5G Communications: Potential Impact on Education Technology in Higher Ed.

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ABSTRACT

Revolutions in the communication and information technologies have led to tremendous innovations in education technologies in the 21st century. 5G is the fifth generation wireless technology for digital cellular networks, support a large amount of data traffic and massive number of wireless connections. In order to accomplish higher order thinking skills, the application of latest technology must be integrated into the curriculum. However, researchers face challenges to 5G revolution on education that takes 4G LTE (Long Term Evolution) does and make it better, faster and more reliable. This paper reviews some potential impacts of 5G on education technology through the experiences of teachers and students in the classroom that creates a more stimulating learning environment.

INTRODUCTION

Revolutions in the communication and information technologies in the 21st century have led to tremendous innovations in educational technologies. From the advances in educational technologies, all education programs, such as traditional education, distance education, e-learning, massive open online courses, adult education and lifelong learning, are being positively influenced in our day [11]. In addition to this, reference [1,15] emphasized that the next fifth-generation (5G) cellular networks are expected to meet high-end requirements. The 5G networks are broadly characterized by three unique features: ubiquitous connectivity, extremely low latency, and very high-speed data transfer.

The Fifth generation (5G) network support a large amount of data traffic and a massive number of wireless connections. Different data traffic has a different Quality of Service (QoS) requirements. 5G mobile network aims to address the limitations of previous cellular standards (i.e., 2G/3G/4G) and be a prospective key enabler for future Internet of Things (IoT). 5G networks support a wide range of applications such as smart home, autonomous driving, drone operations, health and mission-critical applications, Industrial IoT (IIoT), and entertainment and multimedia. According to end-users' experience, several 5G services are categorized into immersive 5G services, intelligent 5G services, omnipresent 5G services, autonomous 5G services, and public 5G services [24].

PROBLEM STATEMENT

Rapid technological developments give a big impact to the field of education. Thus, changes in education field as the flow of globalization changes. E-learning is a phenomenon that strikes the country's educational world such as 5G communication. However, it has long been an application in developed countries because it is believed to be able to provide various benefits

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in teaching and learning sessions. This paper reviews the impression of 5G communication to higher education in our country.

OBJECTIVES

The objectives in this research are:

i.   To identify the impact of technology 5G in higher education.
ii.   To identify challenges 5G in higher education.
iii.   To analyze findings and provide suggestions for future research.

RESEARCH QUESTION

The research questions are as follows:

i.   We investigate and discuss serious limitations of the fourth generation (4G) cellular networks and
ii.   We investigate the technical requirements for 5G in higher education.

LITERATURE REVIEW

Background of 5G

5G is the fifth generation cellular network technology. 5G NR speed in sub-6 GHz bands can be slightly higher than the 4G with a similar amount of spectrum and antennas. Major countries using 5G and their readiness. According to a report by accounting firm Deloitte published in recent days, China is leading the way ahead of U.S. in the global 5G competition. The 5G revolution will cast a much wider net. It's an information conduit being built to connect self-driving cars, VR headsets, delivery drones, and billions of interconnected devices inside the home. 5G will be crazy fast, crazy stable, and crazy versatile. 10 Gbps speeds won't be unheard of. It'll replace home Wi-Fi networks in many cases, offering faster speeds and better coverage.

To put it into perspective: one 4G cell tower currently supports about 2,000 devices with some traffic delays. A 5G tower will support more than one million connected devices per square kilometer with negligible delays. This massive jump in bandwidth will be able to handle more cumbersome traffic loads required for smart classrooms, augmented reality (AR), and virtual reality (VR), with ease. According to the research [22], the main features that technology might have are as follows:

- High speed, high capacity, and low cost per bit. It Support interactive multimedia, voice, streaming video, Internet, and other broadband services, more effective and more attractive, Bidirectional, accurate traffic statistics.
- Introduction of a new radio system is possible in which different radio technologies will share the same spectrum. This can be done by finding unused spectrum and then adapting to the technology of the radio technology with which the spectrum is being shared.
- Every mobile in a 5G network will have an IP address (IPV6) according to the location and network being used.
- The technology is expected to support virtual private networks and advanced billing interfaces.

- With 5G Enabled phone, you might be able to connect your phone to your laptop to get access to broadband.
- 5G technology is providing large broadcasting of data in Giga bit which supporting almost 65,000 connections.

According to the required services and applications, Figure 1 shows a trade off between latency and data speed, and the potential of next-generation networks to support their demands. UHD: ultra-high definition [15]. Therefore, reference [16], emphasized that 5G networks are perceived to realize the three main features as below:

- Ubiquitous connectivity: In future, many types of devices will connect ubiquitously and provide an uninterrupted user.
- Zero latency: The 5G networks will support life-critical systems, real-time applications, and services with zero delay tolerance.
- High-speed Gigabit connection: The zero latency property could be achieved using a high-speed connection for fast data transmission and reception, which will be of the order of Gigabits per second to users and machines.

High-speed/low-latency area	High-speed/high-latency area
This area requires very low latency as well as very high data speeds, which represent the challenge of 5G mobile systems	This area tolerates the latency, but requires very high data speeds
Application examples: Virtual and augmented reality, tactile Internet, instant UHD video downloading and sharing, and other future applications Can be handled only by 5G systems	**Application examples:** Streaming and downloading UHD videos Support for higher connected devices Can be handled only by 5G systems
Low-speed/low-latency area This area tolerates the data speed, but requires very low latency	**Low-speed/High-latency area** Application requirements are not high, as it tolerates both speed and latency
Application examples: Emergency/disaster systems, vehicle-to-vehicle communication, M2M, and Internet of Things Can be handled by D2D and the use of hotspot millimeter-wave band	**Application examples:** Weather forecast stations, Internet browsing, send/receive email Downloads moderate file sizes (or HD movies) over long time period Can be handled by 4G

Figure 1. Data speed vs. latency.

5G in the Classroom and Its Impact to Higher Education

According the review of this research, here is what educators can expect the impact of 5G to higher education:

- Immersive Lessons with Augmented Reality (AR) and Virtual Reality (VR)

Mixed-reality content and video require high bandwidth and low latency to perform optimally. Similarly reference [9], focuses that 5G is aimed to reduce latency to a few milliseconds (ms) than 4G that latency interval is recorded as 50 to 80 milliseconds (ms). The low latency will enable new services such as VR/AR, tele-medicine and tele-surgery; in some cases, latency not more than 1 ms is critical [13]. Thus with 5G, experiences will be seamless. Students may tour

the human body or visit other planets in VR. With AR, they can explore concepts through touch, pinching and zooming through the Earth's layers as fast as they think it. This technology could improve the concept of interactive classrooms by the use of high-performance AR and VR technologies. They allow the user to see and touch any kind of 3D design.

Futhermore, another field of application of AR/VR over 5G is music education. Music implies the exchange of multimedia information, at least in form of high-quality audio streams, in order to support professional applications; moreover, other data types are relevant in a music education context, including symbolic information (score, metadata, lyrics, etc.) and video streams, that are demanding in terms of bandwidth and latency requirements [6] All the mentioned data should be supported in order to provide a comprehensive environment for distance learning and distributed music performance. Music education over the net intrinsically poses a number of constraints to network characteristics, and, on top of that, AR/VR approaches add other information layers [5].

- Smart Classroom IoT Saves Teachers Time

Setting up devices and gathering feedback in class takes time, even when everything works perfectly. With the Internet of Things (IoT) on 5G, teachers can automatically log in as soon as they enter the classroom. Menual administrative tasks will be automated, and students can deliver feedback digitally. Higher bandwidth will help signals remain strong throughout entire lectures and presentations, preventing occasional dropped connections and derailing focus.

- Download Videos in Seconds

Gen Z loves video, and it makes sense when YouTube is also their preferred educational resource. Downloading a high-definition video on 4G can take minutes to an hour. With 5G, downloading a feature-length movie will take seconds, maybe less. 5G supports network speeds at around 20 Gbps or higher, enabling a user to download, for example, a full High Definition (HD) movie in seconds, and streaming high resolution (8K) videos. Also having a latency in millisecond levels; this is essential for future technologies like AR, driverless vehicles, and tactile Internet to work effectively [13].

- Greater Assistance for Students with Special Needs

Children with special needs may require more frequent or full-time assistance from teachers. There are robot applications to help with problem-solving, but they aren't as responsive as the children they're designed to help. 5G will enable robots to be full-time assistants and support teachers by responding immediately to help with learning exercises.

- More Flexible Learning

Every student's learning style and ability is different. 5G will help students continue their education outside the classroom, delivering the same data speeds and responsiveness in the classroom to their phone or laptop. Regardless of distance or location, 5G empowers students to access the same information and exercises as their peers.

- Applications that demand low latency and faster information processing.

In addition to this, the research [8] discusses that the use of 5G technology in the education of the Software will allow you to create applications that demand low latency and faster information processing. Thus, the Software Engineer with the use of ICT may develop all their areas of knowledge into different context and without limitations.

- Low latency tactile Internet

Low latency tactile Internet will facilitate remote learning and education by haptic overlay of teacher and students. For these identical multi-modal human-machine interfaces, round trip latency of 5-10 ms is allowed for perceivable visual, auditory, and haptic interaction, tactile Internet will allow to play musical instruments from remote locations [17]. Thus, drastic changes in multiple network domains need to be addressed to achieve this low latency.

5G Challenges in Education

In the study [13], author addressed that there is an arsenal of emerging technologies such as 5G, AR, Artificial Intelligence (AI), and the IoT that are expected to have significant impacts on several application areas. These technologies may also play a significant role in improving the effectiveness of public safety and mission-critical personnel, especially first responders. Additionally, the new technologies may drastically change the way public safety activities are handled 5G. The use of new mathematical and statistical tools such as machine learning and deep learning to deal with so-called "Big Data" will bring entirely new approaches to handling public safety activities.

In addition, we found that prices requirement of 5G is the common challenges in education. Users have requirements every higher for wireless services, which raises the prices of almost stringent requirements for the technical indicators of the network [11]. 5G as a successor of the current4G, its main feature is the increase in performance in data transfer and decreased latency necessary to satisfy use cases as extreme as augmented reality, the Internet of Things, or the billions of devices.

Furthermore, in the research [13] discusses that VR (Virtual Reality) technology and its products (helmets, goggles, etc.) are used to allow the user to be placed in a virtual environment, which is mainly designed/created for a specific application. The user is isolated from the real world and just interacts with various elements (animals, human-like symbols, etc.) in an imaginary, fabricated world. On the other hand, AR combines virtual reality with the real environment. The user of an AR product is always in touch with the real world, while interacting with virtual, created contents in the real world that we see and live in, so the experience is real and contextual.

AR devices include smartphones and tablets, other mobile devices specially designed for a specific workforce, Head-Up Displays (HUDs) (for windshields, visors, etc.), Trainees with hands-free, head-up AR glasses can see live video and data in a simulated environment. With these kinds of AR tools, activities of various response teams in education can be monitored, remotely and locally, with more accurate information so that much more efficient coordination can be established. The instructors can intervene in real time by providing guidance and introducing new obstacles into the simulated scenarios. Several technical and economic obstacles need to be overcome before AR devices become useful for critical communications applications. However, the higher cost, heaviness, limited range, limited battery life, software unavailability, and limited field view are some of the problems associated with these early versions of AR devices on the market.

The next Big Data is one of the main challenges in 5G communication. Criminals and terrorists use the digital media such as web, emails, messages, Facebook, Twitter, YouTube and etc. They leave behind a wealth of data that can be captured, analyzed, mapped into a social graph, and used in crime-fighting operations. An example is the identification of the influential people and their followers in criminal and terrorist activities [13]. The significant advances in storage and computing and communications technologies, along with data mining and machine learning software and related application systems, it is possible to store, search, view, and visualize a

broad set of cases spread around various jurisdictions nationwide. The techniques and algorithms employed in this type of analyses is will be helpful for predicting criminal behaviors and for predicting where and how terrorist activities may take place.

FINDING AND DISCUSSION

Latency is highly critical in some applications such as automated industrial production, control/robotics, transportation, health-care, entertainment, virtual realty, education, and culture. IoT is quickly becoming a reality which connects anything to any other thing anytime, and anywhere. Thus, smart wearable devices (smart watches, glasses, bracelets, and fit bit), smart home appliances (smart meters, fridges, televisions, thermostat), sensors, autonomous cars, cognitive mobile devices (drones, robots, etc.) are connected to always on hyper-connected world to enhance our life style. In some cases, we need latency as low as 1 ms with packet loss rate no larger than 10−2. Several latency critical services which need to be supported by 5G are described as follows. In such scenarios, supporting network latency lower than few milliseconds becomes crucial [17].

Based on the situation, we need to consider the challenges in facing the 5G towards education. A significant change from 4G to 5G is the number of connected devices. Education is starting to see an increased use of IoT with solutions such as student RFID cards, wearable fitness trackers in PE, and security systems. While that is only two years away, the infrastructure is not ready yet. Wireless providers will need to install more towers or antennas relatively close together, and add them across the nation, in order for users to receive the same amount of coverage.

However, as we all know, funding is already tight for school districts, let alone finding funding to support 5G. Plus, older devices likely won't have the requisite technology to connect to 5G networks, forcing districts to purchase the newest mobile devices that are 5G-enabled. However, we don't believe it will be directly in the education world until prices go down and the infrastructure is built. There will still be students who cannot afford Internet at home, especially if pricing continues to increase from today's cost of broadband while 5G seems like it could help close the digital divide in the future. The range of 5G is smaller and requires more antennas than 4G.

As the technologies become more mature, number of information and data published electronically are increased and will continue to increase rapidly by without time and location dependency. Thus, it is found out that 5G technologies will anticipate especially to mobile learning as it efficiently providing the educators with efficient learning scenarios and satisfies high priority learner requirements. However, as the emerging 5G technologies currently under design, testing and validation, it is important to find out the security and privacy aspects as well as the authentication mechanisms for efficient performance degradation as future research aspects [9].

CONCLUSION

Today the rapid advances in technology are reshaping our society, social institutions and schools. Modern technologies have fastly increased our capacity to know and do things and to communicate and collaborate with others. They allow us to transmit information quickly and widely, linking distant places and diverse areas of endeavor in productive new ways. The students have a wide range of new technology open and available to them.

According to the situation, educators must be prepared in the course of the 4.0 industry revolution by leveraging on the fifth generation mobile technology or 5G which will be

commercially used by 2021. The preparations should be done from now as it will offer data speeds that will make value added to the standard of living included in the field of education.

Overall, the university, polytechnic, community college or any other higher education centre are the system developer and responsible for the provision of facilities and infrastructure. Meanwhile, the lecturers are responsible for encouraging active students to use this type of technology. Thus, the students should use the opportunity to be in the world of technology and information that will only led to enhancing our educational system in the 21st.

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