Peculiarities of Training Engineering Students with Disabilities

https://doi.org/10.3991/ijep.v11i4.21361

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Abstract—In this day and age, there are increasing discussions and calls for shifting towards inclusive education. In view of this, the present study intended to identify the most severe challenges disabled engineering students face according to their own view and find possible ways to solve them. For this particular aim, a survey of 555 students from five universities of Russia, Kazakhstan, and Uzbekistan was performed. These were the Bauman Moscow State Technical University, Northern Trans-Ural State Agricultural University, Sarsen Amanzholov East Kazakhstan State University, Tashkent Institute of Irrigation and Agricultural Mechanization Engineers, and South Ural State University. The survey was carried out in two stages. The first focused on identifying the main problems of disabled students (physical environment, staff skills and knowledge, theory-practice relationship, assessment peculiarities, and bias). The second intended to define the most critical of them (unadapted physical environment and reduced abilities to apply theoretical knowledge in practice). To resolve these issues, the authors propose the following recommendations to be adopted. These include adapted laboratories and equipment; programs that allow performing practical tasks; engineering tutors able to assist in performing practical tasks; an adapted assessment system with reference to health condition; psychological support to integrate disabled students into an inclusive team and eliminate prejudices. The obtained research

findings can be used by other universities to promote a comprehensive integration of students with special needs into the educational process.

Keywords—Disabled students; engineering education; engineering students with disabilities; students with special needs

1 Introduction

1.1 Impairments and engineering education

People with disabilities are likely to encounter numerous barriers in their everyday activities in a modern society. Research findings available confirm that the structural environment, education quality and accessibility, family circumstances, living conditions, and income are the factors that significantly affect people with disabilities. This effect is not always positive [1]. Today, young people more often choose engineering and technical education that presents particular challenges for people with disabilities. These challenges are tackled in a variety of ways, which the study intends to explore.

The information on disability is most comprehensively organized by the World Health Organization (WHO) within the International Classification of Functioning, Disability and Health (ICF). According to ICF, the concept of disability rather relates to an individual view of impairments and limiting effects imposed on people within their unique environment, nor socially accepted "normality standards" [2]. Historically, people with disabilities, whether physical or mental, have had very limited access to high-quality education. Despite considerable efforts made by governments, their experience in higher education is connected with many obstacles [3].

According to the legislation of all countries where the studied universities are located, as well as most of the UN member states in general, no person with disabilities can be denied access to higher education [4]. Nevertheless, people with disabilities still have problems in choosing the courses they want because of limited access to teaching and learning facilities, such as laboratories [5].

1.2 People with disabilities

The world practice shows that such socio-cultural factors as peer relationships and academic advisory contacts are more significant for the disabled than the classroom size, lighting, or handouts color [6]. However, this brings another problem: the lack of properly trained personnel who can facilitate the acquisition of higher education by people with disabilities via becoming their mentors and making the learning environment more accessible [7].

Research shows that students with disabilities face greater challenges than those without any impairment [8]. Various disability complexities require universities to make adjustments that go beyond standard regulations. Besides, in order to minimize cases of discrimination and guarantee that these adjustments are reasonable, universities need to create a special supportive environment [9,10].

Mobility equipment or other forms of resources and assistance can reduce a substantial part of such individuals' income that would be sufficient for people without any impairment to pay for higher education [11]. People with special needs may suffer from a lack of earnings, as they may need more money to perform functions similar to others, for example, to buy a wheelchair for mobility [12].

1.3 An educational institution coping with the problem

When it comes to education for the disabled, two scenarios are possible. The first lies in identifying the needs of students with certain disabilities and providing necessary equipment in accordance with their needs (e.g., a university bus to bring them to an educational institution). However, such kind of individual support may negatively distinguish them from others, and in general, it does not address the necessity for attitude change towards such people [13]. Another option is to treat all students the same and offer standard conditions. This scenario may also become somehow problematic, as it can result in a failure to make relevant external provisions, like adapted student residences or additional learning support for those who might require it [14].

According to official documents, the number of students with reduced capabilities entering higher education is slowly increasing [15]. At the same time, this group remains underrepresented in STEM – science, technology, engineering, and mathematics. This fact poses a serious challenge: students with disabilities are often discouraged from taking engineering-related courses [16]. Those who do enroll in engineering and other STEM majors often do not receive adequate support and are left to navigate university structures usually designed for people without disabilities on their own [17]. Many empirical studies offer solutions to various problems in the field of engineering education for people with disabilities [15,16,18]. Proponents of inclusive education point to positive social, psychological, and cognitive outcomes for all individuals, while opponents point to a lack of resources and support for disabled students and educators [18].

While there are continuous debates about the expansion of inclusive education, including in the field of engineering, these conversations most often relate to race and gender, leaving people with disabilities aside [19]. As of this day, STEM areas face the risk of an insufficient labor supply due to a lack of trained professionals able to work and prepare future specialists in STEM-oriented fields [20]. People with health impairments could help overcome this lack. Despite adequate training, they remain underemployed in STEM careers. People with physical and even with some mental impairments can to a greater extent prove themselves in engineering specialties than in others [1,3]. However, according to the National Science Foundation and National Center for Science and Engineering Statistics [21], disabled with a bachelor's degree make up about 7.2% of the science and engineering workforce.

Given the data above, one can infer that obtaining a higher education by people with disabilities has its own peculiarities. The question of this study is how people with disabilities themselves assess the main challenges that are significant for them in obtaining higher engineering education, and how they assess them in terms of their importance. This will highlight the most important points for improvement in the process of inclusive higher education. An essential contribution of presented research to the community is to determine the opinions of students with disabilities to assess

the best ways to further improve the conditions of inclusive higher engineering education.

These challenges refer not only to engineering but also to any other field. In this regard, the objectives of this study were formed as follows:

- Find out what difficulties people with disabilities may have in obtaining an engineering education
- Determine the most common challenges
- Suggest possible solutions.

The introduction contains the background of the research, its goals and problems, the formulation of the research question and research objectives, as well as a brief literature review. Methods section describes in detail the methodology of conducting two surveys. Results contain descriptive statistics and recommendations. Discussion provides the links between the findings and similar studies.

2 Materials and Methods

2.1 Research design and participants

Provided the nature of the goals set, it was decided to collect information by surveying university students. The research uses a qualitative research methodology. The survey method was supposed to allow considering the problem under study from the point of the direct recipients of engineering education. Besides, interviewing students majoring in engineering and analyzing their attitude to the issue made it possible to understand the attitude towards engineering students with disabilities. The survey addressed bachelor's and master's degree students from five universities, three of which are in Russia, one in Kazakhstan, and one in Uzbekistan. Research sample comprised a total of 555 people aged from 18 to 25 (215 women and 340 men).

Table 1. Research Sample Data

Educational institution	Number of students
Bauman Moscow State Technical University	100
Northern Trans-Ural State Agricultural University	110
Sarsen Amanzholov East Kazakhstan State University	125
Tashkent Institute of Irrigation and Agricultural Mechanization Engineers	115
South Ural State University	105

2.2 Participant's selection criterion

The study year had no statistical significance for the research. Therefore, the examination involved both undergraduate and graduate students. Since the study focused on engineering students' health impairments, it enrolled only those majoring in engineering or undergoing training under the programs close to this field. Such training programs included Engineering; Mechanical Engineering; Applied Mathematics and Informatics; Technologies, Mechanization and Power Equipment of Agriculture,

Forestry and Fishing; Technosphere Safety; Nuclear Physics and Atomic Energy; Agricultural Mechanization; Descriptive Geometry and Engineering Graphics; Theoretical and Construction Mechanics; Mathematics and Mechanics.

2.3 Research tools

To determine the possible difficulties that students with disabilities may face, research participants were asked to freely answer the question: "In your opinion, what difficulties may arise for students with reduced capabilities receiving an engineering education?" The survey was conducted remotely using the Google Forms service. Each student enrolled was sent a link with instructions and a response form. For more representative results, respondents were explained that students with disabilities in this case meant not only individuals with physical limitations but also with mental health issues (for example, those having an autism spectrum disorder) and hearing and visually impaired.

After the lexical and semantic analysis of the survey answers, five categories of the most significant difficulties of disabled students were identified. This list of categories was further used to create a Likert scale in the next step of the study.

At the next stage, respondents were given a list of selected categories, which they were asked to distribute from the most to the least critical (see Table 2).

Table 2. Most Common Problems of Disabled Engineering Students (Survey)

Challenges facing engineering students with disabilities For each statement, choose one number depending on the criticality you would give it (1 − very critical, 5 − noncritical) NOTICE that every number can be chosen only once!		
Staff skills and knowledge	Ability to help students with special needs	1 2 3 4 5
Theory-practice relationship	Inability for students with health limitations to apply their knowledge in practice due to non-adapted environment	1 2 3 4 5
Assessment features	Same knowledge assessment systems for all students without regard to their physical-mental characteristics	1 2 3 4 5
Biased attitude	Biased treatment (including by the employer) of disabled students due to their limitations	1 2 3 4 5
Physical environment	Inadequate equipment of universities (including laboratories, etc.) for teaching students with special needs	1 2 3 4 5

This approach enabled concluding on what problems, according to the research participants themselves, are most acute for disabled engineering students. In fact, survey participants were asked to rate 5 categories on a Likert scale, each of which represents one of the most common problems for engineering students with disabilities. Each of the categories offers an assessment of 1 to 5 points according to the degree of influence of this category on the student's academic performance, emotional background and general life activity according to his/her subjective opinion (where "1" - "affects least of all", "5" - "affects most strongly"). At the same time, the respondents were asked to build the categories according to the ranks, so that the assessments of any two categories did not coincide.

2.4 Research issues and limitations

One of the main limitations of this study is its focus exclusively on those studying in universities. This does not allow making any judgments on possible difficulties of impaired college students. That is why a number of challenges identified within the present work, as well as their recommended solutions, are applicable only to the considered group of respondents.

One of the important limitations of the study is that there was no division of students into separate categories according to the types of disability; thus, the study cannot be representative of individual groups of disorders. Such an analysis remains a topic for further research.

Future research in this field can be more widespread. For instance, it can be conducted across much more countries to assess the world views on the matter under study or include representatives of other technical specialties, schoolchildren, or even higher education representatives in general.

2.5 Data analysis

All responses received through Google Forms were taken into account and analyzed. The most common answer options were identified and grouped into categories, each of which was given a detailed explanation for better understanding.

Thus, two groups of answers were analyzed: 1. Free-form assessments of the main obstacles to learning for students with disabilities, grouped into five main categories of obstacles. This group of responses provided an opportunity for a deeper understanding of specific needs and specific details of the problems. This group, due to the free form of answers, is not subject to statistical description and has the form of a qualitative study. 2. Answers on the Likert scale with an assessment of the degree of influence of certain types of obstacles and the degree of criticality of each of them. This group is further represented by an analysis of descriptive statistics. The Results section is followed by an analysis of the first group of responses, then the second, which includes descriptive statistics.

2.6 Ethical issues

Research participation was entirely voluntary. Before surveying started, letters of invitation were sent to the relevant departments of universities to inform potential respondents about the possibility for everyone wanting to be enrolled. Not less important is that the study was conducted anonymously. The surveys submitted in Google Forms had no fields for entering personal data. After receiving the link to the survey, students filled out and submitted forms, which were automatically processed by the service.

3 Results

The analysis of responses allowed distinguishing five categories of challenges that disabled engineering students run into during university training. Each of them is considered in detail below.

3.1 Physical environment

Answers in one way or another related to the physical environment were the most frequent. In this case, the physical environment refers to the equipment of universities provided for students with health limitations. Many respondents noted a lack of such elements as ramps or elevators that can accommodate wheelchair accessibility. Apart from this, research participants mentioned that laboratories are usually not adapted for people with special needs.

3.2 Staff skills and knowledge

Another common option was inadequate staff preparation for work with such students. Sometimes, impaired individuals may need additional support from the teaching personnel. When it comes to engineering and scientific specialties, such support becomes much more important due to the environment's unsuitability. That is why educators should be appropriately trained and ready to react to non-standard situations arising in the learning process. The training of assistant tutors can include both additional on-the-job training of teachers and previously trained colleagues.

3.3 Theory-practice relationship

When obtaining a technical education, it is crucial not to study the theory alone but also to be able to apply this knowledge in practice. For students with disabilities, this can cause difficulties in studying and later in finding a job. They will possess insufficient skills in applying theoretical knowledge and may not fully understand how to work with some equipment or act in a certain situation.

3.4 Assessment features

Students may confront this problem when it comes to completing any projects or assignments with specific criteria. For example, a person with cerebral palsy may find it more challenging to work with drawings than one without physical disorders.

3.5 Biased attitude

Issues related to prejudice against students with special needs can rather be attributed to the post-training period. Respondents tend to assert that in the professions related to the exact sciences, the employer may be more likely to prefer a healthy job seeker over someone who has physical or intellectual disabilities, even though they will both be equally competent specialists.

Despite the fact that the identification of the most often expressed matters of concern was possible already at the stage of answers' analysis and grouping, this observation was not statistically confirmed. For this reason, it was necessary to determine the ratio of the problems regarded as the most critical (Fig. 1).

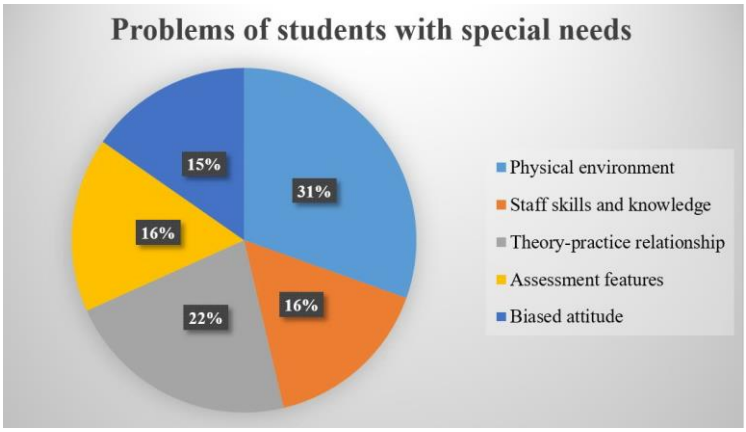

Fig. 1. Most Common Problems of Disabled Engineering Students

A thorough analysis of survey outcomes confirmed assumptions made previously. The majority of respondents (31%) consider the unadapted physical environment to be the main obstacle for students with health limitations. The next in criticality was the impossibility for such students to put theoretical knowledge into practice adequately (22%). This result can be considered logical because it is the physical environment's imperfection that hinders active participation of disabled students in practical assignments. Votes on three remaining items were distributed almost equally. Though, this does not mean that the issues of staff unpreparedness, prejudice, and assessment are less sharp.

The authors of the present research believe that elimination of these problems is much easier than it could seem at a first glance. For this, the following recommendations are to be implemented.

3.6 Providing an accessible learning environment

The problem of an accessible environment for people with disabilities is one of the most pressing in our society and education. In order for all students to have the opportunity to learn fully and use their knowledge in practice, educational institutions' administrative staff must take care of an environment that meets special needs of individuals with various disabilities. When it comes to engineering education, the solution is to build more inclusive laboratories and supply specialized equipment.

3.7 Education computerization

As already noted above, technical education is mostly applied in nature, which may cause some troubles for disabled people. Another way to resolve this issue can be the computerization of education. Not all students can work, for example, with real drawing tools. This difficulty can be easily leveled by developing a specialized computer program allowing creating drawings through real tools' simulation. Such software already exists and is being actively developed, which is discussed below. Work in these programs can be carried out without drawing away from the curriculum. After completing the corresponding module that requires practical work, some students perform it in the traditional way, and some (in this case, students with disabilities who find it difficult to work with conventional equipment) – using special software. This will allow individuals with health impairments to practice without deviating from the general course syllabus.

In the meantime, such a decision necessitates technical capacities that differ across universities to be taken into account. A specialized software creation requires involving specialists (programmers, developers, etc.) able to design it suitable for both high-performance computers and older models. This can be achieved by writing a program with a minimal set of the most important functions, agreed by university teaching staff. At the same time, to reduce the load on the computer processor, separate programs for individual needs (for drawings, building 3D models, etc.) can be created. This decision will allow students to install only the necessary software, which will also reduce the program's requirements and, therefore, enable using it even on low-performance computers. The introduction of such programs stipulates compulsory preliminary training of teaching staff for them to be able to explain their working principle and functions, as well as help if any difficulties or errors emerge. In the future, such practices can be expanded to the preparation of fully distance courses for disabled students.

3.8 Training engineering tutors

Tutors can also be involved to help students with reduced capabilities. Though, since engineering education is quite narrowly focused, training of engineering tutors in order to provide high-quality preparation is also critical. One of the options may be the training of laboratory assistants who will help students with disabilities in carrying out practical tasks and work in laboratories. If necessary, such a tutor can adjust the

equipment, prepare the workplace in advance, and take part in the study process him/herself. Such assistance should be done under a student's guidance, as it is essential for a tutor only to support and not fulfill a student's duties. In a similar vein, a tutor can positively influence the disabled individual by providing psychological support when completing an internship or contacting potential employers at competitions and conferences.

3.9 Improved knowledge assessment system

If university authorities agree and no negative impact is predicted upon the preparation quality, a separate assessment system can be elaborated for disabled students. Wherever possible, this new system can take into consideration special needs of such people. It can also be expanded by developing separate assessment approaches for both students with physical and mental disorders.

3.10 Psychological support

With the aim of reducing potential negative experience, university-based psychology sessions can be organized. This will help the disabled deal with possible doubts and anxiety associated with their physical/mental condition and future profession. When conducting such meetings, it is important not to separate healthy individuals from students with disabilities to avoid health condition-related stigmatization. The sessions should be held in an inclusive format. As a basis, a round table model can be chosen where all participants are free to discuss possible obstacles for disabled people and suggest ways to solve them. It is reasonable to attract educators and develop joint projects, which can then be presented at the appropriate forums and competitions. A similar positive contribution will make the organization of open days with potential employers invited and psychologists' participation. This may assist in eliminating prejudices and forming a positive attitude towards future specialists with special needs.

4 Discussion

Inclusive education issues are being extensively studied in modern society. One of the top-discussed matters when considering the problems of students with health limitations is learning environment accessibility. For STEM careers, the issue of laboratory accessibility is reasonably represented as one of the sharpest [22]. Analysis of various scientific literature on disabled students' performance in science and engineering laboratories has revealed that many researchers [22,23] consider the lack of an adapted environment the key obstacle to practicing. It should be specially noted that although the problem of students with disabilities has existed for a long time and inclusive education at all levels has been developing for decades, the problem of an adequately adapted environment continues to be reported in modern empirical research around the world [16-18,21,22].

The barriers and necessary facilitators mentioned in the literature can be roughly grouped into the following three categories:

1. Learning environment of the laboratory, including interaction with others (e.g., student peers and laboratory instructors)
2. Physical built environment of the laboratory
3. Tasks to be performed in a laboratory space (e.g., setting up or using laboratory equipment or tools) [24].

The indicated sequence of problems in terms of importance strictly corresponds to the results of the survey in this study. This is due to the fact that the problems of psychological adaptation, collaboration and interaction with a teacher are easier to solve and do not require significant material costs from the administration [4,25]. Perhaps this is the main reason why the problems with adaptive environments for students with disabilities remain.

Multi-year research has shown that similar problems are to one degree or another inherent to Spain [26], Australia [22], the United States [27], and many other countries of the world. Researchers from all over the world provide numerous recommendations to help students with limited capabilities cope with possible obstacles when working in laboratories. They include the following:

1. Educators should individually collaborate with a student to identify methods contributing to full participation in laboratory activities (e.g., setting up the laboratory experiments);
2. Educators should assess critical laboratory activity functions and student's abilities [28];
3. University support services (e.g., for people with special needs) should connect educators to programs or seminars that involve closer work with impaired students;
4. Educators should hire full-time laboratory assistants for students with disabilities;
5. Educators should modify or relocate equipment (e.g., extension cords);
6. University support services (e.g., career services) and faculty should support mentorship opportunities outside the laboratory [29].

The implementation of the above recommendations requires, first of all, the allocation of more time in the curriculum for a teacher to interact with students with disabilities; a teacher is to be trained the methods of such interaction. It is also required to do at least minimal re-equipment of laboratories and improve the quality of safety equipment, taking into account the needs of people with disabilities. Such minimal changes can be funded by government programs, which will allow universities to implement these programs more quickly.

Early training in the elements of robotic skills through special children's kits [30] and training people with disabilities from early childhood for the future of a technical or engineering profession using specialized mobile applications [31] will increase natural adaptation in the process of higher education [30]. A huge role is played by the early acquaintance of people with disabilities with software concepts and engi-

neering-mathematical type of problem solving using well-known social applications [32].

One of the recommendations of the authors of this study is the virtualization of the part of the learning environment associated with laboratory exercises. Means for this in the form of software packages based on the STEM methodology exist and are being actively developed [33,34]. Many such projects set themselves the task of achieving complete substitution of real virtual experience and maintaining the quality and applicability of skills acquired in virtual activities in interaction with a real technical environment [35].

In addition to barriers in the learning environment, scholars also consider barriers after graduation. The study of Li [36] is of significant interest in this field since he highlights the problem of employment of the disabled as that of the utmost importance. To a certain degree, the present research is in line with his opinion as one of the problems outlined by study participants was employers' prejudice. Overcoming prejudice can be realized through early acquaintance with prospective graduates during their training on the part of an employer. An employer can be convinced of the quality of the training of students with disabilities and their personal qualities [12,27].

The main research results show that people with health impairments either do not receive the required education or claim that it is more academically oriented and not useful for professional practice. This subsequently negatively impacts employment opportunities. Researchers indicate that employers' concerns in this regard may be related to the fact that a student with a disability has not acquired the required professional skills [37].

Some solutions proposed to address the employment problem to some extent overlap with the current study. Collins et al. [4] propose to provide disabled students with a more detailed job description before employment. This would allow them to understand the requirements of each specific place and better meet them. Sometimes, students express particular concern about the negative attitude they might encounter during employment and therefore choose not to disclose their disability information. In turn, the employer's ability to provide the necessary equipment may be affected exactly by the individual's unwillingness to disclose information about some limitations [38]. In any event, Nolan et al. [25] rightfully note that the attitude of professionals towards disability should be discussed and further changed since, in most cases, disability does not have any effect on the employee's professional competence.

Another pressing issue is the qualification of educators working with impaired students. It was noted that taking professional development courses affects the knowledge, skills, and attitude of educators teaching students with special needs and learning disabilities. Stites et al. [39] indicate that such courses make instructors feel better equipped to use resources, develop and implement sound learning strategies, and generally act as advocates for the rights of disabled to education with equal opportunities in STEM areas. These conclusions are in line with the present study results, particularly with the developed recommendations, calling for the preparation of teachers specifically for working with special needs children.

Delaine et al. [9] claim that the inclusion of diverse people in the profession improves their work quality. While diversity and inclusiveness can be seen as a prereq-

uisite for morality and fairness, engineering and business communities tend to regard it as an asset that enhances team creativity, makes solutions more workable, products more convenient, and citizens more aware of society's issues.

Despite numerous studies on the matter [40-42], people with disabilities are still underrepresented in STEM. Consolidation of inclusive education best practices used globally and optimization of research-based approaches may be an additional incentive for people with limitations to become more involved in engineering and make their professional contributions to the field's development.

Thus, following on from the research carried out and the literature reviewed, one can conclude that the global practice of inclusive engineering education is still at the stage of development and requires many challenges to be addressed. The universal difficulties typical for students with disabilities in the field of STEM include an unadapted working environment and prejudice. They make it difficult and sometimes even impossible to find a job.

5 Conclusion

Research results unveiled that engineering students with reduced capabilities may face some difficulties in obtaining an education and in subsequent employment. Such conclusions were obtained as a consequence of a two-stage survey among 555 university students (bachelors and masters) from Russia, Kazakhstan, and Uzbekistan. The survey involved individuals majoring in engineering or similar specialties. In total, five categories were identified according to the results of a survey with a free form of answers: physical environment, staff skills and knowledge, theory-practice relationship, assessment peculiarities, and bias. Meanwhile, the most acute problems were an ill-fitted physical environment and reduced abilities to practice, which was confirmed by the survey conducted in both forms (in free answers and on the Likert scale).

In response to the challenges highlighted, research authors proposed several possible ways to tackle them. It is necessary to provide an accessible environment for students with disabilities, for instance, by making specialized laboratory equipment available and adapted to their needs. It is possible to promote the computerization of education by transferring some of the practical tasks from the real world to the virtual, as well as combine traditional classes with web-based ones. It is essential to arrange corresponding instruction courses for educators and develop the assessment system. It can be elaborated and further applied exclusively for disabled students with reference to their mental or physical characteristics to assure fair knowledge evaluation. Collaboration during the so-called career fairs may help reduce bias and form a positive attitude towards future specialists with disabilities.

The results of this article can be used by other universities across Russia and other countries to conduct their own further research on the problems of engineering students with special needs. The research findings can facilitate decisions about the direction of funding or the direction of efforts to change the learning environment and curriculum. Further research can be conducted in colleges, as well as among students of other majors.

6 References

[1] Yaron, G., Meershoek, A., Widdershoven, G., Slatman, J. (2018). Recognizing difference: in/visibility in the everyday life of individuals with facial limb absence. Disability & Society, 33(5): 743-762. https://doi.org/10.1080/09687599.2018.1454300

[2] Schiariti, V., Selb, M., Cieza, A., O'Donnell, M. (2015). International classification of functioning, disability and health core sets for children and youth with cerebral palsy: a consensus meeting. Developmental Medicine & Child Neurology, 57(2): 149-158. https://doi.org/10.1111/dmcn.12551

[3] Arduin, S. (2015). A review of the values that underpin the structure of an education system and its approach to disability and inclusion. Oxford Review of Education, 41(1): 105-121. https://doi.org/10.1080/03054985.2015.1006614

[4] Collins, A., Azmat, F., Rentschler, R. (2019). 'Bringing everyone on the same journey': revisiting inclusion in higher education. Studies in Higher Education, 44(8): 1475-1487. https://doi.org/10.1080/03075079.2018.1450852

[5] Shrewsbury, D. (2015). Disability and participation in the professions: Examples from higher and medical education. Disability & Society, 30(1): 87-100. https://doi.org/10.1080/09687599.2014.982785

[6] Abawi, L. A., Bauman-Buffone, C., Pineda-Báez, C., Carter, S. (2018). The rhetoric and reality of leading the inclusive school: Socio-cultural reflections on lived experiences. Education Sciences, 8(2): 55. https://doi.org/10.3390/educsci8020055

[7] Moriña, A., López-Gavira, R., Morgado, B. (2017). How do Spanish disability support offices contribute to inclusive education in the university? Disability & Society, 32(10): 1608-1626. https://doi.org/10.1080/09687599.2017.1361812

[8] Majoko, T. (2018). Participation in higher education: Voices of students with disabilities. Cogent Education, 5(1): 1542761. https://doi.org/10.1080/2331186x.2018.1542761

[9] Delaine, D.A., Tull, R., Sigamoney, R., Williams, D.N. (2016). Global diversity and inclusion in engineering education: Developing platforms toward global alignment. International Journal of Engineering Pedagogy, 6(1): 56-71. https://doi.org/10.3991/ijep.v6i1.5372

[10] Moriña, A. (2017). Inclusive education in higher education: challenges and opportunities. European Journal of Special Needs Education, 32(1): 3-17. https://doi.org/10.1080/08856257.2016.1254964

[11] Sen, A. (2017). Ethics and the foundation of global justice. Ethics & International Affairs, 31(3): 261-270.

[12] Anastasiou, D., Kauffman, J.M., Michail, D. (2016). Disability in multicultural theory: Conceptual and social justice issues. Journal of Disability Policy Studies, 27(1): 3-12. https://doi.org/10.1177/1044207314558595

[13] Smith, E. (2018). Key issues in education and social justice. Sage.

[14] Bonvin, J.M., Laruffa, F. (2018). Deliberative democracy in the real world, the contribution of the capability approach. International Review of Sociology, 28(2): 216-233. https://doi.org/10.1080/03906701.2018.1477101

[15] Cunninghame, I., Costello, D., Trinidad, S. (2016). Issues and trends for students with disability: Review of NCSEHE-funded research. National Centre for Student Equity in Higher Education, Curtin University.

[16] Groah, C.H., Getzel, E.E., Rachel, C., Graham, C.W., Russell, C.E., Walker, A. (2017). Perceptions of GI Bill recipients with disabilities of Science, Technology, Engineering, and Math (STEM) as a viable career choice. Journal of Vocational Rehabilitation, 47(1): 109-117. https://doi.org/10.3233/jvr-170887

[17] Kimball, E.W., Wells, R.S., Ostiguy, B.J., Manly, C.A., Lauterbach, A.A. (2016). Students with disabilities in higher education: A review of the literature and an agenda for future research. In Higher education: Handbook of theory and research. Springer, Cham, pp. 91-156. https://doi.org/10.1007/978-3-319-26829-3_3

[18] Kirby, M. (2017). Implicit assumptions in special education policy: Promoting full inclusion for students with learning disabilities. In Child & Youth Care Forum (Vol. 46, No. 2). Springer US, pp. 175-191. https://doi.org/10.1007/s10566-016-9382-x

[19] Spingola, E. (2018). Literature review on disability participation in the engineering field. In Proceedings of the 125th Annual American Society for Engineering Education Conference.

[20] Kersanszki, T., Nadai, L. (2020). The position of STEM higher education courses in the labor market. International Journal of Engineering Pedagogy, 10(5): 62-76. https://doi.org/10.3991/ijep.v10i5.13905

[21] Rivers, E. (2017). Women, minorities, and persons with disabilities in science and engineering. National Science Foundation.

[22] Jeannis, H., Joseph, J., Goldberg, M., Seelman, K., Schmeler, M., Cooper, R.A. (2018). Full-participation of students with physical disabilities in science and engineering laboratories. Disability and Rehabilitation: Assistive Technology, 13(2): 186-193. https://doi.org/10.1080/17483107.2017.1300348

[23] Klingenberg, O.G., Holkesvik, A.H., Augestad, L.B., Erdem, E. (2019). Research evidence for mathematics education for students with visual impairment: A systematic review. Cogent Education, 6(1): 1626322. https://doi.org/10.1080/2331186x.2019.1626322

[24] Supalo, C.A., Humphrey, J.R., Mallouk, T.E., Wohlers, H.D., Carlsen, W.S. (2016). Examining the use of adaptive technologies to increase the hands-on participation of students with blindness or low vision in secondary-school chemistry and physics. Chemistry Education Research and Practice, 17(4): 1174-1189. https://doi.org/10.1039/c6rp00141f

[25] Nolan, C., Gleeson, C., Treanor, D., Madigan, S. (2015). Higher education students registered with disability services and practice educators: issues and concerns for professional placements. International Journal of Inclusive Education, 19(5): 487-502. https://doi.org/10.1080/13603116.2014.943306

[26] Moriña, A., Perera, V.H. (2020). Inclusive higher education in Spain: students with disabilities speak out. Journal of Hispanic Higher Education, 19(3): 215-231. https://doi.org/10.1177/1538192718777360

[27] Cahalan, M., Perna, L. (2015). Indicators of Higher Education Equity in the United States: 45 Year Trend Report. Pell Institute for the Study of Opportunity in Higher Education.

[28] Grout, I. (2015). Supporting access to STEM subjects in higher education for students with disabilities using remote laboratories. In Proceedings of 2015 12th International Conference on Remote Engineering and Virtual Instrumentation (REV). IEEE, pp. 7-13. https://doi.org/10.1109/rev.2015.7087284

[29] Avendano, L., Renteria, J., Kwon, S., Hamdan, K. (2019). Bringing equity to underserved communities through STEM education: implications for leadership development. Journal of Educational Administration and History, 51(1): 66-82. https://doi.org/10.1080/00220620.2018.1532397

[30] Papadakis, S. (2020). Robots and robotics kits for early childhood and first school age. International Journal of Interactive Mobile Technologies, 14(18): 34-56. https://doi.org/10.3991/ijim.v14i18.16631

[31] Papadakis, S. (2020). Tools for evaluating educational apps for young children: a systematic review of the literature. Interactive Technology and Smart Education, in press.

[32] Orfanakis, V., Papadakis, S. (2016). Teaching basic programming concepts to novice programmers in secondary education using Twitter, Python, Ardruino and a coffee machine. In Hellenic conference on innovating STEM education (HISTEM), pp. 16-18.
[33] Ghergulescu, I., Lynch, T., Bratu, M., Moldovan, A., Muntean, C.H., Muntean, G.M. (2018). STEM education with atomic structure virtual lab for learners with special education needs. EDULEARN18 Proceedings, 1: 8747-8752. https://doi.org/10.21125/edulearn.2018.2033
[34] Reece, A.J., Butler, M. B. (2017). Virtually the same: A comparison of STEM Students content knowledge, course performance, and motivation to learn in virtual and face-to-face introductory biology laboratories. Journal of College Science Teaching, 46(3): 83-89. https://doi.org/10.2505/4/jcst17_046_03_83
[35] Lynch, T., Ghergulescu, I. (2017). Review of virtual labs as the emerging technologies for teaching STEM subjects. In INTED2017 Proceedings of the 11th International Technology, Education and Development Conference, 6-8 March Valencia Spain, pp. 6082-6091. https://doi.org/10.21125/inted.2017.1422
[36] Li, H. (2017). Employment situation and settlement mechanism of disabled people. In 2017 International Conference on Education, Culture and Social Development (ICECSD 2017). Atlantis Press, pp. 143-146. https://doi.org/10.2991/icecsd-17.2017.31
[37] Kendall, L. (2016). Higher education and disability: Exploring student experiences. Cogent Education, 3(1): 1256142. https://doi.org/10.1080/2331186x.2016.1256142
[38] Lindsay, S., Cagliostro, E., Leck, J., Shen, W., Stinson, J. (2019). Disability disclosure and workplace accommodations among youth with disabilities. Disability and Rehabilitation, 41(16): 1914-1924. https://doi.org/10.1080/09638288.2018.1451926
[39] Stites, M.L., Rakes, C.R., Noggle, A.K., Shah, S. (2019). Preservice teacher perceptions of preparedness to teach in inclusive settings as an indicator of teacher preparation program effectiveness. UMBC Faculty Collection. https://doi.org/10.2478/dcse-2018-0012
[40] Eastman, M.G., Christman, J., Zion, G.H., Yerrick, R. (2017). To educate engineers or to engineer educators? Exploring access to engineering careers. Journal of Research in Science Teaching, 54(7): 884-913. https://doi.org/10.1002/tea.21389
[41] Capraro, R.M., Capraro, M.M., Scheurich, J.J., Jones, M., Morgan, J., Huggins, K.S., Curlu, M.S., Younes, R., Han, S. (2016). Impact of sustained professional development in STEM on outcome measures in a diverse urban district. The Journal of Educational Research, 109(2): 181-196. https://doi.org/10.1080/00220671.2014.936997
[42] Armstrong, M.A., Jovanovic, J. (2015). Starting at the crossroads: Intersectional approaches to institutionally supporting underrepresented minority women STEM faculty. Journal of Women and Minorities in Science and Engineering, 21(2): 141-157. https://doi.org/10.1615/jwomenminorscieneng.2015011275

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Article submitted 2021-01-20. Resubmitted 2021-05-03. Final acceptance 2021-05-04. Final version published as submitted by the authors.