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Perspectives of Using Online Learning Technologies in Higher School: Results of Empirical Study

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Abstract

With the advent and rapid growth of massive open online courses (MOOCs) in the world education market in the last decade, online learning technologies are becoming increasingly widespread not only in the non-formal education sector but also in higher and supplementary vocational education. The use of MOOCs for implementing educational programs at the universities opens wide opportunities in terms of expanding the educational choice of students, the development of virtual academic mobility, reducing the cost of educational services, and improving the accessibility of education. However, the effectiveness of using different online learning technologies in the educational process of universities and the consequences of their widespread adoption has not been sufficiently explored.

In this research a comparative analysis based on an empirical study of the application of different online-learning models in the educational process within a university was carried out. An experiment was undertaken in which different groups of students of the Ural Federal University were encouraged to master some disciplines in the framework of a blended learning model and an online learning model with tutoring support. The results of the pilot study were compared with the training results of a control group of students who mastered the same disciplines in a traditional taught format. It was shown that both models using MOOCs in the educational process demonstrated greater effectiveness in comparison with the traditional model; both in terms of educational outcomes of students and in terms of their satisfaction with the learning process. For engineering and technical disciplines, there is no statistically significant difference in using blended or online learning technologies, whereas for humanitarian disciplines, where the communicative component of the learning process is significant, the blended learning technology produced better results. Conclusions of the empirical research can be useful for heads of educational organizations and teachers in the modernization of the educational process, improving teaching methods, and increasing the effectiveness of new educational technologies. The results of the research will also be used for implementing the State Priority Project "The Modern Digital Educational Environment of the Russian Federation".

Keywords

Model of learning, online learning, blended learning, mass open online-courses, MOOC, higher education, empirical study, educational process.

Introduction

Development of the information society, and technological structure changes, create new challenges for the national education system. The need for active, interested, lifelong learning is becoming a reality. This demand remains unsatisfied despite the rapid spread of massive open online course and increased access to education. The reasons for that can include both imperfection of the online courses, and low level of motivation for the students, that generally belong to the so-called "Generation Z" [35] and have a number of specifics with regard to apprehension of information, i.e. dependence upon technologies, impatience, desire for involvement [7], and a habit of obtaining data through search, among other distinctive traits [9; 10; 33]. Contrary to the specified trend of developing, and the widespread adoption of, online technology in education, the basis of online–learning is still mainly content-conservative mass education programs focused on certain categories of consumers, and does not take into account a variety of options for combining traditional and online learning. That is partially due to the lack of specific data on online education efficiency (see, for example, [13]). Representatives of the traditional approach regard MOOC content as a sequence of standard text blocks, forgetting that within the past 20 years learning means not only access to information, but also leads to the acquisition of specific knowledge and skills [22; 25]. As a result, the open course statistics in several cases show a sharp decline of interest in the educational process from the students, and a gap among student expectations [3] and offerings from educational institutions [4]. While overcoming the traditional canons, it is necessary to remember that the generation of online courses creates technological, methodological, and general humanitarian conditions for the development and implementation of a new educational paradigm [12; 16].

The following trends of online education, affecting the experiment, were discovered within the last 3-4 years by the specialists, and can be listed as follows:

Shifting the focus of organizational activities related to the implementation of MOOC in higher education from quantitative to qualitative indicators [5]. This trend became especially noticeable in the last three years;

Extension of theory development and research with respect to both MOOCs and student perception of the online courses (page 13 in [26]);

European universities demonstrating an intent to move to independent monitoring of students' knowledge, which involves using MOOC as an instrument of assessing results of learning in higher education;

Desire to explain MOOC statistics using cognitive and psychological research (the study of data perception ways - p.147 in [30]; study of personal factors related to online course selection [28]; student involvement analysis by means of surveys and interviews [1]);

Increasing understanding of a need to abandon an idea of overall MOOC implementation, and, therefore, of diversification of the online education sphere (p. 18 in [26]);

Increase in the number of programs that consist of MOOCs in part or in whole. For example, in 2017 the number of micro master programs on international online learning platforms reached 35, number of the X Series programs – 40; number of vocationally certified programs – 17;

Use of interactive MOOC elements for blended learning in order to achieve educational goals. [11]

Policy of any university related to online courses aims at expanding educational [2; 19; 24], personal, and communicative [38] capabilities of the students in the course of education, and the cutting of education costs. Use of massive online courses allows universities to solve staff, methodology, and logistical support problems related to the educational process. Educational process cost reduction mechanisms may vary: transferring educational process support and control functions to online course tutors, that are less qualified teachers; providing organizational and methodological student support in MOOC–based online learning; reduction of class workload for teachers. Despite the obvious advantages and economic benefits from the introduction of massive online learning technology, universities encounter several internal and external barriers.

Analysis of domestic and foreign publications allowed for definition of key organizational, methodological, and psychological challenges encountered by universities when implementing e-learning [14;15; 18; 20; 21; 31]. They arise due the lack of strategy in online learning implementation in education, insufficient support by university management, but also due to the low level of confidence the academics have towards distance learning, and lack of understanding the opportunities related to personalization of education that are provided by online courses. The latter is a reality for modern society and economics in general [6; 8; 32; 36; 37;].
Universities are extremely conservative, and are not ready to implement the structural and organizational changes required for wide use of online technologies in education. In particular, changes are required to staff composition in favor of tutors, assessors, and technicians. Redistribution of educational loading is also required when using online courses [17, 23]. The reasons for that are related to the interest of educational institutions in preserving the classroom workload, the absence of a single center for planning and administering the educational process, as well as to the conceptual and structural dissipation of the online courses developers, differences in their approaches to e-learning, and inclusion of online courses in educational process. It is also necessary to note the low level of student motivation with regard to online learning, and an inability to study course parts on their own. That prevents increasing education flexibility and efficiency [34] and creating a new, up to date educational environment.
Overcoming these barriers requires engagement of all the educational process actors and stakeholders, and specific data generation and analysis for objective, efficient, evaluation of different online education models within the university.

Methodology

As a result of analyzing theoretical and empirical material on e-learning development (see, for example, [11; 29; 30]) five key approaches to the application of online courses in the educational process were defined. According to the hypothesis of the study, the choice of methods (models) for using online courses in the implementation of an educational program in a university depends upon the educational goals and student body. Different disciplines and student categories may require different models of online learning in order to be efficient, but it is necessary to use these models purposefully. Let us briefly present the organizational, financial and functional aspects of the models being studied.

Models of online learning

Model 1 “Use of the massive open online course (MOOC) as a support material”
In this case the MOOC is used as an additional training and methodological material only. It can be used by the teacher to prepare for classes, and organize self-studies by the students. Use of the MOOC in the educational process is not mandatory. The teacher needs some time to select and evaluate several online courses corresponding to training content and learning outcomes of a discipline or a module. The model involves neither additional financial, nor administrative costs for either university, or student. It does not change the load of the teacher, and student tuition fees remain the same. The use of the model does not involve significant changes of the traditional educational process.
Model 2 “Blended learning model using parts of the MOOC for mastering the discipline / module” (“flipped class” model)

The MOOC is used to master a certain part of the discipline / module (for example, theoretical materials of the course). The model allows use of those components of an online course that are located on a public website in open access and do not require user identification. The teacher provides organizational and methodological support of e-learning, practical exercises, and control activities with an in-class final assessment. The model does not require conclusion of agreements with the educational organization that developed the online course. This allows a saving of, time, labor, and logistics costs, for the university. Education costs do not change, hence, additional expenses on behalf of the university are not required.

Model 3 “Blended learning model on the basis of the MOOC with performing current and final examinations online and preserving part of the face-to-face classes”

The model assumes partial transfer of the educational process to the electronic information and education environment. Students gain access to electronic educational resources, including video lectures, text materials, training tasks, and tests. They allow mastery of the discipline or module using e-learning and independent test control of the learning outcomes. The teacher provides organizational and methodological support for the students in class during some face-to-face classes and advisory hours. The educational institution pays for training of their students in other universities based on partnership agreements between the educational institutions, or contracts for educational services. The local normative base of the university should include documents regulating educational process organization relating to e-learning and credit transfer procedure. The price for training each student is determined on a contractual basis. Results obtained in the course provided a part of a discipline online are credited to the main educational program. The cost of teaching a student in a university that implements the educational program does not change.

Model 4 “Online-learning model, using MOOCs and internal organizational and technical support by the tutors”

This model includes the complete transfer of the educational process to the electronic information and educational environment, whereby students obtain access to electronic educational resources. Tutors provide organizational and technical support to students mastering the course. The university using the course pays for training of its students in another university based on a partnership agreement or agreement for additional educational services. The university pays for the education on the online platform in full. The client university has to develop regulations that govern the process of e-learning. This model is efficient if the university lacks teachers to provide required courses and / or subjects by choice. Other reasons can be the following:

Expanding the number of courses to offer individual learning paths to students;

perform the adaptation of the first-year students to university life and learning requirements;

The elimination of student debts, the elimination of academic differences in the curricula for the students that were transferred from one educational program to another, or to other educational organization;

Development of information and communication-related skills among the students;

Use of online courses from leading universities;

Reduction / redistribution of the workload of teachers;

Limiting workload for the teachers.

The efficiency of this model is influenced to a degree by, student preparedness for working in an online environment, concentration on results and, timely tutor assistance.

Model 5 “Exclusive online-learning using MOOC”

Within the framework of the model, the online course completely defines the methodology and technology of training, determines the content of the module and the course of the learning process. The materials of the MOOC are used in their full, therefore, the university

using the online course of another university must make a contract covering the network form of the educational program implementation, or an agreement concerning provision of services for training students in non-mandatory courses. Based on the contract, the university is paid for teaching the selected course to students. When implementing a model of exclusive e-learning, universities have the opportunity to save and redistribute resources for development in other areas. This model can suit those universities aiming at reducing teacher workloads in order to redistribute resources to other needs of the university, and for improving education. Students' personality is very important for success of this model; students are expected to self-organize, focus on the result, and to be able to work in an online environment.
All of these models are already in use in different Russian and foreign universities. For the purpose of examining their efficiency for realizing educational programs, the authors performed an experiment aimed at comparing learning outcomes of students who mastered the same disciplines in the different formats. The experiment took place in the Ural Federal University – UrFU (Ekaterinburg, Russia). It is the biggest Russian university which has more than 35 000 students. During 2015-17 twenty five massive open online courses were created by teachers and scientists of UrFU for National Open Education Platform (NOEP: www.openedu.ru). Given the peculiarity of UrFU as a technical university, academic subjects (modules) of the engineering educational programs were chosen for the experiment. Preference was given to those online courses providing for the basic component of such programs, thus ensuring the maximum number of students who were studying these subjects simultaneously. The following disciplines were chosen for the experiment: engineering mechanics, engineering graphics, and philosophy as a humanitarian discipline of the engineering educational program.

Students

More than 800 students of Bachelor programs of various majors were involved in this experiment. All of them were first year students who studied the following engineering educational programs: "Engineering" (18,2%), "Software Engineering" (11.0%), "Design and Technology for machine building industries"(7.4%)," Special Purpose Vehicles"(3,8%), "Automation of technological processes and production" (6.8%), "Machinery and equipment" (5.6%), "Land transportation and technological complexes" (5.6%), "Radio technics" (4.9%), "Technosphere safety" (4.2%) and a number of other fields, whose shares were below 4%. Curricula of these educational programs are similar for the first year students.
In the framework of the experiment three models of implementing a discipline were selected: extended traditional format (model 1); blended learning with online examination (model 3); and online format with tutor support (model 4). All these models of online-learning were compared with each other and the traditional learning format.
Students were divided into batches in order to take different approaches to studying a discipline. Summarized data on student batches are presented in Table 1.

Table 1 - General information on students studying using four models

Model	Number of students	Number of students in batches by discipline		
		Philosophy	Theoretical mechanics	Engineering graphics
Traditional format	138		115 (ThM-1 batch)	23 (EnG-1 batch)

Model 1	31			31 (EnG-2 batch)
Model 3	316	139 (Ph-1 batch)	148 (ThM-2 batch)	29 (EnG-3 batch)
Model 4	339	130 (Ph-2 batch)	209 (ThM-3 batch)	

ThM 1 and EnG 1 (138 in total) took traditional face-to face training without using the online courses. EnG 2 (31 people) batch used an online course while training in traditional format. For Ph-1, ThM-2, and EnG-3 batches (316 persons in total) training was conducted in blended format with part classwork and online current and final testing. Online learning with organizational and technical support by tutors was implemented for 339 students in Ph-2 and ThM-3 batches.

Analysis

The following experimental data were collected concerning participating students:
General student data from the university database including their average score on the Unified State Exam (USE) and average performance for the period of previous study;
Data on current academic performance of students during the experiment, uploaded from the grading system of the university (for traditional models), or from the online platform (for blended and online models);
Data from student questionnaire.
Experimental data were processed using the following algorithm. In the first step, normality and homogeneity in terms of initial training level for different groups of students that mastered disciplines in different models were assessed using Kolmogorov-Smirnov criterion. No pretests were performed before the experiment, so the average score on USE was selected to characterize the initial training level of students. Since all students participating in the experiment were first year students, their USE scores were an objective indicator of their initial training level. The data on academic performance of students for the previous semesters could not serve as an adequate parameter for assessing the homogeneity of the student sets, as it was subject to the influence of exogenous factors associated with adaptation of the first-year students to university study. Such factors as changing living conditions, different levels of adaptation to university study, different levels of self-discipline, etc., affect student academic performance in the first semester.
In the second step, the descriptive statistics tools were used for processing the distributions of students' average scores for the previous study at the university (for the first semester of the 2016-17 academic year). Statistical distribution indicators were calculated and frequency chart bars were plotted, that allowed clustering of student groups according to their previous academic performance. Selected subgroups corresponded to different score ranges in accordance with the standard evaluation criteria used in the university grading system. Thus, the "honor students" corresponded to the range of average scores above 80; "good students" - from 60 to 80 points; "weak students" - below 60 points. The average scores on the previous study served as input parameters for analyzing the efficiency of different models and as a controlled variable when comparing models with each other.

In the third step, statistical indicators of the students' final score distribution on a discipline in different learning models were analyzed using descriptive statistics. For students who mastered disciplines in the purely traditional format we used data from the university grading system. When students mastered disciplines using the online course (Models 3 and 4), the progress of students was taken from the online learning platform. The frequency distributions of the students' final scores served as an output parameter for analyzing the efficiency of different models.

The distributions of the initial and final grades and their statistical indicators were compared. It was shown that the type of distributions of the students' output scores was far from normal, which made it impossible to apply the methods of correlation-regression analysis or one-factor analysis of variance for processing the experimental data and drawing unambiguous conclusions about the impact of learning technology on students' learning outcomes.

For a more detailed comparison of online learning models with each other and with the traditional model, a hypothesis was put forward that different teaching technologies have different effects on performance of academically strong and weak students. Subgroups of students with different input scores were singled out as indicated above. Further, the analysis of the students' final scores for each subgroup of students in all the models was carried out, and the percentage ratios between students who have lowered their academic performance, retained their previous level of performance and increased it were calculated. Integral assessment for all subgroups allowed comparing efficiency of applying various learning technologies in teaching different disciplines.

Results

The engineering discipline selected for analysis is "Theoretical Mechanics" which is a compulsory subject for all engineer training programs. It was implemented in three different models:

Traditional training without using online course (control group – ThM-1);

Model 3 (the first experimental group – ThM-2);

Model 4 (the second experimental group – ThM-3).

The total number of students mastering the discipline in each model exceeds the minimum requirements for sample size (at least 25 people per each group), calculated on the basis of reliability and validity criteria of statistical inference. The total number of participants was 472 students: 115 students in the control group, 148 students in the first experimental group; 209 students in the second experimental group. All students mastered the discipline in the second term of the 2016-17 academic year.

To analyze the homogeneity of student sets for all the groups and the normality of the distribution according to the level of initial training, the Kolmogorov-Smirnov (K-S) criterion was applied. As data on the initial training level, the average scores on the USE, uploaded from the administrative database of the university, were used. The maximum value of difference between the empirical and normal distribution of average USE scores was calculated. For the control group of students, the maximum deviation value of the experimental distribution from the theoretical normal law is d_{emp}=0,052, which is in statistically insignificant area: $d_{emp} < \min(d_{cr})$, where d_{cr} is displayed in Table 2:

Table 2 – Critical value of Kolmogorov-Smirnov test of distribution normality

n	d_{cr}	
	$p \leq 0{,}05$	$p \leq 0{,}01$

115	0,127	0,152
148	0,112	0,134
209	0,094	0,113

Thus, the empirical distribution of the students' average scores on USE is close to normal. Similarly, the same calculations of K-S criterion for the normality of distribution for two experimental groups were performed. For the blended learning model the empirical value of deviation from the normal distribution was d_{emp}=0,055, which is less than the critical value (see Table 2). For the model of online learning with tutor support d_{emp} = 0,074, which confirms a statistically insignificant difference between the empirical and theoretical distributions.

To verify the homogeneity of the student groups (similarity in characteristics for all the models), the K-S test was also undertaken. To compare the distributions of the students' average scores on USE for control and experimental groups the calculations of the maximum difference between these distributions were performed.

The empirical value of K-S-test is equal to λ_{emp} = 1,199 that is less than λ_{cr} ($p \leq 0.05$) = 1,36, which provides the basis to conclude that the difference between distributions of the average USE scores in the control and the first experimental groups is statistically insignificant. In the same way, the empirical differences were calculated when comparing the distributions for the 1st and 2nd experimental groups. The resulting value of K-S test is λ_{emp} =1,118, that is in the area of statistical insignificance.

Thus, we are dealing with three homogeneous distributions on the initial training level of students mastering the discipline in three different technologies, which excludes the influence of the initial sampling parameters on the result of statistical processing and allows a comparison of the efficiency of all three models with each other.

Figure 1 shows the frequency distributions of the average USE scores of students who studied Theoretical mechanics in three different models.

[insert Figure 1]

Figure 1 – Frequency distribution of the average USE scores of students who studied Theoretical mechanics in three different models: traditional model of learning (solid curve with squares), blended learning with current and final online attestation (dashed curve with rhombs) and online learning model with tutor support (dotted curve with triangles).

The results of calculation by the method of descriptive statistics have shown that statistical indices for these three groups are the same within the accuracy of calculations.

Minimum values of the average USE scores range from 44 to 47, and maximum ones - from 81 to 100. At the same time, the percentage of students with the average USE scores below 60 is between 13% and 22% for different teaching technologies; for the average USE score from 60 to 80 it is 76% to 80% of students; and the share of "honor students" (more than 80 points) in different samples ranges from about 1% to 8%.

Analysis of information from the administrative database of the university on the average USE scores have shown that the majority of students in the groups (75%) are "good students". This fact determines the average performance and uniformity of the sets. Shares of the "honor" and "weak" students are significantly lower and they are not essential to affect statistical indices, except for the variance, which shows the range of values of the average USE scores from the expected value. For the control group of students, the value of the dispersion is minimal, and for the second experimental group – it is maximum, that determines the difference in the mean square deviations in the groups.

Referring to the analysis of the average performance of students in the previous period of study, this is the input parameter when comparing the efficiency of learning in different models. The information was taken from the administrative database of the university. Results of calculation of statistical indicators for average students' scores distribution for the fall term of 2016 - 17 academic year are shown in Table 3.

Table 3 - Statistical indicators for average students' scores distribution for the fall term of 2016 - 17 academic year

Statistic indicators	Control group	1st experimental group	2-nd experimental group
Average	65,0	64,4	69,3
Standard Error	0,733	0,894	0,732
Median	65,6	63,1	69,7
Modality	50	58,5	90,8
Standard deviation	7,858	10,878	10,576
Variance of the sample	61,755	118,338	111,852
Minimum	47,17	42,69	40,96
Maximum	81,09	93,35	92,65
Amount	7480,59	9526,66	14476,37
Score	115	148	209
Reliability level (95%)	1,452	1,767	1,442

An analysis of the distribution of the average students' scores of the intermediate certification of students revealed an insignificant shift in the mean and median values of the previous performance to large values, as well as an increase in variance in all three samples. In this case, the shape of the distribution changed quite strongly, and the differences from the normal distribution of the groups were statistically significant. Figure 2 shows the frequency distribution of the average scores of intermediate certification of students belonging to different samples.

[insert Figure 2]

Figure 2 – Frequency distribution of the average scores of intermediate certification of students belonging to different samples corresponded to: traditional model of learning (solid curve with squares), blended learning with current and final online attestation (dashed curve with rhombs) and online learning model with tutor support (dotted curve with triangles).

The most significant difference was observed for the students of the 1st and 2nd experimental groups: two maximums appeared on the frequency distribution of scores. For students of the 1st experimental group, one maximum arose at 60 points, and the second - at 70, while for the students of the 2nd experimental group the maxima were at the level of 65 and 75 points. In addition, the share of "good" students in the 1st and 2nd experimental groups decreased, and the share of "honor" students increased to 18% and 32% in the 1st and 2nd groups, respectively (Table 4). For the control group, the percentage of "good" students remained at the same level, but the share of "weak" students decreased significantly and the share of "honor" students increased.

Table 4 - Shares from the total number of students in the samples that have average scores of intermediate certification of students in the ranges: less than 60 ("weak"); from 60 and less than 80 ("good"); 80 and higher ("honor")

Range of Average Intermediate Certification Points	Traditional format of training	Blended learning model with current and final examinations online	Online learning with tutor support
0 <score <60	12,17%	18,92%	7,66%
60≤ score <80	77,39%	63,51%	60,77%
score≥80	10,43%	17,57%	31,58%

Comparison of the distribution of USE scores and the average performance of students in the previous semester does not make sense, since the assessment technologies and the format of the exams vary considerably. In addition, as shown above, the results of the first session can be influenced by the different level of adaptation of students to the new conditions, as well as different motivation and self-discipline.

In the next step of processing, the experimental results were analyzed by the final points on the subject "Theoretical Mechanics", which were obtained from two sources: the progress of students on the online platform (for students mastering the discipline in terms of the model 4 online learning), the score of university grading system (for students studying in the traditional format) and from both sources for students who study in the framework of the model 3 blended learning model. Figures 3a show the frequency distribution of final points on the subject (output frequency) compared to the average performance scores in the previous period (input frequency) for students trained in the traditional model.

[insert Figure 3a]
[insert Figure 3b]
[insert Figure 3c]

Figure 3 - Frequency distributions of the final scores on the discipline (output frequency depicted by the dashed curve) and the average score of the intermediate certification (input frequency depicted by the solid curve) for students trained within: (a) the traditional model, (b) blended learning technology with current and final examinations online, (c) online learning model with tutor support.

As can be seen from the figures 3a-c, the distribution of the final scores on the discipline differs significantly from the distribution of the scores of the average performance for the previous period of study. In all three models, the range of final scores is wider than for the previous performance of students. There is a redistribution of frequencies in the direction of lower points for all three models. This can be explained by the fact that Theoretical mechanics is the first engineering discipline in the curriculum of the first year students who study at the engineer training programs. It requires not only knowledge of the basics of physics, but also the skills of using mathematical analysis tools that are learned by these students in the same semester. As a rule, the students' progress in Theoretical mechanics is lower than in other subjects. In order to support students in mastering this complicated discipline and facilitate their understanding of the laws of mechanics, the teachers created an online course “Engineering Mechanics” at the NOEP and edX platform (www.edx.org), which contains not only video-lectures, theoretical material and control tasks, but also interactive training simulators of real mechanical systems.

Considering the range of low final grades on the discipline, the most number of “weak” students (too more than a half) is observed for the traditional training format. The least share of students who received low points corresponds to the case of online learning model. As for the blended learning model the number of “weak” student increases as well but to less extend. It is clearly seen from the figures that there are two peaks on the curves which correspond to “good” and “honor” students. They are small enough for the traditional case of learning and significantly larger for the blended and online formats. The comparison of the final scores on the discipline for different models was based on statistical indicators calculated using the descriptive statistics tools. The calculation results are shown in Table 5

Table 5 - Statistical indicators of distribution of final points for the discipline "Theoretical Mechanics" for students studying in different models

Statistic indicators	Control group	1st experimental group	2-nd experimental group
Average	32,1	55,0	65,2
Standard Error	2,072	1,985	1,628
Median	28,1	60,4	68,9
Modality	1	0	0
Standard deviation	22,216	24,154	23,536
Variance of the sample	493,5353	583,419	553,959
Minimum	0	0	0
Maximum	100	98	100
Amount	3692,5	8136,5	13617,5
Score	115	148	209
Reliability level (95.0%)	4,104	3,924	3,210

As can be seen, the average score of students in the traditional model is heavily skewed toward lower scores due to the large number of “weak” students. The mean score in the other two models also shifted to the left, but the median values remained the same as for the previous study score. The sample variance increased significantly as compared with the variance of the input scores and, accordingly, the standard deviation increased. Figure 4 shows the frequency distribution of the final points of the discipline for three different models of learning.

[insert Figure 4]

Figure 4 - Frequency distribution of the final points on the discipline for three different models of learning: traditional model of learning (solid curve with squares), blended learning

with current and final online attestation (dashed curve with rhombs) and online learning model with tutor support (dotted curve with triangles).

Comparing models of online learning with one another and with the traditional format is difficult due to the complexity of the distribution function and the ambiguity of the conclusions about the success / failure of students for the entire aggregate sample. In this connection, for further analysis, subgroups with different output scores were singled out from the total samples of students for different models. The principle of clustering was the same: students with a score below 60 (“weak”); students with a score from 60 and below 80 (“good”) and students with no score less than 80 (“honor”excellent") (fig. 5).

[insert Figure 5]

Figure 5 - Distribution of students on the final score for different models of learning: traditional model of learning (diagonal hatching), blended learning with current and final online attestation (horizontal hatching) and online learning model with tutor support (dotted hatching).

A direct comparison of the distribution of students by subgroups for the input and output scores yielded the following results (Table 6). In all the models under consideration, the proportion of students with low scores (less than 60) increased, while the share of "good" fell significantly, and only "excellent" in blended and online models increased.

Table 6 - Shares from the total number of students in the samples that have input and output scores in the following ranges: less than 60; from 60 and less than 80; 80 and higher

Range of final scores	Traditional format of training		Blended learning model with current and final examinations online		Online learning with tutor support	
	Input score	Output Score	Input score	Output Score	Input score	Output Score
0 <score <60	12,17%	86,09%	18,92%	44,59%	7,66%	29,19%
60≤ score <80	77,39%	9,57%	63,51%	34,46%	60,77%	33,01%
score≥80	10,43%	4,35%	17,57%	20,95%	31,58%	37,80%

For a more detailed analysis of the effectiveness of different teaching technologies and the identification of the features of teaching students with different entrance scores, the frequency distributions of students on input score were assessed for each range of final scores on the discipline. This led to a conclusion about which students showed low results in the discipline, and which were good and excellent in progress. Figures 6 a-c show the frequency distribution of the average performance of students in the previous period for different final points ranges and different learning models (percentages herein are calculated on the number of students in cohorts with low, medium and high final score).

[insert Figure 6a]
[insert Figure 6b]
[insert Figure 6c]

Figure 6 - Distribution of the average performance of the previous period of study for subgroups of students who received different final scores on discipline (solid curve with squares corresponds to 0<score<60, dashed curve with rhombs corresponds to 60=<score<80, dash-dotted curve with triangles corresponds to score=<80) for the traditional learning model

(a), the blended learning model with current and final certification online (b), online learning model with tutor support (c).

As can be seen from the figures, the anomalous distribution is observed with the traditional model of training: most students received a low overall score in the discipline (the solid curve in Figure 6a), and this cohort included all “weak”, most “good” and more than half of the “honor” students. In the blended and online models, the subgroup with a low final score (the solid curves in Figures 6b and 6c) consisted mostly from “weak”, but a small part of “good” and “honor” students also satisfactorily coped with the certification in the discipline.
In the range of the final score from 60 and less than 80 (dashed curves in Figures 6 a) there were “good” students in all three models, i.e. they were able to confirm their scores on previous studies. The presence of small “tails” left from 60 points and to the right from 80 points indicate that a small portion “weak” students tightened to the assessment of “good”, and a small part of the “honor” students lowered its rating to “good”. A high score was shown by students who had “excellent” and “good” grades in the previous period of study, in all three models.
Figures 7 a-c present data on progress on the subject “Theoretical mechanics” of students with different entry points of the previous studies. The proportions of students were calculated to the total number of “weak” (Figure 7 a), “good” (Figure 7b) and “honor” (Figure 7 c) students according to the average performance in the previous period of study.

[insert Figure 7a]
[insert Figure 7b]
[insert Figure 7c]

Figure 7 – Final performance score of the students with different ranges of the input score: 0<score<60 (a), 60=<score<80 (b), score=<80 (c) for groups of students mastering discipline in the following models: traditional model of learning (diagonal hatching), blended learning with current and final online attestation (horizontal hatching) and online learning model with tutor support (dotted hatching).

Thus, the analysis of the progress of students who had different entry points of average performance for different learning models showed the following:
In the traditional training format, all students with low input scores showed poor performance in the discipline;
14% and 6% of “weak” students in the blended and online learning models, respectively, were able to improve their performance to “good”, while the rest have confirmed their knowledge as “satisfactory”;
In the traditional model of education, only 10% of “good” students confirmed their rating of “good” for certification in the discipline “Theoretical Mechanics”, 87% “good” students lowered their performance in the evaluation as “satisfactory” and only 3% were able to get “excellent”;
In the blended learning model with the current and final certification online 43% of “good” students confirmed their rating, 48% of “good” students lowered their performance in the evaluation as “satisfactory” and 9% achieved “excellent”;
In the online learning model with tutor support 44% of “good” students confirmed their rating of “good”, 39% of them lowered its performance in the evaluation as "satisfactory" and 17% were able to get “excellent”;
In the traditional model 17% of “honor” students showed excellent knowledge on the subject "Theoretical Mechanics", 17% - lowered their performance to “good” and 66% of them rolled up assessment “satisfactory”;

- In the blended model l62% of “honor” students confirmed their excellent knowledge on the subject ", 19% - lowered their performance to “good” "and 19% had got “satisfactory”;
In the model of online learning with a tutor support 68% of “honor” students confirmed the excellent knowledge of the subject, 24% reduced their performance to “good” and 8%" rated “satisfactory”.

The overall picture of student performance changes with respect to input scores for different training technologies is presented in Figure 8.

[insert Figure 8]

Figure 8 - Changes in the performance of students on the subject ”Theoretical Mechanics” with respect to the input points on the average performance of the previous period of study for different learning models: traditional model of learning (diagonal hatching), blended learning with current and final online attestation (horizontal hatching) and online learning model with tutor support (dotted hatching).

Thus, the detailed analysis of progress on the subject "Theoretical Mechanics" students mastering the subject in different models of training, showed that the discipline of engineering orientation is rather difficult for students participating in the experiment. In all three models, there is a general decline in performance level. In the traditional model, only 21% of students retain the level of achievement in relation to the previous study, 76% showed a lower score, and only 3% increase academic performance. The reason for this may be excessive requirements for students at the exam conducted in the traditional form or low level of training in physics and mathematics [27], which are the prerequisites of the study course "Theoretical Mechanics", semester certification on the subject, and low motivation of students. In the blended and online models a positive dynamic of performance is observed on the subject where more than half of students (54-55%) exhibit points corresponding to the average score for the previous study, 8% of students in the blended learning technology and 11% in the online technology show higher scores, but 37% and 33% in the blended and online models, accordingly, reduce their performance.

These benefits are provided by the learning models, using a specially designed online course in the discipline: the ability to access video recordings and methodical development at any time and from any location; using training simulators for the decision of problems on mechanics; intermediate testing for the training period; uniformity of time teaching load and strictly defined deadlines of control tasks; the opportunity to attend face-to-face classes (in the blended learning technology); and consultations (for both models) with the teacher during the semester. From the above, it follows that the two models of online learning (blended learning with the current and final certification online and the online learning model with tutor support) are proving effective in the implementation of the disciplines of engineering and technical focus, but the difference in learning outcomes of students is statistically insignificant.

The same data processing algorithm was applied for experimental data, which had been obtained for two other disciplines (see Table 1). A humanitarian discipline “Philosophy” was realized by using corresponding MOOC in the following online models:
Model 3 (the first experimental group – Ph-1);
Model 4 (the second experimental group – Ph-2).

The total number of participants was 269 students: 139 students in the first experimental group; 130 students in the second experimental group. All students mastered the discipline in the second term of the 2016-17 academic year.

The final results for the discipline “Philosophy” are presented in Figure 9. As it is seen from the figure in the blended learning model 35% of the students retain their academic performance in relation to their previous studies, 55% show higher scores, and only 10%

decrease their performance. In the online learning model, one can see more restrained, but still positive progress of students on the discipline: more than half of the total number of students (52%) demonstrated scores corresponding to their average scores on previous studies, 32% show higher scores, and about 16% decrease their academic performance.

[insert Figure 9]

Figure 9 - Changes in the performance of students on the subject “Philosophy” with respect to the input points on the average performance of the previous period of study for different learning models: blended learning with current and final online attestation (horizontal hatching) and online learning model with tutor support (dotted hatching).

Thus, the analysis of the students’ progress showed that for humanitarian disciplines such as “Philosophy”, where communicative components of the educational process play an important role for mastering the discipline and reaching learning outcomes, the use of blended learning models with preserving a part of face-to-face teaching, gives better results.
A detailed analysis of the academic progress on the discipline "Engineering Graphics" for students who mastered the subject in different models of training was carried out. As it was pointed in the Table 1 tree models of online learning were used to implement the discipline:

Traditional training without using an online course (control group – EnG-1);

Traditional training with using an online course as additional material (the first experimental group – EnG-2);

Model 3 (the second experimental group – EnG-3).

The total number of the first year students who took part in this part of the experiment was 83 people including 23 students who were taught in the traditional format; 31 students used MOOC independently while mastering the discipline and 29 students were involved in blended learning. All of them were the first year students.

The analysis has showed that using MOOC improves the progress of students and facilitates their understanding of the basic concepts of projecting a spatial figure on the plane. Online course "Descriptive Geometry and Engineering Graphics" used in the learning process contains interactive training tasks and simulators that develop spatial imagination and help students to get practical skills for engineering drawings.

In all three models of training (see Figure 10), the majority of students (from 59% to 68%) were able to confirm their average scores on the previous period of study. At the same time, about 40% of students lowered their performance in traditional education, about 20% - in the traditional format with using MOOC, and only 7% - in blended learning model. Using the online course for current and final certification contributed to the achievement of 34% of students, whereas in a purely traditional format no student could raise their academic performance. In the blended model, 10% of students received higher grades in relation to their average scores from the previous studies.

[insert Figure 10]

Figure 10 - Changes in the performance of students on the subject “Philosophy” with respect to the input points on the average performance of the previous period of study for different learning models: traditional model of learning (diagonal hatching), traditional model with online course as an additional material (vertical hatching) and blended learning with current and final online attestation (horizontal hatching).

From the above, it follows that the use of the online course in the traditional model and the blended learning model with current and final online attestation prove their effectiveness in the implementation of engineering disciplines.

Conclusion

In order to study the processes of using online courses for engineering and technical majors in universities, the authors identified five main models of online learning and conducted the experiment aimed at comparing different models of online learning with each other and with the traditional taught format. The results of the experiment allow purposeful model selection for implementation of the educational process considering both specific features of the disciplines, initial training level of students and their readiness for online learning.
We consider the results of the experiment to be fundamentally significant, confirming that the use of online courses does not reduce the learning outcomes of students. Moreover the models using MOOCs in the educational process such as blended learning and online learning with tutor support demonstrate greater effectiveness in comparison with the traditional model. It was shown that even the use of online course as an additional material in the traditional taught format raised the students' academic achievements. Behind this are the advantages offered by the online learning models using specially developed online courses which provide free unlimited access to video recordings and content, the use of training simulators to solve objectives, pass intermediate testing throughout the training period, the uniformity of the training load distribution over time and the strictly defined time limits for the delivery of learning outcomes control measures.
The empirical study has proved that for humanitarian disciplines, where the communicative component of the learning process is significant, the blended learning technology produces better results in terms of educational outcomes of students. For engineering and technical disciplines, there is no statistically significant difference in using blended or online learning technologies.

The results of the empirical study can be used by heads of educational organizations and teachers for modernization of the educational process, improving teaching methods, and increasing the effectiveness of new educational technologies.

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