

Computer science and information systems: implementation features in education during the pandemic

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Abstract. Computer technologies and information systems are being developed and implemented in all spheres of social life. These systems are especially important in the face of emergencies. They are used during biological threats like the pandemic. Local infections that emerged at a certain place on the planet rapidly spread all over the world. Information technologies allow create conditions of life. One of the examples is education – because full-time education significantly increases the risks of contagion. This article addresses the challenges emerging due to the accelerated implementation of digital technologies. We demonstrate examples of solutions allowing to effectively provide education at National Research University Higher School of Economics (HSE University). These include engaging students as digital assistants in helping different types of users with their issues, using gamification methods in educational process and other projects. The application of such approaches results in a positive synergistic effect facilitates educational process during the pandemic.

Keywords: *computer science, information systems, digitalization, semantic interoperability, the Internet of things, big data, digital assistant, gamification, National Research University Higher School of Economics.*

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Introduction

The implementation of information systems and technologies in different spheres of life affects living conditions, including in particular the increased mobility. There emerge new epidemic threats that are related to both increased mobility and malicious application of biological knowledge. Coronavirus pandemic is one of the examples of such threats that require global anti-pandemic initiatives and actions.

One of the most sought-after instruments to effectively organize society in these conditions is the application of digital technologies enabling remote activities.

One of the directions aimed at introducing digital technologies into society is the use of various types of assistants that facilitate the use of information systems by people. The "digital assistant" metaphor is currently gaining ground in the scientific literature and is being used in a variety of contexts. The established semantic content of this concept is still absent.

Most often, the concept of a digital assistant is considered in the context of the use of various types of assistants: chat bots, voice assistants, and other types of software components. They allow you to automate various, usually routine, elements of human activity.

This applies to various subject areas, for example, pedagogical activity [1], medical diagnostics [2,3], and the integrated solution of issues related to daily human activities [4].

So, for example, this term is used as a tool to help the teacher in learning programming languages to form assignments for students [1]. In this case, a digital assistant is understood as software that performs a number of functions for creating tasks when learning programming and processing the results of their execution by students.

However, despite the rapid progress of automation tools, many complex practical problems can only be solved using human capabilities. To solve problems related to the technical support of a complex heterogeneous automated university system, the Higher School of Economics uses the activities of specially trained students [5, p.372]. This ensures a high level of quality in request fulfillment and user satisfaction. This approach is especially relevant in the context of a pandemic, and is also justified in the context of accelerated import substitution of infrastructure elements of an educational institution, caused by the withdrawal of many foreign vendors from the Russian market.

This includes the sphere of education that it is not easy to manage and maintain functional during the pandemic. Education is a sensitive sphere for the economy and society. It engages children and young adults, employs a significant part of working population; the quality of education greatly influences the socio-economic development of a country.

Traditionally, in the course of education a person becomes socially engaged. This includes a face-to-face communication with a tutor. However, this format of interaction is not compatible with the requirements of anti-pandemic measures. The application of information systems, digital technologies is one of the ways out of this situation.

Digital technologies in education are rapidly developing; full-time education is being gradually supplemented with distant learning. However, the current level of implementation of information systems in education is not sufficient to fully substitute traditional educational practices – there are limitations in communication systems, client devices, methodology and software used in the process of education.

However, the use of digital technologies allows to sufficiently address a lot of educational challenges, and by doing so to loosen restrictions, decrease socio-economic costs. At the same time, there is a need to rapidly develop and implement new information technologies in education.

To address pressing challenges in education during the pandemic there is a need of additional service technologies implemented by digital tools. In particular, the article reviews technologies that are being applied and developed at the National Research University Higher School of Economics (HSE University) to supplement the process of education by developing students' practical skills with digital technologies, by developing soft skills, by improving efficiency of students' and university employees' work. New solutions allow engaging students into activities enabling to address challenges facing the University during the pandemic, increasing the quality of education, the performance of digital services and infrastructure and finding new approaches towards some educational challenges. For example, students' participation contributes to more efficient implementation and application of information systems in University's activities and provides additional moral and financial motivation for students during education.

1. Changes and challenges during the pandemic

1.1. Epidemics and environment

Humans survived many epidemics. By now, people have learned to fight them. However, COVID-19

pandemic has certain distinctive features. There emerged a new level of mobility in the society. Many people can travel fast – within several hours – around the world. Providing substantial (measured by days or weeks) incubation period of the disease, it is not possible to effectively control the spread of the infection.

Besides, there are global crisis circumstances in political and economic spheres that provoke opinions on the possibility of artificial origin of the disease. Another distinctive characteristic of the present-day epidemic is the emergence of digital technologies that influence the process of disease diagnostics and treatment and enable a new level of control over the population. The pandemic drives complex changes in the environment, contributes to the emergence of new socio-economic developments. Now we are witnessing a new stage of society and environment coevolution. The needs and conditions to fulfill them are changing. For example, the use of digital technologies during the pandemic has become obligatory. The examples include the information system to control access by QR codes (used sporadically), general video monitoring of territories, face recognition systems, geolocation control over citizens with the use of mandatory-to-wear communication devices etc. State authorities in different countries are now empowered with instruments and ability to control all spheres of society. This is a new bait for authorities and the pandemic may become an excuse for its implementation.

The use of digital technologies affects citizens' environment. For example, there are restrictions on the use of nature objects – no access to parks, recreational zones and forests during fire-hazardous period or during epidemics to avoid contagion etc. Unlike similar situations in the past, digital technologies make available different monitoring systems, allow registering the announced restrictions. Thus, there is a trend towards better management of social and natural spheres. However, sometimes additional restrictions that are being introduced are not justified by social and economic reasons, they are introduced just because it is technically possible.

Living conditions of individuals and society are changing dramatically. There emerge new challenges in people's surroundings. There is a new constant agent in the form of digital and communication devices between a person and natural and social environments. However, the regulation of these changes is greatly delayed [6].

The communication system is also changing. Normal communication is being replaced by different substitute communications – links exchange in social networks, talking on the phone or via different messengers instead of face-to-face communication. The

structure, contents and information scope of communication is changing too. Communication has become impersonal, often it is just a brief exchange of short messages or videos. This is one of the reasons of so called mosaic thinking which wide spread is being often mentioned in literature. These trends also affect the educational sphere. Methods of motivation, methods of training have to be adapted to the changed perception and available technical devices. One of the examples of such changes is the introduction of gamification into education using digital devices available to students. Different gamification methods are becoming more and more popular at higher education [7].

The structure of manufacturing and services is changing; that provokes respective changes in the scope of working activities. Many jobs and occupations are not needed any more. Whole lines of manufacturing of certain products and services go bankrupt and disappear replaced by new ones. For instance, traditional sales and services are being replaced by online services and home delivery systems. During the pandemic social authorities and governing bodies stimulate distant and remote work wherever it is possible.

At the same time new high-margin businesses appear. During the pandemic these are medical services related to testing, treatment and research of diseases. In high demand are the services providing testing for infection, medication for preventive treatment and therapy of coronavirus infection, equipment and infrastructure for the treatment of critically ill patients. There are information technologies enabling the automatization of diagnostic procedures, remote education and distant work in the forms that help decrease the risk of contagion. The distinctive feature of this pandemic is that medical help is needed by much more citizens than usual providing that there is a shortage of resources for emergency care.

There is a tendency to limit contacts and travels of people using information systems to control these spheres, and to stimulate self-isolation.

Organizational forms and life-supporting technologies involving minimal contacts between people are in demand. Application of information systems in healthcare is now a crucial instrument of state's social policy and an argument in the international affairs.

Restrictions for citizens and for the economy are not always justified and consistent primarily because mankind encountered the pandemic of such scale for the first time. Lack of logic in anti-epidemic and social policies in the opinion of an average person who does not have access to statistical data on epidemic situation leads to social tensions and economic losses.

Digital environment is still developing, there is no clear understanding of its potential and required

restrictions, and consequently we cannot yet predict the influence that the application of digital technologies will have on the society and nature. Even despite that digital technologies are widely used during the pandemic in different socio-economic situations to the extent available on the current technological level.

Generally speaking, the understanding that there should be restrictions at the application of digital technologies is not yet formulated. There may be several scenarios of society's transformation in digital environment, different trajectory of changes. There is a need to research technological capacities and their possible effects.

Business activities during the pandemic are complicated because there are beneficiaries and competition on different levels – between developers of medical technologies, manufacturers, states. Manufactures of different automatization subsystems, drugs, treatment methods, vaccines etc. compete with each other. Rivalry between well-known and obvious beneficiaries of the current pandemic is one of the major factors that causes distrust and social tensions in the society.

These issues may be addressed on different socio-economic levels: on the level of business activities, social groups, states, regions. Let us have a closer look at the changes in educational sphere during the pandemic.

1.2. Development of the structure and contents of education

Education is a very important sphere of people's life. It affects children and young adults of different age groups, it influences the prospects for development and future of the society in general. The system of education is one of the foundations for the development of labor resources. It includes pupils, education specialists, parents and pupils and students' relatives and many other stakeholders. Education is also a very important part of the financial sphere.

The system of education reflects to a large extent socio-economic problems. The pandemic has changed the situation dramatically. It was decided to accelerate the implementation of distant education although social and technical readiness for this form of education is different throughout different regions. Applied solutions are dependent on the international political situation, their application can be restricted by sanctions at any moment. One of the examples is the use of popular communication platform for distant education – Zoom [8]. The solution supplier due to the latest sanctions imposed on Russia limited the usage of the solution for companies that are being financed by the state. Microsoft introduced restrictions for the sale of licenses to Moscow State Technical University.

There are risks that the educational process can be impeded by sanctions at any time. To minimize

risks, it is recommended to use Webinar.ru or Kontur.Talk application. Both of these platforms have a record of being used by the university since before the pandemic. Webinar.ru and Kontur.Talk platforms are fully developed in Russia, and thus holds significant potential for usage inside Russian educational system, according to current regulations. That is why the Ministry of Digital Development, Communications and Mass Media of the Russian Federation recommends to use solutions developed by local companies [9].

The pandemic required that distant learning is introduced into the educational system on different levels as soon as possible. The format, structure and scope of educational activities is changing. It is necessary to be able to adapt to the level of competence and abilities of the students. Distant learning introduced as an emergency may become the reason of underexplored transformations – from technological to ethnocultural and social.

During distant learning we more and more use audio and video materials instead of face-to-face communication. It is not obvious how to control the quality of education, what effect the new format of education will have on the results of education in the long run. Oral or written exams that demonstrate student's train of thought is being substituted by tests. Generally speaking, students have difficulties with the development of holistic social perception, understanding of accepted behavior, social limitations, and ability to focus attention.

Information technologies used in education are not good enough to transfer knowledge, emotions, experience, and attitude. There are no clear understanding how to organize distant learning taking into account individual traits of a person. Technologies are constantly developing. However, there are still risks of vain needs, pseudo-knowledge that are being formed during education with technical and social limitations.

Lack of face-to-face communication at distant learning does not help transfer life experience between generations. This experience is not always positive, but this is a real material for assessment and formation of person's own mindset. Accelerated implementation of information technologies in education results in emotional and sensuous starvation of students. Socialization process gets a new meaning. This is especially relevant to pupils and students. The society is not yet ready for digital transformation in education but the pandemic situation stimulates the development of this method.

The problem of communication is highly relevant to Russia. Due to the large territory, uneven density of population in many regions the levels of digital technologies development are different.

Many pupils and students cannot afford quality devices. That means that technical devices had insufficient performance capacity and features to process information in multimedia format.

Many teachers do not have required technical devices, training level in digital technologies is often insufficient. Issues arising during education process are addressed by students themselves as they cannot communicate with the teacher, socialize. These factors are likely temporary and especially crucial outside big cities, in small remote schools.

Distant learning with the use of digital technologies has various impact on different educational methods and age groups. Face-to-face personal communication between students and a teacher cannot be effectively substituted by technical means. The use of information technologies at the level available to a mass user can cause discomfort among people. For example, it is not possible to substitute the environment of a group learning by group video conference.

Distant learning is highly dependent on technical means and technologies. In case of serious problems with information infrastructure distant methods of learning may become unavailable, and traditional methods of learning may be already lost.

We are expecting that the listed risk zones and problems are temporary and that they will stimulate both the development of digital technologies and infrastructure in the sphere of education and information digital culture in general. Technologies that can decrease the impact of described risks and negative factors are in high demand nowadays. Such technologies can be implemented by digital means.

2. Addressing the challenges of education with the use of promising Information technologies during the pandemic

Providing all said above, here is a classification of the main types of risks and potential problems in education:

- Socio-economic.
 - a. Political.
 - b. Content generation, identification of the contents of education.
 - c. Communication, securing interaction between all subjects of educational process.
 - d. Methodological – ways of knowledge consolidation, knowledge adoption control.
- Technical.
 - a. Technological.
 - b. Communication.
 - c. Software.
 - d. Interface-related.

Risks and problems listed above have their peculiarities and resolution methods on different levels of education:

- Preschool.
- School (primary, secondary and senior classes).
- Higher education.
- Training of academic staff with the highest qualifications.
- System of advanced training for personnel.
- Self-education.

Challenges faced by the system of education due to the pandemic are addressed with the use of modern information technologies.

Implementation of 5G and in future 6G will allow making communications available for the purposes of education throughout all the territory of our country, guaranteeing high quality of video and audio content exchange, implementing other resource-intensive types of services [10,11].

The changes are expected in the structure of the Internet – data will be addressed by its contents, and data processing will shift from centralized services to devices on the network peripheral [12].

It is likely that educational system will be significantly affected by the mass implementation of the Internet of things technologies [13] and big data processing systems [14]. These technologies on the one hand greatly change society's environment and on the other constitute the informational basis for the development of new educational technologies.

On all levels of the society there are incentives that drive the development of information technologies. They help to perform different activities during the pandemic – registration and analysis of disease spread, examination of peculiarities and mutation of the virus, provision of situational awareness for authorities and citizens.

The application of information technologies in education allows addressing a lot of educational issues on the new qualitative and quantitative level, decreasing the necessity of physical travels in the course of educational activities. We can expect that in future new information technologies in education will substitute traditional technologies without significant decrease of the quality of education.

There is a general problem of semantic interoperability [15] at the implementation of information technologies: users of information technologies need to be guided in the new digital environment, there should be a mutual understanding between teachers and students. So, there is a need to help people understand the meaning and consequences of his/hers interaction with the objects of digital environment in the context of education.

In order to handle educational issues better it is necessary to train users about digital technologies, increase their level of digital knowledge.

Educational environment modelled with the use of digital means in the course of technological development should correspond to the requirements brought by natural and social environments. We can expect that society using digital technologies will develop adaptive capabilities that will allow effectively address educational issues during the pandemic.

3. Information technologies in education during the pandemic

3.1. Information technologies development trends

Let us discuss widespread digital technologies development trends in education during the pandemic.

Currently we are witnessing a rapid development and advancement of communication environment. The pandemic in Russia coincided with the deployment of 5G and massive adoption of low-cost personal computers, tablets, and smartphones available to the majority of pupils and students for education.

The advancement of technological and communicative basis of digitalization will result in the increase of the quality of education. Some of the quality indicators of digital technologies in education include:

- Realistic presentation of educational content.
- Automatization level available to students in educational situations.
- The level of “intellectualization” of the digital environment when performing educational activities. The ability to identify student's problems and provide recommendations in a proactive manner.
- The format of information interaction. Access to the same or better functionality of educational infrastructure than that is available in traditional education.
- Possibility to use video: for communications, in programmable interactive content, for video archives, for demonstration of situations that shows working experience in the studied field, the quality of video: resolution, color rendering, sufficient framerate.
- The use of new technologies for the implementation of gamification: simulators and training devices, group role-playing games, team work in digital environment, digital tokens for encouragement and punishment. The option to remotely participate in multi-player games.
- The use of artificial intelligence technologies in educational activities allows guaranteeing: to

make content more realistic, to make the interface between a person and an automated system more efficient, to generate standardized replies to students' queries, to interpret texts, e.g. provide explanations along the text, comment it, and to use voice interface.

Availability of the listed features will help enhance the "understanding" between a student and an automated system, and will allow interaction with several interconnected systems simultaneously.

Solutions that meet the required quality criteria allow increasing variability of educational situations, generating (including in remote mode) new situations that are resource-intensive in case of physical implementation.

Students and lecturers in educational establishments use different automated systems that interact with each other. This is specifically applicable to higher educational establishments that have many specific features related to the use of software and hardware. Thus, technical and organizational approaches enabling inclusion of lecturers and students into the existing information infrastructure of an establishment are in high demand.

Let us review some new types of educational activities in the digital environment aimed at the resolution of problems defined above that are now being implemented at HSE University and the results of their implementation.

3.2. Examples of practical implementation

Educational establishments use a complex of soft and hardware that is constantly upgraded, changed and reconfigured.

The users – lecturers, students, other members of the staff need to comprehend the information infrastructure inside the establishment and outside of it, and get help with problems they face whenever necessary. Students can be engaged to provide such help.

To address this issue HSE University has a digital assistant service [16]. Work of digital assistants who are usually students has the following effects:

- Students get practical experience. This experience in many cases corresponds to the area of their studies because students focus on specific tasks.
- This work is paid. Students get additional revenues doing tasks related to their future profession.
- The activity of digital assistants is one of the efficient instruments for students' socialization. They do team work that includes communication with students and lecturers in order to support activities aimed at a wider use of information technologies.

Digital assistants fulfill the task of aiding users with practical application of digital technology. They

are front-line operators of technical support for users of the university's information services. Digital assistants work in integrated digital environments such as Jira Service Management and Confluence (<https://www.atlassian.com>). All user inquiries are registered in Jira Service Management system, which then proceeds to track all stages of solving the user's problem, and also gives feedback when necessary. All incoming queries are sorted into categories. Depending on category, an issue is either solved by the digital assistant themselves, or is rerouted to the next line of support and delivered to appropriate department of the university's technical support.

Digital assistants are capable of solving many of the users' questions on their own. To do this, they use knowledge database existing in Confluence (<https://www.atlassian.com>) information system, which is integrated with Jira Service Management.

Apart from being the front desk of technical support, digital assistants also support the university's online events. They maintain right settings of online conferences and calls, manage access to classes and sessions, and prevent trolling and zoom-bombing incidents.

Being the university's students themselves, digital assistants can also help users with questions connected to organization of study process, or navigate them through correct usage of HSE's digital study tools.

In addition to this, digital assistants also act as "Digital Buddies" for international students. Due to pandemic-induced regulations, some of these students attend their classes online while staying in their country of origin. "Digital Buddies" are responsible for supporting them. This task is handled by students with the highest level of English.

Other promising directions for digital assistants' line of work exist. Most importantly, is every aspect of their work they act as mediators and fill in the gaps in users' understanding of technology, building a bridge between them and the university's digital environment.

The use of services provided by digital assistants allowed to increase the level of students' and staff's digital competencies, to solve many issues that were caused by the accelerated transition to remote and distant education during the pandemic. Nowadays the scope of services and communications of project's participants is growing and expanded beyond the university.

Over the year, 90 students from 10 faculties studying under 15 educational programs of both technical and humanities background took part in the project.

There was a research of students' opinion regarding the project. Students evaluated different aspects of their work. Below are the main results of the research.

To the question “Which competences are you developing and/or have already developed during your time as a digital assistant?” we got the following answers.

Almost 90% of the respondents noted that they developed digital skills via their work with digital tools of HSE University.

The second most popular answer (63,9%) was – “Communication skills and team work experience”.

“Time-management skills” were marked by 61% of respondents. Students think that time management skills were driven by remote work because you have to plan your activities throughout the day and balance work with studies.

Digital assistants pointed out the development of abilities for continual learning (41%) stating that working as a digital assistant helps develop new mini competencies. Continual learning skill developed during the project is a life-changing ability in the digital world where you have to adapt to ever changing conditions and stay afloat.

Over 30% of digital assistants consider that the participation in the project helped them understand new opportunities and risks related to the application of digital technologies.

Answers to the question “What gave you the motivation to participate in the project “Digital assistants?” split up as it is demonstrated in Fig. 1. There

are both purely altruistic and financial motives. Students pointed out the fact that they were getting practical experience that can be later included into their CVs. This point is supported by actual employment of students who participated in the project by the leading IT companies.

Students engaged into digital assistants project get different practical experience. The answers to the question “Which competences are you developing and/or have already developed during your time as a digital assistant?” split up according the Fig. 2.

In the course of work as digital assistants students gain practical experience of communication with people, clients, of interaction within a team. These are important knowledge and skills for future managers and specialists who will be implementing information technologies in different subject areas where graduates will choose to work.

The creation of a pool of talented students is an important result of the project. The work drives students to generate new ideas while university specialists have a chance to look at routine tasks of an educational establishment with fresh eyes of young generation.

The project has a positive impact on the quality of education and distant learning. Students become active participants in the digital transformation of the university, get practical skills in the work with information instruments and experience in providing a per-

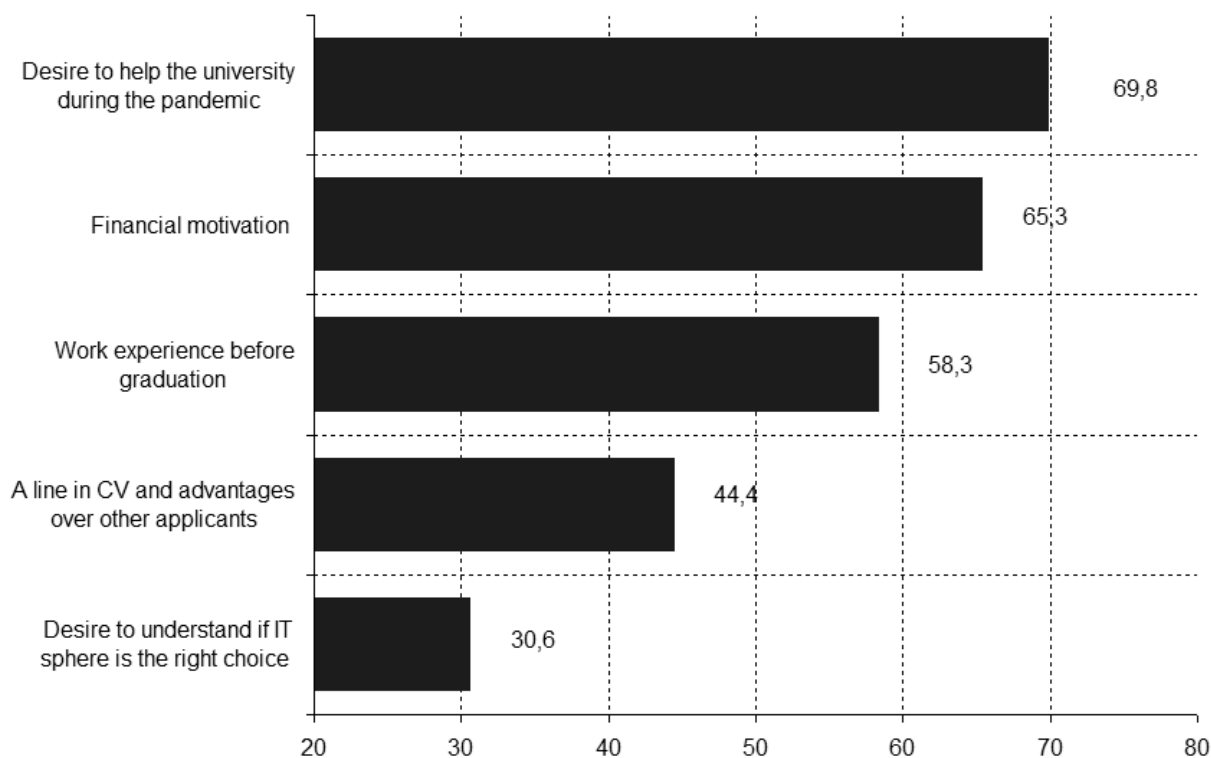


Fig. 1. Motivation of digital assistants for the participation in the project

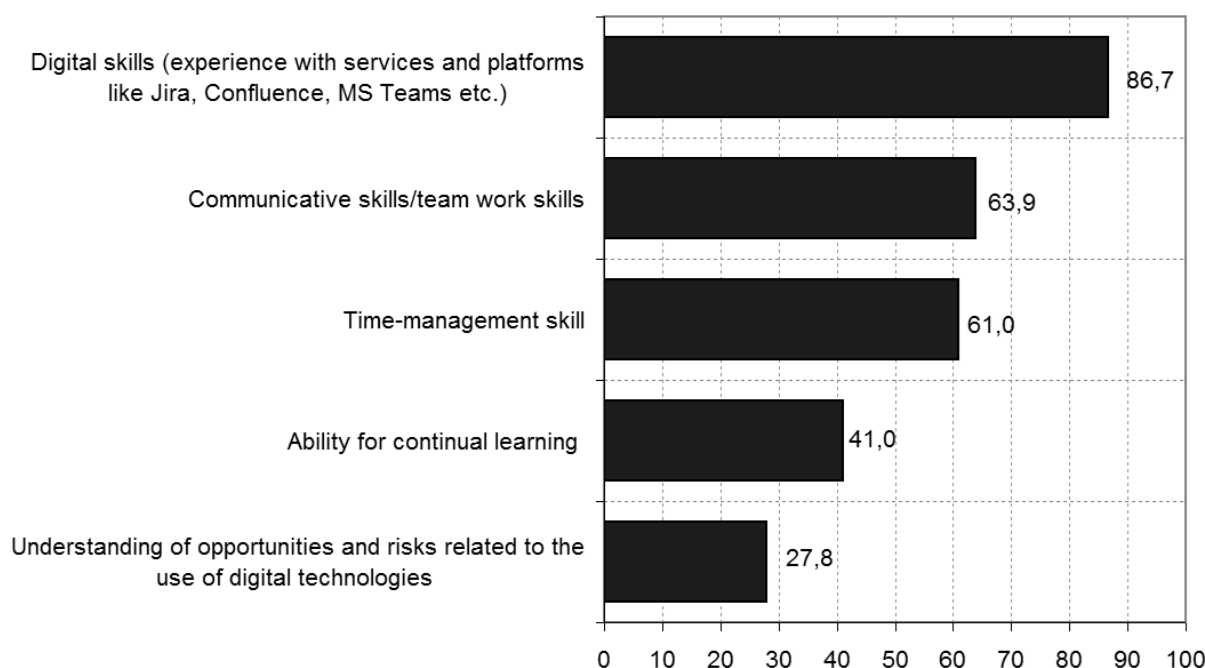


Fig. 2. Self-estimation of competences developed during participation in the project by digital assistants

sonified support to the users. The university in its turn gets additional opportunities for the creation and training of cross-functional student teams that help address issues of university digitalization.

Students participate in operation, development and maintenance of information services inside and outside of the university. In the university these are – scientific, research and extracurricular activities of departments, assistance in organizing online events – seminars, conferences etc. Partnership with the Government of Moscow under the program “Active aging” is the example of university participation in the creating of digital environment outside the university. There are plans to engage students and staff members into helping senior citizens with the use of digital technologies. Besides, there is an idea to engage retired seniors with the high level of competences in digital technologies to work in digitalization sphere.

Students actively participate in the promotion of university’s digital culture in social networks posts, messengers, and popular journals. More than 50% of students who work as digital assistants are willing to share their experience and explain the concept of information services and digitalization in generally. In future the creation of popular scientific-based content will become an important element of project-based interaction with students. The introduction of students’ self-government is a promising development trend of digital assistants’ project. One third of the respondents suggests to engage students as additional project cura-

tors. They will control the work of small student working groups in a horizontal management style. Students will get additional practical skills and knowledge in digital technology sphere as well as a real management and team work experience. This approach helps develop responsibility, realize potential of the youths.

Students’ participation in digital assistant’s project based on the principles of self-governance will allow allocating additional resources for digital transformation of the university and addressing social challenges.

Conclusion

Widespread digitalization, introduction of information technologies allows targeted changes in the society on different levels. However, along with positive effects there are a lot of challenges. It is required to anticipate possible difficulties, manage risks, and measure the implementation of information tools in order to prevent negative outcomes.

The pandemic contributes to the accelerated implementation of digital technologies in activities related to control of socio-economic processes, interpersonal relations, healthcare, education etc.

Education is one of most sensitive spheres to application of information technologies. To overcome issues that emerge during education process it is necessary to introduce new concepts and technological solutions allowing to decrease costs caused by the changes.

New technological, organizational and methodological approaches enabling effective implementation of new technologies are in high demand. HSE University experiment on engagement of students as digital assistants to address educational and social issues is reviewed in this article. We shared the results of the research on the efficiency of this practice and suggest approaches for further development of this activity.

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