

Usage of Online Education in the Field of Mathematics for Hearing Impaired and Deaf Students

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Abstract. The article is devoted to problems of usage of online education in the inclusive education process in BMSTU. Russian and foreign experience in the field of mass open online courses in the system of higher education is briefly described. Information on foreign platform Coursera, Russian online courses construction platform Stepik and the National Open Education platform is given. The experience of Ural Federal University in development of two first online courses for people with disabilities is shown. The article describes educational features and specific needs of students with impaired hearing in the system of higher education on the base of BMSTU's years-long experience in work with groups of students of that type. The model of inclusive higher education in Bauman university is briefly described and explained. Main stages of development and approbation of online course on elementary mathematics knowledge actualization for hearing-impaired and deaf students on the first year of education in BMSTU are revealed. Practical recommendations for online courses' authors on materials selection, preparation, video recording and other stages of online course creation are given. Prospects of the developed course usage and plans for further activities of the university in that field are shown.

1 Introduction

In recent years online education has become one of the leading trends in many countries. According to EdMarket Research [1], in Russia the part of distant education in higher education (in relation to students amount) will have grown up to 9% by year 2021. A bright example of successful online education development is the online magister program organized by Moscow Institute of Physics and Technology (MIPT) in cooperation with Russian Presidential Academy of National Economy and Public Administration under the President of the Russian Federation (RANEPA), which allows to receive the master's degree in economics and get RANEPA diploma in case of successful program acquisition during online education process.

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In a number of countries a blended learning has become normal in higher education, and it is a combination of traditional classroom-based and distance education. As an example the results of research conducted by Allen I. E. and Seaman [2] can be used: about 42% of professionals in the field of USA higher education, among whom the survey for Online Report Card: Tracking Online Education in the United States research was conducted, mentioned blended education as a more promising than the distance one; about 77% of world ranking American universities lecturers consider online education to be equal (and in some cases more preferable) alternative to the traditional education.

One of the largest international projects in the sphere of mass online education is Coursera [3], which has been founded in 2011 in Stanford University. The project has collaborations with universities which publish and run courses in different fields. Student passes the courses, communicate with peers, passes tests and exams directly on Coursera website. By the January of 2020 Coursera joins 40 million users and more than 3600 courses and specializations provided by more than 190 educational organizations all over the world, and by Russian universities too. The access to the course requires to be paid for (the price is 15\$ and higher), but free access to the course is also possible in case of sending a motivation letter and its acceptance by the platform.

This country also has a great number of aggregation platforms and online courses constructors. One of the most popular platforms for information technologies studying is «Stepik» [4]. This educational platform and online courses constructor has been founded in 2013. Its specific feature is that the authors develop adaptive education algorithms, freely collaborate with MOOC (mass open online courses) authors and help in organization of academic competitions and retraining programs. The majority of the courses are free for students and devoted to information technologies but are not limited by this field. The platform has gained a high popularity among students interested in programming languages online studying and other spheres of IT. They also cooperate with leading universities and IT corporations in Russian Federation.

In recent years Russian universities also have become active participants of online courses market. Some universities use them only for their own students (usually as SMOK – small private online courses), while the others open them for everybody and even give certificates by the end of course acquisition.

Finally in 2015 The National Open Education Platform was launched in order to increase accessibility and education quality in the country. The platform has become a result of cooperation of the following leading universities: Lomonosov Moscow State University, SPbPU, SPbU, NUST “MISiS”, HSE University, MIPT, UrFU and ITMO University [5]. All courses placed on the platform can be accessed free of charge and have no formal requirements to basic education level. Those who want the passed course to be accepted for their bachelor or specialist degree have an opportunity to receive certificate. Certificate can be received if the student has overcome all control activities in the online course and has passed personal identification under controlled conditions. Online education fields of the highest priority (on the base of the platform’s statistics) are engineering and other technical sciences [6].

However, in spite of a great number of courses (more than 450 in January 2020) and students using them, there are not many universities thinking of accessibility of that education format for disabled people. It was only the December of 2019 when the platform has opened two first courses taking into account specific educational requirements from disabled people. The course has been prepared by Ural Federal University and devoted to the following topic: “Basics of personal development (for disabled people)” and “Organism resourced development (for disabled people)” [7,8]. Accessibility of courses for disabled people is provided by the following means:

- For hearing impaired and deaf students lessons are presented as simple graphic schemes and short sentences. All video lessons are provided with subtitles [8].
- For visually impaired and blind students lessons are presented as audio tracks [8].
- Moreover, specialists on different defects, psychologists, sign language interpreters and others were involved in the course development.

One of the courses' interface is shown on figure 1.

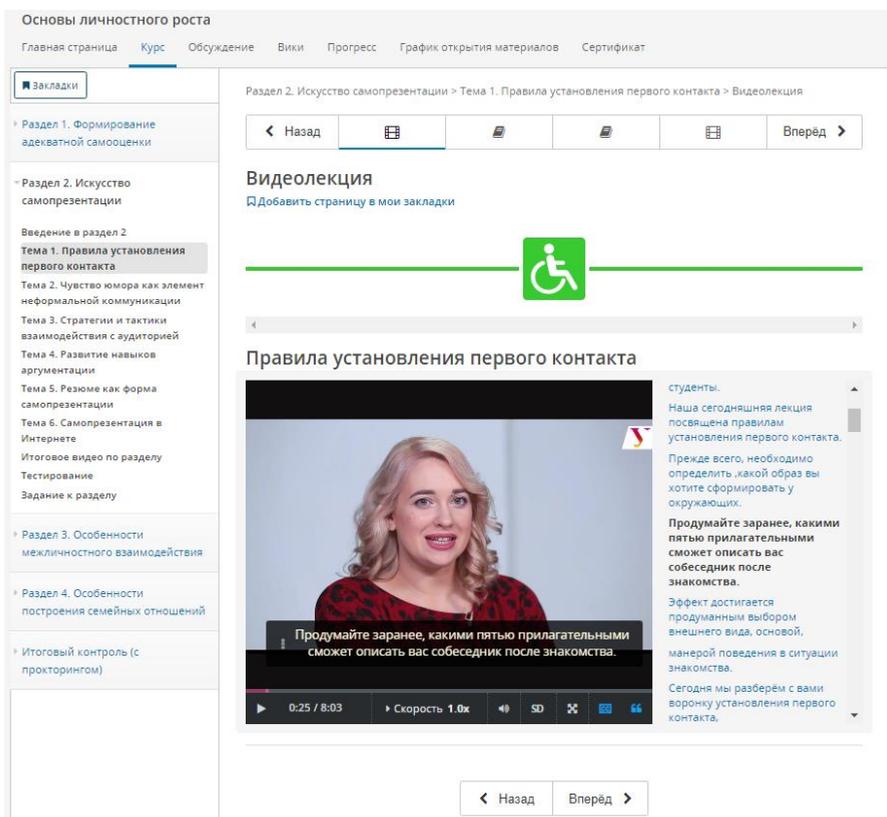


Fig. 1. The «Basics of personal development» course developed by UrFU.

Table 1. Contains of Figure 1.

Phrase in Russian	English equivalent
Основы личностного роста	Basics of personal development
Главная страница	Main page
Курс	Course
Обсуждение	Discussion
Вики	Wiki
Прогресс	Progress
График открытия материалов	Materials accessibility time schedule
Сертификат	Certificate
Закладки	Bookmarks
Раздел 1. Формирование адекватной самооценки	Unit 1. Building of a reasonable self-esteem
Раздел 2. Искусство самопрезентации	Unit 2. Art of self-presentation
Введение в раздел 2	Unit 2 Introduction

Table 1. (Continued) Contains of Figure 1.

Phrase in Russian	English equivalent
Тема 1. Правила установления первого контакта	Theme 1. Rules of first contact establishment
Тема 2. Чувство юмора как элемент неформальной коммуникации	Theme 2. Sense of humor as an element of informal communication
Тема 3. Стратегии и тактики взаимодействия с аудиторией	Theme 3. Strategies and tactics at communication with audience
Тема 4. Развитие навыков аргументации	Theme 4. Argumentation skills improvement
Тема 5. Резюме как форма самопрезентации	Theme 5. CV as a form of self-presentation
Тема 6. Самопрезентация в Интернете	Theme 6. Self-presentation on the Internet
Итоговое видео по разделу	Final video on the unit
Тестирование	Test
Задание к разделу	Task for the unit
Раздел 3. Особенности межличностного взаимодействия	Unit 3. Specifics of interpersonal interaction
Раздел 4. Особенности построения семейных отношений	Unit 4. Specifics of building of family relationship
Итоговый контроль (с практирингом)	Final check (proctored)
Раздел 2. Искусство самопрезентации > Тема 1. Правила установления первого контакта > Видеолекция	Unit 2. Art of self-representation > Theme 1. Rules of first contact establishment > Video lecture
Назад	Backward
Вперёд	Forward
Видеолекция	Video lecture
Добавить страницу в мои закладки	Add the page to my bookmarks
Правила установления первого контакта	Rules of first contact establishment
Продумайте заранее, какими пятью прилагательными сможет вас описать собеседник после знакомства	Think ahead which five adjectives might your companion use after the acquaintance
Эффект достигается продуманным выбором внешнего вида, основой, манерой поведения в ситуации знакомства	The effect is reached by smart choice of the appearance and behavior patterns for the acquaintance
Сегодня мы разберем с вами воронку установления первого контакта	Today we will discuss a funnel of first contact establishment

In 2018 BMSTU has started that work: development of a course accessible for hearing impaired students. It's not unexpected, because hearing impaired and deaf students have been studying in this university for more than 85 years, and 25 of these years the process has been supervised by a special department of the university – The head educational, research and methodological center for vocational rehabilitation of persons with disabilities (GUIMC). By the January of 2020 the number of hearing impaired students studying on different fields in inclusive form has reached about 140 people.

Educational process for such groups of students has its own specific features. During first two years they study fundamental, social and technical disciplines with addition of special adaptive disciplines in separate groups made of students with different majors; in the beginning of the third year the students are divided into groups belonging to the common cohort and further continue educational process with the students who are not hearing impaired and finally are totally integrated into the university's life. The need in such type of educational process organization caused by the fact that hearing impaired and deaf students experience difficulties with high rate of traditional education model which is oriented on contact work in classrooms and direct interaction between lecturers and

students. Supposedly, integration of mixed education model elements (here it means online course) into educational process might allow to decrease study load and make the rate of education more comfortable.

Let's consider basic characteristics of hearing impaired students which have been revealed and proved during long-year work of GUIMC specialists in BMSTU. Such students show difficulties in visual thinking, increased time of perception and understanding of educational material, insufficient attention concentration, slow rate of memorizing, difficulties in finding key points of the material and connections in the studied material, difficulties in understanding of the material, difficulties in analysis and synthesis of new results on the base of the material. These problems stimulate education specialists not only to improve existing methods of work, but also search for new ways and means which would help to increase efficiency of educational process for hearing impaired and deaf students [9-16]. One of such means is online education which is actively integrated into education systems in foreign countries [17-22].

The research of mathematical skills of hearing impaired and deaf students performed in several countries in recent years, shows that by the end of middle school hearing impaired and deaf students have a lag about 1.5-3 years in the field of mathematical disciplines comparing to other students [23]. The research has also allowed to reveal that there is no functional dependence between mathematical skills and grade of deafness [24]: about 15% of deaf students demonstrate the same mathematical skills as their peers who are not hearing impaired.

Hearing impaired and deaf students use the same logic and way of analyzing of mathematical problems as students who hear well; mistakes made by them during tests are the same as those made by students who hear well. Slow rate of their education is due to difficulties in perception of verbal and written language, and, as consequence, high concentration on the language component of study [25]. The educational process rate can be increased by the usage of visual patterns of mathematical ideas under study [26-28].

2 Actualization of knowledge in elementary mathematics with the help of online course

2.1 Task setting

Classes on mathematical disciplines for students with hearing disorders during first years at a university helps to reveal remarkable gaps in their knowledge of the material and insufficient skills for solving of basic mathematics school tasks. During higher mathematics course it regularly makes it necessary to remind them notions, theorems and formulas from school course, what decreases educational process efficiency.

The online course has been developed in order to make it possible for students to fill in their knowledge gaps in basic mathematics school course and acquire practical skills in elementary mathematics basic tasks solving. The aim of the course is to update and regularize basic mathematics ideas which would be used in subsequent learning of mathematical disciplines such as "Mathematical analysis", "Analytical geometry", "Linear algebra" and natural-science disciplines like "Physics".

2.2 Course preparation and practical recommendations

The stages of the online course development and support have been organized as follows:

1. Training results planning, defining targets, tasks and online course structure.

2. Working out mixed education technology, correction of teaching model based on active, practice-oriented education.
3. Development of control activities system and methods of their estimation.
4. Selection of education materials and defining its volume.
5. Development of tasks for self-checking.
6. Presentation development.
7. Director's script development.
8. Additional material selection.
9. Testing video recording.
10. Video recording of the course.
11. Complex examination of the online course.
12. Publication and probing of the course.
13. Support and exploitation of the course.

Let's formulate some recommendations that might be useful for authors of online courses:

1. Information in the course can be divided into the following groups according to the content:
 - obligate (its knowledge is evaluated by tests);
 - additional (it broadens knowledge in general and allows to build complex advanced trajectory);
 - entertaining (increases audience involvement).
2. The obligate information should be given to students during the course, while an external link is enough for the additional part of the information.
3. The information which can potentially be changed and cause the need to be updated is preferable to be given in a text form rather than in a form of a presentation in order to avoid recording of the video again.
4. Text information requires linguistic correctness (editor's or corrector's involvement is preferred), well-designed structure and typographics (placement, decoration, fonts, colors, indents).
5. External educational materials used in the online course shouldn't violate copyrights. It is necessary to pay attention to conditions of usage of fonts, graphical elements, illustrations in lecturer's presentations, videos, sounds and other. It is necessary to name the source of images, and if it is unknown, it is better to avoid its usage and involve a designer into this work.
6. All information on the screen must be visually recognizable while watching it on the smart phone. Extra information should be placed in additional or text materials.
7. It is necessary to follow the lecturer's speech rhythm and gradually show the new information on the screen (it is mostly important for hearing impaired students). If an illustration should appear on the screen, the best moment for it is when the lecturer makes an accent on a key word.
8. Preferably all materials in the video should follow one style (line thickness, colors, fonts and subscriptions), as well as important information should be accented similarly: elements size enlargement, change of color, animation effects and other. Don't make them too different because students should get used to the meaning of each visual effect.

2.3 Course description

"Elementary mathematics knowledge actualization" online course consists of 40 classes, each of which is devoted to a separate unit of mathematics school course, and among them

there are units devoted to algebraic operations on number of powers, operations on polynomials, linear, quadratic, rational and irrational equation solution, solution of equations with the power higher than two, elementary functions characteristics and other.

Each lesson includes theoretical and practical parts. The theoretical part is a presentation which with the help of animation informatively demonstrates studied ideas, formulas, their application and is also followed with a video and lecturer's comments (fig. 2). The duration of the video is 10 minutes. The practical part is a test consisting of 10 tasks aimed at examination of students' memorizing, understanding of the material and ability to apply received knowledge practically (fig. 3).

Students have an opportunity to use subtitles during video lectures. We are planning to add a sign language interpretation to each lesson.

Attestation for the discipline has a form of ungraded examination. In order to pass the attestation it is necessary to do all tests for the discipline, and a final test consisting of 40 tasks for the whole course material as well.

Решение квадратных уравнений

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Лекция 5.2

Квадратное уравнение общего вида

$$ax^2 + bx + c = 0$$

Корни квадратного уравнения общего вида находятся по формулам:

$$x_1 = \frac{-b + \sqrt{D}}{2a}; \quad x_2 = \frac{-b - \sqrt{D}}{2a}$$

Число D называется **дискриминантом** квадратного уравнения.
Дискриминант вычисляется по формуле:

$$D = b^2 - 4ac$$

множество вещественных чисел
 \downarrow

- $D > 0 \Rightarrow x_1, x_2 \in \mathbb{R}; x_1 \neq x_2$
- $D = 0 \Rightarrow x_1, x_2 \in \mathbb{R}; x_1 = x_2$
- $D < 0 \Rightarrow x_1, x_2 \in \mathbb{C}; x_1 \neq x_2$




Fig. 2. A screenshot of video lecture on solution of quadratic equations.

Table 2. Contains of Figure 2.

Phrase in Russian	English equivalent
Решение квадратных уравнений	Solution of quadratic equations
Лекция 5.2	Lecture 5.2
Квадратное уравнение общего вида	General quadratic equation
Корни квадратного уравнения общего вида находятся по формулам:	Roots of general quadratic equation are calculated by the following formulas:
Число D называется дискриминантом квадратного уравнения	Number D is a discriminant of the quadratic equation
Дискриминант вычисляется по формуле:	Discriminant is calculated by the formula:
Множество вещественных чисел	Set of real numbers

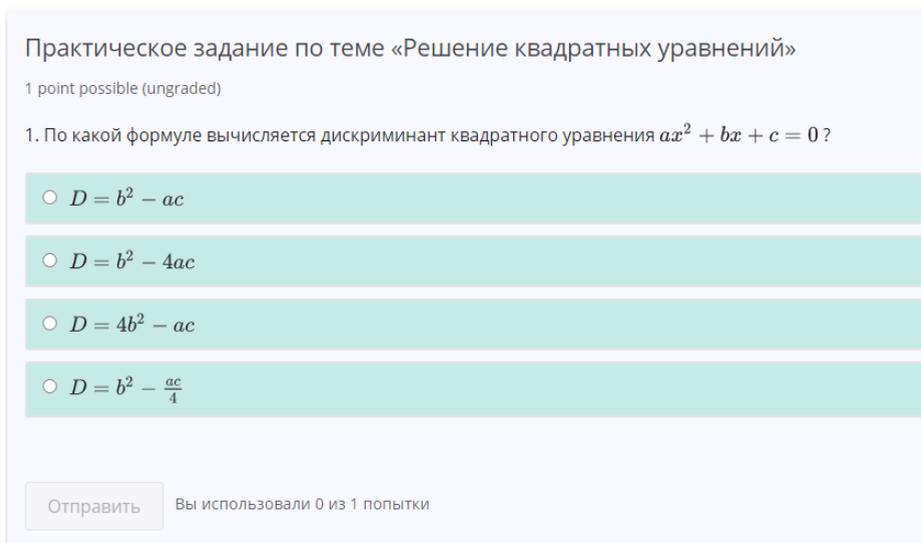


Fig. 3. Example of testing task on solutions to quadratic equation.

Table 3. Contains of Figure 3.

Phrase in Russian	English equivalent
Практическое задание по теме «Решение квадратных уравнений»	Practical task on “Solutions to quadratic equations”
1. По какой формуле вычисляется дискриминант квадратного уравнения	1. Which formula is used to solve quadratic equations
Вы использовали 0 из 1 попытки	You’ve used 0 of 1 attempts

2.4 The course workflow

The course duration is 17 weeks. Week load for a student is 2 academic hours of classroom sessions per week and 2 academic hours of individual work per week. Now we are testing 3 ways of passing the described course:

1. first group of students studies the whole course without assistance: they watch necessary video lectures, presentations and do test without tutors (for example, at home);
2. second group watches video lectures and studies presentations without any assistance, and does tests in the university with the help of the tutor if needed;
3. third group takes the whole course beginning from video lectures till the testing in the classroom with the assistance of the tutor.

Results of the online course passing, and also comparison of the three described approaches are planned to be analyzed and published in a separate work in the future.

During the educational process students receive support and help in overcoming most common problems with the help of “Semantics of technical texts” discipline and tutoring. Within the course of “Semantics of technical texts” several classes are aimed at explanation of right ways of understanding, reading and verbal reproduction of mathematical constructions most common for lectures. As a part of tutoring (technically, individual consultation) every student has an opportunity to individually go through the elements of the discipline which cause difficulties.

2.5 The course workflow

In perspective we are planning to create analogous online courses for each discipline studied by GUIMC students during first years. By nowadays development of the online course for “Mathematical analysis” discipline has already been started. The format of the material explanation within this course is different from the one de-scribed in the unit 3.2 from that side that the lecturer is standing next to a blackboard (fig. 3); it helps students better see face mimics and read information from tutor’s lips. An opportunity of addition of subtitles and video image of sign language inter-preter in the right upper corner of the screen in order to increase a number of infor-mation channels and give a student an opportunity to choose the channel to perceive the lecture.

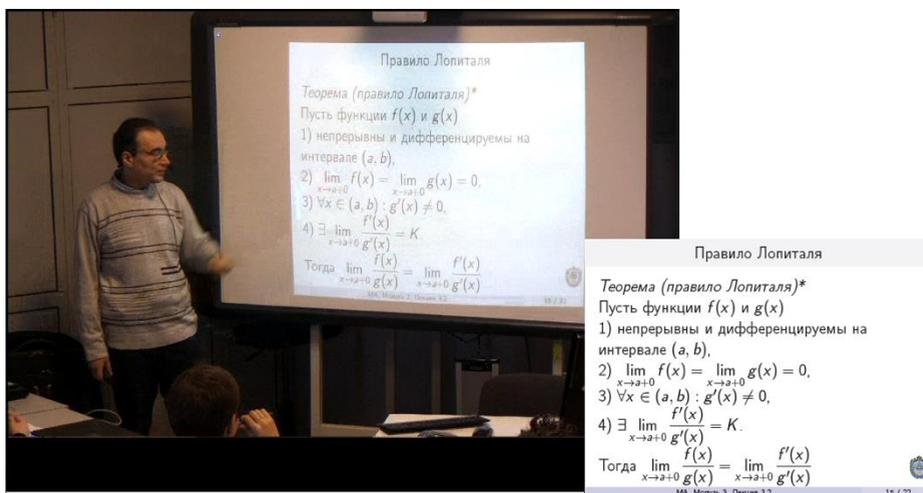


Fig. 4. A screenshot of video lection on L’Hospital rule (“Mathematical analysis” online course).

Table 4. Contains of Figure 4.

Phrase in Russian	English equivalent
Правило Лопиталья	L’Hospital’s rule
Теорема (правило Лопиталья)	Theorem (L’Hospital’s rule)
Пусть функции $f(x)$ и $g(x)$	Let the functions $f(x)$ and $g(x)$
1) Непрерывны и дифференцируемы на интервале (a, b)	1) be continuous and differentiable on the interval (a, b)

3 Conclusion

Now “Elementary mathematics knowledge actualization” online course is on the stage of beta-testing: we have organized 3 groups of students each of which is undergoing the course in their own mode (see unit 3.3). In perspective we are planning to provide video lectures with sign language interpretation and connect the online course with those courses on higher mathematics which are studied by students during their first terms in the university. The last fact would allow to avoid loss of time during lectures and practical classes on explanation of mathematical ideas from a school course and give students an opportunity to receive necessary information from corresponding parts of the online course.

The results of integration of “Elementary mathematics knowledge actualization” online course into educational process are planned to be published in our future works.

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