

# New Generation Mobile Networks and Their Application in Electronic Learning

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**Abstract**—The present article aims at examining the promising capabilities of new generation mobile networks for the implementation of first-class online education based on advanced immersive technologies. The study describes the main functional drivers of the modern end-to-end 5G architecture and proposes several options for its application in today's socio-economic life. In order to investigate public opinion toward 21st-century education and identify the prioritized requests for university training among potential students, a survey of the target audience in the business administration segment was conducted. It involved 100 MBA students of the Graduate School of Business of Kazan Federal University (Russia) and 200 business workers. After reviewing the survey outcomes, it was concluded that the main competitive advantages of an educational course are its pace, convenience, and effectiveness in goal achievement. The current work presents the analysis of promising educational opportunities of 5G for creators of study materials and students, such as the extensive use of AR, VR, and robotics; creation and implementation of new educational services that support multimodal interaction and are rich in multimedia content. Educational opportunities of 5G also include unhindered remote interaction between learners; extensive use of AI applications during training; provision of high-quality and real-time mobile education; and implementation of personalized training systems.

**Keywords**—5G technology, Industry 4.0, Digital economy, SMART Education

## 1 Introduction

The global expansion of the network space and the rapid introduction of innovative digital solutions into industrial business processes and social life are changing the

basic features of the socio-economic interaction. Modern transformational processes in the present-day society are accompanied by the penetration and development of digital technologies as well as changes in the conditions for the global socio-economic system's functioning [1]. The transformation of society's mentality and the emergence of innovative communication models give rise to a hyper-contact and mobile hybrid environment. This environment is characterized by the interweaving of the virtual and real fields of cooperation based on the systemic interaction of digital IT developments and algorithms [2]. Technologically, the new digital ecosystem is based on discoveries of 4th industrial revolution (Industry 4.0), in particular, on new production technologies, big-data analytics, complex algorithms, quantum communication technologies, virtual, augmented and mixed reality (VR, AR and MR), advanced consumer interfaces, cybersecurity technologies, smart sensors, 3D printing, the Internet of Things (IoT), multilevel communication systems, robotics, sensor and geolocation technologies, blockchain and distributed ledger systems, neurotechnologies, and artificial intelligence (AI) [3].

Due to modernization of the 4G network and the large-scale deployment of 5G communication networks, technologies of the fourth industrial revolution are able to maximize their potential [4]. The combination of core services will define a 5G satellite network coupled with three basics terrestrial 5G business models: Ultra-reliable low-latency communication (URLLC), Massive Internet of Things connections (mIoTc), and enhanced Mobile Broadband (eMBB) [5].

The global socio-economic system is entering a new era, characterized by breakthroughs in new technologies, the development of artificial intelligence and higher data rates, the combination of which is designed to transform almost every aspect of everyday life through automation and digitalization. In the long term, 5G networks will have an impact on almost all processes of everyday life of society and will be considered an essential part of the national infrastructure, providing increased productivity, efficiency and value of assets in the business segment. The next technological revolution will be driven by immersive technologies supported by 5G and artificial intelligence, delivering optimized support for the service industry, diversifying traffic load and creating variability in end-user communities. AI and 5G mobile technologies have great potential for providing innovative products and services not previously available [2].

Recent research of modern scientific works has provided evidence that Industry 4.0 is putting significant pressure on education to keep pace with innovations. Digital technologies usage in almost all aspects of social life has changed the approach to training specialists and actualized the need to introduce modern technological solutions into educational programs. In the new industrial era, 5G is to be an enhancer of Industry 4.0 as well as SMART Education (SmE), Smart University (SmU), and Smart Campus (SmC) [6]. Distance learning, virtual reality (VR) and robotics capabilities will be enhanced with next-generation networks [7]. Personalization and adaptation to user's needs substantially accelerate the achievement of learning goals, provide teachers with a wide range of new training tools, and allow defining effective learning scenarios. The differentiation of services as well as the network's quality improve the learning process due to various information content – diverse videos,

audios, interactive games, etc. 5G provides engineers with many opportunities to create new learning solutions that meet the needs of students and educators and make learning more enjoyable and effective than ever [8].

Technological innovation in education is a source of ongoing debate and controversy between scholars and experts. Nevertheless, most of them agree that technology-based educational innovation should not be an end in itself but, rather, a way to dramatically improve the educational experience and to better meet the needs of teachers and learners [9].

Educational institutions have been instrumental in transforming the technology of the future by acting as testing laboratories for innovation and striving to move beyond the traditional educational approach. Educational institutions have reached a new level of quality in the provision of educational services by strategically using the latest technology to prepare students with the necessary knowledge and skills [10]. With digital technologies' development, the shelf life of the modern set of educational skills is becoming shorter and thus specialists are required to constantly improve knowledge and skills to keep up with Industry 4.0 requirements [11]. In addition, professional success, both personal and corporate, in Industry 4.0 is highly dependent on a set of educational skills that foster direct human-machine collaboration. In this regard, educational institutions are faced with obstacles associated with the creation of modern educational conditions [12]. The transformation of educational institutions for effective functioning in the global digital realities is impossible without the necessary infrastructure: advanced technologies, big data, institutional configurations and qualified experts [13]. The revolutionary technologies of the new digital era are based on IoT, AI, VR, genomics, nanotechnology, robotics, fog, frontier, cloud computing and other technologies. The fusion of technology in universities is to bring social sciences and humanities closer together through knowledge sharing and a shift from a task-setting approach to a person-centered approach [14].

The modern educational trend is mobile learning, which accelerates the exchange of knowledge, provides students with the opportunity to access educational resources at the moment of need, and provides a smooth, continuous, easy and comfortable learning experience. Since the release of touchscreen tablets, the mobile app industry has grown rapidly [15]. Mobile devices are popular since the general public has begun to view them as an alternative to the graphical user interface (GUI) of computers or laptops [16]. Although tablets (iPads) were initially offered primarily to business users, they almost instantly became a popular medium for both entertainment and learning [17]. Along with advances in mobile engineering, the popularity of smart mobile devices and applications in education grows rapidly. Such digital devices offer wide access to educational materials [18] and contribute to the cognitive, emotional, and social development of students [19].

In today's digital realities and the manifestation of global socio-economic processes, educational institutions are aimed at developing a continuous learning culture and tools that might become a key factor in attracting, developing and optimizing talent. There is a need to develop new skills, meet new student expectations, and form learning goals that are closely related to the business environment. The future employment of students in the digital age is an urgent issue for educational institutions, since there

is a demand for a quality workforce, the key criteria of which are digital literacy, innovation, developed critical and analytical thinking, high level of emotional intelligence, adaptability and learning, the ability to cooperate and show professional inclusion. The requirements of modern companies for the quality of personnel have also changed students' expectations of educational programs towards individual and unique learning experience, easy styles of assimilation of knowledge and the possibility of their social testing, synergy of educational and work processes, personal control over the learning process (in the context and time aspect), mobility and informality.

This work aims to study the promising capabilities of new generation mobile networks in the context of ensuring the implementation of high-quality online education based on advanced immersive technologies.

The research process includes the following steps:

- Characterizing functional drivers of the new end-to-end (E2E) 5G network architecture and identifying possible options for its implementation in socio-economic life;
- Determining the prospects of 5G in the new digital era as an enhancer of Industry 4.0 as well as SMART Education;
- Conducting a public survey concerning the vision of 21st-century education and identifying the priority of students' requests in business education;
- Specifying students' requests for business training in modern realities taking into account digital transformations of the socio-economic life;
- Outlining promising educational opportunities in the 5G technological field for creators of study materials and learners.

This article contains the following sections: introduction that sets up a rationale for the study, research design of presented examination, results related to the consumer trends and requests in business education, as well as authors' discussions and conclusions.

## **2 Methods and Materials**

In the course of the study, business administration students were surveyed to analyze their requests for 21st-century education. The examination included 100 MBA students from the Kazan Federal University's Higher School of Business (Russia) who study IT, healthcare administration, cultural management, agribusiness administration, and oil and gas administration. Besides, the investigation involved 200 representatives of business in the field of manufacturing, transport services, healthcare, financial services, retail, energy, entertainment/media. The research sample constituted 193 men and 107 women aged from 29 to 45 (Tables 1 and 2).

**Table 1.** Research Sample – Students of Kazan Federal University’s Higher School of Business

Educational program	Specialty	Number of participants	Gender	Age
Master of Business Administration (MBA)	IT	25	M – 13 F – 7	35-45
	Healthcare administration	15	M – 10 F – 10	35-45
	Cultural management	21	M – 7 F – 5	35-45
	Agribusiness administration	19	M – 9 F – 10	35-45
	Oil and gas administration	20	M – 15 F – 14	35-45
Total		100	M – 54 F – 46	35-45

**Table 2.** Research Sample – Representatives of Business Field

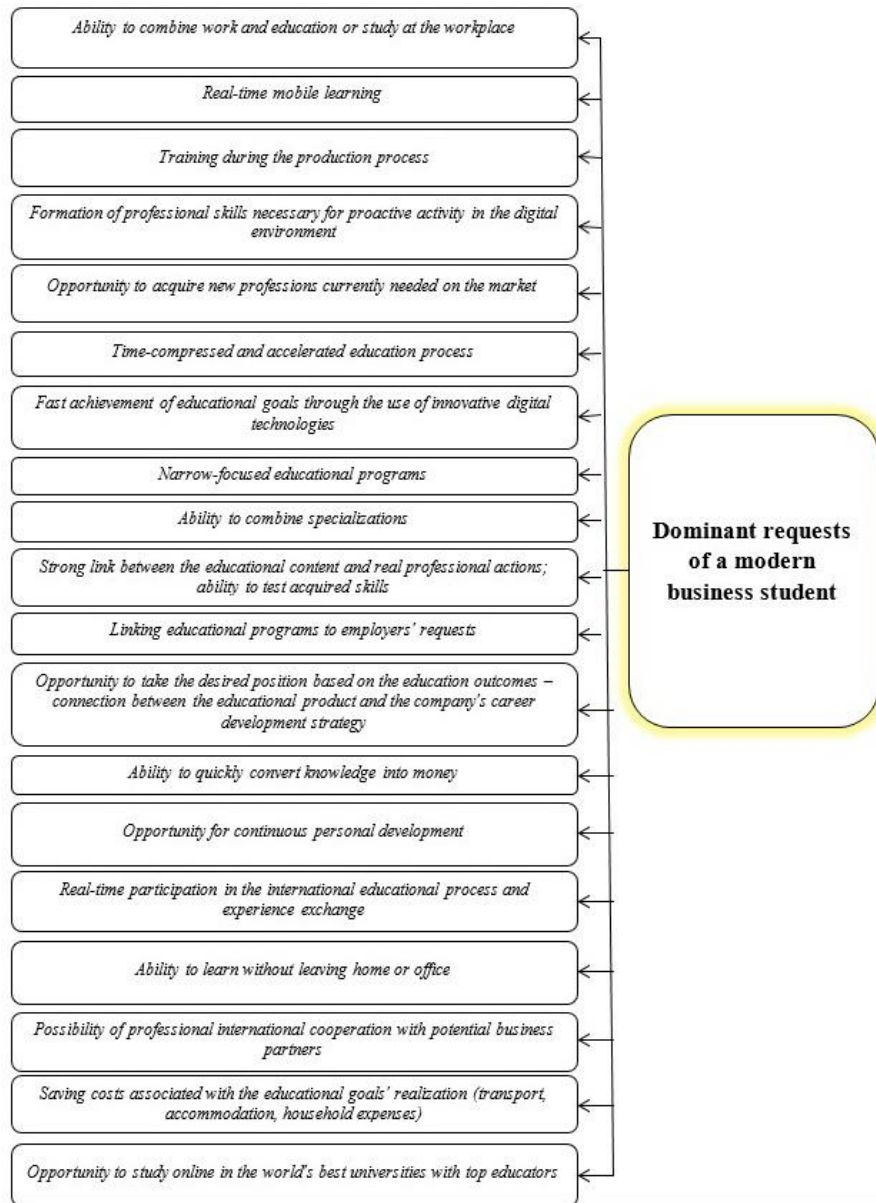
Sphere of activity	Number of participants	Gender	Age
Manufacturing	33	M – 23/F – 10	29-45
Transportation services	20	M – 12/F – 8	29-45
Healthcare	26	M – 15/F – 11	29-45
Financial services	30	M – 20/F – 10	29-45
Retail	39	M – 21/F – 11	29-45
Energy	20	M – 14/F – 6	29-45
Entertainment/media	32	M – 17/F – 15	29-45
Total	200	M – 139/F – 61	29-45

All the respondents were offered a questionnaire that included 50 potential requests of a modern student (with both conservative and innovative views on education). Study participants were asked to evaluate each request’s priority in the context of the current realities of doing business and digital transformations of the socio-economic life on a 100-point scale.

The research sample was made up of persons who were actively involved in social and production processes and had a Bachelor’s degree in business administration. In this regard, the study results presented the dominant demands of only those individuals who consider educational services only in the context of developing their professional business skills and abilities. This research did not include requests for education that are typical for students of other educational programs.

### 3 Results

According to the survey outcomes, researchers revealed 20 consumer trends and requests in business education, evaluated by the respondents from 75 to 100 points (Fig. 1).



**Fig. 1.** Key trends and requests in business education  
(Source: developed by the authors)

Reviewing the most important requests for education, one can argue that the main advantages of an educational course include its convenience, training pace, and effectiveness in goal achievement. In the future, full compliance with these demands will become possible through the synthesis of 5G and other digital educational solutions.

Today’s 5G enthusiasm has a lot to do with speed. 4G reaches a maximum speed of 100 Mbps and 5G reaches 10 Gbps, which is faster 100 times than 4G. In the educational context, the increased speed will provide students and teachers with the ability to achieve a seamless distance learning process. 5G will also accelerate the adoption of VR technology and robotics in education as powerful and useful learning tools. 5G in business education will satisfy the main students’ educational requests and allow universities to implement high-quality mobile learning in real-time. 5G is expected to accelerate the training process and contribute to the fast achievement of educational goals using the capabilities of innovative digital technologies. It will open up opportunities for acquiring new knowledge without leaving one’s work and save students’ expenses related to the realization of educational goals (transport, accommodation, household expenditures). 5G networks are the future of the digital economy that are going to cover all areas of the world. By 2035, 5G technology is projected to generate \$3.6 trillion and support 22.3 million jobs [3]. Key functional drivers of the new E2E 5G network architecture and possible options for its implementation in socio-economic interaction are proposed in Fig. 2.

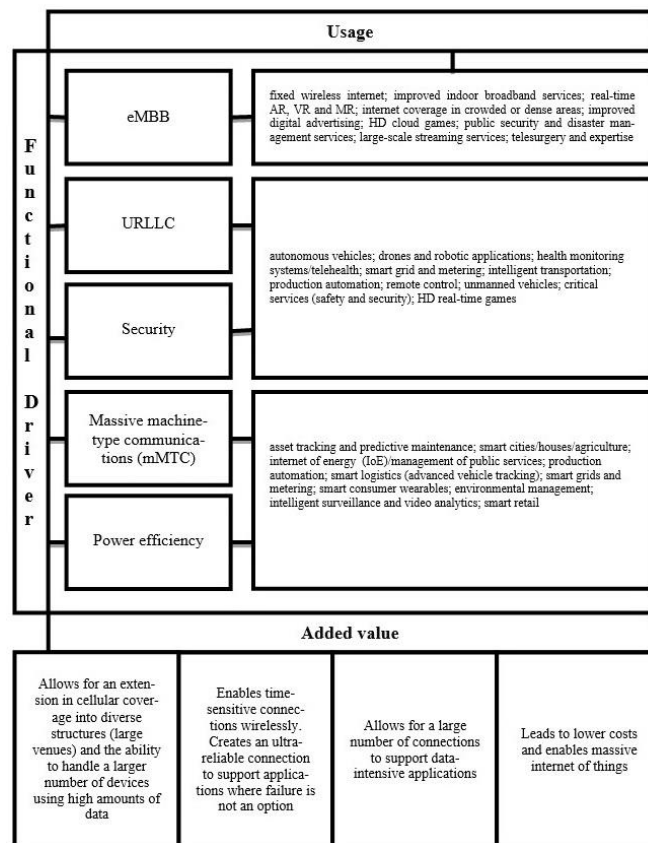


Fig. 2. End-to-End 5G Architecture (Source: developed by authors based on [20]).

In current conditions, Industry 4.0 allows various sectors to increase their competitiveness and contributes to regional economies' development. Industry 4.0 is based on both already established and emerging technologies, including the IoT, AI, advanced data analysis, Robotic Process Automation (RPA), cloud computing, VR, AR, 3D printing, and drones. Topical issues in the development and standardization of 5G technology are the provision of 5G coverage of large areas and the creation of a 5G satellite segment during the 2020-2025 time period. It is believed that 5G can create numerous advantages for educational and business sectors within the context of Industry 4.0. Given this, Fig. 3 presents the prospects of 5G in Industry 4.0.

Technological development in the socio-economic environment significantly impacts consumer demand in the business education segment, changing the requirements for the provision of services and mandatory educational content. The rapid pace of the technological revolution actualizes the demand for training in the format of a real production process. Nowadays, students are increasingly paying attention to the connection of the educational course with professional actions, the company's career development strategies, and the ability to convert knowledge into money immediately.

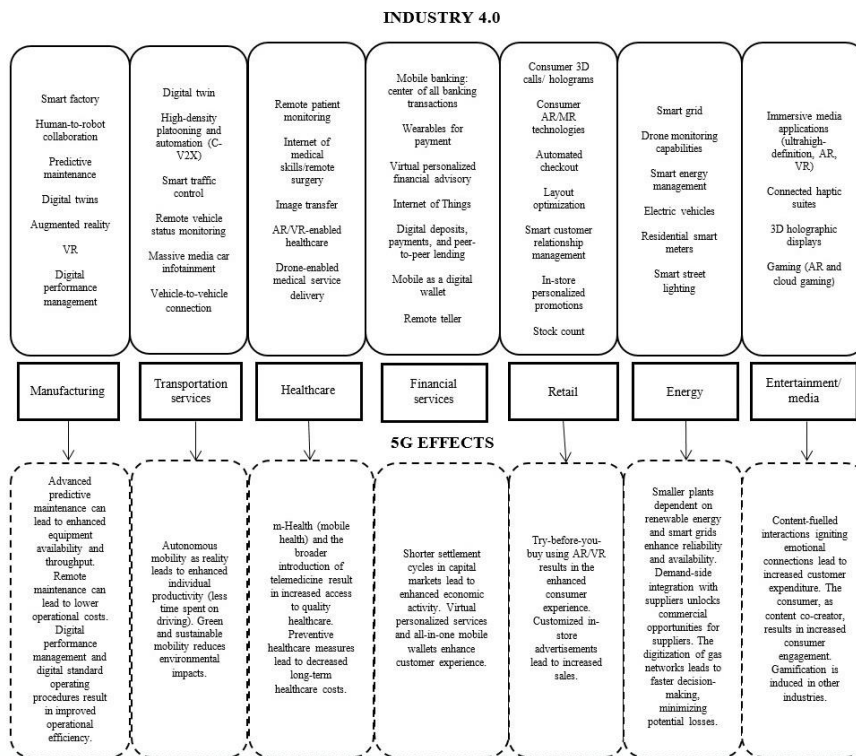


Fig. 3. Prospects of 5G in Industry 4.0 (Source: developed by authors based on [3])

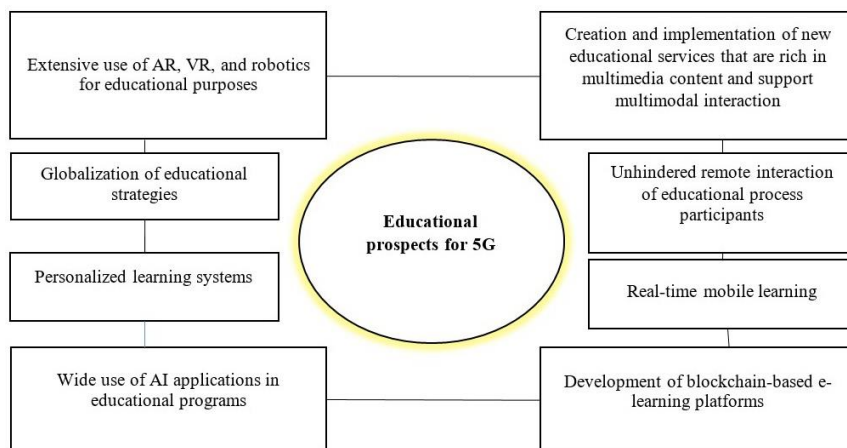
Modern universities can benefit from 5G and mobile learning technologies. Learning using mobile devices is becoming more and more popular as it provides an oppor-



tunity to learn at any time in any place. The worldwide mobile education market is about to give a notable impetus to economic growth and reach \$78.9 billion by 2025, owing to the significant growth of its potential (23.7% annually) [21]. 5G automation bases on three models of 5G ecosystem: URLLC, eMBB, and mMTC, using the automation characteristics, intelligent connectivity, collaborative control, and real-time data monitoring. These features allow device to device (D2D) communication, machine to machine communication (M2M), and machine learning (ML) [6].

Among the main requests of a modern business student, it is worth highlighting the opportunity of distance learning in the world’s best universities with top educators; the possibility of professional interaction with potential business partners at the international level; the ability to study abroad and participate in experience exchange programs in real-time; the opportunity to combine professional specializations; and the formation of professional skills necessary for activity in the digital environment.

5G network’s core features, its improved bandwidth and security allow designing and implementing innovative learning services that have diverse multimedia content, multimodal interaction and are customizable for users. Potential possibilities of using 5G aimed at providing a competitive advantage of an educational product are presented in Fig. 4.



**Fig. 4.** 5G educational prospects (Source: developed by the authors)

In such a manner, 5G network is going to extend the capacities of distance learning, robotics, and VR, thereby affecting almost all spheres of social life and forming new requirements for education quality.

## 4 Discussion

Education systems differ around the world. The benefits of 5G will be for the whole world, although not at the same time. 5G is going to enable connections at lower costs, allowing more and more people to use technology for education. 5G will

also enhance AR technologies usage. In any case, 5G is changing the way of social interaction and learning strategies [22].

According to research and advisory company Gartner [23], in 2019, 5G has become one of the most commonly referenced technology trends, along with AI and digital ecosystems. To a large extent, it can be connected with the need for fast and uninterrupted communication during the development of large-scale industrial and innovative projects, the introduction of digital twins of enterprises, the Industrial Internet of Things (IIoT), emergence of self-driving cars, cloud computing, and other breakthrough technologies.

In February 2020, professional services company Accenture published a study on the 5G networks' future perspectives and challenges in the business sector which involved 2623 technology and business decision makers from 12 industrial sectors of the USA, Great Britain, Australia, Japan, Italy, France, Germany, Spain, Singapore, and the UAE. The study found that 90% of involved recognize 5G as a new opportunity for their business, 79% think that 5G is to have a great impact on an organization, and 57% believe that 5G is going to be far-reaching [24].

In the Global 5G Landscape Report, analysts cite 5G as the foundation for Industry 4.0 and consider the US, South Korea, and China as leaders in the implementation of 5G networks [25]. The US launched its first commercial 5G network in 2018. To accelerate the rollout of fifth-generation communications, the US used a strategy that was based on private sector initiatives and already showed its effectiveness during the 4G implementation. In early 2020, the US authorities, together with US technology companies, began to create advanced software for 5G telecommunication networks to ensure national security and reduce, if not eliminate, reliance on Huawei equipment [26]. South Korea has deployed 5G network second in the world, and now it is to become the world leader in 5G spread. Such fast 5G spread resulted from Korea's focus on the telecommunications industry. Thus, in January 2020, 5G networks in South Korea covered 81 settlements. China is believed to be the biggest mobile communications market. The country is projected to have the world's largest 5G infrastructure by 2025. Already in November 2019, such communications service providers as China Unicom, China Telecom, and China Mobile have begun offering 5G services in 50 cities [27]. China's Ministry of Industry and Information Technology stated that as of March 2020, 198 thousand 5G stations have been built across China, involving over 50 million users [28].

In March 2020, 5G services have been deployed in 10 countries of the European Union and the UK [29]. Now, 5G is of great importance for digital economy and European society. EU is taking measures to lead global development towards 5G. By the end of 2020, it is planned to launch the first commercial 5G networks in 138 European cities [30].

The introduction of 5G technology in Russia is a matter of state strategic planning. The Federal project "Information infrastructure" of the National program "Digital Economy of the Russian Federation" is set out to provide sustainable 5G coverage in all major cities with a population of over one million by 2024 [31]. Thus, in June 2019, MTS and Huawei signed an agreement on the development of 5G in Russia [32]. In August the same year, Tele2 and Ericsson telecom carriers launched a 5G

pilot zone in the 28 GHz band in non-standalone mode, which allows 5G to be deployed in LTE networks [33]. Furthermore, in September 2019, Skolkovo Institute of Science and Technology started the first 5G base station within the test zone, which operates in the 4.8-4.99 GHz radio frequencies spectrum in accordance with the permit issued by the State Commission on Radio Frequencies. In September and October 2019, Tele2 opened an interactive 5G Hub [34] and a 5G cloud gaming service with a data transfer rate of over 1 Gbps and a delay of up to 5 m [35]. Recent 5G tests revealed that Huawei Mate 20X smartphones achieved 3 Mbit/s data transmission speed [36]. According to the GSMA research company, Russia, being a mature mobile market with an unusual mobile penetration rate of 89%, will begin commercial implementation of 5G in 2020. The forecasts suggest that the total 5G base set will amount to 46 million by 2025, equivalent to 20% of all base connections [31].

The 5G network is actively implemented in Russian educational institutions. For example, in September 2019, Saint Petersburg University and MegaFon telecommunications carrier opened the first 5G laboratory in Russia (5G Dream Lab) on the base of the Mikhailovskaya Dacha Campus. This laboratory was equipped with a 5G test zone to develop new services based on 5G technology. Researchers assume that this site will become a unique environment for the self-realization of young talented developers, testers, and project managers, which will allow them to grow professionally and make a contribution to digital world transformation. In 5G Dream Lab, future developers can study the distinctive features of fifth-generation communications, learn how to work with the latest frameworks and developer tools, and gain skills in the fields of the user interface (UI), automatic quality control, and programming solutions. Future managers can learn how to launch and work with high-tech products and manage the development process [37]. Therefore, 5G Dream Lab will become a place for collaboration between specialists from different fields, including education and business [38].

## **5 Conclusion**

This study examined the promising capabilities of 5G network in the context of ensuring the implementation of high-quality e-learning based on advanced immersive technologies. The present research characterized the functional drivers of the new E2E 5G network architecture and identified possible options for its application in socio-economic life. It was revealed that the large-scale deployment of 5G communication networks allows one to fully realize innovative technological solutions and form the world digital economy infrastructure. In the long term, 5G is to be an enhancer of Industry 4.0 as well as SMART Education, enabling rapid ML, as well as the realization of M2M and D2D technologies. This paper provided the results of the survey aimed at discovering the perspective image of 21st-century education and distinguishing the prioritized requests for university business training. The study process involved 100 MBA students of the Graduate School of Business of Kazan Federal University (Russia), undergoing their study on IT, healthcare administration, cultural management, agribusiness administration, and oil and gas administration, and

200 representatives of business field connected with manufacturing, transportation services, healthcare, financial services, retail, energy, entertainment/media.

The target audience was offered a questionnaire that included 50 requests of a modern learner with both conservative and innovative views on the educational process. The survey participants determined each request's priority in the context of the current realities of doing business and digital transformations of Russian socio-economic life. The analysis of questionnaire results made it possible to identify 20 consumer trends and requests in education, which were front and center in the contemporary business environment. Based on the examination of students' preferences in the educational segment, it was concluded that the dominant competitive advantages of an educational product are its speed, convenience, and efficiency in goal achievement, which may be improved in the future through the synthesis of 5G and digital educational technologies. Considering this, the main 5G prospects for education include the extensive use of AR, VR, and robotics; creation and implementation of new educational services that support multimodal interaction and are rich in multimedia content. Among other prospects of 5G technologies in education are unhindered remote interaction between learners; extensive use of AI applications during training; development of blockchain-based digital e-learning platforms; provision of high-quality and real-time mobile education; and implementation of personalized training systems.

The practical value of the article lies in the study of business students' educational needs, which in the long term will make it possible to realize demand and competitive educational products in the segment of entrepreneurial activity.

In the scientific aspect, the article reveals the priority directions of 5G development in socio-economic interactions, which is a necessary basis for the generation of innovative technological solutions that meet educational needs.

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