

A Model of Mathematics Distance Learning in University Training E-Environment

Elena F. Timofeeva
North Caucasus Federal University
Stavropol, Russia, 355009
teffena@mail.ru

Lusine A. Grigoryan
North Caucasus Federal University
Stavropol, Russia, 355009
honey.lusine@mail.ru

Tatiana V. Marchenko
North Caucasus Federal University
Stavropol, Russia, 355009
tatiana-marchenko-25@yandex.ru

Kristina A. Khalatyan
Stavropol State Pedagogical Institute
Stavropol, Russia, 355029
Khalatyan_K.A@mail.ru

Abstract

The article studies modernization of higher education with the use of distance technologies. The aim of the project is the development of training content for teaching Mathematics with the use of distance learning technologies, its introduction into the training process and testing. The paper presents a model of blended learning (a modified model of distance learning) implemented in North-Caucasus Federal University. LMS Moodle is employed as a learning platform that provides a wide range of features to support e-learning. A brief characteristic of virtual learning environment is provided. The structure, basic principles and peculiarities of model functioning and its management system are described. The results of the study suggest that the introduction of distance learning tools into the training process should be based on a comprehensive approach of enhancing the quality of education through integration of traditional place-based and e-based learning, improvement of psychological and educational support for students, and collaboration between the university, teaching staff and IT-infrastructure specialists. A comparative analysis of distance learning and the proposed modified model of distance learning, as well as the results of students' academic performance in the process of model testing, suggest that the given method of distance learning appears to be efficient.

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1 Introduction

The global process of community informatization entails changes in scientific and technical areas as well as intellectualization of all human activities and development of qualitatively new information environment that enhances creative potential of an individual [Kur15], [Nik15], [Sur16], [Khu4]. Nowadays the activity connected with information appears to be one of the dominant ones. It makes a person meet new requirements: be capable of navigating in information flows and create one's own flows based on obtained and analyzed information. Information technologies are being increasingly introduced in education. Present-day professionals are expected to continuously extend their knowledge and develop skills, shift from the "education for the whole life" paradigm to a "lifelong learning" approach. Russian higher school faces the challenge to train a comprehensively competent and adaptive specialist by means of advanced tools in training management. It calls for innovations in higher educational institutions, development of information-oriented learning in line with flexibility and convenience learning process. Education should be accessible and available, based on information technologies. It is expected to provide a student with all necessary information for professional and personal development. The Internet technologies are of special importance as they offer considerable opportunities for teaching and learning a wide range of subjects [Tre16], [Moo11], [Gor11]. This requires new software and technical tools, as well as new training methods and principles of training material delivery in order to achieve the best possible combination of technical means and presentation methods. The above-mentioned confirms the relevance of innovating higher education with distance technologies.

The starting point of distance learning development in Russia was marked by the order of RF Ministry of General Education and Vocational Training of 30 May 1997 1050 "On carrying out an experiment in the sphere of distance learning" [And14], [And99]. The outcomes of training quality assessment obtained in the project proved distance learning to be a prospective direction for the development of national system of education.

In Russia, distance learning is methodologically regulated, above all, by Federal Act of 29 December 2012 273-FZ "On Education in the Russian Federation". Article 13 stipulates the implementation of training programs with the use of different training technologies, including the distance ones [Fed18]. Since that time, according to sociological surveys distance learning has been gaining popularity.

Preparation and transition to distance learning in North-Caucasus Federal University has started with the enactment of the order of the Ministry of education and science of the Russian Federation of 23 August 2017 816 "On Approving the Regulations on the Use of E-learning, Distance Learning Technologies in Training Programs Provided by Educational Institutions".

2 Task

The Project "Introduction of courses delivered with distance learning technologies for students trained at Bachelor degree programs" in North-Caucasus Federal University (NCFU) was initiated due to implementation of projects aimed at enhancement of economic efficiency of higher educational institutions under the RF Ministry of Science. The representatives of the University took part in the seminar "Mechanism tools for planning and implementation of sustainable economic development of a university".

In October 2017, the project was successfully defended in FSBEI HE Plekhanov Russian University of Economics, and early in November the same year NCFU launched the pilot project and implemented the road map on introduction of courses delivered with the use of distance learning technologies. The project was enlisted in the passport of the priority university development "Digitization of educational and research activity, computational modeling and computational experiment". The objectives of the project "Introduction of courses delivered with distance learning technologies for students trained at Bachelor degree programs" are as follows:

- improved quality of learning achievements thanks to providing access to high-quality training materials, best lecturers' lectures and the possibility to view them repeatedly;
- development of university training based on distance learning technologies;
- education quality enhancement through integration of place-based classroom and e-learning;
- participation of NCFU in global educational process;
- enhancing the efficiency of student's independent seatwork and ensuring automated (partially automated) control over the performance;
- cost optimization of training process management and implementation;
- learning individualization.

In order to achieve the given objectives of developing and implementing e-learning and distance learning technologies for the course of mathematics the team of authors was assigned the following project-related tasks:

- creation and information content development of an e-course to implement training programs with the use of e-learning and distance learning technologies;
- compilation and accumulation of assessment tools in electronic format;
- training process quality enhancement;
- implementation of blended learning technologies in the training process;
- approbation of distance testing as implemented into the training process;
- monitoring users' (students') activity: frequency and duration of their work with the course and its modules;
- registering the implementation of the training;
- self-control of students throughout the training process.

3 Development of methodology

3.1. Principles of distance learning

Distance learning is a form of training process based on IT technologies providing communication and interaction between the participants that are distant in time and space [Fed18]. Along with it, there is information exchange by means of innovative technologies [Pol4]. A student takes the training individually, he is provided with qualified methodological support and an opportunity to communicate with the teacher.

Functionally a system of distance learning comprises several stages:

- training management (automated compilation of training programs, management of access to courses and tests, report generation) [Ser12];
- ensuring interaction between the participants of the training process;
- development of training content.

The following principles were observed during the development of a distance learning course in mathematics for students of the Institute of Engineering in NCFU:

- 1) humanization principle: flexible time-frame; opportunity to choose an individual pace and path of learning;
- 2) interactivity principle: and learning activity is actualized within the framework of distance-learning system; students and teachers are engaged in interaction on a systematic basis;
- 3) identification principle: (personality identification of a trainee) the principle is observed in order to prevent falsification of training activity results;
- 4) regulations principle: students can work on tasks any time of the day but they are expected to have a clear timetable for tests;
- 5) principle of pedagogical feasibility as regards the use of IT and compliance with ergonomic requirements: the choice of training tools should conform with best possible correlation of printed books, Internet sources and videos; it is necessary to take into account the factors that enhance the efficiency of skimming;
- 6) the principle of the subject's independence and responsibility: such features as responsibility, time-management skills, independence and self-control are required in order to achieve the results;
- 7) modularity principle in development of network courses: a complex of systematized training materials in different forms (hard copy, e-version) aimed at the creation of educational environment;
- 8) the principle of virtual educational process management: a set of rules, regulations and analytical reports of IT specialists is compiled.

The given system of psychological and pedagogical conditions reinforced by the principles outlined above, a wide range of pedagogical and psychological methods ensure the efficiency of the training process and the achievement of better performance.

3.2. Distance model implementation

It appears to be relevant to consider three integrated factors determining the stages of preliminary preparation and implementation of the project on introduction of distance educational technologies into the course of mathematics:

- 1) technological;
- 2) pedagogical;
- 3) organizational.

The first one on the list is predetermined by information technologies used to develop, deliver and support the training courses and the training process in general. The relevance of the second factor is specified by a set of methods and tools employed in the training process. The third factor characterizes the peculiarities of organizational structure of distance learning.

The model of distance learning described in the study incorporates integrated educational environment with optional relevance specification of different components: technological, pedagogical and organizational-methodological.

An essential prerequisite for efficient training process management within the framework of blended learning (a modified model of distance learning) is the choice of learning management system [Gra5]. NCFU uses LMS Moodle as an information system that provides managerial, technical and methodological support of e-learning processes. It is a customizable software system used to create online courses, provide e-learning with distance educational technologies, analyze student's performance, carry out assessment, etc.

Web-support is provided mainly to manage independent seatwork with the use of e-resources (e-content). Unlike file stores, modern LMS foster individualization of learning paths through feedback options. LMS functional tools ensure interactive and communicative character of the learning process (tests, tasks, forums, surveys, interactive objects – lectures, etc.), thus specifying the level of interaction: “student – content”, “student – teacher” or “student – student”, and the resources (files, hyperlinks, comments, etc.).

It is to be mentioned that the methodology of creating and applying LMS interactive elements in electronic courses is of special importance. The main role should be given to the model adopted for learning with distance educational technologies [Vay17], [And99], [Ale9]. The choice of the model in NCFU was predetermined by the analysis and review of different approaches to classify the learning models with distance educational technologies as proposed by different authors [Vay13].

Partial substitution of place-based workload by electronic educational resources in implementing blended learning model is only possible in case there are massive open online courses on this subject [Uva15]. This is exactly the course that has been developed by a group of specialists. It is available on LMS Moodle learning management platform and ready for use in the training process of NCFU.

From the pedagogical point of view, the proposed model is a copy of pedagogical scenarios of traditional contact training with a number of peculiar features. They are as follows: the teaching staff sets the objective and develops the course, a clear timetable for the training course is established, the course comprises a specified set of tasks, and trainee's assessment is a part of the process.

The protocol for the development of a distance learning course in mathematics and different stages of its development are shown in Fig. 1. Modules 1, 2, 3 and 4 represent the flow of the process.

For instance, at the executive stage (2) the working group developed the training programs, unified the topics assigned for distance learning, studied and analyzed the best practices offered by the leading national universities. The introduction of a blended learning model entails the revision of local university regulations, establishment of the relevant infrastructure, teaching staff training [Yak16]. In order to carry out the project at the highest possible level the teaching staff took up a special continuous development program.

Diagnostic and corrective stage (3) reveals the challenges faced by students while working with the course; some corrections are introduced into the test part and the criterion indicators. The purpose of this stage is to analyze how efficiently the course operates, consolidate qualitative changes and set the guiding lines for further enhancement of the distance learning model.

The figure not only illustrates the development process but also makes it possible to track and determine the efficiency of the preparation process at different levels as contrasted with the indicators in the relevant areas.

3.3. The structure of a distance learning model

The course content incorporates a welcome module with the outline of the course and its objectives, a set of videolectures, textbook and presentation material, as well as assessment funds for ongoing and interim assessment.

Videolectures are accompanied by slides in 20pt font size, including formulas in bold and bigger size, and image animation. Slides and presentations are available for separate viewing. The duration of a module is 12-15 minutes. Each module covers one topical point, the points stand out of the lists gradually, one by one.

Tests are based on both open and closed task types. The developers observed a set of principles in test tasks:

- equal plausibility of tasks;
- clarity of the text;
- maximum brevity of the wording;

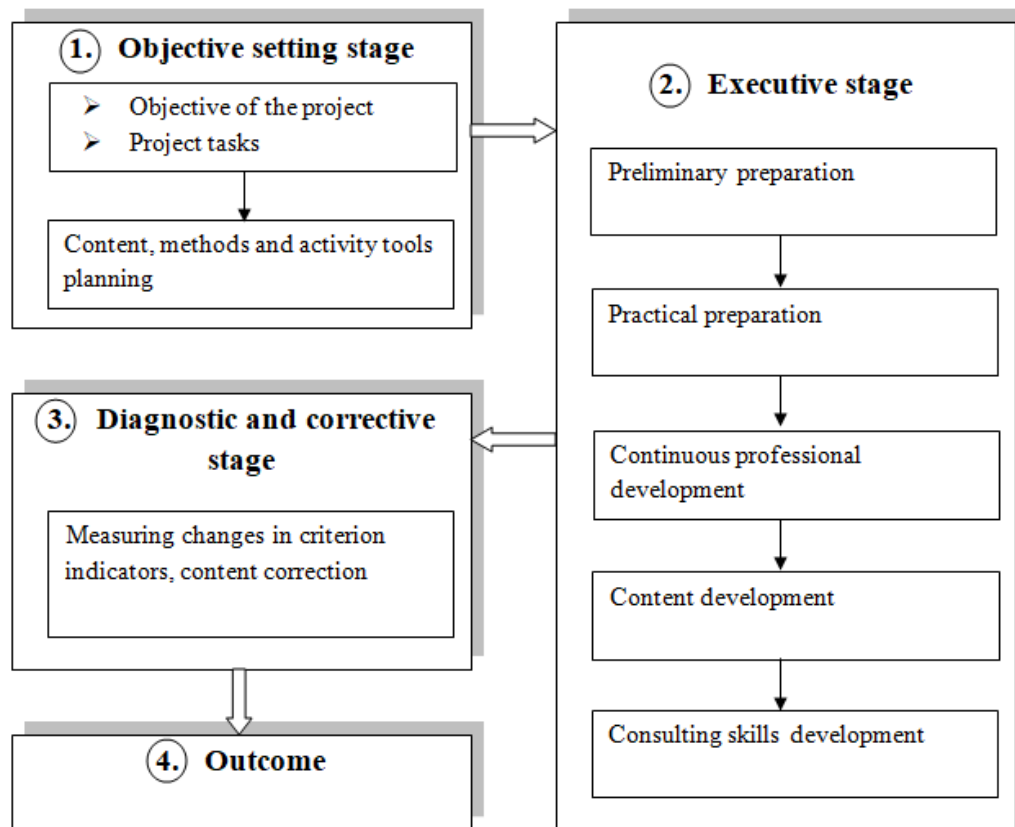


Figure 1: Development Stages and Levels of a Distance Learning Course in Mathematics.

- simplest stylistic constructions;
- the task is expressed by more words than the answer;
- correct and incorrect answers have equal length;
- all irrelevant words in the task are omitted;
- a unified instruction is provided (to fill in the number of the correct answer);
- there is only one correct answer;
- word repetitions in answers are not admitted.

The following parameters were observed at the stage of test task development: the choice of task content, the choice of the task form, compilation of instructions and test description, test approbation, interpretation of outcomes, test quality expertise.

The effectiveness of distance learning is achieved provided that the teaching staff is highly qualified, ready for time- and effort-consuming work, and is aware of organizational, technological, psychological and pedagogical peculiarities of this activity.

As for purely pedagogical aspects, in videolectures special attention was paid to speech culture: grammatically correct wording, brevity and clarity of expression, suprasegmental features, i.e. intonation patterns, tempo and pausing, correct use of special terms.

Different ways of training material presentation, independent seatwork and testing can be used in distance learning. A math lecturer uses the same means and forms of activity, as they are capable of developing necessary competencies with a student.

4 Results

To date, within the framework of the training project with the use of distance learning technologies the amount of place-based workload has been reduced. According to the road map, contact hours in the course of Mathematics have been reduced by 50

The following results have been achieved during project implementation:

- designing of a set of teaching materials on the course of mathematics delivered with the use of distance learning technologies;
- development of digital educational resources (educational content) for lectures delivered with the use of distance learning technologies;
- development of assessment system for the students trained at the program with e-learning;
- introduction of a training program in Mathematics with the use of distance learning technologies into Bachelor studies in NCFU's Institute of Engineering;
- conversion of Mathematics course into a course with partial online training. In 2018-2019 during the first stage of project implementation, 350 students trained in 10 areas offered by the Institute of Engineering took up a course with distance learning technologies.

In order to assess the application of blended learning in the educational process different types of reports compiled in LMS Moodle have been examined and the statistical analysis of efficiency as regards forming the skills in Mathematics have been carried out [Nov4]. Under the experiment, two groups of 50 students each were tested for training outcomes: the experimental one and the control one.

The results of assessment procedures stipulated by the training process were compiled into tables according to the level of students' academic performance [Nov4], [Bar11]. The outcomes of academic performance dynamics as assessed on the completion of the experiment are shown in Table 1.

Table 1. Comparative data of academic performance in experimental and control groups as assessed before and after the skill-forming experiment (SFE).

Level of academic performance	Control group of students (%)		Experimental group of students (%)	
	Before SFE	After SFE	Before SFE	After SFE
High	21,6	24,8	21,2	35,4
Intermediate	40,8	53,4	39,9	57
Low	37,6	21,7	38,9	7,6

The bar chart below shows the results obtained in the experiment (Figure 2).

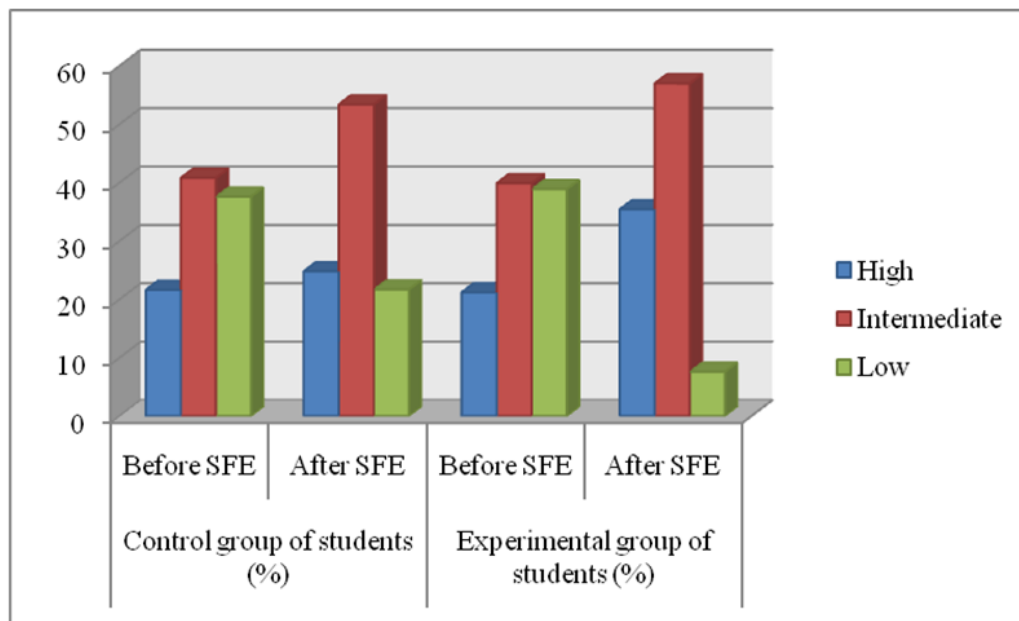


Figure 2: The bar chart of dynamics in academic performance of the experimental and control groups.

The bar chart shows that the students with low level of academic performance demonstrate extremely poor results that can be validated by LMS Moodle reports on average time spent in the system, average number of views and average number of days between the visits. A-students worked in the system more actively though

they had fewer views than C-students. The C-students referred to the content more often but for shorter periods. The analysis has revealed a correlation between the level of student's academic performance and the activity in the use of LMS Moodle.

The findings of the study indicate that the active use of blended learning technologies enhances both the general efficiency of training and the academic performance of students. The statistical data suggest that training in e-environment fosters the development of individual training skills that are essential for the life-long learning concept.

Significant positive dynamics shown by the experimental group in the process of training within the framework of modified distance learning model could serve a criterion of efficiency and expediency of experimental work. Seen as a whole, the combination of traditional contact classes and LMS Moodle distance learning in the form of a modified distance learning model shows highly favorable outcomes.

5 Discussion

Along with a wide range of advantages offered by distance learning there are some drawbacks. However, the modified distance learning model based on integration of online and place-based classroom interaction can compensate for the shortcomings. Table 2 shows a comparative characteristic outlining the key challenges in distance learning and the ways they have been tackled in the modified distance learning model.

Table 2. A Comparative Characteristic of Distance Learning and the Modified Distance Learning Model.

№	Drawbacks of distance learning	Drawbacks compensation in the modified distance learning model
1.	Lack of immediate didactic emotional student-teacher contact, as well as student-student contact.	The gap is bridged through student-teacher contact in the process of discussing and studying the topics of the course at classroom-based lectures and practical contact hours.
2.	High level of self-organization and time-management are required to complete the tasks and master the content.	Freedom in choice of time and training pace is regulated by certain dates.
3.	Challenges in identifying a student during the assessment procedure.	Along with tests in the process of online training, classroom-based assessment tools are used.
4.	Lack of positive "side effects".	Integration of different training types allows combining <u>videlectures</u> and classroom-based lectures. The process of taking notes trains the fluency of handwriting, develops mechanical memory, and teaches how to single out the most relevant fragments from the flow of information on the spot. These useful skills are beneficial in everyday life. Purely distance learning does not provide an opportunity to develop them.

Thus, the introduction of distance learning technologies into the training process is to be based on a complex approach of education quality enhancement through integration of electronic and traditional training tools, as well as elaboration of psychological and pedagogical mechanisms to support students and cooperation between the university, teaching staff and specialists in IT infrastructure. One of the peculiar features of e-learning technologies is the increased level of teacher's workload at all training stages – starting with development and introduction and up to ongoing supplementation of the e-content.

6 Conclusion

The use of the proposed modified distance learning model substantiates and boosts student's motivation for training activity, whereas self-control and self-criticism on the part of students give them an opportunity to gain more independence and initiative, offer a wide scope for creative activity, and above all, develop scientific and research skills.

The experience obtained through the development and implementation of the model of mathematics distance learning contributes to the overall educational ecology in a number of ways:

- best practices of integrating the model into university educational environment can add to further enhancement of legal framework for e-learning;

- the observations within the project can bring about improvements and updates of the model / similar models;
- the protocol for the development of a distance learning course in mathematics can be applied in other subject areas.

The given model has been implemented, still its functioning requires constant upgrading, supplementing and enhancement. It also dispels any bias against the use of distance learning technologies and proves the relevance of the topic for present-day higher education.

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