



# Teaching Mathematical Subjects to Students with Musculoskeletal Disabilities: Public and Peer Discussions

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## ABSTRACT

The Russian and international legislation ensure equal educational rights to all people regardless of whether have a disability or not. However, traditional approaches to organization of educational activities often do not provide a high enough level of education (including higher education) for people with disabilities as they do not take into account their special needs. This significantly narrows down the scope of professional options for people with disabilities. Mathematical disciplines are among the most difficult to master which means that if people with disabilities are not provided with specific support it might cut them off from professional fields that require mathematical competence. This determines the relevance and importance of the present study. The main objective of our research is to identify features of effective teaching of mathematical subjects to bachelor students with disabilities. We specifically focus on the group of students with musculoskeletal disabilities as this type of disabilities is one of the most common. The main research method is expert assessment of teaching practices (within mathematical subjects) and evaluation of influential factors, effectiveness indicators and resources. Representatives of public organizations, ministries, psychologists (that specifically specialize in working with people with disabilities), representatives of higher education, employers and HR managers – all in all 95 people took part in the experiment.

**Keywords:** higher education, teaching mathematics, inclusive education, musculoskeletal disabilities, bachelor engineering programs.

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### **State of the literature**

- In accordance with the current legislation all people have equal educational rights (regardless of any special needs). However, the traditional approaches and methods commonly used in educational organizations do not ensure the adequate level of quality in education offered to people with disabilities, including higher education. As a result professional opportunities are limited for people with disabilities.
- The issues of education for people with musculoskeletal disabilities enrolled in bachelor engineering programs can hardly be found in the literature devoted to the theory and methodology of mathematics education.
- International experience in creating adequate educational conditions for people with musculoskeletal disabilities presents real examples of adapted organizational structures which facilitate: the development of up-to-date methodological materials for running a course; experience sharing; information distribution; the development and implementation of CPD courses, educational materials and technologies. Nevertheless, the lack of specific components in the educational programs designed for people with musculoskeletal disabilities prevents them from acquiring deep mathematical knowledge necessary for an engineering degree.

### **Contribution of this paper to the literature**

- The present study identifies the characteristics of teaching mathematical subjects to students with musculoskeletal disabilities enrolled in bachelor engineering programs.
- With the use of the expert evaluation method the following significant factors have been identified for the first time: the design of a barrier-free educational environment, the introduction of new types of specialists who work with adapted measuring and calculating technical and programmable tools; the efficiency indicators: the adapted mathematic programs that take into account psycho-physiological characteristics of people with disabilities; the number of educators teaching mathematics who completed CPD courses aimed at preparing to teach students with musculoskeletal disabilities; resource provision: normative (regulatory) provision, provision of material and technical needs, methodological and software support for conducting engineering calculations.
- The creation of the identified conditions ensures the accessibility of quality education (including the degrees that require advanced mathematical knowledge) to people with musculoskeletal disabilities of all age groups.

## INTRODUCTION

### *Relevance of research*

Effective socialization of people with physical disabilities, their full participation in various spheres of public life, their self-realization and self-development in many respects depend on educational opportunities that they have as young people. International and Russian laws ensure equal educational rights for all people. However, current outdated approaches to organization of education do not enable people with disabilities to acquire education on

higher levels (including higher education). As a result their career prospects are extremely limited. This in turn exacerbates social and personal problems that people with disabilities face which increases their dependence on external factors (Kharitonova, 2009; Olesov, 2012; Markic & Abels, 2014).

Nowadays, the amount of effort and resources to enable people with disabilities to obtain high quality education are substantially growing in the Russian Federation. In order to integrate people with disabilities into the larger society, to give them an opportunity to socialize and to improve the quality of their life a number of state initiatives has been introduced: the state program "Accessible Environment" (2011-2020) approved with the governmental resolution No. 1297 on December, 1 (The state program "Accessible Environment", 2015); the Action Plan "Changing social spheres to increase efficiency of scientific work and education", approved with the Governmental Act No. 2620-r on December 30, 2012 (The Act of the Government, 2012); the state program " Education Development" (2013-2020) approved by the governmental resolution No. 295 on April 15, 2014 (The state program " Education Development", 2013). All of these initiatives aim to create an effective system that can ensure that people with disabilities have real opportunities to obtain higher education with subsequent employment and professional fulfillment.

When organizing mathematical lessons for students with musculoskeletal disabilities, we have to consider difficulties that these students experience when calculating and conducting graphic works. Therefore, it is necessary to obtain special equipment. For example, for practical and engineering lessons, wheelchair students need a multipurpose supportive orthopedic chair with locomotor apparatus fastening. Moreover, it is needed for practical lessons to use a specialized installation with an adjustable working surface that can accommodate students with various degrees of musculoskeletal problems. The installation design allows its working surface to be adjusted and this enables students to position themselves so that they can follow instructions and utilize their devices and tools effectively. Such technical facilities also allow students with disabilities to be fully engaged in the process of theoretical learning. The main objective of our research is to identify effective practices in the context of teaching mathematical subjects to bachelor students with musculoskeletal disabilities in professional engineering education. In the article we are proposing mathematical subjects to be organized with a strong emphasis on the special needs of students with disabilities and/or chronic diseases. We have conducted our study in the context of professional engineering education submitting our findings at all stages to peer review.

### *The main goal and objective of the study*

The main goal of the study is to identify the characteristics of effective teaching of mathematical subjects to students with musculoskeletal disabilities who are enrolled in bachelor engineering programs. This type of nosology determines the level of accessibility for the certain forms of mathematical information consumption and transmission. The

following objectives form the core of the study: to study the specificity of conditions related to the contents and organization of educational activities for students with musculoskeletal disabilities who are enrolled in bachelor engineering programs through the analysis of international experience; to analyze the professional standards in Russia for the professions requiring advanced mathematical knowledge; to evaluate with the help of experts the methodological approaches to teaching mathematical subjects.

## MATERIALS AND METHODS

### *Research methods*

In the course of this study we have used the following methods: the analysis of normative documents, psycho-pedagogical, methodological and mathematical literature review, the analysis and generalization of the materials derived from educators sharing their experience and from reflecting upon our own experience of teaching in the system of higher engineering education (qualitative data), the analysis of educational outcomes, the method of expert evaluations (peer reviews), the design of educational methodological materials for higher education, diagnostic methods, pedagogical experiments.

### *Experimental base of research*

Generalization and approbation of the results were carried out through: teaching mathematical subjects to bachelor students with musculoskeletal disabilities and then discussing our work with peers and other members of the public. We invited professionals from a range of fields to participate in our discussion: representatives of public organizations focused on working with people with musculoskeletal disabilities (4 organizations); representatives of the Ministry of Education and Science of the Russian Federation, representatives of the Ministry of Labor and Social Protection of the Russian Federation; psychologists who specialize in providing psychological support for disabled people (4 organizations); employers (from 5 Russian regions); representatives of higher education institutions (9 organizations from three Russian regions).

### *Stages of research*

The research had three stages.

- (1) The first stage involved: analyzing the current state of the problem in theory and practice of teaching mathematical subjects in the system of higher education, studying and evaluating relevant normative documents, psycho-pedagogical, methodological and mathematic literature, observing teachers and analyzing their views.
- (2) The second stage was aimed at developing methodological approaches to facilitate the mathematical education of students with musculoskeletal disabilities. Prior to that the existing methodological approaches had been analyzed within the context of the professional educational programs "Land management and inventories" (the Order of the Ministry of Education and Science of the Russian Federation, 2015) and "City planning and organization" (the Order of the Ministry of Education and Science of the

Russian Federation, 2014). These educational programs are realized in accordance with both the Federal State Educational Standard and specific professional standards (the Order of the Ministry of Labor of the Russian Federation, 2016; The Order of the Ministry of Labor of the Russian Federation, 2015) that are applicable to all people in this field including those with musculoskeletal disabilities. The following academic subjects were considered within the program “City planning and organization”: mathematics, geodesy and cartography, city design, architecture and construction designs, descriptive geometry and computer graphics, technical assessment of buildings and constructions. Within the program “Land management and inventories” the following courses were evaluated: mathematics, descriptive geometry, engineering and computer graphics, metrology, standardization and certification, electronic optical devices, engineering and geodetic problems in topographical planning, topographical drawing and the basics of architectural design.

- (3) The third stage was about testing and verifying our methodological approaches. We verified the effectiveness of specific educational practices through a purposeful public discussion. We have engaged people from a variety of backgrounds and with a range of professional interests in our discussion: the representatives of public associations (4 organizations); representatives of the Ministry of Education and Science of the Russian Federation, representatives of the Ministry of Labor and Social Protection of the Russian Federation; psychologists who specialize in providing psychological support for disabled people (4 organizations); employers (from 5 Russian regions); representatives of higher education institutions (95 professionals from 8 Russian regions: the Perm Krai, the Kaliningrad, Novosibirsk, Kostroma, Nizhny Novgorod, Sverdlovsk, Moscow and Kirov Regions).

## RESULTS

### *International experience of organizing education for people with musculoskeletal disabilities*

Let us consider and compare the international experience of organizing education for people with the musculoskeletal disabilities (examining the examples of Germany, the USA, Japan and Russia) (Sizikova & Tyurina, 2012; Gurkina & Novikova, 2014).

Education (including professional education) of people with disabilities is a highly important issue in Germany. According to the official data from the Ministry of Labor and Social Problems (Bundesministerium für Arbeit und Soziales) there are 9,6 million people with disabilities (11,7% of citizens) in Germany. 7,1 million of them have serious disabilities. The education of these people has been the subject of professional discussions for a long time. The German Society of Student Assistance in Higher Education (Deutsches Studentenwerk) found that 19% of students have problems with health in Germany. 4-8% of students think that the state of their health limits their opportunities to study to some or even a considerable degree. The German Society of Student Assistance estimates that these respondents are

students with chronic diseases or disabilities. The number of students with special needs is significantly higher in some institutions of higher education sometimes reaching 10-15% (Zinovyev & Bersenev, 2011).

There are no specialized higher education institutions in the country. However, Germany has the system of social and psychological support for students with musculoskeletal disabilities. All German institutions of higher education accommodate the needs of students with disabilities. The available services are very similar in their essence but they vary in their quality. Let us consider the example of the Humboldt University (Studium mit Behinderung, 2016), Aachen University (Beratung zum Thema Studium mit Behinderung und chronischer Erkrankung, 2016) and Marburg University (Special Needs Students, 2016).

The Humboldt University has specially trained professionals who organize social and psychological support for students with musculoskeletal disabilities. Besides, there is the psychology and psychotherapy advice center that aims to help students to deal with psychological problems related to their disabilities.

The Aachen University defines the educational opportunities of students with disabilities as one of their top priorities. In view of this the University aims to address and accommodate any special needs of their students with disabilities and/or chronic diseases. The University consistently works on providing unrestricted access to all of the facilities and competent individual consultations. "Officers of interests of disabled and chronically ill students" working at the Aachen university are engaged in the organization of social and psychological support for students with special needs.

The Marburg University is one of the oldest universities in Europe that helps students with different types of disabilities, including musculoskeletal disabilities. There are at least 40 wheelchair students that study at the university each year. In addition to that, there are at least 30 students who are capable of moving without a wheelchair but their movements are still restricted due to their disability. The university established "the service center for students with disabilities" in 1987. The Center addresses any special needs that students with disabilities have (Fassbender, 2010).

The USA has a rather long history of accommodating students with musculoskeletal disabilities and reduced mobility at the institutions of higher education. Higher education institutions in the USA on average have 1% of students with disabilities. The USA experience in organization of social and psychological support for students with musculoskeletal disabilities is interesting. We have monitored the work of the following three universities: State University Wayne, Detroit (Student Services Disability State University Wayne, 2016), Syracuse University, Syracuse (Accessible SU, 2016), Columbia University, New York (Disability Services, 2016; Equal Opportunity and Affirmative Action, 2016).

The departments that work with disabled people consist of full-time and part-time employees. The full-time employees support students at all educational levels – they address a variety of issues including adaptation, examinations and the use of assistive technologies.

The number of full-time employees varies at different universities. For instance, the State University Wayne has three full-time employees: a director, coordinator of programs, and three education specialists. The Syracuse University has seven employees – a director, three consultants, two special coordinators who are responsible for providing learning materials in alternative forms and adapting examinations, and one assistant. The Columbia University has a director, assistant, adaptation coordinator, program coordinator, administrative coordinator additional coordinator, and assistive technology specialists. Part-time employees assist students in reading, writing and other tasks (Zhavoronkov, 2011).

PEPNet Japan is a coordinating center that develops effective support practices and technologies for students with disabilities. It assists all vocational colleges and higher education institutions in accommodating the needs of students with disabilities (Japanese Organization for student services, 2015). Tsukuba University of Technology is the only higher education institution in Japan that is only for people with disabilities. There at the University the Tsukuba Center develops and tests technologies that facilitate access to educational resources.

The development of new teaching and learning methods with consistent improvement of educational conditions is seen as the main objective in working with students with musculoskeletal disabilities in Japan. In order to create obstacle-free educational space new systems and devices are being developed. In addition, new projects are being implemented to make education fully accessible within and outside universities (Special Projects, 2009; Kolyshkina, 2014).

A number of scholars in a variety of contexts are currently working on the issue of adaptation of people with disabilities (Gabdrakhmanova, et. al., 2015; Nasibullov et. al., 2015; Abdullah et. al., 2017; Jacobs and Durandt, 2017; Schnell and Prediger, 2017). A number of scholars view computers as a special educational tool that in addition with special software can be effectively used in organizing education for people with disabilities (Anderson et. al., 1996; Cullen et. al., 2013; Seo & Woo, 2010). Kalinichenko et al. (2016) is focused on speech pathologies, Chang et. al. (2011) and Moore-Brown et. al. (2006) – on physical rehabilitation of people with disabilities, Hishinuma and Fremstad (1997) – educational standards that ensure that the educational needs of students with disabilities are met, Crawford (2008) – on the methods of involving all students regardless of their special needs in research activities. From international experience we see that there could be different organizational structures. Analyzing international practices can facilitate the development of effective methodological support of teacher education and teacher development, exchange of experience, distribution of data.

### ***Analyzing professional standards in the fields that require specialized mathematical knowledge (the Russian context)***

The prospect of actively using mathematical knowledge in one's job is usually the main factor that builds students' motivation to study mathematical subjects within their bachelor

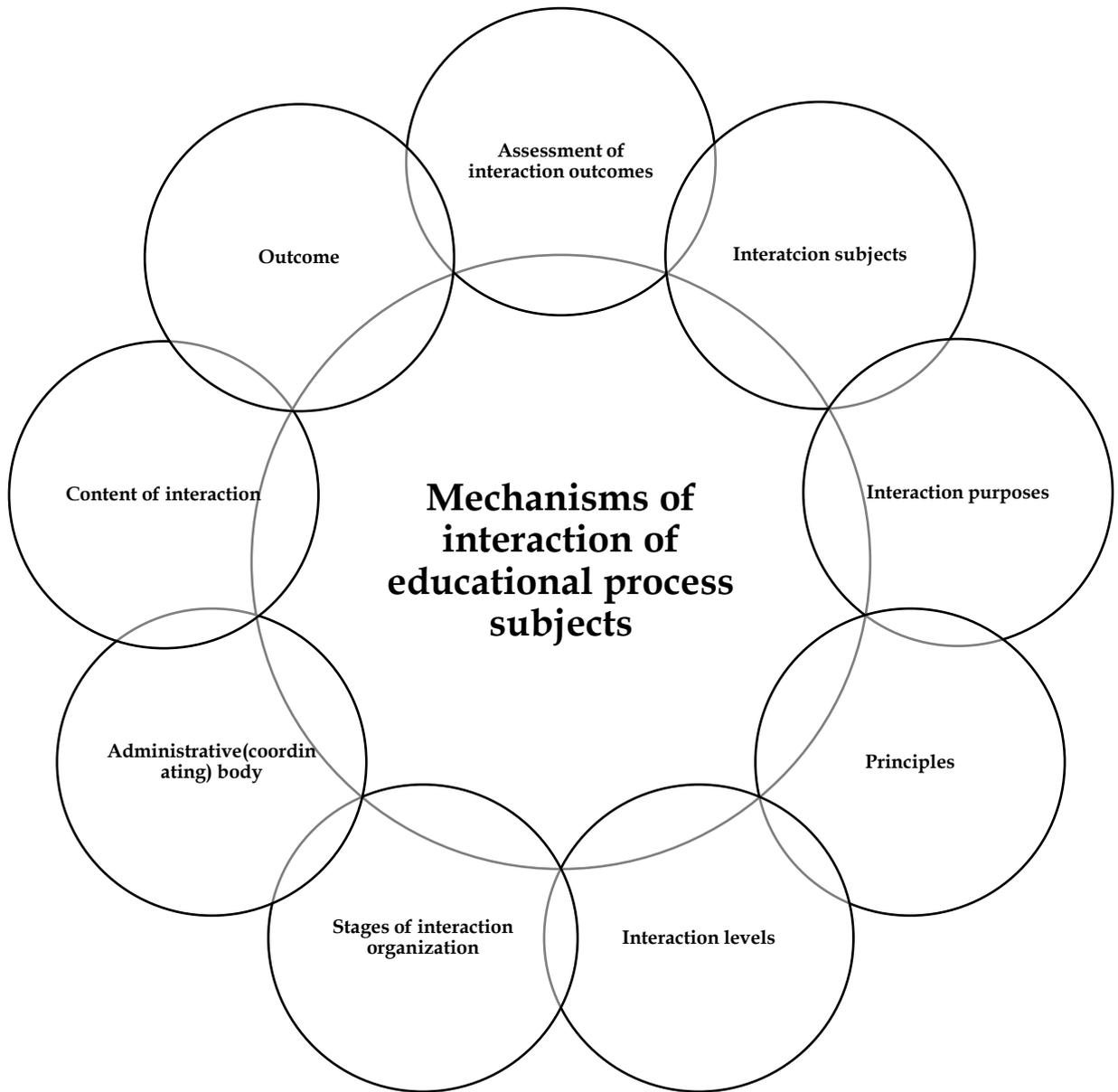
programs. When employing people with disabilities it has to be considered if their future position corresponds to their professional capacities that might be limited in view of their disabilities. Moreover, when employing people with disabilities who are graduates with bachelor degrees in “Engineering, technologies and technical science” it is necessary to take into account all the relevant laws and regulations:

- (1) the normative acts/documents that directly regulate employment of people with disabilities in the Russian Federation;
- (2) the normative acts/documents that regulate professional standards and working conditions in the sphere of engineering, technologies and technical science.

The Labor Code of the Russian Federation declares that all working people have equal rights and it prohibits any form of discrimination in the work place (Article 2). However, it is also stated in the Labor Code that acts cannot be considered discriminatory when they are either determined by specific professional standards (established by the federal law) or by the state protection of vulnerable groups of people from activities that can jeopardize their well-being (The Labor Code of the Russian Federation, 2001). It is reasonable to say that in some cases people with disabilities might have medical contraindications preventing them from engaging in certain professional activities or performing to specific standards. In view of this we decided to establish if musculoskeletal disabilities can potentially affect a person’s ability to perform in accordance with professional standards. Thus, we studied the professional standards (124 items) in 12 professional fields (taken from the Register of Professional Fields) where strong mathematical knowledge is a requirement: Connections, information and communication technologies; Architecture, planning, geodesy, topography and design; Construction, housing and utilities; Wood and paper industry, furniture production; Nuclear industry; Rocket and space industry; Chemistry and chemical technologies; Machine production; Electric, electronic and optical production; Shipbuilding, car industry and aircraft industry. We found that 72 out of 124 professional standards do not contain any medical requirements, i.e. this type of work can be managed by people with musculoskeletal disabilities. Thus, it is reasonable to say that 58% of engineering positions can be taken by people with musculoskeletal disabilities and reduced mobility. Therefore it is important to ensure that there are real opportunities for them to engage in higher education programs that are related to the aforementioned fields.

### *Mechanisms of interaction in educational processes*

To identify the methodological approaches to teaching mathematical subjects, it is necessary to consider mechanisms of interaction within the educational context (as referred [Figure 1](#)).



**Figure 1.** Mechanisms of interaction of the educational process subjects

The mechanisms of interaction are categorized in **Table 1.**

**Table 1.** Characteristics of interaction mechanisms

Components	Characteristics of interaction mechanisms	Features of components for mathematical subjects learning
Purpose	To coordinate the interaction of the participants of educational processes so that to ensure accessibility and quality of education for students with disabilities as well as their effective adaptation	Due to being abstract and formal in nature mathematical subjects allow students to engage in them mentally which helps their effective adaptation
Principles of interaction	<ul style="list-style-type: none"> <li>- the adequacy of the contents and forms of provided along with rehabilitating and pedagogical support to purposes and conditions of professional and educational activity of students with disabilities and restrictive health conditions;</li> <li>- support on the integrative (mixed) collective of disabled students and students, who do not have disabilities;</li> <li>- the principle of supporting purposeful and self-motivated engagement of students with musculoskeletal disabilities;</li> <li>- complementarity principle - rehabilitative and educational activities need to complement each other</li> </ul>	Mathematical subjects can be successfully studied by people with disabilities provided their educational space is modernized and made fully accessible.
Contents of interaction	<ul style="list-style-type: none"> <li>- analytical and diagnostic line</li> <li>- adaptation and rehabilitation line (the line of social and psychological support)</li> <li>- IT line</li> <li>- material and financial line</li> <li>- legal and education line</li> <li>- design line</li> <li>- reflexive line</li> </ul>	A static-dynamic balance is an important feature here. In view of the fact that people with disabilities often need to have regular sessions of muscular relaxation, regular static periods have to be organized.
Stages of interaction organization	<ol style="list-style-type: none"> <li>1. Stimulating Stage (subjects of interaction establish emotional connections with one another).</li> <li>2. Organizational Stage (subjects are informed about the ways and nature of interaction, they collaboratively plan future activities).</li> <li>3. Active Stage (experts directly interact through voluntary and mutually beneficial cooperation).</li> <li>4. Reflexive Stage (subjects evaluate the outcomes of their interaction)</li> </ol>	Teachers need to be specifically trained because in order to effectively engage students with musculoskeletal disabilities in educational activities, the educator has to interact with them in a specific way. For instance, not all students with physical disabilities can stand up in the beginning of a lecture (to clarify: Russian students usually greet their teachers and indicate their readiness to work by standing up). In view of this some students might need to agree with their instructors a certain gesture that will be indicating their readiness. When interacting with wheelchair students (within an individual consultation), instructors need to position themselves on the same the level as their student.
Interaction levels	Interaction issues can be dealt with on the regional level. However, some issues need to be addressed on the federal and even international levels. Issues and problems that are urgent and delicate in nature can be solved on the municipal level (i.e. within one city or area). Issues and problems that are urgent and delicate in nature can also be solved on a local level - mainly within one intuition (in the course of interaction of different individuals or departments).	Interaction on different levels is necessary in order to equip study spaces with equipment. Individual study spaces for students with physical disabilities need to be equipped with a special adjustment table and chair. Moreover, some practical lessons might require additional equipment. Different electronic libraries, databases and other information resources necessary for independent learning may not always be easily accessed by people with disabilities. Therefore, it is necessary to ensure that there are necessary assistive technologies in place to enable students with special needs to use all possible learning resources.
Subjects of interaction	There are 2 groups of subjects - "internal" and "external" in relation to educational space of higher education institutions.	Tutors who accompany students with special needs, assist them and operate their equipment need to be counted as subjects of interactions.
Administrative interaction (coordinating) body	Centers of inclusive education coordinate all lines of interaction. They regulate interaction on different levels.	Centers of inclusive education are in charge of accommodating the educational needs of people with disabilities (they maintain the register of teachers who are specifically trained to work with these students, maintain specialized equipment, adapted and assistive software, etc.)
Outcome	Students with physical disabilities are successfully adapted for the economy and life.	Graduates are fully qualified to perform jobs in their chosen field.
Assessment of interaction outcomes	In order to assess in accordance with the following set of criteria: <ul style="list-style-type: none"> <li>- personal qualities;</li> <li>- cultural and professional competences;</li> <li>- rehabilitation competences.</li> </ul>	Mathematical subjects form the basis of professional competence. Therefore, academic performance (as the indicator of professional competence) should be considered in the first place.

### *Methodological approaches to teaching mathematical subjects*

In order to analyze how mathematical subjects are taught we will first consider the adapted (for students with musculoskeletal disabilities) versions of the bachelor engineering

programs “Land management and inventories” and “City planning” that are designed in accordance with the Federal State Educational Standards. Within the “City planning” program we have considered how the following academic disciplines are mastered: mathematics, geodesy and cartography, city planning, architectural and construction designs, descriptive geometry and computer graphics, technical assessment of buildings and constructions. Within the “Land management and inventories” program we have considered how the following disciplines are mastered: mathematics, descriptive geometry, engineering and computer graphics, metrology, standardization and certification, electro-optical devices, solving engineering and geodetic problems of topographical plans, topographical drawing, the basics of architectural and engineering design.

In order to effectively transition to advanced level mathematical subjects (modules) it is reasonable to offer special adaptation modules first (starting from the first semester). For example:

- (1) “Adaptation to the labor market”, “Professional self-development” – modules that help to adapt to the labor market;
- (2) “Special measuring and graphic means” – modules that enable students to use special professional use;
- (3) “Adapted information and communication technologies (using AutoDesk (AutoCAD, Revit, Inventor, etc.), MathSoft (MathCAD, MathLAB, etc.), GraphoSoft (ArchiCAD), JetBrains (phpStorm), etc.)” – modules that develop computer skills.

We see the following adaptive mechanisms as the most important:

- (1) Method of contextual learning (learning through regular revisions that require transferring of knowledge to various contexts).
- (2) Method of collaborative learning (compensating for the solitary nature of educational activities of learners with physical disabilities and reduced mobility taking into account derivational factors).
- (3) Adhering to the static-dynamic schedule of classroom activities (balancing periods of relaxation and activity, effectively using equipment and paying attention to educational environment of students, organizing balanced dieting, etc.).
- (4) Effectively using assistive technologies to improve and support skills and to increase autonomy of students with musculoskeletal disabilities.

The most commonly used forms of education for learners with disabilities are lectures, practical lessons (seminars, laboratory work), internships and independent learning.

Lectures have to be carried out using specific methodology and specifically organized material.

In order to actively engage students with musculoskeletal disabilities (those who are able to speak) in educational processes lectures can be organized as discussions based on the direct contact of the lecturer with students. Moreover, students with disabilities might need

some assistance of their lecturer to actively join a discussion. When presenting material lecturers need to draw students' attention to the most important questions, issues and problems at the same time balancing lecture pace in accordance with all students' abilities. Lecturers can pose questions to their whole audience or to particular individuals. Student with reduced mobility might sometimes need more time to answer questions than other students. Lecturers have to make sure that all presented questions get answered. Moreover, at the end of each discussion lecturers need to give brief critical feedback and at the end of a lecture there needs to be an overall conclusion.

In order to compensate for sensory deprivation of students with physical disabilities and reduced mobility, different types of visualization can be used (natural, figurative, symbolical). Types of visualizations or their combinations are selected depending on the material. When presenting visualization materials psychophysiological characteristics of students with disabilities need to be considered (for instance, their eye-hand coordination and possible eye problems). When organizing visual lectures it is necessary to take into account that when transitioning from textual to visual forms or when transitioning from one visual form to another need some information might get lost. Therefore, it is necessary to help students focus their attention on the most important aspects.

- (1) When carrying out lectures lecturers should be watchful of their pace because some students with reduced mobility might be experiencing difficulties with taking notes. In view of this fact these students need to be able to use voice recording devices.
- (2) Along with carrying out lectures instructors should provide hand-outs with summaries of their lectures to prevent any gaps that might be caused by students' impaired perception and stamina (most students with musculoskeletal disabilities usually can work effectively no longer that for 15-30 minutes and then protective inhibition comes into action). Intellectual exhaustion can seriously affect student ability to learn.
- (3) Oral presentations need to be accompanied by visual materials in order to effectively battle the sensory deprivation of students with disabilities. Instructors need to teach students not only how to take notes during lectures but how to make their own concept maps and schemes - these might be helpful when they later revise their lectures.
- (4) When teaching advanced level mathematical subjects, it is necessary to use the method of contextual learning so that students could see complex concepts and ideas from different perspectives and develop extensive understanding of their future profession. In classroom work different schemes, drawings, and other graphic materials should be used. Along with that students need to always be able to give their feedback. Moreover, presenting theoretical material should be come along with practical tasks as this effectively encourages the development of professional competences and motivation of students with reduced mobility.

When carrying out seminars and practical sessions, it is necessary to consider the following:

- (1) Instructors have to have special reception-transmission mechanisms when working with students with disabilities, especially when organizing educational activities that involve modeling, designing and drawing.
- (2) Instructors should provide examples, select tasks, ask questions so that to connect new material with previously covered topics. Students learn more effectively if they have an opportunity to familiarize themselves with forthcoming tasks and topics in advance. In view of this instructors need to provide guidebooks “Methodological instructions for practical sessions” that contain key theoretical material, recommended algorithms of solving different types of problems, sample tasks and problems with explanations, required reading lists and recommended information sources.
- (3) Instructors should extensively use practical teaching methods.
- (4) Purposeful and motivated engagement in practical educational activities ensures effective learning. Therefore instructors need to provide tasks and assignments that require students to compare and identify similarities and differences focusing on bringing students to see specific objectives, providing opportunities for students to apply their knowledge and become passionate and independent learners.
- (5) It is important to utilize individualized approaches and differentiated practices. Tasks and assignments need to correspond to different cognitive styles of students. The amount and nature of instructors’ help should also vary depending on the educational needs of students.
- (6) There has to be a balance between non-imitating (i.e. used within traditional forms of educational activities: lectures, practical sessions, seminars, etc.) and imitating (game and non-game) practices because this encourages active learning. By setting obligatory interactive tasks instructor creates educational conditions that build students’ motivation to engage with the material and actively interact with others. This ensures that students participate in active forms of classroom learning (role-playing and business games, discussions, brainstorming sessions, working with case situations, computer simulations) and also builds their ability for independent learning and work.
- (7) When carrying out laboratory work and research projects (for example, in chemistry or physics class) instructors are advised to actively use multimedia tools, online educational courses and educational software. It is necessary to consider when it is appropriate to offer tasks that involve manual activity. Some students with disabilities cannot perform these tasks because of motor coordination difficulties.

All in all, teaching mathematical subjects to students with musculoskeletal disabilities requires instructors to consider many different factors in order to be able to create obstacle-free educational environment for them. When organizing educational activities it is not enough to appropriately equip educational spaces, new effective methods of teaching have to be found that cater to different groups of students.

## DISCUSSIONS

To approbate the results in September 2016 we held a series of public and peer discussions that involved 95 participants: representatives of public organizations, ministries, psychologists (that specifically specialize in working with people with disabilities), representatives of higher education, employers and HR managers. See [Table 2](#).

**Table 2.** Participants of public and peer discussion

<b>Ministry of Labor and Social Protection representatives and Ministry of Education and Science representatives</b>							
State Policy in Higher Education Department (Ministry of Education and Science of the Russian Federation)		Disability Department (Ministry of Labor and Social Protection of the Russian Federation)			Ministry of Social Development of the Kirov region		
1		1			7		
<b>Employers from 5 regions of the Russian Federation</b>							
Nizhny Novgorod Region	Krasnoyarsk Krai	Moscow	Republic of Udmurtia	Kirov Region			
2 organizations	2 organizations	1 organization	1 organization	5 organizations			
<b>Representatives of public organizations</b>							
4 organizations							
<b>Representatives of higher education from 8 regions of the Russian Federation</b>							
Perm Krai	Kaliningrad Region	Novosibirsk Region	Kostroma Region	Nizhny Novgorod Region	Sverdlovsk Region	Moscow	Kirov Region
1 organizations	1 organization	1 organization	1 organization	2 organizations	1 organization	5 organizations	2 organizations
<b>Psychologist (specializing in psychological support of people with disabilities)</b>							
4							

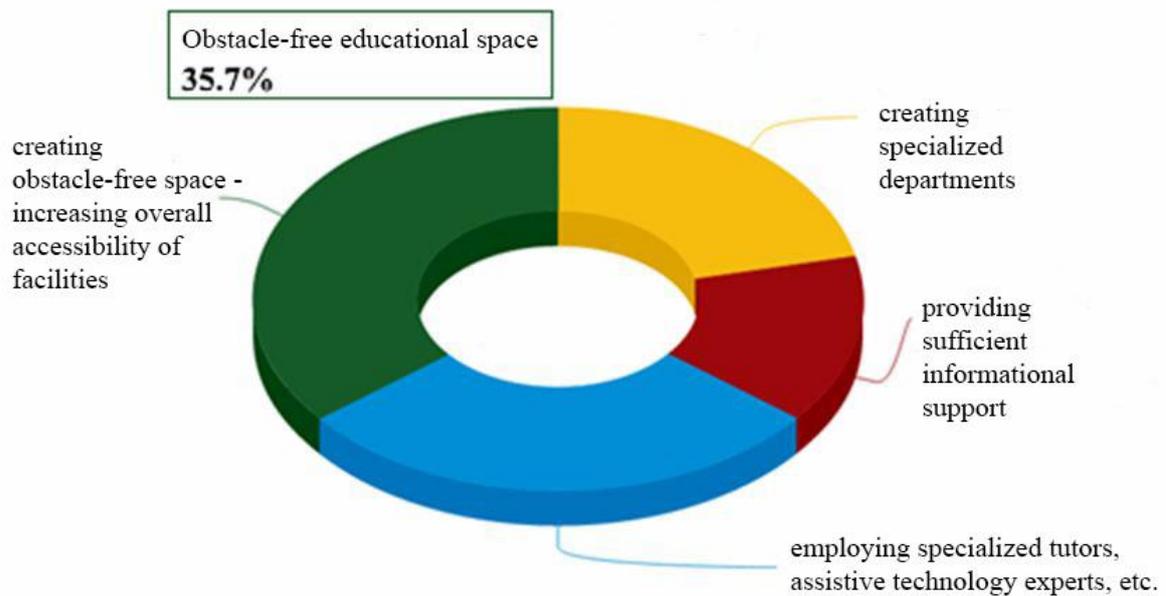
At the end of our discussions we conducted surveys and the questionnaire contained the following questions:

Question No. 1. What should be the main priority (for educational organizations) when organizing mathematical educational activities that involve students with reducing mobility disabilities (select no more than 2 items):

- (1) creating specialized departments;
- (2) updating websites, information stands, etc. to provide sufficient informational support;
- (3) employing specialized tutors, assistive technology experts and experts in special educational practices;
- (4) creating obstacle-free educational environment - increasing overall accessibility of facilities.

During our discussions it was noted that the priority should lie with creating accessible obstacle-free environment (designed in accordance with the special needs of students with reduced mobility) along with creating specialized departments in educational organizations

staffed with tutors and experts on support of students with special needs (as referred **Figure 2**).

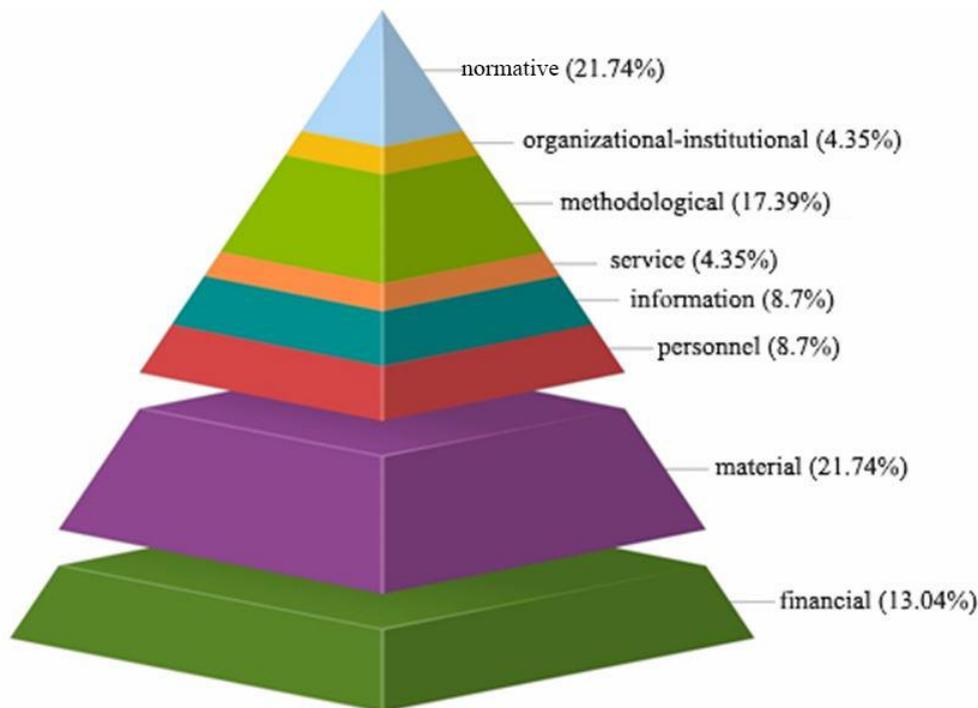


**Figure 2.** Factors promoting effective mathematical learning of students with disabilities and reduced mobility

Question No. 2. Select three most important components of resource provision of mathematical subjects:

- (1) normative;
- (2) organizational institutional;
- (3) methodological;
- (4) service;
- (5) informational;
- (6) personnel;
- (7) material and technical base and equipment;
- (8) financial.

Our discussion participants named normative (1), material and technical base and equipment (7) and methodological components (3) as the most important ones (as referred **Figure 3**).



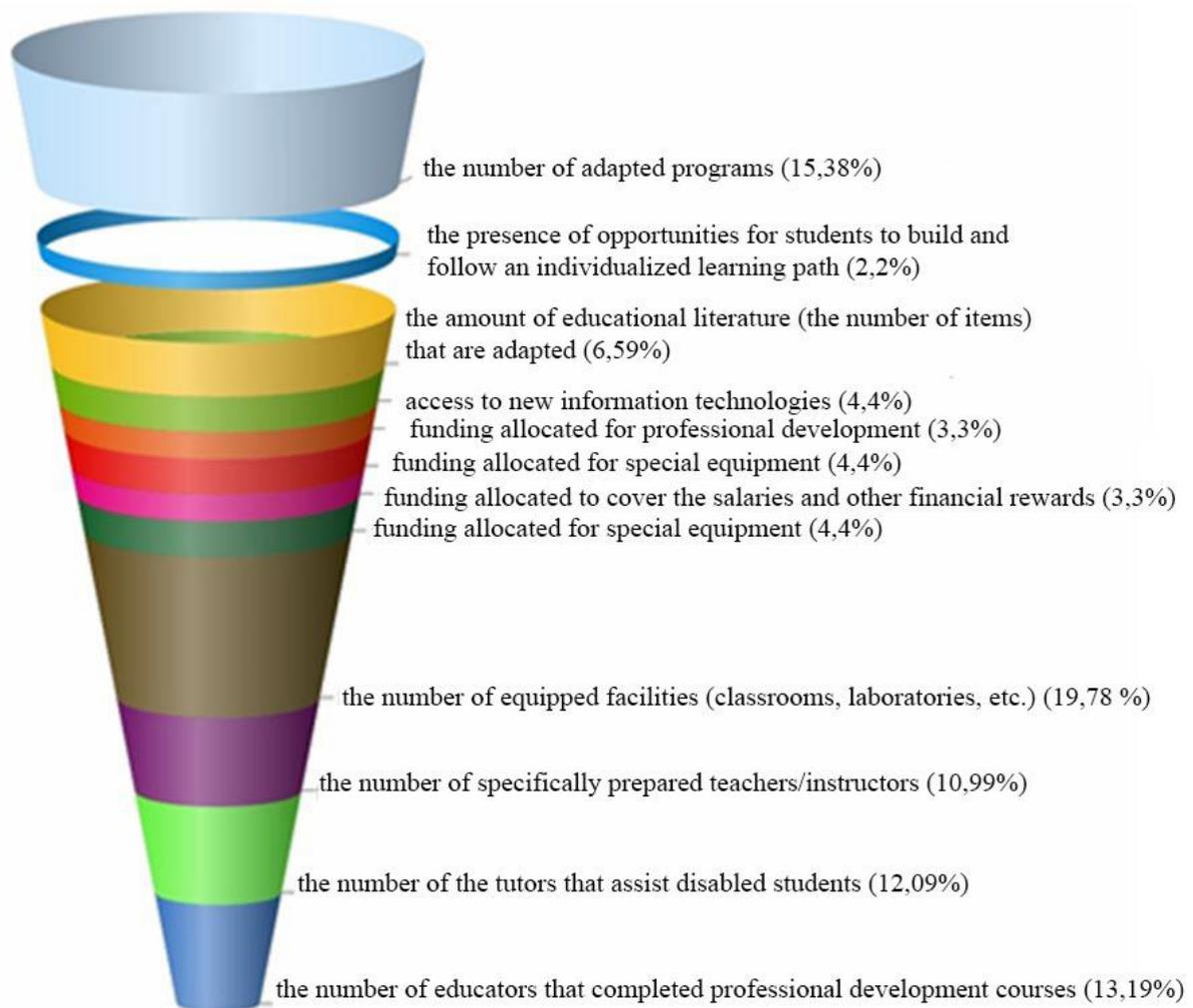
**Figure 3.** The most important components of resource provision of mathematical subjects for students with disabilities and reduced mobility

Question No. 3. Select five indicators that you think should be used as criteria in the effectiveness assessment of education of students with disabilities and reduced mobility:

- (1) the number of the adapted educational programs taking into account psychophysiological features of students with disabilities;
- (2) the presence of opportunities for students to build and follow an individualized learning path;
- (3) the amount of educational literature (the number of items) that are adapted for students with special needs;
- (4) the access to new information technologies and the adapted equipment;
- (5) the amount of funding allocated for professional development of instructors;
- (6) the amount of funding allocated for special educational visualizing equipment;
- (7) the amount of funding allocated to cover the salaries and other financial rewards of specialized professionals working with disabled students (tutors, assistive technology experts, special physiologists, etc.);
- (8) the number of facilities (classrooms, laboratories, toilets, etc.) equipped for accommodating students with disabilities;
- (9) the number of specifically prepared teachers/instructors for work with students with disabilities;

- (10) the number of the tutors that assist disabled students supporting them throughout their entire educational programs;
- (11) the number of educators that completed professional development courses on inclusive education and working with students with disabilities.

The respondents selected the following indicators: (1) the number of the adapted educational programs taking into account psychophysiological features of students with disabilities and (11) the number of educators that completed professional development courses on inclusive education and working with students with disabilities (as referred **Figure 4**).



**Figure 4.** Indicators which should be used for assessment of productivity of student with violations of locomotor apparatus on mathematical disciplines

Our findings indicate psychological readiness of different groups of people to work and adapt bachelor engineering programs in order to create diverse educational opportunities for people with disabilities. Our respondents think that there has to be thoroughly developed

evidence-based methodology of teaching mathematical subjects to students with disabilities and reduced mobility. Moreover, this has to come along with employing sufficient numbers of tutors, assistive technology specialists and other educators – those who could provide additional support. At the same time careful provisions should be made to ensure that there are appropriate normative arrangements and equipment (material and technical base) in place. In addition, it is highly important to adapt educational programs for the special needs of people with disabilities. There should also be a sufficient number of educators/instructors who have completed professional development courses on inclusive education and equipped to work with students with disabilities.

### CONCLUSION AND RECOMMENDATION

Our study revealed methodological approaches to effective teaching of mathematical subjects to students with musculoskeletal disabilities: 1) to provide special foundation modules – modules that help students with special needs adapt and develop their core professional skills before offering any advanced level mathematical subjects (modules); 2) to use the method of contextual learning (learning through regular revisions that require transferring of knowledge to various contexts in order to effectively overcome any learning difficulties that might be stemming from students' disabilities); 3) to organize educational activities always adhering to the static-dynamic schedule of classroom activities (balancing periods of relaxation and activity); 4) to use different types of visualizations in order to compensate for sensory deprivation of students with physical disabilities and reduced mobility (natural, figurative, symbolical); 4) to use a variety of schemes, drawings and other graphic materials in the course of classroom work making sure that students can always give their feedback; 4) to use an adapted assessment system; 5) to organize educational activities taking into account the fact that some students with disabilities cannot perform certain tasks because of motor coordination difficulties and other types of difficulties. These approaches facilitate their effective socialization, enable them to participate in various spheres of public life, develop and realize their potential through acquiring mathematical competences. Moreover, the conducted series of public and peer discussions confirmed that in order to be able to accommodate the special needs of students with musculoskeletal disabilities the following requirements need to be met: creating obstacle-free and fully accessible educational space; employing specialized tutors, assistive technology experts and experts in special educational practices; assessing the effectiveness of education by monitoring the two main indicators – (a) the number of the adapted educational programs taking into account psychophysiological features of students with disabilities and (b) the number of educators that completed professional development courses on inclusive education and working with students with disabilities.

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