

## Reform and future prospects in education based on 5G technology

Haomin Song<sup>1,a</sup>, Yu Liu<sup>2,b</sup>, Ke Li<sup>2,c</sup>, Lihua Ding<sup>2,d</sup>, Xinghua Sun<sup>2,e,\*</sup> and Xiao Zhang<sup>2,f</sup>

<sup>1</sup>Graduate school, Hebei North University, Zuanshinan Road, Zhangjiakou, China

<sup>2</sup>College of Information Science and Engineering, Hebei North University, Fuqiang Road, Zhangjiakou, China

<sup>a</sup> 562423588@qq.com, <sup>b</sup> liuyu29xx@gmail.com, <sup>d</sup> 2963918190@qq.com, <sup>c</sup> aliceding19900924@gmail.com, <sup>e</sup> sunxinghua@189.cn, <sup>f</sup> 780117251@qq.com

\*corresponding author

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**Abstract:** The fifth generation mobile networks (5G) has become a leader of the new generation of mobile communication technology. It has the characteristics of ultra-large broadband, super-large connection low energy consumption, ultra-low delay high reliability and so on. In the 5G era, the entire industry is experiencing a digital transformation, from "being connected with each other" to being connected with all things, which brings loads of opportunities to all fields. 5G technology and the other new technologies together create multiple application scenarios for intelligent education. This paper makes an in-depth study on how 5G service contributes to the educational informatization. 5G has a great influence on the core links of education covering teaching mode, teaching methods and education management. Therefore, it is more than just changing the traditional teaching mode. It's promoting the reform of intelligent education, to a certain extent.

### 1. Introduction

Education is the one and only way for a nation to grow and thrive. General Secretary Jinping Xi made an important speech at the National Education Congress, stressing that education is part of the national plan[2], which indicates that educational informatization is very essential to national development, modernization and education itself. Zhanyuan Du, Deputy Minister of Education, put forward "educational informatization 2.0" for the first time in education big data construction and application seminar on November 2nd, 2017, and put the network education into the report of the 19th National Congress, which is also the beginning of a new era of educational informatization in China; China is about to enter the 2.0 era of educational informatization. Developed countries are the first to apply information and communication technology to the field of education, setting off the trend of educational informatization [3]. The United States issued the National Technology Plan in 2000 and 2004, which promoted the educational technology [4]. Teachers and students are supposed to have certain information technology skills. Trained teachers also push education mode to change, which increases the application of information technology for students. Mobile communication technology has been developing and improving. What changes has 5G brought to education? What is the role of 5G in pushing the intelligent education? How do we improve the integration of 5G and education so than we're able to change the traditional teaching mode, teaching methods and education management more effectively than before?

### 2. What is 5G and Its Key Technologies

The mobile communication technology has already entered into a phase of full maturity. 5G managed to achieve the increased mobile bandwidth, mass machine communication and super high reliability and low delay communication which is shown in Figure 1 [10], which opens up a great number of opportunities for education, energy, industrial manufacturing, medical and health, sports and entertainment, public safety, transportation, tourism, port and other fields. With 5G being used

in education, we are able to create multiple application scenarios of intelligent education, which helps make sure the equal access to education by providing plentiful educational resources and making it possible for students to communicate anytime, anywhere.



Figure 1. Interconnecting all things.

## 2.1. What is 5G

5G, the fifth generation mobile networks, is the latest cellular mobile communication technology and also an extension of 2G, 3G and 4G. Throughout this transition of mobile communication technology, every step of the way is nearly ten thousand times faster [8]. 5G has the characteristics of wide coverage, high speed, high reliability, low delay and low energy consumption, and it was developed by China, Europe, North America, Korea, Japan and other third-generation partner program organizations, also called the "3GPP" [13]. 5G is actually a platform for all the wireless connections in all the fields, which allows literal everything connected. In 2019, China has entered into the first year of 5G, which means there's an industry-wide digital transformation waiting ahead of us and we're official into the era of Internet of Everything.

## 2.2. Key Technologies of 5G Networks

The key technologies of 5G network includes network slicing, edge computing, wide area network technology, millimeter wave transmission, function-customizable network service. And these are exactly why 5G means so much to education.

**Network slicing:** Network slicing is to cut the network entity into multiple independent logical networks to cope with different application scenarios. Also, the networks being independent of each other ensures the security. For example, a teaching video can be divided into several independent networks, and they all share a 20Gb/s mobile broadband; a large-scale IoT(internet of things) can also be sliced into separate networks, and then we have a low-delay, high-density IoT, etc [7].

**Edge computing:** Edge computing is the key to low-delay and high-frequency communication and provides a more reliable platform for users. Edge clouds are some small cloud centers that are deployed on the edge of the network. By placing the applications on the edge of the network, it can meet its network service quickly and reduce the delay effectively. Thus, live teaching can make sure learners get the best resources and VR teaching can give us smooth video stream.

**Low energy consumption wide-area network technology:** Low energy consumption wide-area network technology is to realize long-range wireless signal transmission at a lower price of energy consumption. On one hand, the terminals of the intelligent Internet of things go into a dormant status after completing the transmission. On the other hand, increasing the transmission rate as well as reducing the data speed can expand the coverage, which enables students in remote areas to learn by watching distant live broadcast.

**Millimeter wave transmission:** Although the frequency spectrum doesn't change much at microwave frequencies, it is very active in the field of millimeter waves. 5G data transmission uses the 24.25GHz-52.6GHz frequency band, and its large broadband makes the data rate up to 10Gbps or even higher, which makes high-speed and large-capacity data transmission absolutely feasible. Thus, collecting learners' learning videos and images won't be a problem at all, and then we can analyze these datas and make it reference datas for learning status [8].

Customizable network services: It can plan, configure, and optimize and repair the network automatically, which greatly reduces network interference and also improves the network operation rate. For example, different personalized teaching solutions are pushed for different learners. It is also possible to automatically capture images of learning process and automatically perform data analysis.

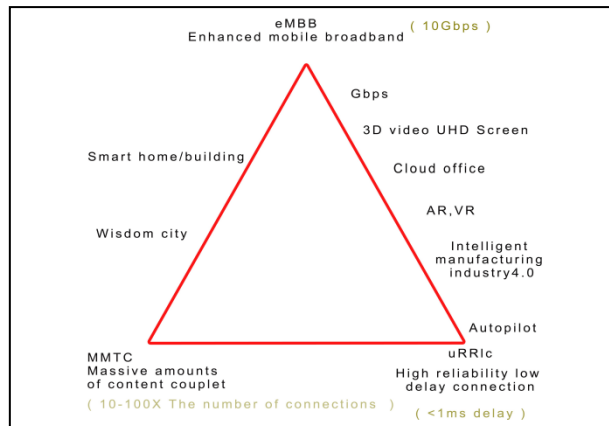


Figure 2. Three major application scenarios.

### 3. Applications of 5G Technology in Education

#### 3.1. Intelligent Environment in the 5G Era

The fifth generation mobile networks, 5G, has become a leader of the new generation of mobile communication technology. It has the characteristics of low delay, high speed, wide coverage, low energy consumption and so on [9], which makes it suitable for all the application scenarios, such as new media, intelligent medical, industrial Internet of Things, intelligent transportation, intelligent tourism, intelligent government, intelligent education, as shown in Figure 2 [10] and also possible for the traditional industries to transform. In the field of new media, 5G new media platform has been established to serve the Spring Festival Gala, the two sessions, the Belt and Road Summit, the World Garden and other important events. As for the medical field, a surgeon has successfully removed the hepatic lobule for a pig on December 18th, 2018, which makes it the first remote animal surgery based on 5G technology around the world. And there's a transnational heart transplantation surgery live based on 5G. Also, in the industrial field, 5G is widely applied to the factory, wharf and so on and one of those applications is Qingdao 5G automation wharf. Concerning transportation, unmanned vehicle remote driving control, Xiamen intelligent network BRT are in the testing stage. In the field of tourism, there are Shenzhen World Window 5G theme park, Shandong Taishan 5G Wisdom Mountain, and so on. Besides, it's been extremely widely used in the field of education, such as the Ministry of Education Moot Assembly 5G+4K distance interactive teaching, the Central Conservatory of Music 5G+ music education, Beijing International Book Expo 5G+ new reading.

#### 3.2. 5G Promoting the Smart Education

The core technologies of 5G, including network slicing and edge computing, are driving the education. Network slicing is to cut the network entity into multiple independent logical networks to cope with different application scenarios. Also, the networks being independent of each other ensures the security [11]. A 5G network has been set up with the help of network slicing, using large-scale display antenna, which guarantees that teachers and students get to enjoy the teaching process, but not be bothered by the low speed network. The edge cloud consists of some small-sized cloud data centers which are deployed on the edge of the network, and it is the key to low-delay, high-frequency communication and also provides a more reliable platform for edge computing. By placing the applications on the edge of the network, it can meet its network service quickly and reduce the delay effectively. With 5G available in daily life, VR experimental courses, VR science

courses can be held to make teaching scenes more real, which allows students to be fully wrapped up in the scenes so that their creativity and imagination can be inspired. At the same time, the technology can also be used to open distant interactive teaching courses so that more students in remote areas can enjoy high-quality teaching resources and more interactions with teachers, and get their hands on the nearly real experiments or something like that. The integration of 5G and education is a strong guarantee for fair education, and the educational resources are getting closer to teachers and students.

#### 4. The Future Prospect of Educational Application of 5G Technology

The rapid development of 5G network technology has brought historic changes to education. The innovative development of educational informatization is now in progress [12]. Education has gone through four stages which are start, application, integration and innovation. We have the strategic cooperation of the Ministry of Education and Central China Normal University Strategic Cooperation in the initial stage. For next stage, the resources are integrated further, rapid improvement of technical level has been made, and various application products came to the market. And then we have the integration of the education cloud network in the integration stage, which creates an ecological circle of education development and cooperation. 5G new technology is constantly pushing the intelligent education and educational information. The application of 5G new technology has brought new opportunities for education, and teaching management, precision teaching and research, customized teaching and so on are in dire need.

##### 4.1. Teaching Transformation under 5G Technology

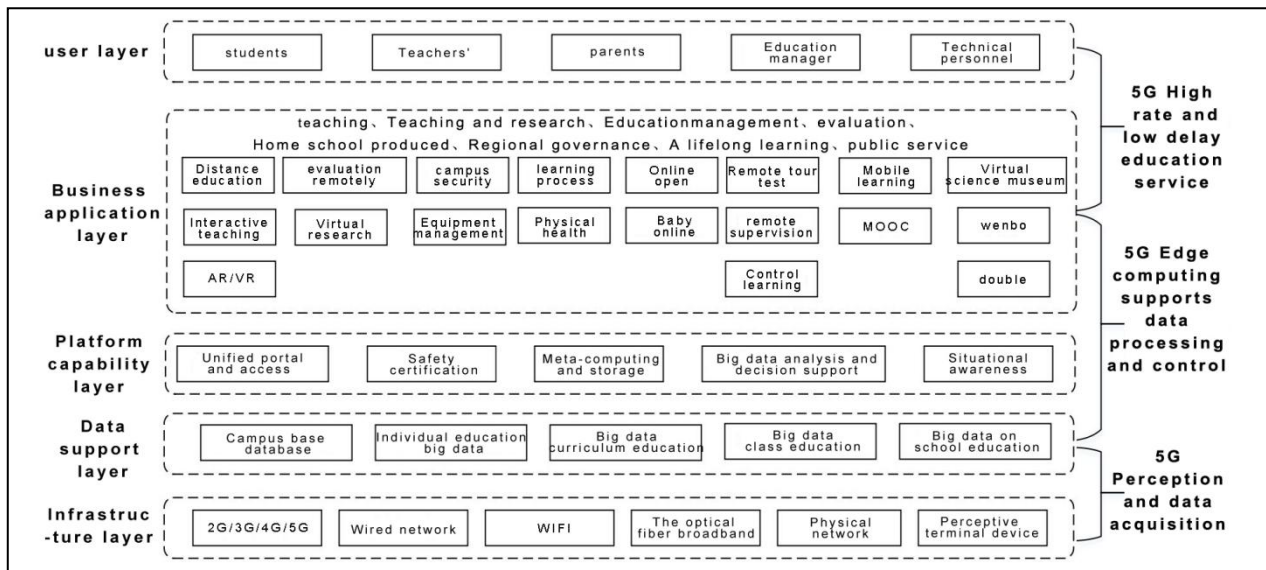


Figure 3. Intelligent education framework architecture.

To realize intelligent education, we have to build a architecture consisting of five layers which are users, applications, platforms, databases and infrastructure, as shown in Figure 3 [5]. And these layers can only be done through the 5G high-speed and low-delay education services, edge computing-supporting data processing, control, perception and acquisition. We used to provide an entire class the exact same learning resources for the students. Thus, they won't be able to get customized education. Intelligent learning service system can be set up to dig deeper into the learning habit of every single student, so every student can get the education that's best for which all thanks to 5th-Generation. For example, setting intelligent cameras to supervise the teaching process and capture learners' listening state, keeping track of the learners' homework completion and knowledge mastering status, and analyzing the learners' learning status and learning level at each stage accurately, we can provide customized learning plans, professional learning resources for different individuals. Consequently, each and every student will be able to find their own talents

and strengths. Under the condition that teaching methods are properly used, artificial intelligence can do efficient face recognition by collecting learners' physiological parameters, but it may also appear some data leakage or misjudgment, so there are some technical ethical problems that need to be attended [10].

The low-delay, high-speed 5G network can help achieve VR teaching and distant interactive teaching, so that students in urban and remote areas can immerse themselves in real teaching situations, get high quality teachers, which helps bridge the gap between urban and rural areas. Urban students can have access to a plant's specific biological information, such as its origin, shape, planting environment at any time, just through VR teaching or online learning platform [13], which transforms abstract text information to a zero-distance physical experience. Traditionally, a class usually has a few dozens of students, which means only they can get the best teacher. The best teachers are hogged by only a small part of the students. The delay, picture freezing and other problems can be solved by 5G. Hence, there can a live throughout the whole teaching process, thus, the same stage learners from other cities and remote areas can share the high-quality teaching resources [14].

#### **4.2. 5G Making Teaching and Research Activities More Precise and Intelligent**

Teaching research helps sharpen up the teachers' teaching skills and solve the problems in teaching and curriculum reform, but it is confined to teachers at the same stage or in the same profession. 5G network ensures the smoothness and high definition of remote video, which makes it possible for teachers to communicate with authoritative education experts and teachers. The teachers can reflect on which part to improve. Educational experts and teachers may watch the teachers teach, and then organize some teaching and research activities to guide them, pointing out the good parts and the bad ones to stimulate them to improve themselves [4]. Mastery of 5G network and artificial intelligence helps to make more intuitive feedback and interactions with learner, bringing down teachers' repetitive work. Intelligent chat robots are very useful in teaching evaluation. Namely, they can analyze students' learning status, performance, and activity participation quickly and accurately, and then we can get a more detailed learning evaluation [15]. More student intelligent learning evaluations and more communications with parents help to improve students' performance and promote the personalized development of students.

#### **4.3. Intelligent Education Management Model**

Intelligent education management mainly involves intelligent campus equipment management. An intelligent campus management system is built with the combination of 5G and artificial intelligence. Traditional smart campuses need to build various network routes, and the school has to spend a lot of financial and material resources which also occupies public resources. Local management or remote management can be much easier with 5G technology. Monitoring the comprehensive status, equipment, and environment can be performed easily.

Intelligent patrol robots are used to do intelligent campus patrols, replacing the traditional distributed attendance and security system on campus and also ensuring the efficient and reliable operation of the intelligent campus [7]. Based on the characteristics of 5G, it will realize the transformation of education and create a reasonable teaching model that enables urban learners, learners in remote areas, and special learners in need and learning enthusiasts to enjoy rich and high-quality teaching resources, thereby truly achieving educational equity.

### **5. Discussion**

Driven by 5G technology, new opportunities are ushered into the field of education. Smart education must be based on, on the one hand, to insight into the needs of the industry; on the other hand, it should take users' opinions into consideration, also rely on R&D (research and development) institutions. Companies and enterprises help to handle the publication under the guide of governments. Meanwhile, schools must give the necessary feedback. Besides, it should cover the core links of the education industry: teaching mode, teaching methods, education management.

Learners who prefer intelligent and personalized learning have been greatly satisfied through the combination of 5G and artificial intelligence; 5G has changed the traditional teaching mode. Teachers can reasonably use VR technology so that students are immersed in a strong sense of presence in the environment, and they can deeply understand the knowledge they have learned, which effectively stimulates their enthusiasm for learning; excellent education resources are easily accessed by learners in remote mountain areas to obtain education fairness. Schools can establish virtual teaching environments, and teachers and students can use the support of 5G network. At the same time, the interface is added to complete the necessary teaching tasks and break the limitations of traditional teaching time and space [16]. The intelligent campus management has promoted campus optimization and governance. Education management has saved a lot of management costs which can be used for teacher professional training to allow teachers to pursue self-improvement.

The flip side is 5G also has brought a severe test for education. Now 5G is still in its infancy, and there are deficiencies in technical ethics, learning resources, and teacher professionalism. 5G technology can efficiently analyze human physiological parameters. Data leakage will damage the learner's privacy, or inaccurate data analysis will lead to misunderstanding of the learner, and there will be some ethical and technical problems or the learners might think it's awful. Also, the quality of the learning resources is not high enough to satisfy the teacher. The needs of students lead to poor use of teachers and students; teachers' information literacy is low, so there may be less obvious teaching effects, or even inferior to traditional teaching methods, which leaves us a problem of how to start teacher training for each school situation; you need to think through whether you need electronic products such as mobile phones, tablets, and computers or not during the teaching process [6].

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