An Integrated Platform for Blended Learning in Engineering Education

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Abstract: Educational system under development of technique and emergence of new technologies faces a problem of specialists' competence, who should design, produce, maintain new technique and use advanced technologies. The analysis of applied forms of education shows that blended learning has advantages over traditional learning and e-learning. For its successful implementation the unified informational educational platform that allows developing educational content, managing the learning process and giving the opportunity of virtual communication is required. The introduction of such advanced educational technologies like a virtual and augmented reality, simulation and gamification will enhance quality of specialists' training. The use of real-world experience of leading enterprises of an automobile industry, as well as the student's evaluation system based on the objective parameters are the main advantages of a proposed concept. At this stage, the development of the module of monitoring the learning process is proceeding.

1 INTRODUCTION

Modern trends of the economy development and, first of all, globalization processes require solutions for complex problems. The development of education system should focus on the long-term prospects of labour market and should correlate with its medium-term trends. However, the current education system was created in the 19th century for specific societal/economic/political goals and has not evolved from 150 years ago. As it is noted in the Concept of the long-term socially-economic development of the Russian Federation for the period until 2020, the necessary condition to form innovative economy is educational system's modernization.

Only an effective use of innovation (including information and telecommunications) technologies can help to overcome the contradiction between rapid development of scientific-technical progress and the existing educational system's inertness. This applies to learning technologies, means for education quality assessment, creating and using educational content, as well as to the organization of interaction between participants of educational process. Some of the contradictions can be smoothed down if a learning environment is formed using computers (IT). We mean, first, the contradiction between the necessity of diminishing the training period and increasing requirements to the quality of the students' competences, along with the process of rapid development of industrial technologies. The second contradiction is caused by the necessity to maintain a high level of teaching competences together with simultaneously increasing teaching loads connected to requirements of updating learning contents. To solve these contradictions a unified informational educational environment should be created. It is desirably to involve manufacturers in this process. This will help not only to join forces in order to develop study courses but also to launch communication between all interested process participants. This will improve feedback, create individual educational paths for the learners and facilitate self-control and quality control. This will modify the entire E-learning concept 2.0 of "Motivation – goal – tools – realization".

2 TEACHING METHODS: FROM TRADITIONAL TO BLENDED

Depending on the saturation of online technologies to deliver content and interaction character of partic-

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ipants, educational process can be: (1) traditional classroom learning (no online technology), (2) traditional learning with web support (1-29% of the course is implemented online), (3) Blended Learning (30-79% of the course is implemented online: it combines classroom learning with e-learning), and (4) full online learning (more than 80% of the course is online, mostly entirely without classroom communication). For many centuries, traditional training was dominating in higher school. Its undoubted advantage is the ability to transmit a large amount of information in a short time. However, it is based on memory, that doesn't contribute to development of creative abilities, independence and activity. In addition, this form of training doesn't allow you to build an individual educational trajectory.

In contrast, e-learning develops creative thinking and independence of learner. At the same time, students experience obvious disadvantages: the lack of full-time communication with teacher; the need of constant access to information sources; insufficient opportunity to acquire practical skills. From the teacher's point of view disadvantages are: the need for constant qualitative updating of training content; the lack of the permanent monitoring of educational process. The introduction of blended learning allows enhancing advantages and reducing disadvantages of these two forms of learning. Identification of causes that prevent problem-solving can improve quality of learning and optimize processes in educational system. The results of a comparative analysis of considered types of training are presented in Table 1.

The problem of assessing a quality of education is the common one to all types of learning. The subjective assessment in a traditional education and the complexity of a student's identification in the process of e-learning requires to intellectualize processes of the knowledge quality control that is possible with a blended learning implementation. Integration of various learning technologies on one platform will allow improving not only a quality of education, but also an adequacy of assessment.

Currently, there are practical examples of combining traditional training and e-learning. Thus, in research of Karabulut-Ilgu and Jahren (2016) learning occurs through video fragments that are subsequently finalized after getting feedback from students, who answer questions checking their understanding of the material. After watching the video, students perform practical interactive exercises in an online environment. Online modules are interactive exercises that demonstrate how to solve problems in construction engineering. Classroom lessons include an interaction of students in order to solve problems and cases from real life.

Table 1: Comparative characteristics of learning types (1 - traditional learning; 2 - e-learning; 3 - blended learning).

Features	1	2	3
Full-time communication with teacher	+	-	+
User identification	+	-	+
Dependent on the place and time of learning	+	-	+/-
Communication with other students	+	+	+
Individualization of training	-	+	+
Lecture material	+	+	+
Tests	+/-	+	+
Practical classes	+	-	+
Monitoring of learning process from the teacher	+	-	-
Clear criteria to assess the quality of knowledge	-	-	-

3 THE ORGANIZATION OF BLENDED LEARNING

3.1 Tools to Organize e-Learning

Software for e-learning on a market of educational software is presented by simple HTML pages, as well as by the complex platforms with greater functionality. They include the learning management system (Learning management system or LMS) and learning content management system, used in corporate networks (Learning Content Management System, or LCMS). Most simply, an LMS is a software application for the administration, documentation, tracking, and reporting of training programs, classroom and online events, e-learning programs, and training content. Many large companies have their own LMS system that is caused by the need for staff training together with the working process.

The main task of LMS is to automate the administrative aspects of education, and LCMS is focused on the content management of "learning objects". Currently, two types of e-learning platforms are the most common. Systems of the first type provide the ability to design training courses and testing students (Claroline, Dokeos), while systems of the second type allow supporting organization of all educational process. So, Moodle and Sakai in addition to a basic functionality to create training courses also have such functions as reporting the training statistics, accounting students, opportunity to personalize them. Such functions as management and moderation of forums are realized in WebTutor system. Systems 1C:OO and IBM Lotus Workplace Collaborative Learning (LWCL) allows conducting discussions and exchange of messages, scheduling of training sessions, create and track training programs is implemented. Although these systems can be used for implementation of blended learning, all learning systems with open source have common disadvantages: the complexity of service and support e-learning, the lack or difficulty of technical documentation. E-learning technologies can become key tools of organizing blended learning. To use the full potential of the e-learning system in the blended learning process, it should have a complete set of functions that are necessary for qualitative training of highly qualified specialists. Thus, there is a need to develop a unified platform, that would allow integrating all opportunities of existing systems and develop functional modules that is necessary for blended learning.

3.2 Blended Learning and Its Features

The use of blended learning could become one of key solutions of problems existing in engineering education, because it allows: (1) more efficient use of time in classrooms, focusing on the problems faced by students, (2) identification of students experiencing difficulties, (3) picking up materials and assignments that are optimal to a particular group and a particular student, taking into account individual characteristics and a level of basic knowledge, (4) use of objective criteria when assessing students knowledge, (5) improvement of education quality by implementation of progressive educational technologies (modeling, gamification, virtual and augmented reality).

Most researchers note that blended learning is a modern, universal method of education focused on individual needs of students. The fundamental difference between blended learning and traditional system is a combination of organizational forms of training in real and virtual campus of the University as well as combination of traditional teaching methods with e-learning technologies. This combination can occur both at the training course and at the educational programs in general. The learning process starts with a setting of a problem (often it is the actual manufacturing tasks). To perform the task student receives access to the content that should be studied in accordance with a teaching program. The presentation form of a material can be various: lectures, practical exercises, videos, presentations, infographics, and tools to learn specialized software products. Student chooses methods and the speed of study by himself, taking into account individual characteristics. At this stage, self-control of the content understanding is conducted in electronic environment. It is important that in the classroom lessons student has all necessary knowledge. The educational platform should also allow teacher to track the points that are not clear for student and require detailed further discussion and study. In addition, it is important that educational platform provides the possibility of online communication between teachers and students. This can be implemented in a form of discussions, messaging, webinars, discussion forums, online conferences, etc.

Teacher plans the classroom lesson on the base of analysis of statistical data of the learning process monitoring, as well as on questions asked online. In classroom students can get answers to questions, that have arisen in the process of self-study. Teacher can also discuss solutions, found by students, their advantages and disadvantages. This increases the creative component of the educational process. This method allows developing communication skills, as well as teamwork skills, that are need for the complex real-world manufacturing problems solving in the future professional career.

4 THE CONCEPT OF THE PROPOSED SYSTEM

Modular open multi-user architecture of developed control system of blended learning is the basis of reliability and stability of its work, as it allows quickly identifying and eliminating causes of failures, excluding their influence on other modules, and also increasing the speed and quality of technical support. This approach allows implementing all necessary functionalities and supplementing them when it is necessary.

4.1 Control Modules of Educational Process for Teacher

The bases for elaboration of educational modules are the Federal state educational standards (FSES) and objective criteria to assess the quality of student’s competencies: general cultural and professional. In accordance with FSES, curriculums for each field and profile training are developed. Teacher determines the structure of the course and enters data, necessary for formation of teaching programs of each discipline. After that, he can create the information base of lectures, practical and other material, as well as tests. The data characterizing the learning process of each student (how much time did the student spend studying the recommended material, what sources did he used, how much time did it take him to perform the tasks) come into the module of accumulation statistics and the learning process control. If student has any questions, he can use the feedback form to contact the teacher. At the end of the section studying, student passes the test. Results (total score, test time, number of attempts) also come into the module for further analysis.

Management of the training quality is based on three-loop diagram (management of the quality of student's learning, management of the quality of the group's learning and management of the learning quality of the specific field of training). To assess effectiveness the system of indicators was developed. Correction of the process in order to increase its effectiveness can be performed at each stage of learning within each control loop. Such factors as a quality of questions asked, the time for teaching, quality of responses, speed and regularity of work can be the criteria for evaluation of effectiveness of student's performance. Based on the personal characteristics of the student an individual approach should be implemented in the proposed system: the teacher can choose such teaching methods, that will be effective for this concrete student. Patrick Buckley and Elaine Doyle (2017: 43-55) state in their paper that it is generally accepted that matching an individual's learning style with the appropriate form of an instructional intervention significantly impacts upon the performance of the student and his/her achievements of learning outcomes.

Analyses of statistical data will allow teacher to determine the reasons for low efficiency. This may be caused by individual characteristics of a particular student, by the complexity of the topic in general or by insufficient quality of the educational content. In the second case, the teacher may post additional lookup materials, and in the third case, this will serve as a signal to the teacher to change educational content. The results of such studies in a field of user personalization behavior presented in the paper (Bent et al., 2017: 456–464), where authors present the modeling of user behavior in the context of personalized education. The user behavior data is modeled and sent to the cloud-enabled backend where detailed analytics are performed to understand different aspects of a student, such as engagement, difficulties, and preferences.

4.2 Modules Organizing Students' Training Process

Modules, that allow students to select courses and to access training content and self-control means are developed to organize the self-study process. In order to start working in system, student must register and select courses, which he will study. The main feature of engineering education is that along with learning theoretical material, there is a necessity to acquire practical skills for the future professional activities. Therefore, the learning content, in addition to already becoming traditional text, video and multimedia, contains resources, using modern educational technologies, that contributes to intensification of perception and development of a creative approach to the practical problems solution (such as models of real situations and systems, virtual and augmented reality).

Modelling and simulation allow the student to see studied process with their own eyes, that has a positive impact on the learning process. The authors of research (Wu et al., 2013: 41–49) outline the educational possibilities of recently developed "augmented reality" (AR), alongside with the problems it has brought in its wake. Thus, in research (Kesim and Ozarslan, 2012: 297 – 302) it is suggested that educationists should collaborate with researchers to develop extended interfaces of reality. Although the key role of producing augmented realities is played by soft- and hardware technologies and there are engineers for designing them, the educational technologies are seriously in need of specialists to design learning activities for augmented reality.

It is shown (Martín-Gutiérrez et. al, 2012: 832 – 839; 2015: 752–761) that one of the AR advantages consists in saving of instructors' time on repeat explanations because students can use them for independent revision. Furthermore, the effect of these technologies is twofold: facilitating the teachers' control of laboratory courses and promoting the students' motivation. Research (Webel et. al, 2013) describes an experiment of applying AR for training of technicians in industrial maintenance and assembling operations. The authors emphasize the importance of drilling technicians in new skills due to increasing complexity of maintenance operations and demonstrate the superior performance of AR tools compared to traditional teaching techniques.

Another tool to enhance learning of students is an ability to conduct tests and experiments in a virtual laboratory. Then he will be more prepared for this experience in real conditions. The application of virtual reality technology enhances an intensification of training. One more tool is a business game in which students are given an opportunity to demonstrate personal and professional qualities. In the implementation process of business games, students will be able to define their role in the team and will have an opportunity to form teams among the students, who will have the highest rate of interaction among themselves. This can be useful for employers, who could visit the business game, have able to see and evaluate actions of learners in the process of solving problems and performing tasks of different complexity levels.

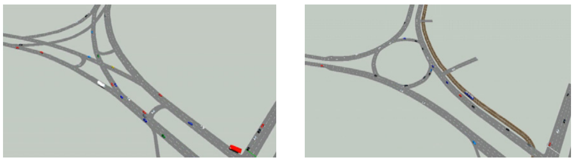
The module of feedback and results output provides an opportunity of communication between student and teacher and checking the training results. Individual or group statistics on specific course or the whole educational program as well as recommendations are available upon request. This can be recommendations for study and development of a particular material, on what it is necessary to pay attention (based on its rating in group, and also on the basis of its individual characteristics).

5 APPLICATION EXAMPLES OF BLENDED LEARNING

To check the efficiency of blended learning in engineering education two groups of students were formed: those who study traditionally and experimental group. To make comparison correct, the number of students and the field of training were the same. The selection was made taking into account preferences of students and their plans of the further career growth: those students who have already selected the future direction of activities were included in experimental group. Their teaching program involves solution of real production tasks.

5.1 Blended Learning of Engineers, Working in Transport Sphere

When teaching specialists in this field, students get a material to study the specialized transportation software (e.g. AnyLogic, PTV Vision), as well as models of problem areas of city road network. As a result, students come to a classroom lessons with suggestions for optimizing parameters of the street-road network, discuss them, check various options which can be used to obtain optimal solution to the problem. The purpose of optimization may be: reduction the possibility of road accidents in this area, increasing the road network's capacity, reduction of the environmental load, etc. (Tosa, C. et. al, 2013). As an example of student's project Figure 1a presents a model of the existing intersection configuration, which is needed to be optimized and Figure 1b presents a model proposed by students during the classes.



a) b)

Figure 1: Configuration optimization of the road network.

5.2 Blended Learning of Engineers Who Design the Production Process

When teaching students-technologists for solving problems to improve production processes specialized software tools, such as Siemens PLM Plant Simulation and Tecnomatix are used. These soft and used in production and allow improving technological processes by using virtual mannequins. The teacher creates learning content and highlights hazardous and complex processes. To classroom lessons students come with theoretical knowledge on the organization of technological processes, studied software environment, as well as got acquainted with the real problems of manufacturer. During classroom sessions, students explore production processes and choose the most traumatic or time-consuming. Thus, in the educational process student not only creates 2D and 3D models of production system and performs engineering analysis, but also can understand what consequences can cause each process.

a) workpiece from outside of the frame

b) workpiece from inner side of the frame

Figure 2: Optimisation of technological process "Rear wing's holder installation".

For example, students have modeled the activities of operators of assembly production and have checked technological process if it is ergonomic and safe. The results of observing the performing of particular work type in a real production system, obtained during the internship at the enterprise, were used for simulation. For modeling an interactive three-dimensional environment Tecnomatix Jack, where a two-dimensional layout of work areas were reproduced in an interactive form was used.

Various methods, such as tool selection, the change of technological process, the creation of auxiliary equipment were used for optimization. Figure

2 presents two variants of technological operation's performing.

5.3 Analysis of the Proposed Training Methodology's Effectiveness

To assess the effectiveness the comparison of academic performance and the quality of graduation projects of the last 5 years have been conducted. The analysis shows, that the quality of graduation projects in experimental groups is higher (Figure 3). This can be explained by the higher motivation of students, as well as by the focus on creativity development.

Comparison of academic performance of master-students and experimental groups was performed. Groups were formed from students of experimental and traditional groups, who wanted to study master course. The quality of learning was assessed by the results of two examination periods for 2015/2016 academic year. The results are presented in Figure 4.

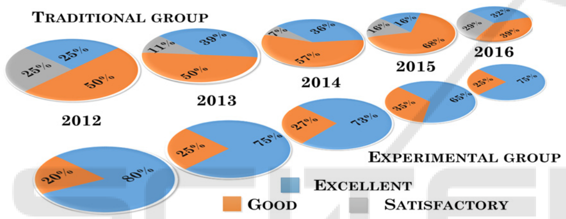


Figure 3: Comparing of aggregated data.

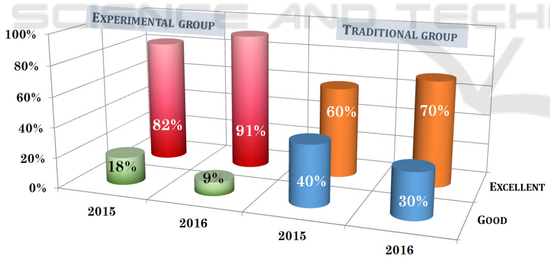


Figure 4: The academic performance of students.

6 CONCLUSIONS

Currently applied education methods do not meet the requirements for the quality of specialists training for the real sector of the economics. An effective solution is application of blended learning, that enables to use advanced educational technologies (modeling, virtual and augmented reality) allowing increasing efficiency of training.

Existing platforms for course development and organization of e-learning do not have got full functionality, that are required for high-quality training of highly qualified specialists. Proposed educational platform will allow increasing quality of the learning process of engineers. This platform also will provide opportunities for student to choose individual educational trajectory. As for a teacher, it will improve the learning process and increase its quality through data analysis of the learning process's monitoring.

The advantage of proposed platform is that modular open multi-user architecture of developed control system of blended learning is the basis of reliability and stability of its work, as it allows quickly identifying and eliminating causes of failures, excluding their influence on other modules, and also increasing the speed and quality of technical support. This approach allows implementing all necessary functionalities and supplementing them when it is necessary.

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