

The Impact of Information and Communication Technology on Medical Teaching and Learning Environment

Dr. Intisar A.M. Al Sayed[†] and Dr. Nedhal A. Al-Saiyd^{††}

[†]Al Nukhba College University Department of Computer Engineering Techniques,, Baghdad-Iraq

^{††}Applied Science Private University Faculty of Computer Science Amman-Jordan

Summary

The advances in Information and communication technology (ICT) emerged to assist health professionals in their medical services including diagnosis, treatment and re-habitation for individuals or population who need such services. The benefits of using ICT in improving healthcare have been discussed by several researchers. However, there exist few studies on the curriculum importance for medical institutes and faculties. This paper reviews the influence of implementing ICT in medical traditional learning (teacher-centered and hospital-based training) and in student-centered learning. It shows the major barriers and the transformation in medical education and practice that motivate learners in different ways. The paper also determines the needs and explains the main activities and propose general architecture to develop intelligent and adaptive medical student-centered distance learning system, which is adapted to learner's specific preferences and capabilities. The international Competency-Based Medical as a promising strategy, adopts the shared mental model of CBME continuing medical education to expand opportunities of medical education. Socio-technical challenges and barriers for medical education are also identified. It is recommended to adopt intelligent learner-based distance Learning and integrate it with the traditional education. Then the evaluation and socio-technical challenges of medical student-centered distance learning systems are presented. In developing countries, it is recommended to promote the digital skills of both students and instructors in medical education and health institutions.

Key words:

Information and Communication Technology, Medical education, medical e-learning Health Information Technology, Education Management.

1. Introduction

Traditionally, medical education is meant the transferring of knowledge and practice skills from the educators to students. Information and communication technology (ICT) and their applications are described as the technology utilized in the development, and implementation of computer systems, software, equipment, tools and networks in the processing and distribution of data. Medical technologies that are adopted by professionals to provide good healthcare quality for individuals and society or systems that use it [1]. Current advances in ICT including

mobile communication, cloud computing and internet of things (IoT), become the most significant applied resources compared to classical resources, where preparing students for the working environments makes the traditional medical education classes insufficient. Various hardware, software and information technologies are integral parts of many curricula [2], [3].

To enhance student learning, medical faculties must successfully integrate ICT in medical education. ICT can assist medical education. The information technology supports medical educational activities and provide students with relevant opportunities to enhance their knowledge and skills, and prepare them for a technological world. The students can be physician, nurses, and physician assistant [4]. The spread in ICT as well as the evolution of World Wide Web in daily life had led to important inferences in the education systems. Online courses, Web-based learning, computer-assisted learning (CAL), virtual reality (VR) and human patient simulators are some the options [5]. Such advancements have affected the way of teaching and the way of student learning, and elaborate with opportunities and challenges in the medical education [1], [5].

This paper reviews the importance of ICT in medical education. The rest of this paper is organized as follows: the upcoming section reviews Integrating ICT technologies in medical education and healthcare. Section 3 presents challenges of traditional Teacher-Centered medical education. Section 4 explains modelling of medical intelligent Student-Centered distance learning systems. Section 5 presents evaluation of medical Student-Centered distance learning systems. Socio-Technical Challenges and Barriers of student-centered distance learning systems are presented in section 6. Lastly, the conclusions and recommendations are given in section 7.

2. Integrating ICT Technologies in Medical Education and Healthcare

The introduction of information processing in medicine and healthcare is called health information technology (HIT), and sometimes it is called healthcare information

technology (HCIT) [5]. It involves the implementation of computer hardware, communication systems and software to store, share, use of health care data and information, and make decisions. The exploitation of IT in the health sector has been very helpful. The rewards of HCIT include enabling of communication between healthcare providers, improving medication safety, tracking and reporting, and encouraging enhanced care.

Therefore, HIT influences the individual and society health life by:

- Improving accuracy of diagnosis in health and reducing diagnostic errors,
- Reducing risks and medical errors,
- Saving potential costs,
- Enhancing administrative and management efficiencies
- Significant improving of clinical procedures, and
- Improving patient outcomes and quality of care and decreasing costs of care.

Health informatics, also called health information systems is a discipline of the intersection of computer science, health care and information science. It is applied to areas in nursing, pharmacy, dentistry, public health, therapy and biomedical research. The evolution of high-quality health informatics research and education has been the goal of many developing economies [6], [7].

The medical colleges and institutes are the ideal places to certify the manner that future doctors would have the required skills to use these technologies in a patient-centered care. Therefore, there exists a motivation for improving the skills of undergraduate students in medical programs to make them well-educated in both medical and information technologies [8], [9]. Many universities use applications to manage their courses, assessments and the educational materials. The students acquire better understanding with interactive digital multimedia materials including 3D imaging to study histopathology, anatomy and heart sounds [8].

The use of ICT facilitates in the formal and informal learning is independent from temporal and spatial limitations exceeds the classrooms boundaries. This will guide to develop medical educational systems to store, manipulate, display, secure and exchange all forms of electronic data related to medical domain, in relatively increased reliability, effectiveness and efficiency. The medical ICT-based systems can be developed to simulate the activities of tele-surgery into clinical practice, undergraduate and postgraduate training, medical training, medical diagnosis and treatment and better structuring and transferring the integrated electronic health records. These systems may have more sophisticated human-computer interactions that facilitates using voice and hand writing. Figure (1) shows the information and communication technology models in medicine and healthcare.

In last decades, the extended use of digital devices including laptops, tablets, mobile and smart phones for many purposes had an influence on data sharing and experience distribution, including formal and informal education. In addition to the traditional medical education and training methods, the students as well as specialists have opportunity to obtain the information anytime and anywhere with the help of the available (ICT) [10], [11], [12].

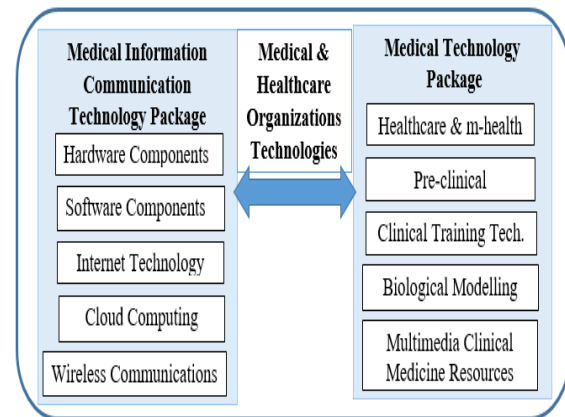


Fig. 1 Information and Communication Technology in Medicine and Healthcare

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The medical education is important that its outcomes affect the whole society and public health. With the development of HCIT, the medical education should be reformed all over the world since the students are computer-cultured these days, besides the continuous medical learning requires more documentation efforts and expertise sharing among doctors and researchers [7], [8].

However, few studies on the importance of information technology in curriculum management; i.e. revising, updating and extending, for medical institutes worldwide [8], [9], [10].

We realize that the progress of new digital educational applications allows medical students to get more information about human anatomy visualization using three dimensional representations, and can get health-related information on any disease using internet search [13]. Hence, this progress will positively influence the future medical personnel education.

3. Challenges of Traditional Teacher-Centered Medical Education

Most of a traditional medical education depends on teacher-centered and hospital-based training, where the core curriculum describes the basic knowledge, skills and attitudes. But, there are some issues that face traditional medical education and consequently influence healthcare [7]:

- It is reasonable to expect that a medicine and its related sciences, tools, and researches are evolved continuously and keep updated and changed over time. Also, the syllabi has technically changed.
- Educational lecture materials are mainly based on the slides of senior professors and workshops of medical professors and there are some difficulties in passing the information to students in medical faculties.
- A great need for medical educators, students and clinicians to continuously update their knowledge and skills, to follow the evolution in healthcare environment and use digital technology in digital environments and be 'digitally literate'.

4. Modelling of Medical Student-Centered Distance Learning Systems

Medical education have to continuously evolve to face the impact of increasing demand of using ICT in the medical field. New techniques are appeared to improve the instructional methods and change the conceptualization of medicine teaching, learning and training, and to reduce barriers of time and place.

Distance learning or Web-based medical education systems are used as synonyms. In the last decade, there is a shift from teacher-centered model to student-centered learning that applies modern pedagogical approaches, emerging practices and artificial intelligent technologies to enhance both learning and teaching processes.

4.1 Determining Needs

The determination of needs in medical student-centered distance learning should be undertaken before the design process. The determination includes special adopted learning techniques that integrate theories with practice and training, effective curriculum design that reflects educational principles, special instructional techniques that will be used in e-classrooms and virtual laboratories, special methods of technical communication that overcome the time, geographical boundaries and access barriers to learning (as in web conferencing), and organizational and

administrative management [14], [15], [16]. The suitable design for web-based education system is proposed in [17]. In any instructional environment, the medical educators play a crucial roles in teaching medical students, postgraduate trainees, or medical trainers. The medical educators and faculties require technology to support medical education. Medical educators are not alone, they need educational technologists and support staff too. The seven core roles that participate in building high-quality medical distance learning system are identified as follows [11]:

- Educational Technology Experts: facilitate the use of technology in teaching and learning by applying pedagogic, skills and professional values.
- Clinician Educators (e.g. pedagogical experts): Identify instructional needs, goals and strategies of blended courses and activities in medical education, and support design, pedagogic consulting, training, and practical work.
- Administrator: manages the learning system, video platform, lecture preparing system, simulation system, consults with vendors, and information technology (IT) groups, and supports user security, privacy, and enrollment
- Leader: contributes to plan and monitor the activities of developing a high-quality medical education system and support team work.
- Designers: discover and document the needs of stakeholders using a variety of formal and informal methods, and develop, and evaluate the success of the proposed system
- Developers: create pedagogical courses in an intelligent Learning Management System (ILMS) to access, edit and distribute videos, add online questions to videos, and write the code of the system and the interface component in web-based learning
- Collaborator: discover the needs within and across organizational (or faculty) units and to achieve the objectives, and outcomes.

We propose in addition to the above seven participants, the "Course designers" to identify the course contents based on the curricula objectives and outcomes.

4.2 Designing Intelligent Student-Centered Distance Learning

To develop intelligent and adaptive medical distance learning system, the main activities and general architecture are introduced in the following:

- Identification for intended medical learners, emphasizing on learning outcomes,
- Identification of pedagogical medical outcome-

based curriculum; includes well-organized theoretical and laboratory's lessons and coursework in texts, images, diagrams and multimedia videos format that cover medical know-what, know-how, and ethical practices. These materials may store on the cloud [17].

- Micro-learning design, which is one of the most popular emerging e-learning trends to provide the knowledge and skill effectively in short-time (from 2-15 minutes long). It includes design and prepare of short-term lessons, projects, or coursework,
- Instructional design to make the course structure clear by unifying the course titles for all the lessons, pages, and tasks [17], [18], [19] related to the outcomes.
- Suggesting a list of textbooks and references per lecture to use when needed.
- User-interface design assist learners to and teachers effectively communicate and collaborate during learning and teaching processes. User-interface component support adapted visual friendly-interface based on the profiling information. Medical students and their teachers may keep connecting even when they are away from college [17], [18], [19].
- The relevant learning materials are retrieved adaptably according to the specific learner's preferences and the capability of the learner. Each learner needs to fill in e-questionnaires to create learner's profile that will be stored in database [17], [18], [19]. It needs building intelligent information management system.
- Identification of the required online platform; websites that host medical knowledge, e-lectures, e-lab and videos for demonstrating skills through synchronous and asynchronous modes.

Figure 2 shows the proposed intelligent distance student-centered learning.

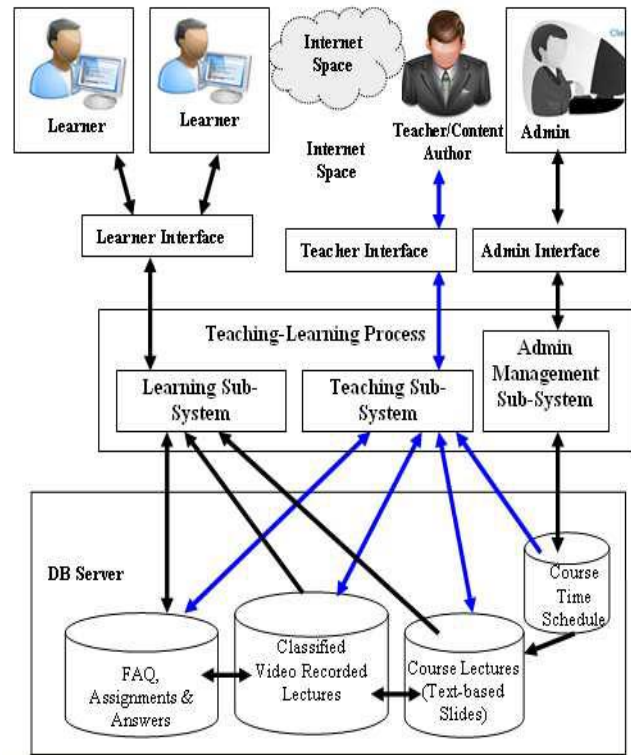


Fig. 2 The structure of intelligent student-centered web-based learning system [17]

In 21 century the education and training are primarily focused on the required outcomes for learners rather than the structure of the educational system. Therefore, the international Competency-Based Medical Education (ICBME), as a promising strategy, adopts the shared mental model of CBME that will serve as an approach toward the widespread implementation of medical education, training and practice. It uses resource-intensive system and has a vision of what a good doctor mean and what outcomes he requires. This approach transfer our interesting from focusing on knowledge to a competencies and professional skills [20]. The new technique is appeared to improve the instructional methods and change the conceptualization of medical education.

5. Evaluation of Medical Student-Centered Distance Learning Systems

Because, there is lack of precise cause-and-effect data, and unfortunately, there is no proof about the best method to develop best online medical education system to achieve particular set of objectives that are dedicated for particular type of students. There is no clear-cut evidence to measure or confirm that high-quality, well designed, and comprehensive are produced [21].

Also, presenting and covering the medical content at a distance learning usually takes longer period of time than explaining the same content or performing the same medical education practices in a traditional learning.

Therefore, the study and evaluation of the impact of the various online learning in medical learning and education systems that presently exist is an important issue to encourage development of high-quality systems that meet the intended goals.

Learning process can be evaluated by checking system strengths and weaknesses. Process quality evaluation can be done using a peer review, taking into consideration the easy to navigate, the quality of content materials and content presentation, the effectiveness usage of multimedia for medical education, the appropriate interactive communication for different levels of learners, system appearance, and required hardware and software resources. Outcome evaluation examines how the system results are produced. It includes four measuring levels: learner's satisfaction to access and interaction with the system, learning technology, changes in learner's behavior, and medical and healthcare organizational and institutional changes and their impacts on medical education [5], [6].

Evaluation of the content to match the aligned curriculum and clear learning objectives

Evaluation of teacher-learner interactions, assessments, and feedback. In CBME, the teacher helps the learner to be the owner of ownership of his medical education and training [20].

6. Socio-Technical Challenges and Barriers of Distance Student-Centered Learning Systems

During the past decades, ICT has changed how medicine is taught or practiced [12], while there are still some important challenges and barriers when developing and deploying the system [22], [23], [24], [25]:

- The cultural resistances amongst academic staff to integrate e-learning into teaching practices is considered as one of the barriers to engage student in technology-based education.
- The evolving and changing in medical education to be abreast of technological advances put extra pressure on overworked faculty staff.
- Preparing material requires a longer period of time than what is needed in traditional learning. Medical educators may have a pressure in finding sufficient time to develop and implement online learning using digital tools to manage teaching materials.
- The lack of infrastructure technologies and poor internet connectivity are considered as another barrier typically in low-medium income countries

[23].

- Some platforms have limitations in direct monitoring students, feedback, maximum number of participants viewed on computer screen, student attention, and the number of interactions between students and teacher in virtual classes and video conferencing.
- The lack of scientific and systematic development of intelligent student-centered distance learning models based on student-centered approach, which negatively influence the system utility [23]. Student-centered approaches put more work on students, when they tried to develop practical applications for the theoretical materials.
- The validity period of the questionnaire component to build the profiling file is limited,
- It is difficult to assess the performance and practices of students and simulate the virtual patient cases.
- Inadequate developing and technical skills of teachers when preparing teaching materials. Lack of practices or the recorded demonstration videos are inadequate or of low-quality. Also, there is lack of appropriate tools that are used in clinical teaching.
- Nevertheless, in developing countries the computer networking and the internet technologies and the related infrastructure are prerequisites before moving to update the curriculum or to comprise IT in the medical study plans.
- The main challenge for CBME strategy is the resource-intense requirement for multiple evaluators to determine level of learners' competence through multiple, and direct observations. Multiple evaluators have different perspectives, and many stakeholders are involved [20], besides lacks of global standards.

7. Conclusions and Recommendations

The importance of ICT has been reviewed for the healthcare and medical services and a focus is made on the medical education. ICT complements the teaching and learning processes with constantly evolving technological tools and resources. It offers learners with a new paradigm and in an effective and efficient learning process, and helps to achieve medical skills required by graduates. The medical faculties and institutes should take into consideration all technological advances in their strategic teaching plans and using health information technologies. The paper highlights the main activities and propose general architecture to develop intelligent and adaptive

medical student-centered distance learning system, which is adapted to learner's specific preferences and capabilities. The international Competency-Based Medical Education (ICBME), as a promising strategy, adopts the shared mental model of CBME that will serve as a promising approach toward the widespread implementation of education, training and practice in continuing medical education. The new technique is appeared to improve the instructional methods and change the conceptualization of medical education. They are more flexible techniques that reduce barriers of time and place. Then the evaluation of medical student-centered distance learning systems is presented.

However, in the 21st century, there is still a need for improving many areas before fully computerize the medical education or in healthcare policy especially in developing countries and in rare or remote areas. Another recommended concern is about the security issues of the electronic medical education and healthcare system. This includes hacking of medical data records in health care system or educational materials. Also, it is recommended to adopt intelligent learner-based distance Learning and integrate it with the traditional education also use virtual reality (VR) techniques in practices. In developing countries, it is recommended to promote the digital skills of both students and instructors in medical education and health institutions.

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Dr. Intisar A.M. Al Sayed. She got her BSc. She got her B.Sc. degree in B.Sc. in Control and Systems Engineering from University of technology in Baghdad-Iraq in 1986, M.Sc. in Electronics and Communication Engineering. College of Engineering, Al-Nahrane University in Baghdad-Iraq in 1993, and PhD degree in Control and Computer Engineering, from University of Technology, Baghdad-Iraq in 2000. She is an Associate Prof. at Department of Computer Engineering Techniques, in Al-Nukhba College University, Baghdad-Iraq. She has got more than 23 years of teaching experience. She has published several papers in major international journals and peer-reviewed international conference proceedings. Her research interests include: Intelligent Systems, control systems, soft computing, and Software Engineering.

Dr. Nedhal A. Al-Saiyd. She got her B.Sc. degree in Computer Science from University of Mosul-Iraq in 1981, M.Sc. and PhD degrees from University of Technology, Baghdad-Iraq in 1989 and 2000 respectively. She is a Prof. at Computer Science Dept., Faculty of Information Technology, in Applied Science University, Amman, Jordan. She has got more than 28 years of teaching experience. She has published several papers in major international journals and peer-reviewed international conference proceedings. Her research interests include: Software Engineering, Ontology Engineering, Intelligent Systems, User Authentication, Security, Image Processing and Speech Processing.

