Research article

Developing Digital Skills Among Students of the Sverdlovsk Region

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Abstract. Research on the development of digital skills and competencies has primarily been concerned with the current socio-economic situation. Based on statistical data compiled by the Institute for Statistical Studies and Economics of Knowledge of the National Research University Higher School of Economics, there is a gap in the level of digital skills of both the entire population of Russia and young people in comparison with the populations of most European countries. This research explored some of the issues of the structure of digital skills, identifying their levels and the areas necessary for assessing the development and formation among students. This study was based on the data of a sociological survey conducted among students of higher education institutions of the Sverdlovsk Region in their first year of a bachelor's degree, as well as for various training profiles (humanitarian, science and mathematics, engineering and socio-economic). The role of the university as a filter was revealed, and also its role as an agent in the process of professional socialization of young people. However, the institutions did not meet the requirements of the modern digital economy.

Keywords: students, economy digitalization, digital skills, socialization

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1. Introduction

Currently, adaptation to the dynamic environment and changing socio-economic conditions always implies the development of new, contemporary skills and competencies. The current situation in the world economy is characterized by some researchers with the use of the term "The Fourth Industrial Revolution", and it is manifested in the massive introduction of cyberphysical systems into the economy — artificial intelligence, production robotization, the Internet of Things, unmanned transport vehicles, robot cars, three-dimensional printing, nanotechnology, quantum computation, etc. [1]. It requires the development of digital skills and competencies [2]. At the same time, the level of digital skills in Russia, according to the Institute for Statistical Studies and Economics of Knowledge of the National Research University Higher School of Economics, is markedly

lower than in most European countries: according to the data collected for 2019, as a percentage of the total population aged 15 and over in Russia, a total sum of 25% of the population do not use the Internet or do not have digital skills, 39% have a low level of skills, 24% have a basic level, and only 12% have above the basic level [3].

The basic level is considered to imply only one skill or having only entry-level skills of 22 actions in 4 skill groups (information, communication, problem-solving skills, and software skills). For comparison, in the Netherlands, the rating leader, only 4% of the population do not use the Internet or do not have entry-level skills, 16% have a low level of skills, 30% — basic and 50% — above the basic level. Based on the computed integrated rating calculated by the National Research University Higher School of Economics, Russia is somehow lagging behind in terms of the level of proficiency in digital technologies in comparison with all European countries excluding Bulgaria and Romania.

The study cited also provides comparative data by the age range of the Russian Federation population. On this basis, a common stereotype is confirmed: the level of proficiency in digital technologies is inversely proportional to age: the digital proficiency is inversely proportional to age. If at the age of 15–25, the number of users is above the basic level — 22.4%, by the age of 75, it gradually decreases to 0.2%, while on the contrary, the number of those who do not use the Internet and do not have digital skills is consistently growing from 3.7% (aged 15–24) to 91.6% (aged 75 and over). At the same time, comparing age differentiation with the differentiation of digital skills in European countries, it should be mentioned that even the “advanced” in relation to other age groups Russian youth aged 15–24 are significantly lagging behind the population of all ages in most European countries: only the population of Italy, Poland, Bulgaria, and Romania has a lower level of basic digital skills than Russian youth. Thus, the digital skills of modern Russian youth are below the level of digital development of an average European country. It should be noted that for all issues about the research methodology of the National Research University Higher School of Economics, this fact means that in the future, at the level of a whole generation, in terms of the development level of digital skills, Russia’s gap with European developed countries will only increase.

A key factor in the success in the digitization processes is the sufficient availability of highly qualified personnel and training systems with certain competencies for qualified people to develop and implement digital technologies [4]. In the field of digital technologies to close the digital gap in Russia, on July 28, 2017, by the order of the Government of the Russian Federation, the state program “Digital Economy of the Russian Federation” was approved. The program states that the digital economy

"improves the competitiveness of our country, the quality of life of our citizens, ensures economic growth and its national sovereignty". The program assumes the achievement of the following indicators in relation to personnel and education itself by 2024:

1. the number of graduates of educational institutions of higher education in areas related to information and telecommunication training technologies — 120 thousand people per year;
2. the number of graduates of higher and secondary vocational education with competencies in the information technology field at the average world level — 800 thousand people per year;
3. proportion of the population with digital skills — 40 percent [5];

However, the program does not define what digital skills are and what level of digital skills are in question. In the analysis of European and international experience in the classification of international skills and competencies, including the booklet *The Digital Competence Framework for Citizens* of the European Union [6], three levels of digital skills are distinguished (in general, it corresponds to the approach of the National Research University Higher School of Economics mentioned at the beginning of the article): basic, intermediate, and specialized. Basic functional skills are the entry-level skills required for the basic use of digital devices and applications. Intermediate skills required to use digital technologies constitute a group of intermediate skills. Specialized skills form the basis of professional careers in the field of information and communication technology. The content structure of digital competencies is presented in the following areas: information literacy, communication and cooperation, digital content creation, security, problem-solving, and professional competencies [7].

2. Methodology and Methods

The authors analyzed the data received in a survey of university students in the Sverdlovsk Region, conducted in December 2020 — January 2021 with an online quota sample (computer-assisted web interface). In total, 2573 students from 17 universities of the Sverdlovsk Region were covered. The online survey results were supplemented with data from the analysis of students' personal pages in social networks (701 pages). In this case, targeted selection was used — the authors searched for the web pages of users who indicated the Sverdlovsk Region as one of his/her universities as a place of study.

Table 1: Structure of digital skills in the study of students of the Sverdlovsk Region

Field:	Level:	Skill:
Information literacy	Advanced	Research and analysis of public and political information
	Advanced	Basic software packages (for example, MS Office)
	Specialized	Website creation and moderation
Communication and cooperation	Advanced	Use of virtual communication platforms, social media for training
	Specialized	Group management in social media
Problem-solving	Advanced	Search and analysis of information for study
	Specialized	Electronic commerce
Security	Advanced	Recognition of unreliable information
	Specialized	Protection of information
Professional competencies	Advanced	Professional software packages needed in one's profession (for example, Adobe Acrobat Pro, Kompas 3D)
	Specialized	Proficiency in professional programming tools

This research assumed that the students (their average age according to the research was 20.2 years) were the "advanced" part (according to the data of the National Research University Higher School of Economics) of the Russian population in the digital world, due to not only their age but also the specifics of their educational activities — training in modern and digital technologies. There is another reason why the overwhelming majority of students had basic levels of digital technology — the forced transition of Sverdlovsk Region universities to digital distance learning in the spring semester of 2020 and the fall semester of 2021. Students and teachers had to learn these technologies compulsorily because of the quarantine introduced in connection with the spread of COVID-19. As a result, the authors surveyed only the advanced level (applying and evaluating) and highly specialized (creating) level of digital skills (see Table 1).

The level of proficiency in each skill was surveyed at three levels corresponding to the widespread youth and IT slang — "guru" (advanced level of skill proficiency), "user" (basic), and "dummy" (no practical skills). In order to compare and rank the degree of proficiency in skills, the authors conditionally quantified "dummy" as the zero (0) level of proficiency, "user" as the average level of proficiency (0.5), and "guru" as the highest level of proficiency (1). The result is a "Digital Skill Index", ranging from 0 ("dummy") to 1 ("guru").

Since this index is conditional and is not subject to the normal distribution, non-parametric ranks criteria were used to assess the statistical significance of differences

between different groups of students: the Kruskal–Wallis test to assess nonlinear ties and Jonckheere's trend test to assess linear ties. The data collected were processed and analyzed through the Vortex software for the analysis of sociological and marketing information.

3. Results and Discussion

As Table 2 shows, students in the Sverdlovsk Region are the most proficient in:

1. The skills of searching and analyzing information for study (advanced skills in dealing with problems arising in their training activities) — the conditional digital index of proficiency in the skill is 0.700, since 45.6% of the surveyed students believed that they had this skill at the "guru" level and only 5.6% admitted that they were "dummy" in this case.
2. Basic software skills (advanced level of digital literacy) — the conditional digital index is 0.682.
3. The use of virtual communication platforms and social media for training — the conditional digital index is 0.671.

As for the rest of the skills, according to the data in Table 2, students possess significantly lower skills, especially such as:

1. Professional software skills required for the profession (advanced level of professional competencies) — the conditional digital skill index is 0.431.
2. Website creation and moderation (specialized level of information literacy) — the conditional digital index is 0.247.
3. Proficiency in professional programming tools (specialized level of professional competencies) — the conditional digital skill index is 0.230, since only 9.3% of students rated themselves in this field as "guru" and 63.3% rated themselves as "dummy".

Digital skill index measured from 0 ("dummy") to 1 ("guru").

Thus, one can conclude that university students in the Sverdlovsk Region have a rather good level of digital communication and collaboration skills, to an average degree — security skills, problem-solving, and information literacy and are the least proficient in professional competencies.

Table 2: The level of digital skills according to the results of a survey among students of the Sverdlovsk Region (December 2020 — January 2021), % from the number of students surveyed

Digital skills:	Dummy	User	Guru	Digital skill index[a]	Rate
Research and analysis of public and political information	11.3%	59.3%	29.4%	0.590	4
Basic software packages (for example, MS Office)	6.8%	50.1%	43.1%	0.682	2
Website creation and moderation	59.8%	31.1%	9.2%	0.247	10
Use of virtual learning, communication platforms, social networks	9.6%	46.5%	43.8%	0.671	3
Group management in social media	18.8%	46.5%	34.7%	0.580	5
Search and analysis of information for study	5.6%	48.7%	45.6%	0.700	1
Electronic commerce	43.5%	44.0%	12.6%	0.346	9
Unreliable information recognition	12.8%	61.3%	26.0%	0.566	6
Protection of information	21.4%	56.6%	22.0%	0.503	7
Professional software packages needed in one's profession	34.4%	48.7%	16.9%	0.413	8
Proficiency in professional programming tools	63.3%	27.4%	9.3%	0.230	11

The reasons for these imbalances can be explained by the fact that communicative digital skills of modern students whose childhood and socialization took place in the digital age have come from a digital technology era; they belong to the conditional generation "Z (Zoomers)" [8]. Therefore, they interact with peers, classmates, friends, and even relatives and parents mainly with the help of digital communication methods, in particular, messengers and social networks.

The reasons for the lag in digital professional competencies are ambivalent in nature. On the one hand, they have learned those skills mostly at the university only, having chosen their professional development in the specialization. Moreover, the specifics of the curriculum of any discipline include the introduction of general courses at the junior level of general competencies in junior courses, and professional competencies and disciplines, as a rule, are relegated to senior courses. On the other hand, the low level of digital skills of senior students can be caused by substantive shortcomings of the educational process: curricula are not up to date, the material and technical base is insufficient (in the learning process, there is not enough practical access to modern equipment and software), or teachers are incompetent or not able to teach digital skills or form digital competencies. To find out these possible reasons and to record the

Table 3: Conditional digital skill index of students of the Sverdlovsk Region by academic year[a]

Digital skills:	1st year	2nd year	3rd year	4th year	Kruskal--Wallis test[b]	Jonckheere's trend test[b]
Research and analysis of public and political information	0.596	0.557	0.590	0.601	0.363	0.509
Basic software packages	0.668	0.670	0.676	0.731	0.070	**0.046**
Website creation and moderation	0.208	0.209	0.268	0.264	**0.006**	**0.003**
Use of virtual learning	0.703	0.652	0.663	0.700	0.107	0.881
Group management in social media	0.565	0.574	0.586	0.594	0.776	0.298
Search and analysis of information for study	0.720	0.674	0.689	0.731	0.127	0.749
Electronic commerce	0.325	0.305	0.366	0.356	**0.038**	**0.037**
Unreliable information recognition	0.568	0.525	0.571	0.590	0.119	0.150
Protection of information	0.505	0.496	0.508	0.507	0.967	0.772
Professional software packages	0.357	0.424	0.406	0.467	**0.004**	**0.004**
Professional programming tools	0.201	0.201	0.247	0.243	0.106	0.082

Conditional digital skill index measured from 0 ("dummy") to 1 ("guru").

[b] Bold indicates skills with a significance level less than 0.05

dynamics of the development of digital skills, the authors differentiated students into groups by a year and a profile of study and presented the data in Tables 3 and 4.

Table 3 shows data on bachelor students and specialty students (in a number of Sverdlovsk Region universities, training in some specialty programs has been preserved) from the first to the fourth year of study. The Kruskal–Wallis test column shows the significance level of non-parametric rank criteria for nonlinear data. Jonckheere's trend test column shows the significance level of non-parametric rank criteria for linear data. If one proceeds from the significance level 0.05 adopted in such studies, then the Kruskal–Wallis test value is below 0.05; it can be interpreted as the presence of a statistical significant tie without taking into account its direction (both linear and nonlinear), and the value of Jonckheere's trend test below 0.05 as having a statistically significant linear tie. The second criterion (Jonckheere's trend test) is the most interesting; with its help, one can identify sequential linear changes. Accordingly, based on this criterion, with a significance level of less than 0.05, it can be stated that as students move from junior years to senior ones, their digital skills significantly grow:

1. basic software skills (from 0.669 in the first year to 0.731 in the fourth year of study);
2. website creation and moderation skills (from 0.208 in the first year to 0.264 in the fourth year of study);

3. e-commerce (from 0.325 in the first year to 0.356 in the fourth year of study);

4. professional software skills (from 0.357 in the first year to 0.467 in the fourth year of study).

As for the proficiency in professional programming skills, there was a sharp increase in skills between the second (0.201) and third year of study (0.243), but due to the insufficient sample size, this growth turned out to be statistically insignificant (significance level 0.087). For the rest of the skills, the significance level was even higher, but in general, one can see that almost all of them had small growth, which was insignificant due to the small sample size for each course separately.

In addition to the small sample size, the reason for the lack of significant growth in the level of digital skills may be that in different specialties at the university, there is an emphasis on the formation of various digital skills necessary for students' future professional activities. To this end, the surveyed students were divided into four major profiles of study: humanitarian specialties (259 students from the 1st to 4th year), natural science and mathematics (375 students), engineering and technical (380 students), and students in social and economic fields (680 students), and the relevance of the consistent growth of digital skills depending on the year of study was tested. Despite the smaller size of samples, which could cause the absence of statistically significant relationships, the authors revealed a fairly consistent picture of the growth of certain digital skills among students of various educational profiles (see Table 4).

Students of humanitarian specialties initially were high in the assessment of their digital skills (i.e., even in their first year, these skills were significantly higher than in students of other specialties) in the field of managing groups in social networks, searching and analyzing information for study, information security tools. At the same time, their skills in basic software packages, professional software packages, and professional programming tools were lower than in other specialties. In the process of training, students of humanitarian specialties consistently and significantly increased the skills proficiency index:

1. website creation and moderation (from 0.210 in the first year to 0.350 in the fourth year), the significance level 0.004;

2. special software packages (from 0.310 in the first year to 0.525 in the fourth year, and a significant increase was revealed precisely in the fourth year), the significance level 0.014;

3. proficiency in professional programming tools (from 0.150 in the first year to 0.288 in the fourth year), the significance level 0.016.

Thus, humanitarian students, through training, markedly improved their digital skills in information literacy and professional competencies.

Students of engineering and technical specialties initially (i.e., in their first year of study) assessed their own skills most critically in comparison with students of other specialties: they were rated below others in terms of group management skills in social media, skills in searching and analyzing study information, skills of basic and professional software packages, and skills in professional programming. In the process of training, the index of proficiency skills of students of engineering and technical specialties consistently and significantly increased:

1. basic software skills (from 0.622 in the first year to 0.750 in the fourth year of study), the significance level 0.010;
2. professional software skills (from 0.346 in the first year to 0.629 in the fourth year of study), the significance level 0.000;
3. professional programming tools (from 0.181 in the first year to 0.271 in the fourth year of study), the significance level 0.012.

It turns out that students of engineering and technical specialties in the process of training sharpened their skills of general-purpose software and if they lacked them, they mastered professional software and could develop their own software to solve professional problems.

Students of social and economic specialties initially (in their first year of study) also had a critical approach to the assessment of their own digital skills: they assessed their own skills in basic and professional software and professional programming tools lower than students of other specialties. At the same time, among students of socio-economic specialties from the first to the fourth year of study, the proficiency skills index consistently and significantly grew:

1. search and analysis of public and political information (from 0.600 in the first year to 0.701 in the fourth year), the significance level 0.018. This skill growth reason is that it is not a general skill for students of these specialties, but a professional skill;
2. unreliable information recognition (from 0.467 in the first year to 0.612 in the fourth year), the significance level 0.014. This skill is closely related to the previous one

— public and political information in modern digital conditions is generated in many sources and may contain unverified information, rumors, deliberately spread gossip and fakes. So, the skill of recognizing inaccurate information becomes a professional skill for students of this specialty;

3. basic software skills (from 0.611 in the first year to 0.776 in the fourth year), the significance level 0.016;

4. skills of search and analysis of information for study (from 0.656 in the first year to 0.813 in the fourth year), the significance level 0.014. The reason for the growth of this skill is the same — students of socio-economic specialties have to search, form, and analyze arrays of socio-political and statistical data, including for educational purposes.

Thus, students of the socio-economic profile in the process of training significantly improved their skills in working with socio-political information, as well as skills in basic, but not professional software.

As for students of natural sciences and mathematics, they initially (in the first year of study) assessed their own skills of work with basic and professional software, tools for professional programming, research and analysis of information for training, analysis of information for study, and recognition of unreliable information higher than students of other specialties. At the same time, in the learning process from the first to the fourth year of study, no significant directed increase was observed in any digital skills among students of this study profile. Perhaps this is due to the fact that initially, it was necessary to separate students of natural science, mathematics, and IT profiles, since the processes of growth of digital skills in them proceed in different directions, but in such a situation, one would receive very small samples where no meaningful conclusions could be drawn.

Interpreting the results of the study based on the respondents' self-assessment, one should make a significant point of situations of the undirected Kruskal–Wallis test, when the directed Jonckheere's trend test is insignificant. The reason for such situations is often the famous Dunning–Kruger effect [9], easily recognizable by the overestimation of their own digital skills by first-year students (as insufficiently competent) and careful assessment of these skills by senior students (as more competent). These include:

1. social media skills for study and acquired information security means for students of humanitarian specialties,

Table 4: Conditional digital skill index of students of the Sverdlovsk Region by academic year and professional specialization[a]

Digital skills:	1st year	2nd year	3rd year	4 th year	Kruskal–Wallis test[b]	Jonckheere's trend test[b]
Humanitarian specialties students						
Research and analysis of public and political information	0.660	0.608	0.495	0.600	**0.012**	**0.036**
Basic software packages	0.680	0.676	0.642	0.688	0.802	0.726
Website creation and moderation	0.210	0.209	0.311	0.350	**0.023**	**0.004**
Use of virtual learning	0.740	0.662	0.574	0.675	**0.022**	0.059
Group management in social media	0.670	0.581	0.553	0.663	0.123	0.542
Search and analysis of information for study	0.780	0.689	0.637	0.713	0.060	0.089
Electronic commerce	0.320	0.250	0.326	0.438	**0.038**	**0.055**
Unreliable information recognition	0.580	0.493	0.526	0.550	0.435	0.849
Protection of information	0.600	0.439	0.442	0.525	**0.019**	0.246
Professional software packages	0.310	0.385	0.379	0.525	**0.044**	**0.014**
Professional programming tools	0.150	0.203	0.268	0.288	0.113	0.016
Science and mathematics students						
Research and analysis of public and political information	0.569	0.544	0.624	0.485	0.058	0.873
Basic software packages	0.734	0.644	0.713	0.662	0.272	0.478
Website creation and moderation	0.255	0.189	0.332	0.147	**0.003**	0.603
Use of virtual learning	0.702	0.689	0.720	0.618	0.347	0.646
Group management in social media	0.559	0.622	0.614	0.426	**0.029**	0.569
Search and analysis of information for study	0.766	0.711	0.738	0.647	0.137	0.177
Electronic commerce	0.351	0.278	0.411	0.191	**0.002**	0.920
Unreliable information recognition	0.601	0.533	0.614	0.544	0.274	0.976
Protection of information	0.516	0.533	0.572	0.426	0.104	0.976
Professional software packages	0.468	0.367	0.507	0.309	**0.002**	0.779
Professional programming tools	0.287	0.244	0.342	0.191	0.070	0.881
Engineering and technical students						
Research and analysis of public and political information	0.585	0.532	0.550	0.564	0.602	0.682
Basic software packages	0.622	0.663	0.661	0.750	**0.028**	**0.010**
Website creation and moderation	0.186	0.179	0.269	0.243	0.068	0.055
Use of virtual learning	0.681	0.632	0.657	0.671	0.751	0.904
Group management in social media	0.500	0.532	0.525	0.550	0.835	0.430
Search and analysis of information for study	0.676	0.632	0.669	0.707	0.450	0.418
Electronic commerce	0.309	0.358	0.360	0.400	0.498	0.150
Unreliable information recognition	0.580	0.542	0.570	0.614	0.579	0.497
Protection of information	0.505	0.521	0.504	0.571	0.477	0.317
Professional l software packages	0.346	0.484	0.521	0.629	**0.000**	**0.000**
Professional programming tools	0.181	0.174	0.252	0.271	0.054	**0.012**

Table 4: (Continued)

Digital skills:	1st year	2nd year	3rd year	4 th year	Kruskal–Wallis test[b]	Jonckheere's trend test[b]
Students in social and economic fields						
Research and analysis of public and political information	0.600	0.538	0.602	0.701	**0.043**	**0.018**
Basic software packages	0.611	0.692	0.671	0.776	**0.023**	**0.016**
Website creation and moderation	0.156	0.295	0.235	0.299	0.099	0.197
Use of virtual learning	0.722	0.641	0.658	0.791	**0.010**	0.085
Group management in social media	0.589	0.615	0.593	0.687	0.203	0.171
Search and analysis of information for study	0.656	0.705	0.686	0.813	**0.007**	**0.012**
Electronic commerce	0.322	0.321	0.357	0.351	0.837	0.617
Unreliable information recognition	0.467	0.526	0.563	0.612	**0.085**	**0.014**
Protection of information	0.378	0.500	0.497	0.478	0.135	0.298
Professional software packages	0.200	0.397	0.344	0.343	**0.021**	0.083
Professional programming tools	0.122	0.205	0.203	0.216	0.366	0.263

[a]Conditional Digital skill index measured from 0 ("dummy") to 1 ("guru").
[b] Bold indicates skills with a significance level less than 0.05.

2. groups managing in social networks and good command of professional software skills packages for students of natural science specialties (in the senior years, it becomes clear that they do not know this software well enough, or that there is still professional software that they are not familiar with),

3. social media study skills and professional program packages skills for students of social and economic specialties.

As for public policy research skills, in the first year of study, humanitarian specialties students estimated them even higher than students of socio-economic specialties (0.660 versus 0.600), but in the process of training, this skill gradually decreased among students of the humanitarian specialties, probably because the general interest in public and political life was replaced by professional tasks in the chosen humanitarian specialty.

4. Conclusions

This research has shown that the universities of the Sverdlovsk Region perform their usual function of a filter and a mediator of professional socialization: as a result of the Unified State Exam and qualifying tests for higher education (preserved in some universities in creative specialties), students with certain digital skills are chosen for

higher education. Such skills are necessary for training and well developed at a sufficient level. These skills are improved in the course of training, but as the calculations show, they are not very significant, and they are only in the field of professional competency. At the same time, generic digital skills are developed only in situations where they are related to professional competencies.

This situation severely hampers the development of the digital skills of university graduates, considering that Industry 4.0 will pay special attention to the ability of workers to constantly adapt and learn new skills and approaches in a variety of contexts [1, p. 42]. That is, the fixation on professional digital skills (the sufficiency of formation of those is also another problem) and the ignorance of general digital competencies make university graduates not flexible enough, not ready to adapt to constant changes and drifts of the digital economy. As a result, even Russian youth lags behind in the development of digital skills compared to the population of most European countries.

However, the authors' previous study showed that students themselves were more aware of the illusiveness of the concept of a profession in the modern world: the proportion of students willing to work in their specialty from 1995 to 2016 almost halved (from 66 to 34%) [10]. Therefore, while maintaining the role of the university as a filter and agent in exclusively professional socialization, one can predict a further decline in the value of higher education and an increase in the number of higher education students solely for formal reasons.

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