The impact of digital technologies on the quality of life of the population: measurement methodologies and assessment results

Olga Kolosova[1,*], *Sergey* Salkutsan[1], *Marina* Efremova[2], *Nikolai* Shimin[2], and *Olga* Chkalova[2]

[1]Peter the Great St. Petersburg Polytechnic University, Institute of Advanced Manufacturing Technologies, Saint Petersburg, Russia
[2]National Research Lobachevsky State University of Nizhny Novgorod, Nizhniy Novgorod, Russia

Abstract. The article summarizes the results of studies of scientific approaches to the measurement and evaluation of the quality of life in the application of digital technology. The authors studied the state of development of digital technologies and identified priority areas of digitalization in the Russian Federation. The article, based on the results of studies published in open sources, systematized indicators of the quality of life in certain countries of the world. The authors also substantiated the need to develop new methods of assessing the quality of life in the context of the increasing role of digital technologies.

1 Introduction

The living conditions of post-industrial society significantly change the quality of human life. Digital technology has now penetrated into all spheres of social and economic life and has become the dominant factor in its development [10]. There is no doubt about the positive impact of digitalization on the quality of life. Along with the positive aspects, digital technology has negative consequences. Humanity has very limited experience of existence in a digital environment, so researchers have yet to recognize and assess the risks of digitalization [3, 6, 21].

Traditional approaches to assessing the quality of life become little acceptable in digitalization. This requires rethinking the links between digital technologies and the quality of life of the population, studying them, and developing methods for measuring the scale and depth of the changes taking place. In order to identify key changes in the quality of life under the new conditions, we must study the changes taking place, clarify the opinions of researchers about the new directions of development, and identify the existing problems [2, 13].

This article studies the quality of life of the population under the application of digital technology, to assess the state of digitalization in the Russian Federation, and to systematize methods for assessing the impact of digitalization on the quality of life. All this will make it possible to respond more quickly and effectively to such changes in the future. We will also

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[*] Corresponding author: okolosova@spbstu.ru

try to gain in-depth knowledge of how digitalization has changed the socio-economic structure of society, to understand these changes, and to contribute to the creation of sustainable development of society with a digital component.

The results of the study will allow us to make sense of the changes that have taken place and to develop forward-looking strategies to improve the quality of life of the population. Our discussion is neither definitive nor exhaustive and aims to start a discussion of this issue among a wider range of researchers in order to learn lessons and speed up the growth of the quality of life in digitalization.

The development of technology in the first decades of the 21st century, structural changes in market interactions because of the emergence and spread of a new type of pandemic coronavirus COVID-19, and significant transformations in world politics and economics are reflected in the scientists of various branches of science. The analysis of academic papers in the international Scopus citation database with the phrase "digital transformation of society" in their title or content shows a multiple increase in the number of scientific publications devoted to the impact of technology on all spheres of society. While from 2010 to 2015 the total number of such studies was 518, from 2016 to 2021 there are already 1,742 (over 900 for the "pandemic" period 2020-2021). These studies include quite a wide range of digital change issues and the role of technology in the present and future: innovation in the fashion industry (Bertola, P., Teunissen, J., 2018; Bertola, P., 2021), tourism (Pereiro, X., Sacramento, O., 2020) [25, 26, 30], machine learning (Sellhorn, T., 2020), big data (Marciano, A. et al., 2020) [28, 31], risks to civil society (Aseeva, I., Budanov, V., 2021), economic security (Mikhaylova, A., 2019; Spivakovskyy, S. et al., 2021) [24, 29, 32], sustainable development (Vovchenko, N. et al., 2019; Vilks, A., Kipāne, A., 2020), and human capital use (Stryzhak, O. et al.; Alavi, S., Habel, J., 2021) [23, 33, 34, 35].

A special place belongs to the works that affect the changes in the quality of life of people because of the development of Industry 4.0 and the widespread use of the latest technologies, which ensure the satisfaction of needs for access to any necessary information by search engines and the possibility of communication by IP-telephony, creation of individual websites, blogs, and social networks [21]. Being both a subject and an active participant in the processes of digital transformation, a modern person should have "digital maturity," that is, demonstrate digital equipment, digital competence, and digital flexibility [12]. Digital technologies contribute to the welfare of the population, simplify the procedures of interaction with the state, and ensure increased satisfaction of people's needs through the emergence of new types of services or ways of providing them [22]. The major result of digital transformation is the social digital effect, which has both objective (providing access to digital infrastructure and digital platforms) and subjective (economic and social comfort) components [18]. Determining the influence of the speed of development and spread of digital technology on the qualitative characteristics of society is a significant problem that requires more in-depth reflection and analysis.

2 Materials and methods

To achieve the goal of the research, we applied the analysis of empirical data published in the statistical collection of the Higher School of Economics, the official websites of the Ministry of Digital Development, Communications and Mass Communications of the Russian Federation (Minkomsvyaz), the analytical center NAFI. We analyzed the articles of the international citation database Scopus from 2010 to 2021 with the term "digital transformation of society" in the title or content. To assess the quality of life of the population in the conditions of digitalization, we used publicly available information on the official websites of international organizations that form the world rankings.

3 Results

3.1 Scientific approaches and methods for assessing the quality of life in the digital economy

The growth of digital technology has had a significant impact on all aspects of human life. Researchers [10] have defined digital technology as a "new paradigm of sped up development," one target of which is to improve the quality of life. This requires rethinking the links between digitalization and the quality of life of the population, measuring these links, and also developing techniques for measuring the depth of the changes taking place.

The economist J. Galbraith first applied the concept of "quality of life" in his book The Affluent Society (1958). After the U.S. President J. Kennedy in 1963 pronounced this term in a report, politicians began to actively use it. According to researchers [5, 11], the quality of life is a multidimensional concept, which has no unambiguous definition. Quality of life, in a general sense, is the satisfaction of the material and spiritual needs of people, conditioned by their social experience and the environment.

Active research began in the second half of the 20th century. We can distinguish two main approaches for assessing the quality of life of the population:
- objective, based on statistical indicators of the socio-economic situation of a particular territory (income of the population, employment rate, life expectancy, etc.);
- subjective, based on surveys, focus groups, in-depth interviews, etc.

The authors of [15, 19] summarized the main approaches and methods of assessing the quality of life of the population (Table 1).

Table 1. Main ratings/indicators of the quality of life of the population.

Rating	Rating structure (indicators)
World Happiness Index	GDP per capita, life expectancy, social support, health care, corruption, civil liberties
Better Life Index	Living conditions, income level, employment, level and quality of education, health, environment
Index of quality of life or life satisfaction	Health, optimism, basic needs of society, civic engagement, trust in national institutions
Happiness Rating	GDP per capita, life expectancy, civil liberties, sense of security and confidence in the future, stability of families, job security, corruption, indirect indicators of the state of society (trust, generosity, generosity)
Global Barometer of Hope and Despair	Index of the level of economic hope: economic optimism and pessimism
Weighted Index of Social Progress (WISP, MIQOLS QOL Indicators)	Weighted Index of Social Progress or WISP, MIQOLS QOL Indicators (International Society for Quality of Life Studies, ISQOLS)
The concept of the quality of life of the population (research center The Economist Intelligence Unit)	Material well-being, health, political stability and security, family life, social life, climate and geography
Human Development Index (United Nations Development Program)	Social security, spatial and social mobility, cultural development of population, health, unemployment rate, state of criminality, etc.
Quality of life of the population	Indicators describing health and the health care system
Rating of regions (rating agency "RIA Rating" of the media group MIA "Russia Today")	Rating of the quality of life of Russian regions with the definition of integral rating scores by groups of indicators: income level, employment, housing conditions, security, demographics, environmental and climatic conditions, etc.

Continuation of Table 1.

Non-state monitoring of the socio-economic situation and health status of the population of the Russian Federation (Russia Longitudinal Monitoring Survey-HSE)	Structure of income and expenditures, material well-being, employment, migration behavior, health, system of values, etc.
Russian regional index of the digital component of the quality of life of the population	Digital goods, digital competences, the quality of labor life and social sphere in the conditions of digitalization, electronic public services and security of information activities of the population.

Table 1 shows that most of the methodologies are based on determining an integral indicator/rating that reflects the quality of life of the population, and have the goal of determining the world rankings of countries. Many international and national organizations have been working on rankings since the second half of the 20th century. Thus, the British research center - New Economics Foundation, offered the World Happiness Index, the Organisation for Economic Co-operation and Development (OECD, France) - the Better Life Index, the American Institute of Public Opinion, engaged in the study of public opinion - the happiness rating and the global barometer of hope and despair. Specialists of the World Health Organization, which prioritizes human health and the environmental sphere, also study the quality of life of the population.

The United Nations (UN) created a broad system of indicators at the end of the XX century and published annual reports, where they proposed the Human Development Index (HDI) for the first time. HDI is an integrated index, reflecting the system of views on improving the quality of life and showing the actual achievements of the country in health, education and actual income of citizens by the value of gross product per capita. Today, the HDI is one of the universally recognized indicators reflecting the quality of life of the population.

The above ratings (Table 1) allow us to form a general picture of the quality of life in a particular country. However, life is rapidly which significantly changes the quality of life of the population. Most researchers [4, 9, 15, 27] consider the digital revolution and digitalization of society to be a significant factor, starting the emergence of new indicators of the quality of life.

The authors noted that the digital revolution started the emergence of new indicators reflecting the changes taking place [4, 10, 15, 18]. Scientists speak of the need to update approaches to the study of digitalization and the measurement of the population's quality of life, considering its digital component [7, 11, 15].

The work [20] proposes two groups of indirect and direct impact indicators, differing in influence on the economy and social life of the country (Table 2).

Table 2. Indicators of direct and indirect impact on the economy and social life.

Indicator	Calculation methodology
Indirect impact indicators	
Networked Readiness Index (NRI)	The level of development of information and communication technologies (ICT) in a particular country according to 53 parameters, divided into 3 groups: - availability of ICT development conditions; - the readiness of citizens, businesses and government agencies to use ICTs; - the level of use of ICT in the public, business and government sectors

Continuation of Table 2.

Global Innovation Index (GII)	Characterizes the potential of innovative activity and its result. It is calculated as the average of two sub-indices: - the innovation cost subindex assesses the elements of the national economy in which innovation processes take place: (1) institutions; (2) human capital and research; (3) infrastructure; (4) the level of market development; and (5) the level of business development; - the subindex of innovative results reflects the actual results of such efforts: (6) results in knowledge and technology, and (7) results of creative activity
Direct impact indicators	
Digital Economy and Society Index (DESI)	It is used in the EU countries, calculated based on the values of five aggregated parameters, defined by their specific indicators (31 indicators): Country connectivity to digitalization results - characterizes the ability to access communication systems (e.g. access to broadband internet). Measures installed (fixed) broadband, mobile broadband, broadband speed, and prices; Human Capital - Measures the digital competencies of the population, including evaluating online work, use of digital technologies, advanced skills, and their development; Citizens' use of the Internet - measures consumption of online content (videos, music, games, etc.), use of modern communications, online transactions (online shopping and banking); Integration of digital technologies in business - reflects the level of integration of digital technologies in production activities, measures the level of digitization of business and the use of online sales; Digital public services - reflects and measures the digitization of public services, focusing on the formation of e-government and its infrastructure
International Digital Economy and Society Index (I-DESI)	All the evaluated countries are divided into two subsets: - EU countries (as a separate unit), Japan, South Korea, USA, Australia, Canada, Iceland, Norway, and Switzerland. The ranking uses 5 aggregated parameters based on 28 indicators to assess the level of digitization of countries in this subset. - All countries in the first subset and additionally Brazil, China, Israel, Mexico, New Zealand, Russia, and Turkey. Only countries from the same subset can be compared with each other

The major supplier of primary statistics for calculating the above indicators is the international interstate organization of economically developed countries, the Organization for Economic Cooperation and Development (OECD). The results of OECD studies are the most authoritative. The European Union and the UN Statistical Commission use them in their work. The Partnership on Measuring ICT for Development also collects relevant statistics. It brings together 14 international organizations, including the International Telecommunication Union (ITU), the UN Conference on Trade and Development (UNCTAD), the UNESCO Institute for Statistics, the UN Department of Economic and Social Affairs (UN DESA), the European Commission, the IMF and the World Bank. The representativeness of the organizations included in the partnership testifies to the depth and significance of the research being conducted for the global community.

3.2 Assessment of the level of digitalization in the Russian Federation

Ensuring sped up implementation of digital technologies in Russia's economy and social sphere is one of the strategic priorities. The Government of the Russian Federation formed the national program "Digital Economy of the Russian Federation". [14]. The Ministry of Digital Development, Communications and Mass Media of the Russian Federation approved the methods for calculating four key indicators (2020) to assess the effectiveness of the program implementation [16, 17]:

- "digital maturity" of key sectors of the economy and social sphere, including healthcare and education, and also public administration;
- the share of socially important services available in electronic form;
- the share of households with broadband Internet access;
- investments in domestic IT solutions.

Specialists of the Higher School of Economics created the Index of Digitalization of the Economy and Social Sphere at the end of 2022 to assess the dynamics of digital transformation and the life of society. The integral value of the Index was 15.7 points at the end of 2021, which is 0.4 points higher than in 2020 because of the growth of three sub-indices ("Use of digital technologies", "Digitalization of business processes", and "Cybersecurity").

The statistical compendium of the Higher School of Economics [8], prepared jointly with the Ministry of Digital Development, Communications and Mass Media of the Russian Federation and the Federal State Statistics Service, contains the main indicators of digital economy development in Russia, grouped according to several key areas:
- expenditures on the development of the digital economy (by type and sector);
- ICT research and development (publications in Scopus, patent activity, advanced production technologies);
- digital infrastructure (dynamics of communication services, access to the Internet);
- human resources for the digital economy (structure of students by groups of professions and specialties in digital technologies, structure of ICT specialists by employment groups);
- the digital reality of the population (digital skills, access to the Internet, frequency and purpose of Internet use);
- e-commerce and electronic public services (goals, quality, ways of obtaining);
- information security and digital technologies.

Gross domestic spending on the development of the digital economy from all sources in 2021 amounted to 2.2% of GDP. The number of publications of Russian authors on ICT in Scopus was 17778 units in 2021, which is almost three times more than in 2015 - only 6896 publications). The share of Russia in the global number of ICT publications was only 2.98%.

The number of broadband Internet subscribers is gradually increasing. Thus, the value of fixed access was 23.7 units per 100 people, and mobile access was 107.5 units per 100 people in 2021. The most demanded specialties among students in ICT in 2021 were "Informatics and Computer Engineering" (62.2% of the total number of secondary vocational education students and 5.3% of the total number of Bachelor's, Specialist and Master's degree students), "Electronics, Radio Engineering and Communication Systems" (13.4% and 1.6% respectively) and "Mechanical Engineering" (12.2% and 2.7% respectively). Although the share of ICT specialists in the Russian Federation is only 2.4% (while in the leading country Sweden - 8%), the share of specialists under 35 years old in Russia (50.2%) is one of the highest among all European countries (higher only in Turkey - 58.3%, Malta - 57.6%, Lithuania - 56.1%, and Latvia - 50.4%).

The level of digital skills of the Russian population compared to European countries remains quite low. Only 38% of Russians aged 15 and older have a basic level of Internet skills (whereas the minimum level in European countries is 40%, and 86% in Iceland, the leading country for this indicator). 84% of Russian households had access to the Internet in 2021 (86% in urban areas, 78% in rural areas) - and that's only 36th among the 41 countries surveyed (comparable levels are in Bulgaria (84%), with lower levels in Serbia (82%), Brazil (71%) and Mexico (61%)). 69% of Russians aged 15 to 74 used cell phones or smartphones to access the Internet (92% in Sweden, the leader). The following Internet activities were most popular with Russians: making phone calls or video chatting (83.8%), social networking (74.5%), instant messenger communication (71.8%), watching news and weather information (60.1%) and bank transactions (59.9%). The key factors that deter people from using the

Internet are lack of need (lack of interest, unwillingness to use) (67.6% of respondents), lack of skills (34.9%), and the high cost of connection (12.9%).

Russia ranked only 32nd among the 36 countries surveyed for e-commerce development in 2021: only 47% of respondents aged 15 to 74 used the Internet to order goods and services (the top three countries for this indicator were Norway (92% of respondents made online purchases), Denmark (91%) and Great Britain (90%)). The most popular categories for online shopping in Russia are clothing, footwear, sporting goods (66% of all purchases), financial services (44.4%), household goods (36.8%), telecommunication services (31.2%), and food and groceries (29.8%). Russians preferred to pay for Internet orders with bank cards (90.2% of respondents), cash on delivery (33.3%) and online payment services (12.4%).

The proportion of citizens using the Internet for interaction with state and local authorities has increased significantly over 6 years (from 2015 to 2021): 68.2% of 80.1% of respondents who interacted with the authorities in 2021 did so on official state websites and portals (in 2015 only 18.4%). 85.1% of respondents aged 15 to 72 received state and municipal services electronically. The most popular electronic services in 2021 for population are health care and medicine (making an appointment to see a doctor, receiving a referral to hospitalization) - 59,1% of respondents, taxes and fees ("find out your TIN", make an appointment to the tax inspection, check tax debts) - 42,3%, services of Ministry of Interior / State Traffic Safety Inspectorate (check fines, issue / replacement of driving license, vehicle registration) - 30,5%, housing and communal services (getting information) - 18,6%. - 18,6%. The main purposes of electronic addresses of citizens to the state and local authorities were to get information (through official websites and portals of state and municipal services) - 75,6% of respondents, to make an appointment - 55,9% and to make obligatory payments (payment of duties, taxes, fines) online - 55,5%.

Respondents consider unauthorized mailing (spam) to be the most significant threats to information security - 26.6% of respondents, virus infection resulting in loss of information and/or time to remove it - 6.4%, and receiving fraudulent emails asking to send personal data - 3.1%. The share of Russians who do not use the Internet because of security reasons is 4.5% in 2021 (4.1% of respondents do not use the Internet because they do not want to disclose their personal data). For security reasons entrepreneurs chose means of electronic digital signature - 70.1%, antivirus software - 64.5%, technical means of user authentication - 51.9%, means of strict authentication - 51.8%, and software that prevent unauthorized access of malicious programs - 45.9%. The most promising areas of development, application and implementation of information technology by 2024, according to experts at the Higher School of Economics, will be wireless communication technology - 324.1 billion rubles, neurotechnology and artificial intelligence - 253.4 billion rubles, distributed registry systems - 227.6 billion rubles, virtual and augmented reality technology - 40.2 billion rubles, robotics and sensorics components - 30.3 billion rubles, new manufacturing - 26.7 billion rubles, and quantum technology - 2.8 billion rubles [8].

The following integral indices/indicators allow us to evaluate the introduction and use of digital technology in various sectors of Russian society compared with similar values in other countries of the world (Table 3).

Table 3. The main indices assessing the level of development of digital technologies in the Russian Federation. *

Integral index/indicator	Number of countries participating in the ranking	Rating Publisher	The place of Russia (for the last year, for which there is a report)
E-Government Development Index (EGDI)	193	UN Department of Economic and Social Affairs	36 (2020)
E-Participation Index (EPI)	193	UN Department of Economic and Social Affairs	27 (2020)
Human Development Index (HDI)	189	UN Development Programme	52 (2020)
Better Life Index (BLI)	40	OECD	33 (2020)
Network Readiness Index (NRI)	134	Portulans Institute (USA)	48 (2020)
Global Innovation Index (GII)	131	Cornell University (USA), INSEAD Business School, WIPO	47 (2020)

*Compiled by the authors based on the results of the study.

The COVID-19 pandemic has been a significant factor in accelerating the pace of adoption and increased use of digital technologies. According to research by the NAFI multidisciplinary analytical center [1], during the year of the pandemic, almost half of Russians (43%) spent more time using electronic devices (6 hours a day on average). 68% of respondents use digital devices for work tasks (on average 5 hours a day), for personal needs - 77% of respondents (on average 3 hours a day). Every third user (32% of respondents, or 14% in terms of all device users) felt addicted, anxious or stressed. The digital literacy index of the population of the Russian Federation (calculated using the DigComp method) amounted to 64 points on a scale from 0 to 100 in the first half of 2021 (people under the age of 44 showed the highest index score - 68 points, the lowest index score, 60 points). people over the age of 55). We analyzed digital competencies according to five main parameters:
- information literacy - skills to search for information on the Internet, competence to work with data and assess the credibility of online messages (parameter value for respondents - 67 p);
- communicative literacy - the ability to use various types of online services and electronic devices, compliance with the norms of communication on the Internet (parameter value for respondents - 67 p);
- digital content creation - a person's competence in creating and editing digital content, skills in working with copyrights on the Internet (parameter value for respondents - 59 p);
- digital security - the ability to assess the risks of social engineering and online fraud when working in the digital space, knowledge of measures to ensure the security of personal data, and understanding the negative impact that digital devices have on the environment, physical and mental health of the person (parameter value for respondents - 65 p);
- problem-solving skills in the digital environment - skills in using mobile applications and computer programs to perform everyday tasks, expanding knowledge of digital technologies, the ability to solve software problems (parameter value for respondents - 65 p).

The pandemic of a new type of coronavirus COVID-19 has also affected the rate of digitalization of enterprises. The SMB digitalization index increased in six months (from September 2020 to May 2021 to 51 points on a scale from 0 to 100, and the share of companies with a low level of digitalization decreased from 20% to 11%. Businesses are

actively using the Internet (the share of companies with a full website with detailed information increased from 41% to 63% from September 2020 to May 2021), using messengers to work with customers (share increased from 80% to 85%), placing online advertising (share increased from 58% to 66%, and the share of those who use offline promotion decreased - from 43% to 26%). Small and medium-sized businesses are trying to get closer to their consumers. 70% of businesses have a page on social networks (the most popular is Instagram - 77%, "Vkontakte" - 72%. 17% of companies use the system of fast payments when making payments to individuals (this figure was only 1% in 2020). The number of small and medium-sized businesses combining offline and online document management increased in 2021 (compared to 2020) from 45% to 58%, using cloud solutions and data storage - from 52% to 63%, corporate messengers - from 24% to 39%, online systems for teamwork - from 15% to 24%, services for big data analysis - from 5% to 11%. Small and medium-sized companies paid more attention to information security: every third company (34%) has an approved information security policy, and every second (53%) has an information privacy policy [1].

4 Discussion

The conditions of post-industrial society are significantly changing human life. Digital technologies open up new opportunities, and, at the same time, they bring negative consequences, which researchers have yet to assess. Many authoritative organizations at the international level are collecting and studying information describing the quality of the population in digitalization. The position of the Russian Federation, according to various estimates, looks ambiguous. For example, according to the OECD, the Better Life Index (BLI) ranked Russia 33rd out of 40 in 2020. Russia's position on other indicators in the world rankings looks much lower. According to the index of electronic government development (EGDI), the country takes 36th position out of 193, and according to the index of electronic participation (EPI), 27th position out of 193. Somewhat better position in the Human Development Index (HDI) - 52 position out of 189 possible, the Network Readiness Index (NRI) - 48 of 134, the Global Innovation Index (GII) - 47 of 131.

Russia launched the National Digital Economy Program in 2018 to speed up the development of digital technologies in the Russian Federation. The state is budgeting substantial funds for implementing digital technologies, which is already yielding tangible results. Broadband Internet covers a significant part of Russian territories: the value of fixed Internet access for subscribers was 23.7 units per 100 people, while mobile access was 107.5 units per 100 people. Although the value of mobile access to the Internet is comparable with the values of this indicator in the leading European countries, the value of fixed access to the network is much worse - Russia occupies only 36th position out of 41.

The level of digital skills of the population compared to the European countries is still low: only 38% of Russians aged 15 and older have basic level and are above, while in Iceland (the leading country in this indicator) - 86%.

The development of e-commerce is far behind that of the world's leading countries. Russia ranked only 32nd among 36 countries in 2021. Only 47% of respondents aged 15 to 74 used the Internet to order goods and services.

5 Conclusions

The COVID-19 pandemic has given a major boost to digitalization. People and businesses are more actively using digital technologies. The most promising areas by 2024 will be wireless communication technologies, neurotechnologies, artificial intelligence, distributed

registry systems, virtual and augmented reality technologies, robotics and sensorics components, new manufacturing and quantum technologies.

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