Lessons Learned From Implementing E-Learning for the Education of Health Professionals in Resource-Constrained Countries

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Abstract: The growing global demand for tertiary education has led to the increased use of e-learning approaches around the world. Demand has increased most rapidly in low and middle income countries (LMICs), which account for half of the students currently enrolled in higher educational institutions (HEIs). But the implementation of e-learning programmes in resource-constrained settings faces many obstacles. This paper explores some of the key issues involved in implementation of e-learning in HEIs involved in the education of health professionals, given the resource constraints within which many institutions have to function. We present case studies of three such LMIC institutions of varying size and primary purpose. The paper suggests use of appropriate ICT infrastructure, both in terms of hardware and software, combined with effective access and bandwidth management policies is crucial to the successful implementation of e-learning courses on health within HEIs based in LMICs.

Keywords: e-learning; global health education; connectivity; bandwidth management; capacity building; educational technologies

1. Introduction

The development of innovative ICTs, increased accessibility of the internet, and a growing global demand for tertiary education (Wende, 2003) has stimulated interest in e-learning – "the use of digital or electronic technologies and materials to support teaching and learning" (Power, 2014) – in many countries (Tinio, 2002). Investment in e-learning has the potential to provide high quality teaching at a lower long-term cost per student (Bates, 1995 ; Olsen, 2015), though initial costs may be higher (Kumpu, et al., 2016). It has been argued that the internet provides opportunities for the development of a 'global classroom' where individuals can learn in distant locations, at different times, and at their own pace, leading to a "borderless education … that crosses the boundaries of both time and space" (Middlehurst, 2006). By extending access to health professionals who are highly motivated but struggle to overcome the financial and social costs associated with full time attendance at a tertiary education institution, e-learning could contribute to capacity building in resource poor regions where they are most needed (Marrinan, et al., 2015; Hvorecký, et al., 2005).

The global demand for higher education is rising rapidly, with over 150 million people estimated to be seeking tertiary education by the year 2025 (Suhail, Lubega and Maiga, 2014). This demand is particularly prevalent in those 'low and middle-income countries' (LMICs), as defined by the World Bank, which account for half of the students currently enrolled in higher education institutions (World Bank, 2000). In particular, there is a rapidly increasing demand for global health related courses (Kerry, et al., 2011), which is reflected in the 34% growth in the number of recognised medical schools over the five years from 2007, many in LMICs (Duvivier, et al., 2014). In resource-poor environments, the advantages of e-learning may offer a way to satisfy this demand. There has been strong support in many LMICs for the integration of e-learning into existing healthcare teaching programmes, given a recognition of the need to substantially increase the number of qualified providers and ensure their more equitable distribution within a context of limited financial resources and academic staff (Frehywot, et al., 2013 ; Bollinger, Mckenzie-White and Gupta, 2011). However, implementers

Reference this paper as: Gupta M et al, "Lessons Learned From Implementing E-Learning for the Education of Health Professionals in Resource-Constrained Countries" *The Electronic Journal of e-Learning Volume 15 Issue 2 2017*, (pp144-155) available online at www.ejel.org

of e-learning programmes in these settings face many obstacles. Experience has taught that the integration of ICTs into the activities of any organization is a complex process that needs careful conceptualization and detailed planning (Greenhalgh and Stones, 2010). There are also obvious cost implications associated with both the initial acquisition of required hardware and software and, often not sufficiently considered, its long term maintenance and eventual replacement (Kumpu, 2016; Khan, Hasan and Clement, 2012). Even where financial constraints can be overcome, a lack of suitably qualified and experienced personnel may be a serious limitation, given that the success of e-learning projects is "often dependent on the skills and quality of technical support provided to end-users" (Gray, Ryan and Coulon, 2003). Without such support, the ability of even the most enthusiastic teachers and students to access and use the technology effectively may be severely hindered (Prostiv and Atkins, 2016 ; Valdez, et al. ,2004) . Users need continuous and timely help from technical departments, which may prove very difficult to provide when resources are severely limited (Moolman and Blignaut, 2008). Here we address some of the technical and logistical constraints to be negotiated by those attempting to develop new e-learning initiatives.

2. Methods

The aim of the paper is to inform those wishing to explore the potential for e-learning in courses targeting the health professions in HEIs using case studies from three institutions that deliver such courses. The case study approach seemed most appropriate, given that there has been limited previous research in this area. It seemed reasonable to assume that multiple interacting factors, concerning which we have at best anecdotal knowledge, would play a role in determining the relative success or failure of e-learning initiatives, and that those factors might vary considerably between institutions. The possibility that a case study could "*examine a particular instance but illuminate a general problem*" (Merriam, pp. 30) seemed most appropriate to the present task.

We selected the case studies from the twelve academic institutions in LMICs that collaborated on a recent e-learning project (Lucas and Kinsman, 2016). Selection was based on the diversity of the cases, in terms of both size and purpose. On this basis we selected: a major university with a prestigious College of Health Sciences; a medium size health research institute; and a relatively small academic institute primarily concerned with the education of health professionals. The case studies were conducted by three of the authors in their own institutions. They were conducted using a combination of their existing knowledge, a review of the variety of internal documents detailing the evolution of e-learning activities, and a series of semi-structured interview with key informants, both those involved in the development of courses and those supporting the use of ICTs in their implementation. The interviews focused on the resource and technical issues that arose during the design and implementation of relevant courses. In particular, they addressed: current, planned and potential e-learning activities; the main challenges encountered in course implementation; and strategies adopted or suggested to overcome those challenges.

Whilst we recognise that there is great variation between resource constrained countries and between individual institutions in those countries, we aim to identify some key issues raised in one or more of the studies and consider the approaches used to address them, in the hope that this may assist other health sector organisations who wish to incorporate e-learning into their training programmes.

3. Findings

3.1 Case Study One: Indian Institute for Health Management and Research (IIHMR), India

The IIHMR (Jaipur) is a university in Rajasthan, northwest India. It focuses on management, research, education and training in the health sector, with 300 students per year accepted onto its MBA courses, and with 46 faculty members covering a wide range of disciplines. It also collaborates with Johns Hopkins University (JHU) in offering their MPH programme as a blended learning course. This is designed to provide high quality public health capacity building at a relatively low cost, targeting students from LMICs.

Alongside traditional modes of instruction, IIHMR uses a wide range of educational technologies, with teaching content delivered via the internet, the Institute intranet and DVDs/CDs. Internet-based courses use an interactive learning management system (LMS) and incorporate a range of multimedia components including live streaming and recorded videos. The MPH course uses a LMS developed and maintained by Johns Hopkins University, with onsite technical support provided by IIHMR. This degree of outsourcing was seen as the best

option, given the significant financial investment, resources and expertise that an on-site server room demands.

There is a single ICT department (12 employees) providing technical support to the Institute, including network administration, software installation, network maintenance, resolving hardware and software problems, and security. The Institute runs a basic digital literacy course for students, removing the need for the ICT department to deliver such training. The internet connection is provided through both a local area network (LAN) and a wireless network. Staff and students access the internet using 200 computers maintained by the ICT department and connected to the LAN, or laptops and mobiles linked to the Wi-Fi network. The university relies on leased lines from two commercial Indian ISP providers, at speeds of 20 Mbps for regular operations and 5Mpbs as a standby option.

3.1.1 Challenges

Increased use of ICTs for educational purposes has provided many opportunities for IIHMR students but has raised a number of managerial, financial and technical challenges. These include: providing the required Institute-wide infrastructure (in terms of both hardware and software); designing and implementing an e-learning platform, which involved substantial initial expenditure and a dedicated team to maintain and upgrade it; providing support to both faculty and students; and managing bandwidth to avoid network congestion and allocate resources in line with Institute priorities. The ICT department has identified three main risks related to the network: excessive consumption of bandwidth; lack of compliance with Government regulations (for example, visits to websites banned by the Indian Panel Court); wilful misuse of the system, for example cyber bullying, computer hacking; and use of unauthorised software.

Growing use of multiple devices (mobiles, laptops, tablets) by students has led to increased consumption of bandwidth, placing a considerable additional burden on the network. The university environment is very challenging to monitor and manage, given the diverse range of demands on the system and potential for rapid and sometimes unexpected fluctuations in demand over time. Many students use the internet not only for educational purposes but to access social media sites or download music and videos. Such activities may consume much of the bandwidth and substantially downgrade access for other users. However, they are very difficult to prevent without imposing constraints on those who wish, for example, to access educational videos, download academic articles or attend relevant webinars.

3.1.2 Management strategy

In order to improve the performance of the network within existing resources, the department has adopted a multifaceted approach to reducing congestion. This focuses on: a fair usage policy agreed with users; network monitoring; and effective enforcement of access regulations. Network administrators monitor traffic flows, detect and eliminate viruses and provide real-time performance indicators. The freely available monitoring tools Wireless Network Watcher and Find Mac Address have proven very useful in identifying computers and devices connected to the network, including laptops, tablets and mobiles, allowing resolution of IP conflicts and restricting access where necessary.

In order to reduce overload, the ICT department uses a number of network optimization techniques:

1. A user authentication system, restricting access to the network.
2. Local caching for frequently used materials including e-textbooks and video clips.
3. Implementing a unified threat management approach (Christopoulos, 2011) using an all-in-one security application. This also allows users to check their internet usage and generate reports (figure 1), making users aware of the demands they are making on the system.
4. Blocking peer-to-peer torrent sites used to (sometimes illegally) download video and music files, except in exceptional circumstances and under the supervision of a member of the IT department.
5. The formation of user groups for prioritizing of network traffic.
6. Offline access to electronic mail services.

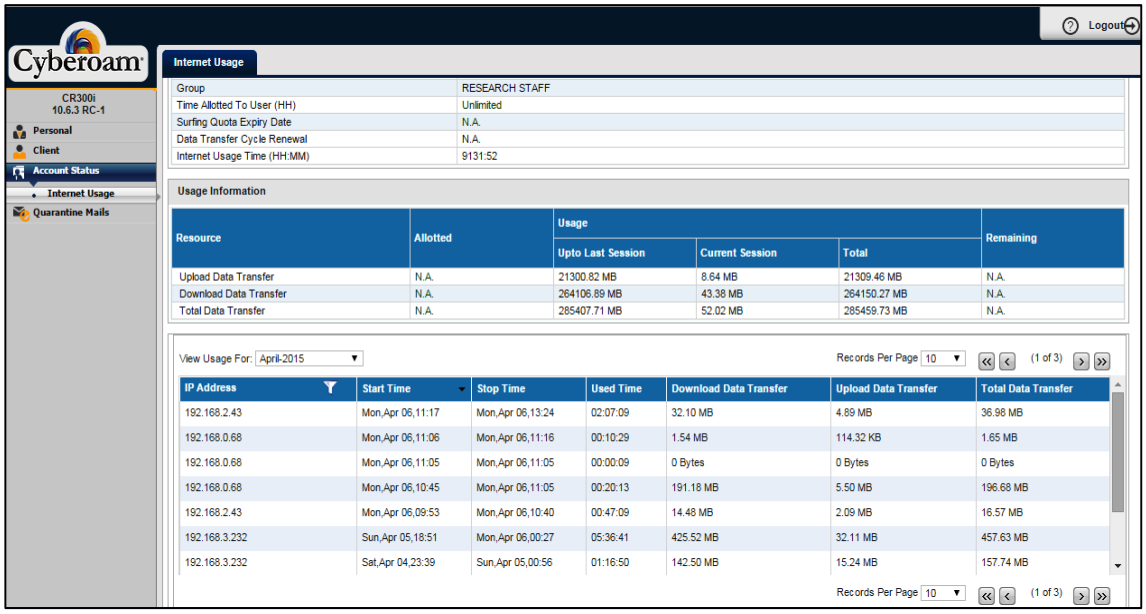


Figure 1: Snap shot of Unified Threat Management presenting data usage by a user

3.2 Case Study two: Indian Institute of Public Health Gandhinagar (IIPHG)

The Public Health Foundation of India (PHFI) is a public-private initiative with headquarters in Haryana. It oversees four academic institutions, the Indian Institutes of Public Health (IIPH), engaged in public health education, training, research, and policy advocacy. IIPHG has 12 faculty and runs two full time on-campus courses, Public Health Management and Industrial Health, and four online courses: Research Methodology; Managerial Effectiveness for Healthcare; Health, Safety and Environment Management; and Public Health and Hospital Management for Nursing and Allied Health Professionals. To date, 277 students have enrolled in the online courses. A variety of technologies are used for course delivery including stand-alone computers, the internet and DVDs. Teaching activities include webinars, video conferences, and the use of videos made by students to facilitate classroom discussions.

Resources include around 35 desktop computers, 50 laptops, printers, still and video cameras, voice-recorders, microphones, a LAN and Wi-Fi enabled internet facility, a computer laboratory, video conferencing facilities and a library of educational CD/DVDs. The online courses are hosted via a Moodle based platform run on a local server. Apart from basic course content, reference materials and assignments, each course has provision for periodic online interactive sessions between students and faculty, a discussion board and online quizzes. Adobe Presenter and Camtasia are used to record lectures and WiziQ for interactive sessions. The learning platform also allows online registration, fee payment, application tracking, automatic email reminders, certification, and student feedback. It can be accessed by enrolled students over any available internet connection. Almost all online courses are in blended format, allowing both faculty-enabled and self-learning modes. Each includes a series of voice-over-power-point (VOPP) lectures by faculty members.

IIPHG leases a 2 Mbs internet line for around $US3,200 per year. As indicated above, the internet is available through LAN and Wi-Fi connections within the institute. Additionally, portable internet data cards are provided to all faculty and research staff to facilitate internet access elsewhere. When IIPHG moves to a new campus with upgraded ICT infrastructure, access will also be provided via mobile phones.

While PHFI has a dedicated ICT department to support the IIPHs, IIPHG has a single officer who manages all ICT related needs. This officer has a diploma in Computer Applications, 20 years of experience and is trained in networking and visual learning, internet security processes, network storage and digital documentation management.

3.2.1 Challenges

Alongside increasing demand, the IIPHG distance learning platform is also evolving to meet rising student expectations. It is planned to phase out VOPP as the primary mode of delivery in favour of approaches which

make full use of multimedia content. Compatibility with other online applications that can add to the learning experience such as Skype, Google Hangout and WhatsApp are also being pursued. A related challenge will be the recruitment and retention of individuals with the qualifications and expertise in both software and multimedia required to translate materials provided by IIPHG staff into exciting and attractive formats for online courses.

One specific problem in the preparation of VOPP lectures is the difficulty in ensuring high quality sound. At present recordings have to be done outside of normal working hours and noise reduction software used to improve audio quality. As the number of distance learning courses increases, there are plans to create a recording studio to enable higher quality audio and video materials. Plagiarism in submitted assignments by students is another concern of faculty responsible for online courses. Manual recognition is the only safeguard at present but with increasing student numbers there is a felt need to install and use plagiarism software.

3.2.2 Management strategy

A number of factors have led to increased demands for bandwidth, including use of multiple devices – laptops, mobiles and tablets – by students, interactive methods of teaching online courses and live demonstrations by faculty. Various strategies are used to address bandwidth limitations. It has been necessary to place strict limitations on internet access by visitors and outsiders. As indicated above, the majority of lectures in online courses are VOPP presentations. These are pre-recorded and uploaded, usually on a weekend, holiday or evening as maximum bandwidth demand occurs during normal office hours (Fig.2 and 3). Similarly, interactive sessions and those using live telecasts are timetabled on weekends and it has become standard practice to record all live discussion and chat sessions held between faculty and students. Such recordings are used to prepare question and answer banks to help students who could not attend live sessions.

Options for purchasing a higher bandwidth connection are currently being considered. A range of other ways to improve bandwidth management are also under discussion including a dedicated firewall, single sign-on per user option and a revised allocation policy governing bandwidth distribution to different user groups. In the meantime, for online courses that have high student uptake and need improved bandwidth support, it may be necessary to run parallel course units with limits on the number of students in each unit.

PHFI has a defined Internet Usage Policy and a firewall that can be used to manage and monitor network usage. There is an automated system that monitors how many times the distance learning portal has been accessed. This data can be analysed by course, student, location of access, etc. Within IIPHG, while a dedicated firewall has been established for one project, none is yet operational across the institution. Currently there is no restriction on bandwidth usage by type of user groups and no automated system to block unauthorised websites. Additional features of some purchased software, for example the Quick Heal anti-virus package, are installed and used in all institutional computers to block certain sites, manage cookies, intercept spam messages, etc. Additionally, a manual bandwidth tracking system helps the IT department understand usage patterns and restrict questionable activity, for example downloading very large files. If the latter is regarded as necessary, specific requests must be made to the IT department to facilitate its acquisition without disruption to other users. For example, material can be downloaded during periods of low bandwidth demand and circulated using the local server or pen drives.

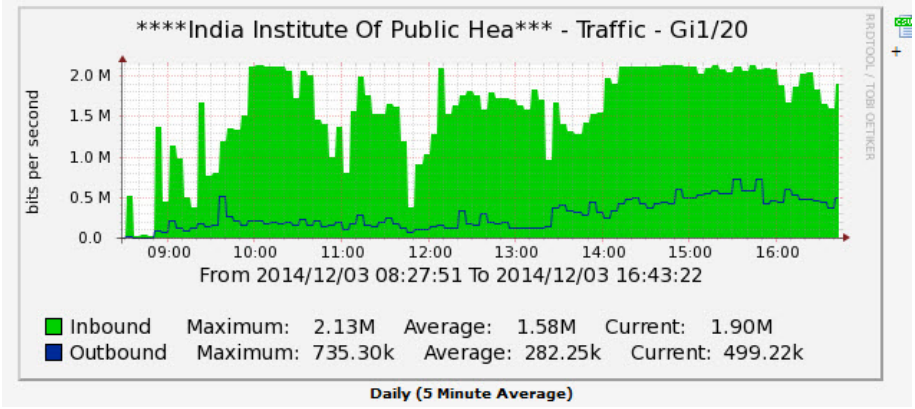


Figure 2: Broadband usage tracking system: Usage on 3rd December 2014 (Wednesday)

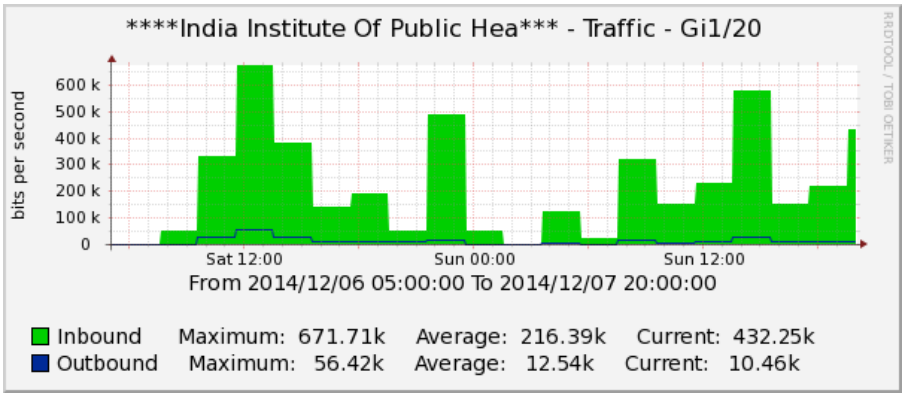


Figure 3: Broadband usage tracking system: Usage on 6th December 2014 (Saturday)

3.3 Case study three: Makerere University College of Health Sciences, Uganda

Makerere is one of the oldest and most prestigious Universities in Africa. The College of Health Sciences is one of nine constituent colleges that offer day, evening and external courses to some 42,000 undergraduates and 3,000 postgraduates. There are some 4,000 academic and administrative staff. While the College has a considerable degree of autonomy, many ICT services are centralised and overall policy and resource allocation decisions have to involve multiple stakeholders. The University e-learning policy aims are:

1. To improve the quality of graduates, utilizing modern instructional materials and methods, including increased use of ICT.
2. To provide greater access to university education through non-conventional approaches in teaching and learning i.e. distance education and a 'virtual university'.

These goals are to be achieved by: creating an organizational and technical environment that promotes long-term in-house e-learning training capabilities; ensuring that all students and academic staff are trained on a continuous basis; developing university wide and global e-learning networks based on academic interest groups and research collaborations; and establishing a common Distance Learning Environment.

The Directorate for ICT Support (DICTS) is a central service unit that provides expert services and guidance to all academic and administrative units. It is composed of around 30 personnel with expertise including Database Management, Systems Management, Planning and Maintenance, Networks Management and End User Support. The e-learning function was moved to the College of Education and External Studies and currently comprises two staff concerned with pedagogy and one with providing technical support. The Makerere University e-learning Environment (MUELE) uses the Moodle LMS and has over 60,000 users and 1,500 courses. However, there is a tendency to use the platform as a passive repository for course materials and not take advantage of the capacity for course management, quizzes, setting and marking assignments, student forums, blogs, etc. Use of such facilities can be hampered by University polices which promote a tradition model of education. There are other projects/development partners within the university that run online courses, including the ARCADE-HSSR Project, building capacity in health systems and services research (Guwatudde, et al., 2013), the Regional Universities Forum for Capacity Building in Agriculture, MESAU a partnership of five academic institutions in Uganda targeting the medical education sector and VUCCnet, focused on human resources in cancer control in Africa.

The university leases a 170Mbs connection at a cost of around US$40,000 per month from the Research and Educational Network for Uganda, a consortium of research organizations and institutions. Optical fibre cables were laid underground from the provider source to the university data centre to improve the quality of the link to the NOC. Students and staff can access Internet and Intranet services using cables or via wireless routers .All university ICT services are hosted in the DICTS Network Operating Centre (NOC) with a backup centre approximately 2km away. Since 2005 the University has used various LMSs including Blackboard, Kewl.NextGen and TUSK. In 2008 a decision was made to migrate all courses to Moodle. MUELE is installed on a Power Edge 720 with 8GB RAM and 5TB of hard disk storage with backup on a Power Edge T610 with 4GB RAM and 2.5TB of storage. It uses the Slackware Operating System and MySQL for database management.

A number of blended courses have been run using MUELE, using both asynchronous and synchronous access modes. The technologies used have included Adobe Connect, GoTo Meeting, Skype, SCOPIA and a dedicated Video Conferencing facility. The university also provides OpenCourseWare, developed by the Massachusetts Institute of Technology, and related library services including Dspace, an institutional repository application, and Virtua, a cataloguing system.

3.3.1 Challenges

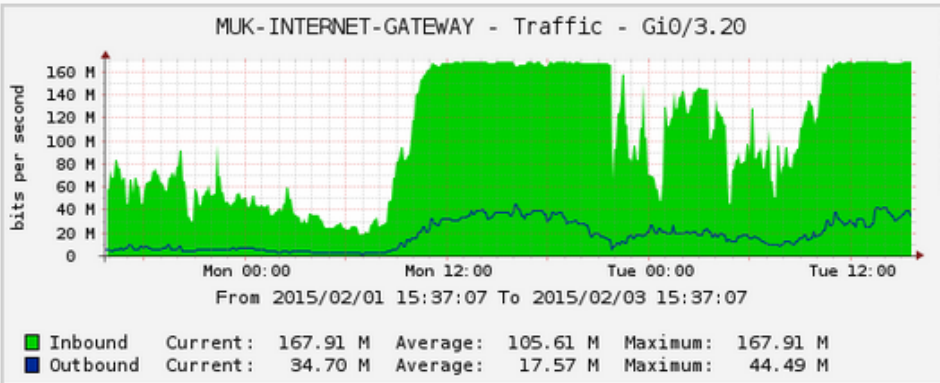
The university has experienced many challenges in implementing e-learning facilities:

1. The growth of the university and associated demand for internet access by an increasing number of staff and students has posed serious problems in terms of available bandwidth. In addition, because priority is given to those working on the campus, access from outside can be severely limited, especially in terms of video and synchronous communications.
2. University policies do not encourage the use of the e-learning platform to support traditional teaching methods – one requires students to attend all lectures face-to face.
3. A relatively small proportion of students can easily access computers to use the internet when off campus.
4. The local network which links the University to the internet has been developed in an ad hoc manner and services are often disrupted by the need to repair cables.
5. Blended courses using video streaming have struggled to overcome incompatibilities between different learning hubs, which often purchase hardware and software without considering the potential limitations in terms of ease of communication with other users if they do not adhere to the guidelines developed by DICTS.
6. Maintaining the technical and user documentation required for the effective use of the e-learning platform has typically proved much more time consuming than expected, resulting in those responsible often delaying making necessary updates.

3.3.2 *Management Strategy*

Various actions have been taken to limit demand. Individual downloads are limited to a maximum of 100Mb per connection during peak hours and access to YouTube, a major contributor to bandwidth consumption, is not allowed during normal office hours. Frequently accessed web-based material is copied and stored on the local server and all university websites and mail services are hosted within the NOC. Such actions have substantially improved the internet experience, reducing access and download times. The University recently procured bandwidth management software which should allow DICTS personnel to efficiently allocate additional bandwidth to individuals or research groups with specific needs, for example to run blended learning sessions or video conferencing.

The real time consumption of bandwidth by each college, and designated groups within each college, is automatically monitored using freely available open source software (PFSense Firewall and CACTI), allowing major users to be identified (Figure 4). Again using open source software (ntopand NAGIOS), any unplanned excessive demands on the network can be rapidly recognised, and decisions are taken as to how respond (Figure 5).



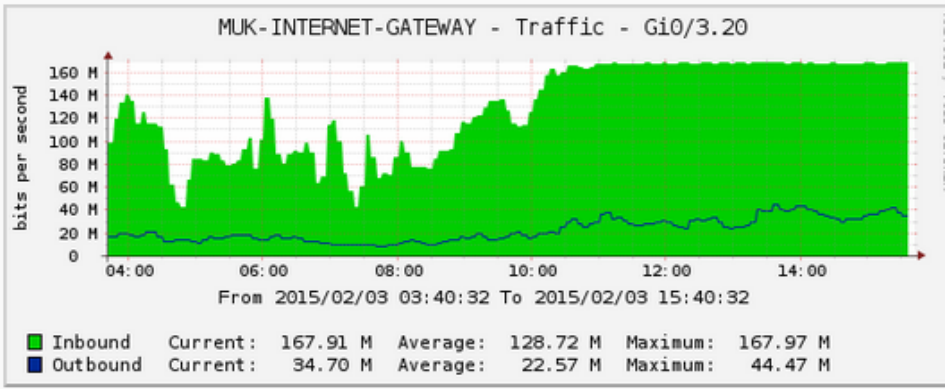


Figure 4: Diagrams illustrating the use of CACTI to monitoring Bandwidth usage

Figure 5: Use of Nagios to Monitor Service Availability at the University

4. Discussion

The three very different health research and teaching organisations described in the above case studies share a common ambition to take advantage of the opportunities provided by advances in the use of new technology in education. Not only do they aim to use the technology to complement traditional teaching methods in the delivery of courses to their own students, but to make such courses available to a much larger audience via distance learning. Taken together they provide an interesting illustration of the trade-off between availability of resources and freedom of action when attempting to establish e-learning courses on public health and health research. Thus IIPHG has limited IT and human resources but, with just 12 faculty members, considerable flexibility in the use of those resources and the potential for rapid innovation. The College of Health Sciences has the equipment, staff and, very importantly, large volume of tried and tested course materials to address much larger challenges but can only do so by navigating existing University protocols and negotiating access to resources with colleagues who may have quite different priorities.

In large organisations there clearly has to be an established resource allocation policy, with clearly defined limits on flexibility, if staff are to have confidence that their access will not be regularly disrupted to meet the 'special needs' of others. Allocation of resources is of course a very familiar problem to those working in the health sector, and the problems of network allocation share some of the same characteristics. While a simple 'equity of access for all' principle may seem to be the obvious basis for policy, this could impose severe

constraints on innovation and experimentation, which often tend to give rise to unpredictable demands for additional resources at short notice.

The case studies reinforce the argument that a lack of suitably qualified, motivated and experienced personnel is a common major barrier to the development of e-learning generally (Khan, et al., 2012), and in global health education. This relates both to the systems professionals required to implement and maintain the necessary hardware and software, and to the need for a teaching staff with the interest and aptitude required to design e-learning materials and collaborate with technical staff in developing systems that are not only attractive and easy to use but consistent with the highest educational standards. Again, close collaboration between teaching and technical staff may be easier in smaller institutions if both sides are encouraged to see themselves as part of a single team. In larger organisations there may be a very important role for intermediaries, either teachers who have acquired technical expertise or IT staff with a willingness to explain technical issues in ways that can be easily understood by teachers (Afshari, et al. , 2009; Nawaz, et al. , 2010).

Another common concern across the case studies is limited IT infrastructure and particularly bandwidth availability (Hvorecký, et al., 2005; Okine, 2006). This has always been problematic but is becoming increasingly so as expectations rise more rapidly than system improvements. Students now expect easy access to everything the internet has to offer not only using the many desk-top computers made available in each organisation but using laptops, mobile phones and tablet computers. Such technical challenges are important considerations for organisations embarking on e-learning, as they may well impact on student overall experience of public health courses (Atkins, et al., 2016), which can in turn impact on educational attainment (Owston, Lupshenyuk and Wideman, 2011 ; Sowan and Jenkins, 2013).

Based on evidence from the case studies, online teaching is perfectly feasible where participants have access to a local intranet based on a server that stores the required teaching materials and on which the LMS is run. All three case studies mention downloading material from remote sites during periods when demands on the internet are at a minimum, for example at night or during holiday periods, and storing it on a local server. This apparently rational solution does have the problem that there is a risk of contravening copyright law, given that many sights make material freely available for individual downloads but explicitly forbid their uploading onto another site. Access to external sites can cause substantially greater problems, but it is the provision of distance learning services to users outside of the network, either in formal learning hubs or accessing learning materials using external wireless links that give rise to major difficulties. Since there are now a multitude of valuable teaching resources on global health and research methods that are hosted on external sites, arranging reasonably high quality access to such sites is also very important. Though direct comparisons of network resources are notoriously difficult due to the multitude of factors affecting quality and speed, table 1 sets out some of the basic indicators, together with those for the UK research organisation of one of the authors for comparison. This may suggest that smaller organisations can be at an advantage, with even a basic communications package allowing a reasonable bandwidth allocation across multiple demands.

Table 1: Staff numbers and bandwidth

Organisation	Academic Staff (A)	Bandwidth (B)	B/A
IIHMR	46	20Mbs	0.43
IIPHG	15	2Mbs	0.13
Makerere	1,477*	170Mbs	0.12
IDS UK	170	98Mbs	0.58

* Makerere Human Resource Directorate as at January 2014

Measures adopted to address the above issues include limiting access to a single device for a given user, using dedicated firewalls, limiting the maximum size of any download at peak times, and blocking access to sites such as YouTube during working hours. One issue raised by IIHMR, but with universal application, is the difficulty of distinguishing 'reasonable' from 'unreasonable' internet access. Downloading of photographs, PowerPoint presentations or videos, which may involve very large downloads, may be a perfectly reasonable action if they enhance the teaching experience. There is no simple way, for example to distinguish between a

YouTube video that is clearly for entertainment purposes, and one that is directly relevant to a given course, without viewing the download.

5. Conclusions

As indicated by the above case studies, there is considerable enthusiasm for the idea of using new technology both to enhance the experience of their own students and to make their courses available to a much wider audience. To achieve their objectives they typically have to overcome major constraints in terms of hardware, software and human resources and they face a continuing battle to meet the challenges of a rapidly evolving technological environment which makes little allowance for those struggling to keep up with the latest developments. Some issues can be addressed by the institutions themselves. Others, such as limited national or regional infrastructure for broadband internet access need to be brought to the attention of policymakers and thought leaders, making clear that this can pose serious barriers to the expansion of access to potentially very valuable e-learning facilities for expanding global health research education. We recognise that the findings from three purposively selected case studies should not be seen as representative of the diverse range of academic and research bodies in resource-constrained environments. Our suggestion is that this research can provide a starting point for further work to investigate other institutions and examine if they have similar challenges and barriers to implementation.

Finally, it is particularly important that academic institutions in high income countries recognise the needs of those in LMICs and support and encourage their counterparts in developing systems that are well adapted to their specific needs and circumstances. Recent developments, for example the growth of 'cloud computing' (Armbrust, et al., 2009) and the promise of greater opportunities for sharing hardware and software resources, could have important implications in terms of allowing easier entry to advanced e-learning engagement by less privileged education institutions in LMICs, and thus contribute to global health capacity.

Acknowledgements

We thank the ICT department from Institute of Health and Management Research, Jaipur (India), Indian Institute of Public Health Gandhinagar (India) and Makerere University, Uganda (Africa) for facilitating preparation of the case studies.

References

Adobe presenter, (2016). [online] Available from: www.adobe.com/uk/products/presenter.html . [Accessed 10 March 2016].

Afshari, M., Abu Bakar, K., Su Luan, W., Abu Samah, B. & Say Fooi, F. (2009). Factors Affecting Teachers' Use of Information and Communications Technology. *International Journal of Instruction*, 2(1).

ARCADE HSSR, (n.d.), [online] Available from: www.arcade-project.org/hssr/ [Accessed 11 March 2016].

Armbrust, M., et al. (2009). *Above the Clouds: A Berkeley View of Cloud Computing*. Available from: www.eecs.berkeley.edu/Pubs/TechRpts/2009/EECS-2009-28.pdf [Accessed 10 February 2016].

Atkins, S, Meragia, E., W Yan, Mahomed,H., Bwanga,F., Rosales,S., Skinner, D. & Zwarenstein, M. (2016). Student experiences of participating in five collaborative blended learning courses in Africa and Asia: a survey. *Global Health Action*, 9. Available at: www.globalhealthaction.net/index.php/gha/article/view/28145/pdf_350 .

Bates, A.W. (1995). *Technology, Open Learning and Distance Education*. Routledge, London. UK.

Blackboard, (2015). [online] Available from: http://uki.blackboard.com/sites/international/globalmaster/ [Accessed 10 March 2016].

BlackDuck OpenHub. (2016). [online] Available from: www.openhub.net/p/5081 [Accessed 11 March 2016].

Bollinger, R. C., Mckenzie-White, J., & Gupta, A. (n.d.). *Building a Global Health Education Network for Clinical Care and Research: The Benefits and Challenges of Distance Learning Tools*. [online] Available from : http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3107515/ [Accessed 4 February 2016].

Cacti, (2012). [online] Available from: http://www.cacti.net/ [Accessed 13 March 2016].

Christopoulos, D. (2011). *Survey of unified threat management appliances*. MSc Thesis. School of Computing and Information System. Kingston University, UK. Available from: http://okeanis.lib.teipir.gr/xmlui/bitstream/handle/123456789/1235/dcom_00165.pdf?sequence=
[Accessed 11 February 2016].

D SPACE, (n.d.). [online] Available from: http://www.dspace.org/ [Accessed 2 March 2016]

Duvivier, Robbert, J., Boulet, J.R., Opalek, A., Marta van Zanten & Norcini J. (2014).Overview of the world's medical schools: an update. *Medical Education*, 48(9):860-869.

Find Mac address, (2015). [online] Available from www.youngzsoft.net/cc-get-mac-address/ [Accessed 12 January 2016].

Frehywot, S., et al. (2013). E-learning in medical education in resource constrained low-and middle-income countries. *Human Resources for Health*, 11(4). Available from: www.human-resources-health.com/content/11/1/4 [Accessed 10 February 2016].

Google+Hangouts, (n.d.). [online] Available from: https://plus.google.com/hangouts [Accessed 10 March 2016].

Gray, D E, Ryan, M & Coulon, A. (2003). The Training of Teachers and Trainers: Innovative Practices, Skills and Competencies in the use of e-learning. *European Journal of Open, Distance and E-Learning*. Available from : www.eurodl.org/materials/contrib/2004/Gray_Ryan_Coulon.htm [Accessed October 2014].

Greenhalgh T. & Stones R. (2010). Theorising big IT programmes in healthcare: strong structuration theory meets actor-network theory. *Social Science & Medicine*, 70:1285–1294.

Guwatudde, D., Bwanga, F., Dudley, L., Chola, L., Leyna, G.H.,Mmbaga, E.J., Kumwenda, N., Protsiv, M., Atkins, S., Zwarenstein, M., Obua, C. & Tumwine, J. K. (2013). Training for health services and systems research in Sub-Saharan Africa - a case study at four East and Southern African Universities. *Human Resources for Health*, 11:68. Available from: www.human-resources-health.com/content/11/1/68 [Accessed 2 March 2016]

Hvorecký, J, Manažmentu, V S & Cesta, P. (2005). Can E-learning break the Digital Divide? *European Journal of Open, Distance and E-Learning*. Available from: www.eurodl.org/?p=archives&year=2004&&article=143. [Accessed 12 February, 2016].

The Task Force on Higher Education in Developing Countries. (2000). *Higher Education in Developing Countries: Peril and Promise*. The World Bank. Available from: http://documents.worldbank.org/curated/en/345111467989458740/pdf/multi-page.pdf [Accessed 23 February 2016].

Kerry, V. B., Ndung 'u, T., Walensky, R. P., Lee, P. T., Frederick, V., Kayanja, I. B., & Bangsberg, D. R. (2011). Managing the Demand for Global Health Education. *PLOS Medicine*, 8(11). Available from: http://doi.org/10.1371/journal.pmed.1001118 [Accessed 4 March 2016].

Kumpu, M., Atkins, S., Zwarenstein M. & Nkonki L. (2016). A partial economic evaluation of blended learning in teaching health research methods: A three-university collaboration in South Africa, Sweden and Uganda. *Global Health Action*, 9. Available from: http://www.globalhealthaction.net/index.php/gha/article/view/28058/pdf_349

Lucas, H. & Kinsman, J. (2016). Distance- and blended-learning in global health research: potentials and challenges. *Global Health Action* 9. Available from: www.globalhealthaction.net/index.php/gha/article/view/33429/pdf_354

Makerere University E-Learning Environment, (n.d.). [online] Available from: http://muele.mak.ac.ug [Accessed 11 March 2016].

Marrinan, H., Firth, S., Hipgrave, D., & Jimenez-Soto, E. (2015). Let's Take it to the Clouds: The Potential of Educational Innovations, Including Blended Learning, for Capacity Building in Developing Countries. International Journal of Health Policy Management, 4(49):571–573. Available from: http://doi.org/10.15171/ijhpm.2015.121 [Accessed 6 March 2016].

Merriam, S.B. (1998). *Qualitative research and case study applications in education*. San Francisco, CA: Jossey-Bass

Middlehurst, R. (2006). A world of borderless higher education - impact and implications. In S. D'Antoni (ed.). *The university-current challenges and opportunities*. UNESCO-IIEP. [online] Available from: www.unesco.org/iiep/virtualuniversity/home.php [Accessed 11 February 2016].

MIT OpenCourseWare, (n.d.). [online] Available from: http://ocw.mit.edu/index.htm [Accessed 9 March 2016].

Moodle, (n.d). [online] Available from: https://moodle.org/ [Accessed 12 March 2016].

Moolman, H B, & Blignaut, S. (2008). Get set! e-Ready, e-Learn! The e-Readiness of Warehouse Workers. *Journal of Educational Technology & Society*, 11(1):168-182.

Nagios, (2016). [online] Available from: http://www.nagios.org/ [Accessed 1 March 2016].

Ntop, (2016). Available from: http://www.ntop.org/ [Accessed 12 March 2016].

Open Tusk, (n.d.). [online] Available from: http://opentusk.org/about.html [Accessed 10 March 2016].

Olsen, A.J. (2015). E-learning in Asia: Supply and Demand. International Higher Education 30, 8-9. Available from: https://ejournals.bc.edu/ojs/index.php/ihe/article/download/7352/6549 [Accessed 23 January 2016].

Nawaz, A. and Qamar A.Q. (2010). Sustained Technical Support: Issue & Prospects for E-Learning In HEIS. *Global Journal of Management and Business Research*, 10(9):32-39.

Okine, R.K., Agbemenu, A.S. & Marfo, J.S. (2006). Access to Internet Connectivity: the Major Bottleneck to the Adoption of Technology-Enabled Education (The Case of KNUST). *AAU Newsletter*, 12. Available from: http://linc.mit.edu/linc2013/proceedings/Session1/Session1Okine-Marfo.pdf

Owston R., Lupshenyuk, D. & Wideman, H. (2011). Lecture capture in large undergraduate classes: Student perceptions and academic performance. *Internet Higher Education*, 14(4):262–8.

Power, T. (2014). Educational Technology Topic Guide. *HEART: Health and Education Advice and Resource Team*. [online] Available from: http://www.heart-resources.org/wp-content/uploads/2014/10/Educational-Technology-Topic-Guide.pdf?x30250. [Accessed 10 March 2016].

Programme of Action for Cancer Therapy, (2014). [online] Available from: http://cancer.iaea.org/vuccnet.asp [Accessed 12 March 2016].

Protsiv, M. & Atkins, S. (2016). Lecturers' experiences of preparing and delivering blended courses on African, Asian and European university campuses: A qualitative study. *Global Health Action*, 9. Available from: http://dx.doi.org/10.3402/gha.v9.28149

Public Health Foundation for India: Centre for distance learning, (2015). *Building Bridges Reaching Minds*. [online] Available from: https://cdl.phfi.org/portal/ [Accessed 10 March 2016].

Qucikheal, (2016). [online] Available from: www.quickheal.com [Accessed 10 March 2016].

Regional Universities Forum for Capacity Building in Agriculture (RUFORUM), (2016). [online] Available from: http://www.ruforum.org/ [Accessed 2 March 2016].

Shahadat, M., Khan, H., Hasan, M., Kum, C., & Prof, C. (2012). Barriers to the introduction of ICT into education in developing countries: the example of Bangladesh. *International Journal of Instruction,* 5(2):1694–609. Available from: www.e-iji.net/dosyalar/iji_2012_2_4.pdf [Accessed15 February 2016].

Sense, (2015). [online] Available from: www.pfsense.org/getting-started/ . [Accessed 11 March 2016].

Skype, (2016). [online] Available from http://www.skype.com .[Access 9 March 2016].

Sowan, A.K., & Jenkins, L.S. (2013). Designing, delivering and evaluating a distance learning nursing course responsive to students needs. *International Journal of Medical Informatics*, 82(6):553–64. Available from: http://doi.org/10.1016/j.ijmedinf.2013.02.004 [Accessed 17 January 2016].

Suhail, N. A., Lubega, J., & Maiga, G. (2014). Optimization Based Blended Learning Framework for Constrained Bandwidth Environment. *Advances in Computer Science: an International Journal*. 3(1):130–139. Available from: www.acsij.org/documents/v3i1/ACSIJ-2013-3-1-322.pdf [Accessed 10 January 2015].

TechSmith, (2015). [online] Available from: www.techsmith.com/camtasia.html [Accessed 9 March 2016].

Tinio, V. L. (2002). ICT in education. *Paper presented at the World Summit on the Information Society*. December 10 to 12, 2003. Geneva, Switzerland. Available from: http://wikieducator.org/images/f/ff/Eprimer-edu_ICT_in_Education.pdf [Accessed 15 January2015].

van der Wende, M.C. (2003). Globalisation and Access to Higher Education. *Journal of Studies in International Education*, 7(2):193-206.

Valdez, G., Fulton, K., Glenn, A., Wimmer, N. A., & Blomeyer, R. (2004). Effective Technology Integration in Teacher Education: A Comparative Study of Six Programs. *Innovate Journal of Online Education*, 1(1).

Virtua, (2016). [online] Available from: www.iii.com/products/vtls-virtua [Accessed 3 March 2016].

Watsapp, (2016). [online] Available from www.whatsapp.com/ [Accessed 11 March 2016].

WizIQ education online, (2016). [online] Available from: www.wiziq.com/ [Accessed 12 March 2016].

Wireless Network Watcher v1.95, (2016). [online] Available from: http://nirsoft.net/utils/wireless_network_watcher.html [Accessed 8 March 2016].