved depending on customer requirements. With various features of the work, there may be a need to create new scenarios for the process, which can be completed by the developer in the shortest possible time.

4. Conclusions
The capabilities of the Moodle program allowed us to create a convenient and flexible monitoring system for checking and evaluating the excavator drivers’ knowledge, in addition, it is possible to identify “blank spots” in the knowledge gained during preliminary training and instruction.

Thus, the use of the Moodle system makes it possible to optimize the work of training and retraining operators of mining and transport vehicles for mining enterprises. The analysis of the assessment results of excavator drivers groups for mining enterprises makes it possible to compose a reserve of qualified excavator drivers for filling vacant posts according to the staffing table of units in accordance with the qualification test data.

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