Full Length Research Article

INTEGRATION OF HOSPITAL SYSTEMS INTO MEDICAL EDUCATION: A BLENDED LEARNING APPROACH

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ABSTRACT

The E-learning tools facilitate and extend students learning experiences beyond the boundaries of the classroom. These tools and applications include activities to increase the interaction among students themselves and between instructors and students on the other side. Medical education requires more practical sessions, and student involvement in medical procedures at various levels. E-learning design and implementation for medical education should be tailored to satisfy such needs. For a productive and interactive learning environment, e-learning tools in addition to access to text books, online updated information and lectures materials, should be able to provide students with access to real cases including medical history, lab results, radiology images, and other patient related information. Such resources and tools would improve the student diagnostic and intervention skills and critical appraisal skills, influence their learning outcomes, and improve students' learning capabilities as well as their accessibility. The current study discusses the approach designed in the College of Medicine and King Saud University Hospitals to build and integrate the medical e-learning system with the main hospital information systems such as hospital information system, picture archiving and communication system, lab system, and operation rooms system to provide medical students with access to hospital information and resources required to pursued their medical studies and to support the blended learning approach. This study was conducted in years 2009-2010 as part of the College of Medicine efforts to integrate e-learning solutions into medical education. The design discussed in the current study considered major challenges of medical education and the e-learning settings requirements and proposed strategies and techniques to satisfy these requirements and overcome challenges. It proposed a solution to the integration concern as well by employing a medical portal to work as an interface layer between the e-learning system and medical systems. This layer should greatly simplifies the integration, and improves the efficiency of the e-learning system. This approach is also useful in securing patient information privacy against unauthorized access and at the same time providing students with required access to analyse, and diagnose educational cases. In conclusion, for medical education, e-learning systems should be designed to overcome limitations such as privacy, space and integration, and to simplify hospital information accessibility furthermore to help in overcoming other medical education challenges and provides an effective approach to integrating technology into pre-clinical and clinical medical education. In addition e-learning systems should advance student engagement in medical procedures and operations, and access to real and life cases with exceptional care in handling the privacy and security of patient data.

INTRODUCTION

Education has evolved from a teacher centred and a material one way based process where the instructor (teacher) focused on offering information to students with no regard to differences in their learning capabilities and preferences.

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Education has changed (at least in theory) to a student (learner) cantered process where students are encouraged to learn at their own pace, students role changed from being a receiver to a learner and the instructor role changed to being a mentor and facilitator guiding students to acquire knowledge and improve their learning skills (Albarrak, 2011). In addition, the rapid evolution and growth of information and communications technologies (ICT) in the past two decades, and the rapidly changing health care environment with

advances in the biomedical sciences in the diagnoses and management of diseases, and delivery of health care services, have led to the development of new strategies and applications. Such strategies and applications have created values in almost every aspect of medical education fields which have witnessed major development because of ICT services and applications (Chen *et al.*, 2005; Whitis, 2001; Albarrak, 2010; Albarrak *et al.*, 2009). E-learning systems are educational systems that utilize ICT resources including Internet, computer networks, multimedia and other resources to enhance the teaching and learning process and provide students with necessary tools to acquire knowledge and professional skills. Various approaches were employed to implement e-learning systems including distance education which enables students to get degrees remotely with no necessity for attending lectures physically. Moreover e-learning systems can be used in conjunction with traditional learning (blended or integrated learning) to expand the resources available for students, and help them focus on their learning objectives (Albarrak, 2010; Albarrak *et al.*, 2009; Hayashi *et al.*, 2006). Blended learning strategy has proved effective in many fields of higher education including medical education. Blended learning includes learning activities that involve a systematic combination of co-present (faceto-face) interactions and technologically mediated interactions between students, teachers and learning resources.

Blended learning can be designed for a specific course or a content that has clear objectives by incorporating suitable learning activities (Albarrak, 2010). Blended learning is a context-dependent approach which demands proper facilitator's knowledge, attitude and skills with respect to teaching techniques and technologies. Thus, a successful implementation of blended learning requires proper training and preparations for both facilitators and learners. Moreover a successful implementation of blended learning in one domain does not necessarily mean that it is applicable for other domains (Albarrak, 2011). The introduction of e-leaning in medical education has made significant changes in the way medicine is taught (Albarrak, 2010). Additionally that made it mandatory for the medical students and instructors to have advanced ICT skills to support them achieve medical education goals and to be able to better manage and utilize e-learning applications, and to gain more from the online information, and the Internet (Albarrak, 2010; Albarrak *et al.*, 2013). Although e-learning and blended learning make use of computers and the Internet, it should be clearly indicated that focus should not be on the technology, rather, the educator must determine the best way to deliver a particular topic to be able to determine how technology could enhance the teaching and learning process (Albarrak *et al.*, 2009; Hayashi *et al.*, 2006; Albarrak, 2010; Albarrak *et al.*, 2013; Kumar and Zayapragassarazan, 2012).

It is well noticeable that the revolution of ICT and advances in computer capacity and e-learning systems could significantly be utilized to enhance and advance both medical practice and education. Computer applications in medical education has been developed to enhance traditional education strategies, and to provide new methods for learning and teaching. For undergraduate students, computer-based learning can be applied in various methods such as drill-and-practice where material is accessible to students and they can be evaluated

immediately by multiple choice questions, discrimination learning where the student is asked to differentiate between two apparently similar sets of clinical findings, and clinical training where the common "visit rounds" are replaced by patient computer simulated programs; as well as searching the Internet for medical information (Scalise and Gifford, 2006; Casebeer *et al.*, 2008; Curran *et al.*, 2006; Choules, 2007; Davis *et al.*, 2007; Koh *et al.*, 2008).

MATERIALS AND METHODS

The current study discusses the approach and design adopted in the College of Medicine and King Saud University Hospitals (KSUHs) to build and implement a medical e-learning system to provide medical students with access to resources they need and further how the goals of such system can be achieved by implementing a medical portal designed for integrating and interfacing different medical information systems such as Hospital Information System (HIS), Picture Archiving and Communication System (PACS), and operation rooms integration and control system with the e-learning system. King Saud University Hospitals (KSUHs) represents the College of Medicine, King Khalid University Hospital, King Abdulaziz University Hospital and King Fahd Cardiac Centre. The number of undergraduate students in these colleges are over two thousands, and the number of College academic staffs are over five hundred. This study was conducted in years 2009-2010 as part of the College of Medicine efforts to integrate e-learning solutions into medical education.

RESULTS

Challenges of medical education

Medical education aims to provide students with the essential skills and knowledge they need to perform their future responsibilities as physicians in competence. Furthermore, medical education is not restricted to undergraduate students; the continuous medical education is an essential component of medical career development (Albarrak *et al.*, 2006). In addition to postgraduate degrees and medical residency and fellowship programs. In order to satisfy the needs of medical students and practitioners, medical education should provide students with the basic sciences courses such as biology, anatomy, and physiology, as well as practical experience including participating in live cases, live operations, and grand rounds which adds more challenges to the traditional educational process. In addition, developments in medical education has also resulted in the conception of the problem based learning (PBL) where students are assembled in small study groups which focus on examining a true or simulated case and learn by trying to find an accurate diagnosis and treatment for this case (Koh *et al.*, 2008; Albarrak *et al.*, 2013).The nature of medical education presents several remarkable challenges including:

Space: Wards, clinics, and operation theatres have limited space for students and interns. The space limitation can prevent in many cases students from attending essential operations and procedures and decrease their chances in fully observing and participating in examining live cases which in turn would have a significant negative impact on their skills and practical experience.

Patient privacy and safety: Health Insurance Portability and Accountability Act (HIPAA) as well as other health regulations attempt to secure patients' data and care for their privacy (Wilson, 2006). This security may be threatened by students' unsupervised and unauthorized activities during accessing patients' data and medical history. These threats may affect the medical institution reputation and may even lead to legal prosecution (Caroline and McCubbin, 2006).

Limited access to patient data: Limited access could result from the lack or limited systems integration. Furthermore, unsupervised access to patient data can lead to serious complications. Therefore, students' access to patient data is usually restricted which prevent students benefiting from having complete history and information for precise diagnosis and full practice experiences.

Problem Based Learning (PBL) requirements: PBL stimulate the acquisition of an extensive and integrated knowledge that is readily recalled and applied to the analysis and solving of patient problems. It also requires students to take responsibility of their own learning activities, and it encourages collaboration between students. The nature of PBL requires resources to be readily available for students, and requires more interaction between students than traditional educational models. These requirements are not always easily provided in medical colleges (Albarrak *et al*., 2013).

Computer skills: Most students and/or faculty members may lack the necessary skills to use computer-based learning applications effectively and are therefore considered handicapped. A minimum set of skills and computer knowledge should be implied for assuring that all medical students/faculties are "computer literate". The emphasis of such requirements should be on familiarity for example with word processing, databases, and electronic mail, and with bibliographic literature searching. Several studies were conducted to assess students' computer silks and family medicine consultants' perceptions to use online resources were conducted. The result of these studies showed that although the students had reasonable general computer skills, they lacked the capabilities to use these skills in medical education and research. Results suggested that students and faculties should receive proper training in order to utilize systems in an adequate way, and urged to add courses in medical informatics for the students in undergraduate medical curriculum (Albarrak *et al*., 2009; Albarrak, 2010; Albarrak *et al*., 2013). These challenges can deprive students from building and improving skills they need for a successful medical career and can consequently cause serious threats to their future patients. Therefore, solutions should be suggested and applied to overcome these limitations. This paper discusses the design and explains in the following section show e-learning can help to eliminate and overcome these limitations and support students with medical skills acquisition and development.

E-learning in medical education

In addition to the above challenges, medical education is a heavily practice dependent education. In other words medical students will never be competent unless they are provided with sufficient practice in form of live cases, clinical procedures, radiology images examinations and diagnosis, patient medical history review, and other medical practices. E-learning can play an important role in medical education both in the theoretical and practical parts. In students' educational practice, e-learning would enable and support students to acquire the necessary medical experience by providing the following benefits (Whitis, 2001):

- Improving student-faculty interaction by enabling student to interact with faculty members from any place using a portal, learning management system (LMS), and smart classroom technologies (Albarrak *et al*., 2010).
- Improving student-student interaction which is essential in PBL and in student collaboration by using, the portal, LMS and discussion boards (Albarrak *et al*., 2010; Anderson, 2003).
- Overcoming the space and time limitation problem by providing students with real cases and operation theatre attendance benefits through modern technologies such as video conferencing, online live and on demand sessions, and simulations, which allows more students to participate in the examination of important cases, attend and review more operations and clinical procedures during their academic years. E-learning tools and materials designed with text, images, audios and videos and simulation would effectively demonstrate complex medical cases. In addition medical students would obtain practical experiences and skills, through video conference, live experiences of operation theatres, Intensive Care Units (ICUs) and other sensitive medical care rooms and observe thrill operations and critical procedures (Wiecha, 2003).
- Preserving patient privacy and safety by limiting the access of students to patients' medical records and possibly hiding patients' personal data.
- Supporting PBL by providing students with structured knowledge through the Internet, online libraries, and accessing published articles and studies, in addition to access to patients clinical data. Furthermore, acquiring knowledge and skills to practice evidence based medicine (EBM) is an essential competence for medical trainees (The Foundation Programme Committee, 2005). For EBM teaching and learning to be more effective, it should be clinically integrated (Khan and Coomarasamy, 2006). However, teaching of EBM and critical appraisal in many cases takes place in the classroom and lecture theatres away from a clinical setting. The integration of the clinical settings into PBL and EBM teaching is considered and important factor for a successful medical education that can be achieved by the support of e-learning systems and tools.
- Enabling students to learn at their own pace from anywhere by using distance learning tools such as LMS. This will enable students to take responsibility of their own learning and help them to become lifelong learners.

In order to utilize the full benefits of e-learning systems e.g. LMS and video conferencing they must be integrated with existing hospital information systems to provide students with the required medical data and to help them analyse clinical cases in the most appropriate way. Such integration represents a true challenge in adopting e-learning in medical education.

Integration challenges

Integrating e-learning systems with existing health information systems faces many difficulties. One major difficulty is the

diversity in these systems, and the different protocols adopted for communicating with other systems. For example, most used healthcare systems comprise a hospital information system holding patients' information including their demographic data, lab results, and allergies. Students should use this system in order to access basic patients' information. Modern HIS systems usually use the HL7 protocol which is used for communications between medical systems (Robert *et al.*, 2001). Picture archiving and communication system is a system that works closely with radiology information system (RIS) to capture, store, retrieve patient radiology images, and formulate reports regarding medical cases (Samuel and Dwyer, 2000). The PACS system data is required by students in attempting to diagnose a case that requires the examination of radiology images. These systems use DICOM and HL7 protocols to communicate with other systems (Dean *et al.*, 1997). Electronic Medical Records (EMR) system holds all patients' history including prescriptions, diagnosis, lab results, discharge reports, and other patients' clinical history data. Patients' history represents an essential source of information required by students to accurately diagnose a case. This system is a database based and mainly requires interfacing with its database to retrieve data.

As shown in Figure 1, diversity in healthcare systems complicates the integration with e-learning systems, and in line, complicates the e-learning systems themselves which may cause difficulties for users specially students in operating these systems and hence may causes deficiencies in the educational process instead of improving its quality and outcome. In addition, one of the main challenges facing integration is to protect the privacy and confidentiality of patients' information. The concern here is to prevent private or sensitive data from being revealed, unnecessarily. Students may need to access patients' clinical information and medical history anonyms without the need to reveal patients identity in most cases. Furthermore patients' sensitive data should always been restricted from access by any unauthorized person, which requires special care when planning the integration to handle these requirements.
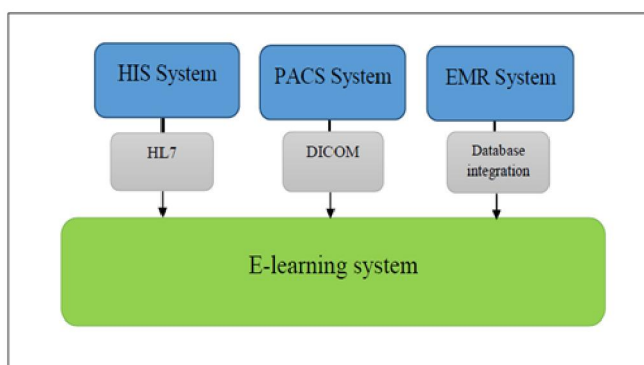

Figure 1. Integration between healthcare information systems and e-learning systems

Implementing integration between systems

In order to overcome the obstacles and limitations facing the integration between hospital and e-learning systems, a careful design of the interface between the two types of systems is proposed. In addition to standard unified access and single

sign on and other usual benefits of portals. The main goals of this design include:

- Minimizing the number of interfaces between systems will sequentially decrease the complexity of the integration, and thus will improve the efficiency and performance of the e-learning systems.
- Interfacing unifications between the different systems will greatly simplify the integration process, and will lead to decreasing the cost and duration of this integration.
- Handling the privacy and security of patient data can be controlled through the integration itself. This means that only the necessary information will be passed from the medical systems to the e-learning systems. Studies conducted to evaluate security and privacy of patients data revealed threats of unauthorized access by mainly nurses and other hospital professional staff. More attention should be given when dealing with junior staff and students (Albarrak, 2012; Albarrak, 2001).

In order to achieve these goals, a new layer can be added to the interfaces shown in Figure 1. This layer will unify all the communication protocols of the medical system into a single layer that can be interfaced with e-learning systems. As shown in Figure 2, this layer is composed of a medical portal with an integration engine. Medical portals have been used in healthcare systems for many years, and have proven their efficiency in unifying the interfaces between different medical systems and in unifying the interface to users of these systems (Kuhn1K *et al.*, 2001). Using a medical portal has many advantages including simplifying system integration, and freeing the e-learning system developers from dealing with complex medical interfaces to communicate with a database application, the medical portal will enable them to focus on the development of the e-learning system itself, and in improving the efficiency of the system. The design of the portal itself is of great importance, since it will be an important gateway link between the e-learning systems and the existing medical systems. In order to design such a portal the following points should be taken into consideration:

- The medical portal should gather information from all medical systems; these data can either be gathered periodically or when requested by the e-learning system.
- The portal should have a clear database topology to simplify the interface with the e-learning systems. It should gather data from those different systems using different interface components and write it on the unified database repository.
- The portal should be flexible enough to provide the e-learning systems with the capabilities to retrieve data based on the requirements of the case under study and the design of the study material provided by the faculty members.
- The portal should have the ability not to pass patients' private information to the e-learning system in order to protect patient privacy and security of data.

Once these design guidelines are applied, integration can be easily established between medical and e-learning systems, providing the students with a powerful system capable of providing them with exact information and enabling students to improve their analytical and diagnosis skills.
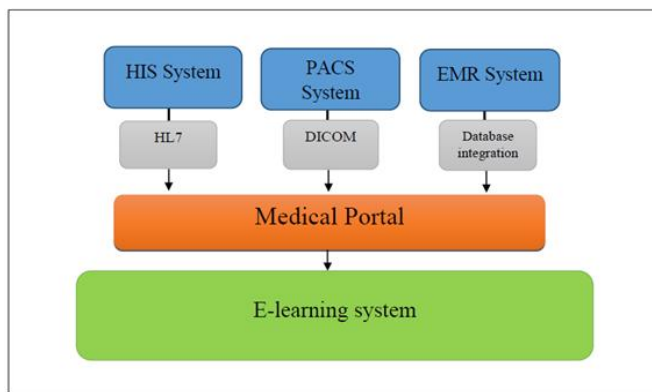
Figure 2. Integration using medical portal

DISCUSSION AND CONCLUSIONS

E-learning applications and tools implementations have greatly increased recently, for example in the United States, almost 3.2 million students had one or more online course in year 2005 (The Sloan Consortium, 2005). A growing number of universities across the world are now offering many e-learning courses that require either zero or little student attendance. E-learning systems can also be used in conjunction with traditional learning (blended or integrated learning) to expand the resources available for students, and help them focus on their learning objectives (Albarrak, 2011; Albarrak, 2010; Albarrak *et al*., 2009; Hayashi *et al*., 2006). KSUHs started to implement a modern state of the art an e-learning system. This system should be used to assist and support the current hospitals and College systems to provide students with tools to improve and manage their learning experiences, and assess their learning outcomes. It aims to combine database of patient cases with the e-learning system to provide medical students with data they need to succeed in their study (Albarrak, 2010; Albarrak *et al*., 2010).

Medical education and practices includes live cases, radiology films diagnosis, live operations, and other practices which represent an essential part of medical education. In order for an e-learning system to be successful in medical education, it needs to address both theoretical and practical sides of medical education and provide students with a similar experiences of real-life practice participation. Integrating e-learning systems with existing hospital systems is not a trivial process; it is always faced by many challenges and obstacles. This paper discussed the approach designed by King Saud University Hospitals in planning an e-learning system, and integrating it with existing hospital systems. This approach proposed a solution to the problem of integration by utilizing a medical portal to work as an interface layer between the e-learning system and the medical systems. This layer should greatly simplifies the integration, and improves the efficiency of the e-learning system.

This approach is also useful in securing patient information privacy against illegal access and at the same time providing students with sufficient data access to practice analysing, and diagnosing medical cases. This study considered the requirements and challenges of medical education and e-learning and proposed strategies and techniques to satisfy these requirements and overcome challenges. It expressed how these strategies and techniques are utilized in designing

KSUHs e-learning system. In conclusion, e-learning systems designed for medical education should consider handling the privacy and security of patient data, overcoming space limitation, and simplify medical information access in addition to other medical education challenges. For future study, the effect of these system on the performance of medical students need to be examined to assess the value of such systems in enhancing medical education and helping students in construction and improving their skills, and hence their performance as physicians in the future.

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