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Building Health Informatics Technologies for Higher Education in the Health Sciences

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Abstract

Building a new state of the art university campus for undergraduate and postgraduate education requires a unique setup that encapsulates the latest in educational advancements and their supporting equipment. Blending technologies into the architecture of the educational venues so that they become integral to the teaching and learning experience is fundamental. When building solutions for a university specialized in health sciences, it is challenging to identify what is demanded of the technology. This paper focuses on the construction and implementation stages of a university that teaches medical, nursing, dentistry, pharmacology and other allied health professions. This university combines both educational and healthcare facilities in its teaching. Data was collected using a qualitative 'Action Research' approach, whereby iterative implementation cycles revealed best practices and project management constructs. The research shows that a technologically advanced health sciences university campus must not only provide smart classrooms, but should also support clinical skills and science labs, simulators, problem based learning tutorial rooms, computer labs and distant learning classrooms with the latest technologies. The study also reveals that health informatics solutions must be in place to support medical records for mock and real patients, as well as actual dental clinics with radiology information systems and picture archiving and communications systems alike. This paper focuses on the project management and implementation experience of a newly constructed university specialized in health sciences, by shedding light on the deployed technological solutions and by means of highlighting the best practices to be taken into consideration when implementing such tools.

Keywords: Higher Education, Learning Technology, Medical Education, Health Informatics

Background

King Saud bin Abdulaziz University for Health Sciences

King Saud bin Abdulaziz University for Health Sciences (KSAU-HS) is a recently established university in Saudi Arabia. It was founded in 2005 under the umbrella of the Ministry of National Guard, Health Affairs (M-NGHA). The Health Affairs as a governmental non-profit healthcare organization is comprised of two medical cities; one in Riyadh and one in Jeddah. There are also hospitals in Dammam, Al Ahsa and Al Madinah and over 100 primary healthcare centres across the Kingdom of Saudi Arabia. KSAU-HS is closely affiliated with the Health Affairs' hospitals as the academic arm of the organization. The KSAU-HS university campuses and accommodations are physically located on the same grounds as the hospitals.

The university has three campuses in three different cities; Riyadh, Jeddah and Al Ahsa. The Riyadh campus is the largest site and hosts seven colleges; Medicine, Nursing, Dentistry, Pharmacology, Public Health & Health Informatics, Science & Allied Health Professions and Applied Medical Sciences. Its sister site in Jeddah has four colleges; Medicine, Nursing, Science & Allied Health Professions and Applied Medical Sciences. The Al Ahsa site is the smallest campus and hosts three colleges; Medicine, Science & Allied Health Professions and Applied Medical Sciences. Being the academic leg of the M-NGHA operation, the KSAU-HS provides and supports courses and opportunities for continuous medical education and oversees the residency training programs.

The M-NGHA sites also encompass the King Abdullah International Medical Research Centre. All three KSAU-HS university sites are connected with each other and also with the M-NGHA hospitals via high-speed data carrying complex wide area network (WAN) communications infrastructure. As a university, KSAU-HS is by all means complex in its structure and purpose.

Purpose of the Study

Although there is a wealth of literature about Health Informatics education and the issues involved (Hasman et al., 2011; Haux, 2008; Johnson & Friedman, 2007; Mantas et al., 2010) (Bacigalupo, Bath, Booth, Eaglestone, & Proctor, 2001), there is very little discussion on the role of Health Informatics practice and tools in higher education in the health sciences and medical fields. The purpose of this paper is to highlight some of the intricacies involved with building information technologies for a geographically dispersed university campus specialized in the medical and health sciences disciplines by examining a case study in practice through an Action Research methodological approach. More specifically, this paper focuses on creating a design blueprint by exploring the complexity of building technologies in health sciences education. The study observes how technologies were blended into the educational architecture, explores how to best combine educational and healthcare technologies, and observes the construction & implementation stages of the project.

Introduction

Continuing Medical Education

Healthcare needs to compete with other sectors for an information literate workforce and to equip its workforce through on going refreshment of information skills (Bacigalupo et al., 2001). Technology solutions have for many years been integral to supporting advanced education provision. Continuing education of healthcare professionals is a key element for the quality and efficiency of a health system. Technology solutions like telemedicine tools enable the communication and sharing of medical information in electronic form, and thus facilitate access to remote expertise. A physician located far from a reference centre can consult its colleagues remotely in order to resolve a difficult case, follow a continuous education course over the Internet, or access medical information from digital libraries or knowledge bases. These same tools can also be used to facilitate exchanges between centres of medical expertise: health institutions of a same country as well as across borders (Geissbuhler, Bagayoko, & Ly, 2007).

Virtual Reality

Virtual reality has also been used as a training mechanism for healthcare practitioners learning to use surgical endoscopic equipment (Sewell & Thede, 2013). Traditional medical education using books, lectures, physical models, and cadavers may no longer be the most efficient methods for teaching complex anatomical relationships. A study by Silverstein et al. (2006) was designed to measure whether teaching complex anatomy to medical students using immersive virtual reality is an improvement over traditional methods. They conducted a study using a networked immersive virtual reality system. First-year medical students were given workshops one day before or after a traditional three-hour lecture or laboratory session. Students who attended only the traditional session served as a comparison group. Improvements demonstrated a statistically significant advantage to the brief virtual reality session over the traditional session, while improved results for those who were exposed to both the traditional and immersive sessions was also better than for the students who were exposed the traditional session. Silverstein et al. (2006) conclude that immersive virtual reality can be an effective enhancement to traditional surgical-anatomic educational curricula.

Biomedical Informatics

Information technology has become pervasive in all aspects of healthcare. It is present in microscopes; in DNA sequencers; in chips for bacteriology; in all types of devices, from pacemakers to MRIs; it is the cornerstone of running hospitals and building community networks. Building the virtual physiological human would not be thinkable without information technology. Advances in DNA sequencing from the field of biotechnology can make it possible to know the whole genome of a patient at a reasonable cost and time in the near future. This opens the door to the practice of a more personalized medicine. Beyond this, advances from physics, chemistry and engineering are facilitating new ways of intervention in the human body to repair or replace parts of it that have failed to perform its function properly, either by accident, disease or aging. These developments are shaping the areas known as Nano medicine and regenerative medicine. Similar advances are occurring in other areas such as sensors or mobile devices.

The challenges related to the promotion of interdisciplinarity can impact on the design of programs for the education of future scientists in biomedical and health informatics. Hasman et

al. (2011) encourage the promotion of training in skills that can be used for these programs. They also encourage the use of social networks to interact and participate with other communities and multidisciplinary research networks utilizing technology to bridge the gap between academic theory and real world practice and to meet students' demands to see the wider picture behind modernization of health services. Furthermore, they stress the importance of education in methods of retrieval, organization and filtering of information that would allow learners to keep abreast of the latest developments in their areas of interest. All of these can be supported with advanced technology tools when technology is considered used as a facilitator of transferable skills. Furthermore, they explain how stimulating collaborative work across multiple health professions has enabled students to understand multiple perspectives of stakeholders by modelling the same social interaction in electronic environments. This demonstrates how technology can enable advanced, social and collaborative learning in healthcare education.

Technology Trends in Higher Education

The Gartner report (Lowendahl, Thayer & Morgan, 2016a) evaluates the top ten business trends that will drive the global higher education industry in 2017, highlighting the impact on IT organizations that are significant to leaders in higher education. These trends include Competency-Based Education, Reinventing Credentials, Analytics Everywhere, Rankings, Breaking Boundaries, Revenue Diversification, Increasing Political Intervention, Innovative Learning Spaces, Personalization in Education and Student Recruiting.

The Gartner Report (Lowendahl, Thayer & Morgan, 2016b) also identifies the top ten strategic technologies relevant to the higher education industry in 2017, highlighting the impact on technology. These technologies include Open Microcredentials, Digital Assessment, Predictive Analytics, Adaptive Learning, Virtual Reality and Augmented Realty, Hybrid Integration Platforms, Institutional Video Management, Artificial Intelligence, Listening and Sensing Technology and Robotic Telepresence. Organizations need to take the time to assess which of these business trends and strategic technologies they have adopted. Most if not all of these trends and technologies should be evident in the fabric of what drives technology strategy adoption in higher education.

Trends in Higher Education in Saudi Arabia

There is evident trending growth in Higher Education in Saudi Arabia. In 2003 there were only eight public universities and seven private colleges in Saudi Arabia with a total enrolment of 550,000 students per year. While in 2014 the Kingdom witnessed significant reform in the provision of higher education with twenty-five public universities, thirty private universities and colleges totaling an enrollment of 1,200, 000 students per year. At least thirty of those educational institutes offer degrees in healthcare.

Spending on Education and Healthcare in Saudi Arabia

According to the Fiscal Budget for the Year 2017 (Kingdom of Saudi Arabia Ministry of Finance, 2017), Saudi Arabia's highest expenditure allocation is on Education & Training with an allocated SAR 200 Billion ($53.3 Billion), which is even higher than Health and Social Development with a budget of SAR 120 Billion ($32 Billion). Compared with spending on Military of SAR 191 Billion ($ 51 Billion) and Security & Regional Administration which SAR 97 Billion ($ 25 Billion), the expenditures on education are notably high (Table 1).

SN	SECTOR	PROJECTED EXPENDITURES 2016	ACTUAL EXPENDITURES 2016	PROJECTED EXPENDITURES 2017
1	Public Administration	28,463,916	26,770,107	26,716,039
2	Military	179,098,762	205,096,320	190,854,490
3	Security & Regional Administration	102,395,439	100,626,987	96,687,000
4	Municipality Services	34,686,603	24,960,543	47,942,215
5	Education	207,144,501	205,826,142	200,329,066
6	Health & Social Development	124,835,481	101,435,223	120,419,691
7	Economic Resources	36,797,919	38,248,009	47,260,814
8	Infrastructure and Transport	30,827,314	37,584,060	52,164,000
9	Public Programs Unit	95,750,065	84,452,609	107,626,685
	TOTAL	**840,000,000**	**825,000,000**	**890,000,000**

Table 1 2017 Budget Kingdom of Saudi Arabia (Kingdom of Saudi Arabia Ministry of Finance, 2017)

Methods of Research

Action Research

Learning by doing is a powerful paradigm and proven as a reliable methodological approach in education; whereby Bacigalupo et al. (2001) explain that students and staff alike can benefit from an action learning approach. In this study a qualitative 'Individual Action Research' approach was used to collect and analyse the data. Data were collected using field notes, analytical memoing, project reports and hundreds of pages of meeting minutes. The latter two were collected over several years spanning from 2010 to 2017. The data were collected and analyzed through various Action Research Cycles (Lingard, Albert, & Levinson, 2008; Peters & Robinson, 1984). Ultimately, the collection focused on four action research cycles; Planning the Project, Implementing the Project, Receiving the Project and Reflecting on Lessons Learned (Figure 1).

Project Implementation Stages

Action research iterative analyses of the four cycles were conducted for four distinctive project implantation stages; 2008: Planning, 2010: Implementing, 2013: Receiving, 2016: Closeout (Figure 2). The findings of the detailed analyses of the various implementation cycles revealed the key components and challenges of building the health informatics technologies for the various colleges and entities of the university campus.

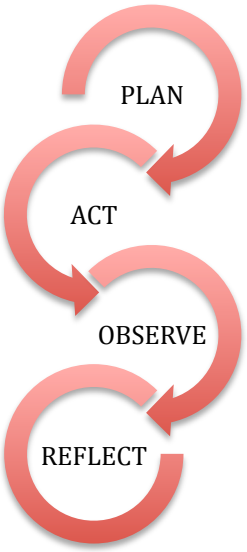

Figure 1 Action Research Cycles

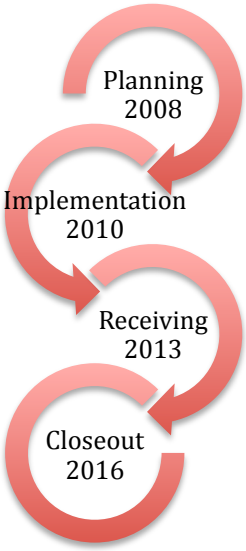

Figure 2 Project Implementation Stages

Results and Discussion

Technologically Advanced Health Sciences University

Observing the various cycles of the project over time and reflecting on the stages revealed health informatics solutions are vital in health sciences education; resulting in eight themes of focus: 1) Building the Infrastructure, 2) Clinical skills and Simulation Centers, 3) Science and Computer labs, 4) Specialized Colleges & Dental Informatics, 5) Virtual Patient for Problem Based Learning Tutorial Rooms, 6) Video Conferencing, 7) Research Labs, and 8) Live streaming Surgeries.

Building the Infrastructure

Being geographically dispersed, building the network infrastructure for the three KSAU-HS campuses and integrating them with each other and the hospitals was an achievement in itself. The three dispersed campuses are connected via the network since the three campuses operated as one university. High speed data carrying network designed and implemented by market leaders and one of the most advanced in the regions providing seamless integration between all sites. A user can easily transfer their profile between regions and have full access to their data, email and other resources from any of the three regions.

Internal IP telephony between the three regions, video conferencing for meetings and for teaching, cross campus seminars and symposiums, conferences, and even the live transmission of surgeries across campuses for teaching purposes is used. Many educational and related extra-curricular activities are care broadcast between the convention centres' main auditoriums including graduation ceremonies, awareness presentations, and inaugural ceremonies.

Clinical Skills and Simulation Centers

Leveraging technology when teaching clinical skills was at the core of the clinical skills and simulation centers built for the three campuses of KSAU-HS. This in itself was a major and challenging project requiring the procurement of specialized equipment. With these types of teaching environments instructors are able to record and save sessions for viewing or feedback therefore allowing them to teach clinical skills without being physically present with the students. Ultimately, by video recording the simulation sessions, instructors and students can observe recorded sessions in real time or offline.

Science and Computer labs

Designing the various labs required special attention. The medical equipment required separate isolated virtual networks to connect devices like microscopes to their backend systems while being seamlessly integrated in the designs of the labs (Figure 3).

Figure 3 Science Labs

Medical education requires students to regularly take objective structures practical examinations. Specialized computer labs were designed for this with the highest levels of security while allowing the students to observe the cases and comfortable conduct their examinations in a secure environment (Figure 4).

Figure 4 Computer Labs

Specialized Colleges & Dental Informatics

A case study examining classroom instructional practices at a U.S. Dental School found that learning experiences that will actually be used in practice are essential to ensuring that active learning and critical thinking are demonstrated in the curriculum (Behar-Horenstein, Mitchell, & Dolan, 2005). The specialized requirements of a dental school are considered the most technologically challenging out of all colleges within the KSAU-HS. Actual dental clinics complete with patient records and real patients become an integral part of the academic college building bring into the design the challenge of providing dental informatics solutions within the core of the dental college.

Virtual Patient for Problem Based Learning

Using the support of technology as observed in an e-learning case study based approach provides one mechanism for group interaction, social learning and collective problem solving (Bacigalupo et al., 2001).

The KSAU-HS College of Medicine opted to adopt a hybrid curriculum that offers a problem based learning (PBL) approach as one of its main strategies along with lectures and other teaching and learning strategies. PBL in this program is extended to a full problem-solving life cycle, starting form enquiry, through investigation and diagnostic decision-making to management and prevention of the problem in a defined number of steps; either eleven or nine steps. The classrooms used for this type of teaching are setup with a meeting room style seating with a limited number of participant (usually limited to 10 students). This is very different from traditional teaching styles and the audio-visual technologies that support this type of teaching were incorporated in the KSAU-HS campus design.

Overall, the number of PBL classrooms in the campus far outnumbers the traditional classrooms. Since these classrooms are designed to teach in small groups, yet each one of them requires a full audio visual setup with interactive board and projector, computer and sound system. The investment in audio visual technologies to support this type of teaching was

substantial, where it is not possible to reply on large classrooms or auditoriums for teaching. The ratio for audio visual setup to number of students becomes around 1 to 10. Using advanced technologies PBL can be offered online allowing hands on experience for students.

Video Conferencing

The classrooms across the regions of KSAU-HS are technologically advanced with over 220 multimedia equipped classrooms. The university campuses are strategically designed to support teaching from any region/site within the infrastructure via video conferencing. These classrooms allow physically dispersed campuses to interlink and let instructors collaboratively teach across the regions and between different colleges within the region itself. Two very successful examples at KSAU-HS are the Masters Medical Education and Masters of Health Informatics (Justinia & Shalaby, 2014) programs that are successfully taught by faculty physically present in Riyadh across three regions (Figure 5).

Teaching through a video conferencing supported approach is a constructive tool that can facilitate the provision of a successful postgraduate course. This type of setup can provide an excellent setting for knowledge exchange and improved collaboration between students. Instructors' time can also be used more efficiently by eliminating the need to repeat sessions. While students generally prefer to learn with a physically present instructor, using video conferencing creates the opportunity to offer educational programs to students in locations that would have otherwise been excluded. (Justinia & Shalaby, 2014).

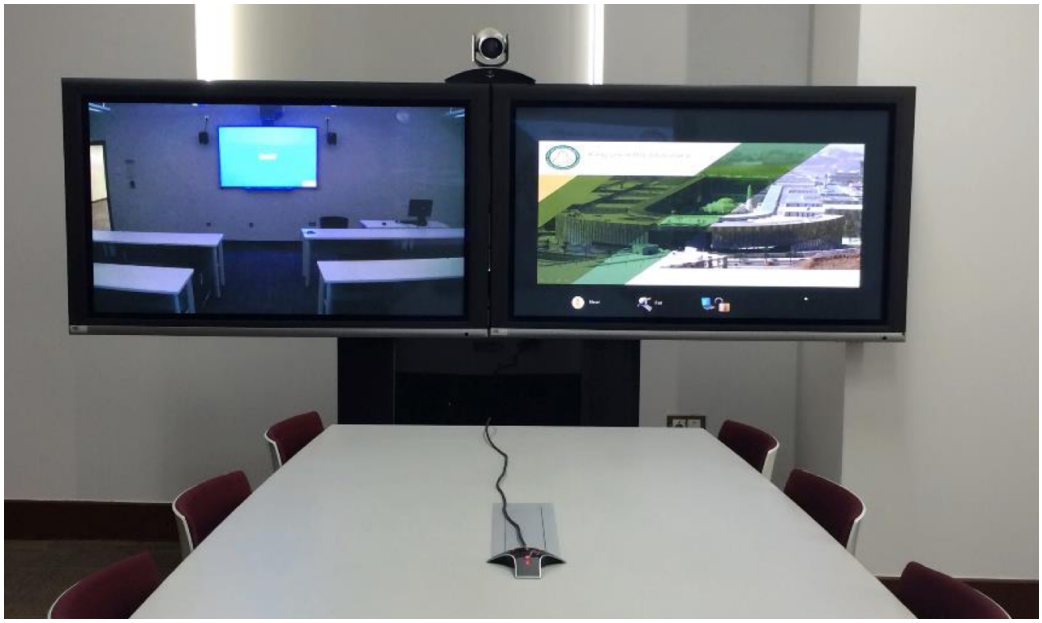

Figure 5 Video Conference Classroom

Research Labs

King Abdullah International Research Centre is the research arm of the organization. The centre itself is also technologically advanced and fully equipped as a state of the art research centre. Equipping the labs with the latest technologies was considered a project in itself and required specialized attention during the installation phases of the implementation (Figure 6).

Figure 6 Research Labs

Live Broadcast of Surgeries

One of the advantages of having he university campuses linked to the hospitals is allowing the students to virtually observe live broadcast of surgical operations via medical quality specialized cameras that transform the massive theatres in each campus into a virtual operating theatre (Figure 7).

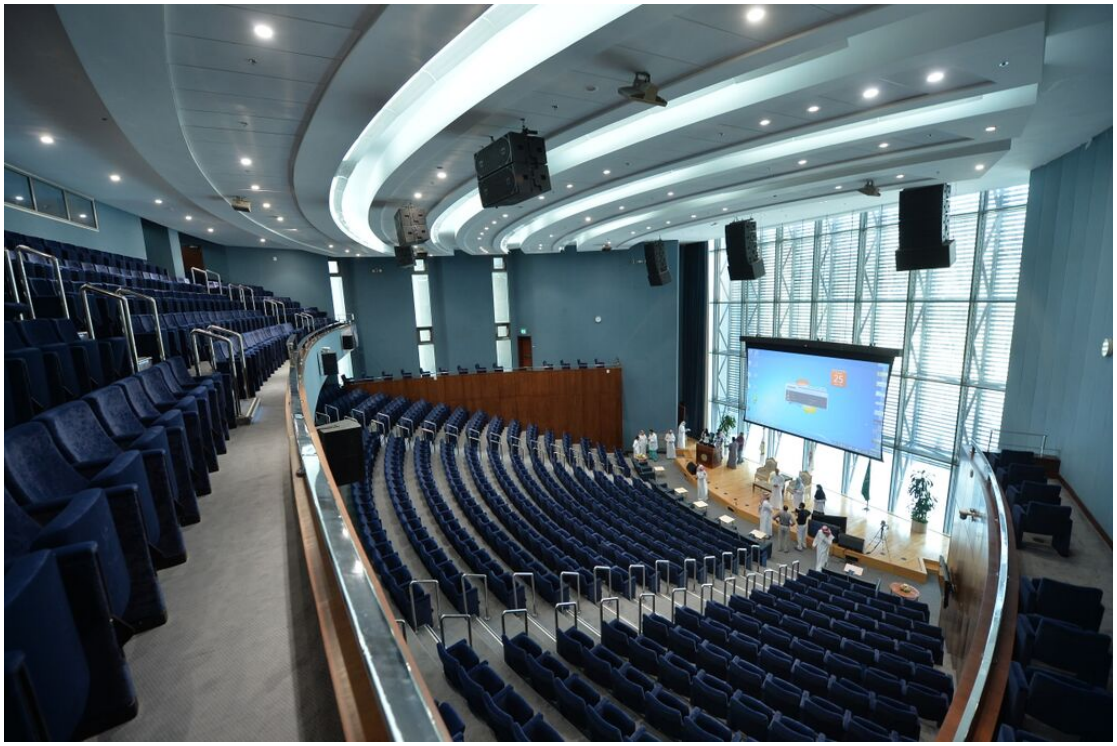

Figure 7 Broadcasting at Convention Centre

Conclusions

Summary of Findings

The leaders of KSAU-HS set out to build a state of the art university campus for undergraduate and postgraduate education with a unique setup that encapsulates the latest in educational advancement and supporting technologies. This vision was incorporated into the architecture of the educational venues that become integral to the teaching and learning experience for faculty and students alike. Their aim was to benchmark themselves against world-class leaders in medicine. KSAU-HS emerged as a technologically advanced health sciences university campus that provide smart classrooms, and supports clinical skills and science labs, simulators, problem based learning tutorial rooms, computer labs and distant learning classrooms with the latest technologies and health informatics solutions. KSAU-HS as university specialized in the health sciences -and spread across three regions of Saudi Arabia- is very unique. Joined with the epic medical cities that engulf it, the university is privileged and in an opportune position for success. The university has a chance to emerge as a model site for technologically innovative medical education, and has the potential to advance the provision of healthcare in the region by reinforcing the root of education using technology tools.

Challenges and Lessons Learned

It is estimated that only one third of healthcare IT projects achieve success (McCarthy, Eastman, & Garets, 2014). Additionally, half of all large-scale IT projects go beyond original budgets by 45% and 7% over intended time, while delivering 56% less value than predicted. (Bloch, Blumberg, & Laartz, 2012). This project was not without its challenges. Mainly, there were project management challenges that can be summarized into six points: 1) Multiple vendors and subcontractors, 2) Linking various types of technologies, 3) Project delays: advances in technology outpaced the implementation, 4) Venders lacked of expertise in Health Informatics, 5) Vendors lacked a holistic view during implementation, and 6) Dispersed delivery of key functions.

Despite the challenges, the university merged as a model site in the Middle East. The smart campuses at KSAU-HS literally pulsate with technology. The underlying technical infrastructure was built to support three interlinked campuses that can literally see each other from within every lecture hall and the advanced technologies have proven as a positive driver for students and faculty alike.

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