

# The Impact of Information and Communication Technology in Education: Opportunities and Challenges

M. Nadeem, S. Nasir, K. A. Moazzam, R. Kashif

## I. INTRODUCTION

**Abstract**—The remarkable growth and evolution in information and communication technology (ICT) in the past few decades has transformed modern society in almost every aspect of life. The impact and application of ICT have been observed in almost all walks of life including science, arts, business, health, management, engineering, sports, and education. ICT in education is being used extensively for student learning, creativity, interaction, and knowledge sharing and as a valuable source of teaching instrument. Apart from the student's perspective, it plays a vital role for teacher education, instructional methods and curriculum development. There is a significant difference in growth of ICT enabled education in developing countries compared to developed nations and according to research, this gap is widening. ICT gradually infiltrate in almost every aspect of life. It has a deep and profound impact on our social, economic, health, environment, development, work, learning, and education environments. ICT provides very effective and dominant tools for information and knowledge processing. It is firmly believed that the coming generation should be proficient and confident in the use of ICT to cope with the existing international standards. This is only possible if schools can provide basic ICT infrastructure to students and to develop an ICT-integrated curriculum which covers all aspects of learning and creativity in students. However, there is a digital divide and steps must be taken to reduce this digital divide considerably to have the profound impact of ICT in education all around the globe. This study is based on theoretical approach and an extensive literature review is being conducted to see the successful implementations of ICT integration in education and to identify technologies and models which have been used in education in developed countries. This paper deals with the modern applications of ICT in schools for both teachers and students to uplift the learning and creativity amongst the students. A brief history of technology in education is presented and discussed are some important ICT tools for both student and teacher's perspective. Basic ICT-based infrastructure for academic institutions is presented. The overall conclusion leads to the positive impact of ICT in education by providing an interactive, collaborative and challenging environment to students and teachers for knowledge sharing, learning and critical thinking.

**Keywords**—Information and communication technology, ICT, education, ICT infrastructure, teacher education.

THE use of technology in education has an ironic history and is being used for the last 200 years starting in 1822 with Charles Babbage, who invented the first computing machine, followed by the invention of the typewriter by Christopher L. Sholes in 1873, the mimeograph by Albert Blake Dick in 1887 and the radio by Guglielmo Marconi in 1894. There were also significant inventions after World War II, which include the photocopy machine invented by Chester Carlson in 1949, the overhead projector by Roger Appledorn in 1950 and the practical videotape recorder by Charles Ginsburg in 1951 [22].

The revolution in technology starts with the invention of personnel computers (PC's) by IBM around 1980 followed by the Internet by ARPANET in the late 80's. Since then, computers and the Internet are being extensively used in academic institutions for learning, knowledge sharing and integration. The invention of interactive white boards (smart boards) by PARC in 1990 has introduced a new innovation into the classroom by integrating the white board with multimedia projectors, computers and the Internet. The use of smart boards have been increasing in academic institutions and created a positive impact [22]. The technology moves on further since the introduction of Facebook by Mark Zuckerberg in 2004. The use of social networks in education is enormous and is considered to be a very good tool for collaborative learning and information sharing [20]. There are many other social networking applications like LinkedIn, YouTube and WhatsApp followed by Facebook and are used in educational environments. Lastly, the invention of the iPad in 2010 by Steve Jobs, enables to connect with thousands of mobile applications that enhance the learning and creativity in students and endows teachers to offer better learning opportunities.

It is very important however, to learn, what is the basic ICT infrastructure required in an academic environment based on international standards? The basic infrastructure includes the provision of computers (desktops), local area network, Internet connectivity, fast bandwidth and related equipment. Students and teachers must have access to basic software for desktop publishing, word processing, spreadsheet, graphics, database and presentations. Students can have access to various websites and can communicate with their peers and teachers through email and other verbal and nonverbal applications. Trained and skilled human resources are required for ICT implementation in an academic institution through which the

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curriculum can be revised to integrate technology in different grades according to international standards such as the K-12 curriculum [5].

In advanced countries, governments are spending enormous budgets on ICT infrastructure development. The whole class room environment is transformed into a new technology-based learning and interactive environment [6], [17], [19]. According to UNESCO [10], in European countries the computer student ratio is between 5 to 7 students per computer but still some of the EU countries like Sweden and Denmark [4], [10]. They have transformed the system by providing the students with laptops and tablets and working on the policy of the one student, one laptop scheme, which is proved to be very successful in enhancing student performance in educational institutions [2]. Most schools in the EU are well connected and creating virtual learning environments for teachers and students [4]. Padayachee, presented a survey of schools in South Africa where ICT is being integrated, and identified the categories of important eLearning applications, electronic devices and related technologies from the perspective of teachers and students [12]. The classical learning model is replaced with blended learning approach in [13]. Kolderie & McDonald presented an approach for the integration of ICT in 21<sup>st</sup> century schools and presented the key findings of the K-12 curriculum [20]. Fig. 1 represents a comparison of the classical (old) approach of education with the new IT-enabled education [20].

However, developing countries in Asia and Africa are far behind in implementing basic ICT infrastructure for primary, secondary and higher secondary academic institutions. This is due to the high cost, energy crises, unavailability of capacity building and the lack of trained human resources [1], [9]. Japan and Singapore are the two best examples from Asia where most of the schools are well equipped with computers, internet facility, fast broadband connectivity and other related resources [3], [16].

Old Model	New Model
Reform existing schools	Create new schools
Larger schools	Smaller schools
Delivering education	Students learning
Read books, listen to talk	Explore the Web
Time-bound/place-bound	Any time/any place
Technology as textbook	Technology as research
Groups, classes	Individualized
Time is fixed	Time is variable
Standardization	Customization
Cover material	Understand key ideas
Who and what	Why and how
Know things	Apply knowledge
Tradition	Relevance
Over-reliance on multiple-choice tests	Written/Oral demonstrations
Testing for accountability	Testing for understanding
"Make 'em"	"Motivate 'em"
Instructors	Advisers/facilitators
Teachers serve administrators	Administrators serve teachers
Administrative management	Professional Partnership
Adult interests dominate	Student interests dominate

Fig. 1 Old (classical) approach of education vs. New (IT-enabled) educational approach [20]

The proposed model for ICT infrastructure is discussed in the next section, followed by ICT in teaching and learning in Section III. Challenges and opportunities are discussed in Sections IV and V, respectively, which is followed by the conclusion.

## II. PROPOSED MODEL FOR ICT INFRASTRUCTURE IN ACADEMIC INSTITUTIONS

There are four important components of in ICT infrastructure, as mentioned in Fig. 2, which include the technology, teachers, students and content.

Administration (management), instructors and students are the direct beneficiary of ICT-based infrastructure. The teacher uses this technology to disseminate knowledge to the students [14], and they use this technology for better communication and blended learning process [13]. However, teachers must have the proper training and guidance on how to use and present that technology in the classroom for effective learning and evaluation [14]. The administration has to manage all the student, teacher and staff records, which includes the financial management, fee collection, human resource management and procurement. The administration also exchanges data with other organizations and governmental agencies. The data management of student academic records and on-line complaint system are important modules of ICT infrastructure [18]. The main objective of the integration of ICT in education is to provide students with better education, as well as access to online knowledge resources and change the classroom environment for improved learning and creative thinking [19]. Students must have access to a computer lab with Internet connectivity designed for learning, development and information sharing [11], [16].

The development of local area network (LAN) with wireless support is the backbone of ICT infrastructure. Internet broadband connection can be used to provide access for students and teachers. Software and hardware resources may also be shared using the Internet. Student accounts should be established to provide them access to the network.

ICT-based content development and curriculum is one of the important aspects of ICT-based infrastructure [18]. The best technology may fail if we have not integrated ICT in the content as per the discipline and cognitive level. There is a dire need that classical content should be revised and technology may also be introduced as a subject and also integrated with the existing disciplines at all intellectual levels.

Technology may also be introduced with hardware and software applications. The hardware components include multimedia projectors, smart boards, PC's and other audio and visual devices. Teachers and staff must be trained or certified to use these devices in the classroom and lab environment. It is very much evident that the integration of multimedia technology and smart boards has significantly raised the involvement of students in the classroom and helps them to better comprehend a subject [8], [19]. Instructors can elaborate and demonstrate things to students by referring online educational resources and use simulations and animated applications to explain the concepts.

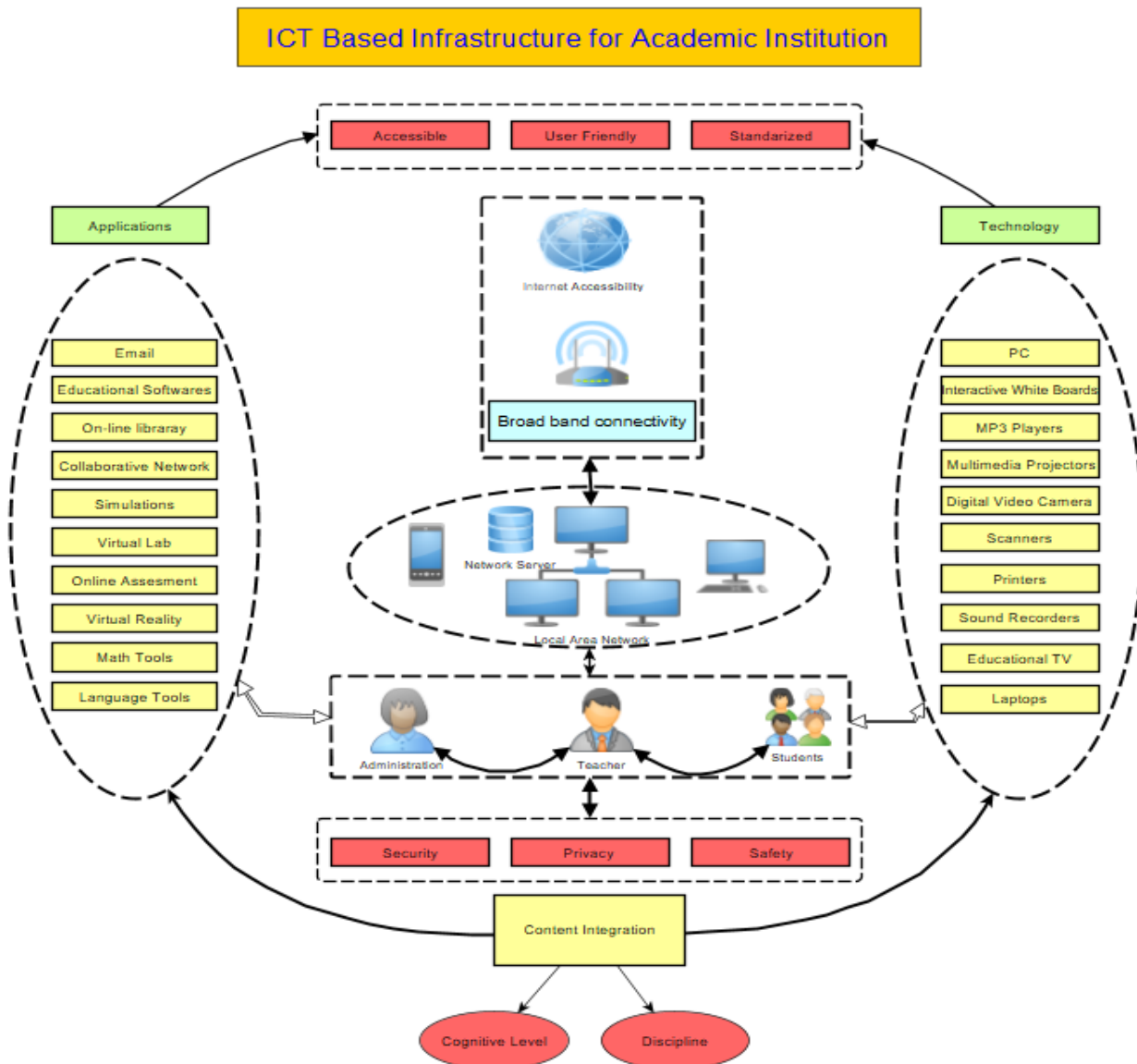


Fig. 2 Proposed ICT Infrastructure for Academic Institution

The hardware technology must be supported by the software applications, educational resources, collaborative learning tools and on-line knowledge resources to supplement the content delivered in the class [15]. Teachers may also use online resources for lesson planning and assessment, while students have access to online dictionaries and encyclopedias for quick referencing. Social networks also play a significant role in the student learning process [21]. It provides a platform for collaborative learning where instructors and students interact in groups and share information.

### III. ICT IN TEACHING AND LEARNING

ICT provides adaptable and powerful tools that can greatly enhance the learning skills of teachers as well as students [17]. These tools must be available in every resource room,

classroom, laboratory, teacher's offices and libraries. We may categorize ICT tools in two categories according to their use in school education at different levels in terms of complexity:

The basic and generic tools refer to the tools which can be taught at all levels of school education without any distinction. However, the complex levels of the tools may be taught at the higher levels with respect to the curriculum. Following are the ICT-based activities for teachers to improve instruction method (communication), learning, and testing and evaluation process.

#### A. Instructions

- Use of presentation and word processing software for better delivery of lesson plans and interactive learning.
- Improve the speech abilities and pronunciation of students using specific software and hardware such as

microphones, headphones and speakers.

- Video conferencing systems can be used occasionally in higher classes to allow guest speakers from distant places or involve students from other schools in shared dialog.
- Smart boards can be used for better interactive lecture delivery.
- Course content and lesson plans can be made available on school website. Students must have access to the Internet in schools and libraries to access the website.
- Encourage students to explore and access information using websites to complete assignment tasks.
- Learning and educational software could be used to enhance student skills in a specified area.

#### *B. Learning*

- Searching and collecting information in the form of facts, lecture notes, lecture slides, pictures and videos from various web sites using internet for submission of class assignments and projects.
- Create folders and save data in files for further use and create animations to understand real world concepts
- Digital books, digital on-line libraries, educational sites and encyclopedias provide quick access to information.
- Creating and managing multimedia content (audio, videos, animations, and images) and integrating them in class presentations as PowerPoint slides
- Simulated learning provides a virtual learning system (feel of real situation).
- Publication of pamphlet/brochures for awareness with the institution and among community members.

#### *C. Testing and Evaluation Process*

- Managing academic records of the students.
- Creating pool of questions for students.
- Generate online tests from the question bank.
- Data analysis and creating summarized reports and charts.

### IV. CHALLENGES

#### *A. Digital Divide*

The digital divide is the gap between individuals and organizations having technology and Internet access compared to those who do not have technology access and Internet facilities. Unfortunately this gap is widening and the countries of the third world in Asia, Africa and other continents have a large number of the population that do not have access to technology due to poverty. It is a great challenge for governments and the respective communities to provide access to technology and the Internet for such deprived students.

#### *B. Content Development*

Content development is one of the important elements of ICT-based education. The focus should be given to the integration of ICT in content and the curriculum at different cognitive levels and disciplines. There are examples of the successful integration of ICT in content such as the K-12 curriculum, but it is unfortunate that most of the content which is being taught in schools has no connection with ICT tools.

#### *C. Capacity Building*

There is a significant deficiency in the capacity of teachers and staff to cope with the ICT infrastructure. Mostly, teachers are not well trained and have no certification. The support and maintenance staff is also deficient in many school settings. In underdeveloped countries this problem is on a larger scale and mostly the skilled personnel are concentrated in big cities. Government and private organizations must initiate short training programs for teachers and staff to increase their capacity.

#### *D. Security and Privacy*

Security and privacy is one of the very important concerns in any ICT-based environment. The students usually are unaware of the fact that their personal data may be seen or accessed by unauthorized persons and that this information must not be seen by others. There are two important strategies to solve this problem, one is to create awareness among teachers, students and staff, and other is to integrate security and privacy related applications to the system for prevention.

#### *E. High Cost*

Although the cost of technology has come down considerably over the last two decades, for under-developed countries, the cost of hardware equipment including personal computers, accessories, smart boards and the establishment of a network is still on the higher side. There is a high cost of providing internet broadband connectivity to all students and staff in an educational setup. Government, NGO's and vendors should come forward to support schools and other academic institutions for building ICT infrastructure.

### V. OPPORTUNITIES

#### *A. Collaborative Learning*

There is an extraordinary growth in the use of social networks such as Facebook, WhatsApp, and LinkedIn in recent years. These social networking tools create an opportunity for a collaborative learning process among students or teachers [21], [15]. Students can share information or ideas among themselves and respond to queries submitted by the teachers. Group tasks and assignments can be given to students. There are also many online collaborative learning tools for students and teachers.

#### *B. Online Education*

Online education is one area of education which emerged in the recent past. The reason for this is the fast and reliable connectivity of the Internet. Individuals can register themselves to be a part of online education. Those living in far distant areas from cities can learn and interact with online education. There is a big scope in this direction and there is an extensive increase in people learning from online courses [7].

#### *C. Blended Learning*

The advent of modern ICT tools lead to the new dimensions of learning called blended learning [13]. The courses are being designed to integrate/blend ICT to comprehend the respective

discipline in a highly interactive manner. The traditional/classical model of face-to-face learning is now replaced with the blended model approach, where the students along with the classical approach, get involved with online (web-based) learning, simulations and interactive sessions to comprehend the content and apply for problem solving.

#### *D. Accessibility to Information/Knowledge Resources*

Accessibility to the Internet and World Wide Web has been a great opportunity for students and teachers to take advantage of millions of online knowledge and educational resources. Many of such resources are free and also available for paid registration. Educational institutions can access many educational resources and they do not have to purchase printed material from the market place. It also encourages students to explore and learn.

#### *E. Creative Thinking*

ICT-based tools are quite helpful in building the fundamental concepts of students in domains like science, math, history, language and geography. The use of simulation software, virtual labs and educational software increases the learning capacity of students and develops their critical thinking skills.

#### *F. Interactive Communication*

The technology advancements in education have lead to the development of innovative interactive technologies including multimedia projectors, smart boards and interactive white boards. Teachers can use these interactive boards as classical teaching tools and also use them to display images, simulations and online resources. This creates interest in the students and involvement can be increased, giving better understanding of different concepts.

## VI. CONCLUSION

Modern ICT tools have played a significant role in the field of education and transformed the classical classroom environment into smart classroom. The optimal use of technology is fully dependent on the correct integration of ICT in schools. This can be achieved by implementing ICT-based infrastructure. The proposed model for ICT infrastructure has four important components, the end users including teachers, students and staff, second technology which includes the hardware systems, peripherals, and devices, and software applications such as educational software, learning games and on-line learning resources. This is followed by the content development which includes the development of curriculum that integrates ICT at all cognitive levels and disciplines.

The use of the Internet to access knowledge resources and information sharing is key for learning and development. On-line learning systems and simulations create interest in the students and motivate them to think critically. The history of the use of technology in education is presented. There are many challenges for the implementation of the proposed ICT infrastructure due to the high cost, capacity building and content development for blended learning. It is quite evident

from the literature that there are successful implementation models of ICT integration in academic institutions. Apart from the challenges, there are many opportunities in this area including online (distance) learning, collaborative learning, interactive communication, and quick access and sharing of knowledge resources.

Technology is a catalyst for change and there is a need to revisit our classical teaching and learning models and advocate blended learning approach which initiates the critical thought process and induces creativity in students.

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