# Information and Communication Technology Infrastructure Analysis of Kwame Nkrumah University of Science and Technology and University of Ghana

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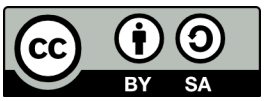
**Abstract**
This paper explores the information and communication technology (ICT) infrastructure for education at the Kwame Nkrumah University of Science and Technology (KNUST) and the University of Ghana (UG) and its implications for health education at the two universities. The author begins with a literature review of studies of ICT infrastructure in education and a look at the telecommunications landscape in Ghana. Using document-analysis and semi-structured interviews, the paper then examines the network infrastructure, technology policy, ICT support staff, and ICT services at each university as well as instructor and student access to and attitudes toward technology. Both institutions recently updated their ICT policies, expanded ICT services, improved the network backbone, and increased bandwidth. Several obstacles limit the growth of ICT at both universities, including lack of awareness of existing ICT services, lack of coordination across campuses and departments, lack of instructor incentives to integrate technology with teaching and research, and frequent power outages and fluctuations. In 2009-2010, both institutions made substantial investments to improve computer and Internet access for teaching staff and students. In order to advance ICT support for health science education at both institutions, the author recommends that both institutions install more surge protectors and backup power supplies, increase publicity about existing ICT services, integrate more information literacy topics into ICT training, establish arrangements for bulk educational discounts, and expand cross-departmental collaboration for multimedia and tech support for instruction.



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## Introduction

The Kwame Nkrumah University of Science and Technology (KNUST, est. 1952) and the University of Ghana (UG, est. 1948) are the two largest universities in Ghana with 23,000 and 30,000 students, respectively. Their respective Colleges of Health Sciences are responsible for training many of the healthcare workers in Ghana. Like many sub-Saharan African countries, Ghana struggles with low doctor to patient ratios. There are only 0.15 doctors and 0.92 nurses per 1,000 Ghanaians, which is well below the World Health Organization's recommendation of 2.0 doctors[1] and 2.5 nurses.[2] In 2008, KNUST and UG entered into a partnership with Ministry of Health (MOH), University of Michigan (U-M), and the Bill and Melinda Gates Foundation to strengthen human resources for health education and healthcare professionals. The partnership activities included a survey of the technical infrastructure to support education at the two universities.

This report explores the information and communication technology (ICT) infrastructure for education at both universities. The report begins with a literature review of studies of ICT infrastructure in education and a look at the telecommunications landscape in Ghana. The paper then examines the network infrastructure, technology policy, ICT support staff, and ICT services at each university as well as instructor and student access to and attitudes toward technology. The paper concludes with the implications for healthcare education at the two universities based on the existing ICT landscape.

## Literature Review

This analysis builds upon previous research regarding the application and evaluation of technology for education. Research in this area tends to fall into one of the following categories: ICT literacy skills, demographics of Internet users in Africa, technology policy and evaluation, and applications of ICTs in higher education within Ghana.

### ICT Literacy Skills

ICT Literacy is valued in many academic and professional sectors, from primary school to continuing education. Compton and Harwood (2003) explored the Technology Assessment Framework from the New England Ministry of Education, focusing specifically on training primary and secondary schools in technological knowledge, understanding, capability, and the use of technology in society.[3]

Modern librarians are often gatekeepers to collections of electronic resources and therefore participate in refresher courses to stay abreast of the latest technology trends to share with their patrons. Mahmood (2007) investigated continuing education needs for librarians and information scientists in Pakistan.[4] After interviewing 200 librarians, he determined that librarians were interested in strengthening their ICT skills and were willing to do so during the evenings or weekends if the employer covered the cost of the training. Eells and Jaguszewski (2008) surveyed Minnesota librarians to identify gaps in their ICT competencies.[5] The authors stressed the importance of including librarians and other ICT professionals in defining the gaps in their ICT competencies and in designing an appropriate curriculum. They proposed a list of ICT core competencies, including how to use desktop computers, file management, navigation (e.g. application windows, mouse,

keyboard, etc), printing, office productivity suites, email, web browsers, calendaring, troubleshooting, workstation maintenance, hardware, and local network configuration.[6]

There exist several studies that focus on ICT literacy among librarians in sub-Saharan Africa. Minishi-Majanja (2003) identified common challenges to ICT education in library and information services programs: staff capacity, low student and instructor ICT skills, and low access to computers.[7] Minishi-Majanja and Ocholla (2004) examined ICT competencies, use, policy, and support in library science degree programs in sub-Saharan Africa and proposed some ideas for ICT literacy topics that a library or ICT support staff specialist should offer.[8] Assistant Librarian and Head Cataloguer at KNUST, Ahenkorah-Marfo (2006), explored training, equipment, and partnerships with other universities to access electronic scholarly articles.[9] He noted that in addition to ICT training for staff, there was a need to increase publicity about the existing electronic services and ICT literacy services offered by the library.

**Demographics of Internet Users in Africa**

Polikanov and Abramova (2003) explored the demographics of Internet users in Africa.[10] The authors identified six technological innovations for Internet access that they believed would be scalable in Africa: 1) satellites and VSATs, 2) mobile phones, 3) dial-up Internet access, 4) internet cafes and public computer labs with nominal service fees, 5) ISPs who offer free Internet access supported by ads, and 6) large wholesale purchases of "last year's model" of computers from more developed countries. Seven years later, dial-up and Internet café's are generally viewed as outdated, and ICT deployment more often focuses on VSAT technology and mobile telephony.

**ICT Policy and Evaluation**

Numerous researchers have studied the process of crafting institutional ICT policies. Allen and Wilson (1995) surveyed 132 higher educational professionals (librarians, academics, directors of ICT centers, chairs of ICT committees) in the United Kingdom about their institution's information strategies and information technology strategies.[11] Lambert (2001) studied the implementation of an ICT strategy for indigenous students at Kormilda College in Australia.[12] The author examined the college's five-year strategic ICT policy, which includes curriculum, equipment and human resources, infrastructure, software, staff development, safety, Internet, Intranet, privately owned laptops, and code of behavior. Hoosen (2010) analyzed Kenyatta University's ICT strategy of the last four years.[13] Her report also highlighted various information systems in place, including ones for student registration and exams, financial reporting, patient records, staff HR records, integrated library system, and learning management system. The management staff interviewed claim that their US$ 200,000 investment in management and administration software yielded a US$ 4 million benefit from improved tracking and enforcement of outstanding student fees. Due to the new system, fee collection increased from 65% to 90%.

Although ICT use in higher education administration has increased, growth in instructional design has been much slower.[14] Privateer (1999) identified several efficiency gains offered by instructional technology and questioned, "Why should institutions continue to pay the high costs of traditional delivery methods when new technologies can make education available in presumably newer, better, and less costly ways."[15] He advocated that

technology should be used for strategic pedagogical purposes, such as online portfolios, modular learning objects and interactive, remote collaboration with other educators and learners.

Evaluation of ICT systems seems disproportionately low considering the high level of investment in ICT. Ballantine et al (1996) interviewed 97 individuals from UK firms and found that companies believed that feasibility studies are dependent on scale, value, and risk of IT investments and were not necessary for all information systems. [16]

**Application of ICTs in higher education Ghana**

A 2007 report by the University of Cape Town Centre for Educational Technology on "ICTs in Higher Education: Ghana," provides a high-level overview about ICT use, infrastructure, human resources and policy across Ghana.[17] Some of the statistics are now outdated, but the authors provide a valuable historical overview of large-scale ICT projects launched in Ghana over the past decade.

## ICT Landscape in Ghana

With basic Internet introduced in 1995, Ghana was the second country in sub-Saharan Africa to have "full Internet access."[18] In 2000, there were 30,000 Internet users. [19] By 2007, the number of Internet users had increased to 610,000.[20] A year later, there were nearly 1 million.[21] Accra, the capital city, is connected to three submarine cables (MainOne, GLO1, SAT-3), which originate in Portugal.[22] In late September 2010, the National Communication Backbone Company (NCBC), which oversees the SAT-3 submarine cable, in order to compete with the new MainOne submarine cable, announced a 50% reduction in the bandwidth prices that it charges ISPs.[23] Consumer prices are expected to decrease by half before the end of 2010.[24] With an estimated per capita income of US$ 600 and computers costing over US$ 1000 and broadband currently over US$ 500/year, home computer and broadband access is still out of the reach of many.[25] The largest Internet Service Providers (ISPs) in the country are Vodafone (which merged with Ghana Telecom), MTN, and Zain.

Table 1: ICT Providers and Usage, Ghana

| *Factor* | *Value(s)* | *Date* |
|---|---|---|
| Internet Users | 997,000 | 2008 |
| Major Internet Service Providers | Vodafone, MTN, Zain | 2010 |
| Communication Cables | MainOne, GLO1, SAT-3 | 2010 |
| Landline Telephones | 267,400 | 2009 |
| Mobile Phone Users | 15.11 million | 2009 |
| Mobile Service Providers | Vodafone, MTN, Zain, Tigo, Expresso | 2010 |

Mobile telephony in Ghana has grown exponentially in the last decade. In 2009, only 267,400 individuals had landline telephones, but 15.11 million had mobile phones.[26] Ghana has five mobile phone providers: Vodafone, MTN, Zain, Tigo, and Expresso (formerly Kasapa). In 2009, both Vodafone and MTN announced plans to upgrade their networks to 3G. A sixth mobile service provider, Glo, has received a license to operate in Ghana. Glo is currently held up in government regulations and has not yet opened service to consumers.

Only two-thirds of Ghanaians have access to electricity.[27] Technology skills are in high demand but few professionals have degrees in technology. Ghana's universities graduate approximately 300 students in computer science and engineering each year.[28]

Over the past decade, the government has launched a number of strategic partnerships with foreign governments and organizations to advance ICT in Ghana:

- In 1997, the government of Ghana joined the World Bank's *African Virtual University* (AVU)[29] project. By 2003, AVU had member sites at University of Ghana, KNUST, the University of Cape Coast's Centre for Continuing Education, the University of Education, and the Ghana Institute of Management and Public Administration (GIMPA).[30] In 2010, none of the Ghanaian universities are still active members of AVU.[31]
- In 2003, the government of Ghana signed a bilateral agreement with the Indian government, which led to the creation of the Ghana-India *Kofi Annan Centre of Excellence* in ICT (KACE).[32] The Indian government provided hardware, software, communication equipment, training for staff, and curriculum guidance.[33]
- A year later, the Ministry of Communication passed its first ICT policy, *Information and Communication Technology for Accelerated Development (ICT4AD*).[34] The policy includes goals for ICT-enabled distance education at the university level.
- In 2004, the Government of Ghana signed a memorandum of understanding (MOU) with Microsoft to form a private-public partnership to improve ICT skills among the workforce. Under the MOU, Microsoft would establish an ICT support center at the University of Ghana to train and certify students in Microsoft Helpdesk accreditation.[35] It is unclear whether the MOU was implemented.[36]
- In 2006, the Vice Chancellors of Ghana, the United Nations Educational, Scientific, and Cultural Organization (UNESCO), the International Telecommunications Union (ITU), and the United States Agency for International Development (USAID), and University of Oregon launched *the Ghana Academic and Research Network (GARNET)*.[37,38] GARNET aims to "to have an advanced network for collaboration and communication in the fields of teaching, learning and research among all public and private institutions of higher education in Ghana."[39] GARNET currently connects 12 public and private universities, including UG and KNUST.
- In 2007, the Indian government established *the Pan African e-Network for Tele-education and Telemedicine*,[40] a partnership between 6 Indian universities, 5 African universities (including KNUST and UG), and 53 learning centers across Africa.[41] Each country selects from a range of diploma-level to postgraduate courses in various disciplines based on their national education strategy.
- In 2010, during President John Atta Mills trip to China, Huawei Technologies Company Limited of China announced a US$ 4 million donation of ICT equipment.[42] The package includes US$ 1 million in telecommunications equipment for KNUST, UG, and University of Cape Coast, US$ 3 million in videoconferencing equipment for the government, and an MOU whereby Huawei Technologies would advise Ghana's e-Government projects.[43]

In 2009, the search giant Google expanded its operations in Ghana and appointed a country lead in Accra. Google has since organized a number of events, including a 2-day workshop focusing on Google Apps for developers and entrepreneurs, TEDxYouthInspire, TedxChange, and a Ladies Information Technology Day. Google also adapted its Google Maps to include Ghana and launched two new African-centric services: an online marketplace called Google Trader[44] and a question-answer service called Baraza.[45]

## University of Ghana

### Network Backbone

The ICT Directorate (ICTD)[46] governs the network infrastructure for university's three campuses: Legon (the primary campus), Korle Bu, and City Campus. With the exception of School of Public Health, all of the College of Health Sciences (CHS) is located at Korle Bu. In September 2010, the Provost of CHS announced that the College would be moving from Korle Bu to Legon.[47] The relocation is expected to cost US$ 700 million and include several construction projects: a new teaching hospital, a School of Biomedical Sciences, a School of Allied Health Sciences, and Skills Laboratory and Diagnostic Center, a new CHS administration building, and accommodations for both students and lecturers. The date of the move is uncertain.

Between 2009-2010, UG launched three externally funded and one university-funded network improvement projects:

1. Unisplendour Software Systems Corporation Limited, which is affiliated with Tsinghua University in China, donated back- and front-end servers to refurbish the Network Operating Center as well as some cable and fiber support. This was a 9-month project at Legon that ended in July 2010.
2. Vodafone is laying fiber to connect the academic departments at City campus and hostels at Legon.
3. MTN is installing fiber at Legon to some of the residence halls (university-owned housing). Unisplendour will finish connecting the rest of the halls.
4. The ICTD is funding a number of projects as well. There is a pre-existing radio link between Legon and the two satellite campuses. The radio link often encounters interference. Due to unreliability of the radio link, in 2011 ICTD plans to add a physical fiber connection between the two campuses. After the fiber network is done, ICTD plans to add wifi to the residence halls at the other campuses. ICTD is also currently seeking funding opportunities (e.g. Google) to increase wifi access on campus.

Due to the bandwidth limitations, Intranet connectivity is much better than Internet. ICTD maintains a local area network (LAN), which hosts the eLearning and email services, university website, library catalog, registration, and student records (academic, financial). The library is the only department that has electronic resources available only on campus. The Korle Bu campus does not have its own Intranet but rather relies on the radio link and virtual private network (VPN) connections to Legon.

The Balme Library and the ICTD Network Operating Center (NOC) have fiber-supported Ethernet access. At present, most classrooms do not have Internet access. Only computer science and computer engineering have wireless access points.

Power outages and fluctuations are common problems. The NOC, Balme Library, and Central Administration all have standby backup generators that operate 24 hours a day, 7 days a week. In order to conserve energy, only parts of the ICTD building have automatic backup generators. Few academic buildings on campus have standby generators, with the business school and faculty of sciences among the exceptions. The largest barrier to access in the CHS lab is sufficient, stable power. For over a year, the staff have advocated for a transformer to regulate power supply to a few strategic buildings including the CHS administration and library. CHS received from government funds to purchase one but the amount received fell short of price. The Provost is currently seeking additional funds for the transformer.

**Bandwidth**

As a complement to the network infrastructure projects, in September 2010, UG entered into an agreement with Vodafone to more than quadruple the bandwidth at Legon. Soon after, Korle Bu and City Campus were connected to the high-speed downlinks at Legon through a VPN.

Schools within CHS often have their own subscriptions to Vodafone. The CHS library has a 50% educational discount on bandwidth from Vodafone. In February 2010, the CHS library paid US$ 2.43 (3.50 GHC) per kbps, totaling US$ 27.75 (40 GHC) per month. Other departments in CHS paid the higher, residential rate. These prices may have since gone down due to the arrival of the MainOne submarine cable.

Table 2: Bandwidth, University of Ghana

| *Campus* | *Source* | *Connection Speed* | *Date* |
|---|---|---|---|
| Legon | VSAT | 1 Mbsp uplink, 2 Mbps downlink | March 2010 |
| | Vodafone | 10 Mbps uplink, 10 Mbps downlink | March 2010 |
| | | 45 Mbps uplink, 45 Mbps downlink | September 2010 |
| Korle Bu | Vodafone (CHS Administration) | 0.3 Mbps uplink, 1.0 Mbps downlink | March 2010 |

ICTD has a number of mechanisms in place to improve network performance. Squid, a caching application, is set up but it has not been working properly. Given the recent network infrastructure improvements, Squid is no longer as important.

**ICT Policy**

In July 2009, UG adopted an ICT policy which provides a framework for the university's eLearning, library, management information systems, ICT facilities, internet and email

services, website, ICT procurement, and ICT project management.[48] The policy promotes ICT in teaching and learning by establishing ICT literacy workshops and a learning management system for instructors and other staff, supporting online research networks, and incorporating ICT into distance education.[49] The policy encourages the use of open source software and prohibits pirated software on any campus-owned computers.[50]

The CHS library does not have a formal ICT policy, but there are a number of security mechanisms in place. For example, in the CHS student computer lab, students cannot save to the hard drive; one of the other lab employees must authenticate for them in order to upload files. There is an antivirus program that scans USB drives when they are inserted into the CHS lab computers.

**ICT Support Staff**

ICTD employs 30 staff members and several National Service Students. ICTD currently includes a webmaster, network and system administrators, hardware technicians, and training specialists.[51] The department plans to hire an educational technologist to provide instructional design support to teaching staff.

CHS employs a number of IT support people. A librarian, two hardware technicians and one support specialist manage the CHS Computer Assisted Learning Centre (CALC). CHS has also hired a full-time media specialist to help with filming and multimedia design of open educational resources (OER).[52] CHS has a Medical Illustration Unit, which employs an artist skilled in illustration and graphic design and a photographer. At the moment, the Medical Illustration Unit is used primarily for intermittent outreach publications, such as newsletters, calendars, and passport photos.

**ICT Services**

ICTD and CALC support staff members offer a wide range of ICT services to the campus community, including ICT literacy classes, computer repair a learning management system, distance education, and video conferencing.

*ICT Literacy Classes*

ICTD staff members offer literacy classes in topics such as an introduction to computers and hardware, how to use windows, how to use the Internet and various search engines, and how to use statistical software. CALC also organizes ICT literacy workshops for CHS instructors and students. There are different instructors for the School of Allied Health than the rest of CHS. CALC staff members teach first year students how to use Windows, Internet security and antivirus software, Microsoft Office, Adobe Reader, and Internet Explorer. They also teach how to evaluate computer specs when purchasing equipment, how to use the library databases, and how to create a webpage.

*Computer Repair*

CALC offers free computer repair to CHS students, instructors, and support staff. This includes personal and university-owned computers. CALC provides the labor free of charge and charges only for any software or hardware costs incurred.

*Learning Management Systems*

UG currently uses a learning management system called KEWL.[53] KEWL is an open source application managed by University of the Western Cape.[54] KEWL is a service provided to all instructors but only a nominal percent make use of it. Most of the content is behind authentication, but there are some public courses.

ICTD is in the process of installing a server to host the OER developed by CHS. CHS purchased a server and the Webmaster installed a dedicated instance of KEWL in March 2010. In October 2010, the server was set up for local access at Korle Bu campus. Staff members plan to make the server publicly available in 2011. The university also plans to experiment with the newly developed open source Drupal-based OER Platform developed by University of Michigan as an alternative to KEWL.[55] A local OER server may work for the campus Intranet, but it would be slow for others outside UG to access the content. For this reason, as part of UG's participation in the African Health OER Network, the OER developed at UG is also available on servers in South Africa[56] and Michigan.[57]

*Video Conferencing*

ICTD manages a video conferencing facility at the Staff Learning Center. The video conferencing equipment, however, has only been used a handful of times for remote consultation. Perhaps the most used videoconferencing facility for health education is the Medical and Surgical Skills Institute (MSSI). MSSI is a partnership between International Aid, Johnson and Johnson, and the West African College of Surgeons. Located on the Korle Bu campus, MSSI trains surgeons and nurses in advanced trauma care (ATOM). Using advanced videoconference technology, MSSI enables local surgeons performing complex procedures to have expert surgeons located across West Africa and abroad to watch the surgery and assist the procedure verbally. At least one surgeon from UG has used the technology to collaborate with a surgeon from University of Michigan.

*Distance Education*

The ICT policy presents distance education as a means to increase access to tertiary education.[58] The Institute of Continuing and Distance Education (ICDE) currently distributes hard copies of reading materials and then convenes students at 10 regional centers several times a year.[59] The project with Unisplendour is part of UG's effort to expand the use of ICT within their distance and continuing education programs. In July 2010, with financing from the Ministry of Education, the Ministry of Finance and Economic Planning and a Chinese credit agency, UG launched its Network Operations Center to support ICT-based distance education.[60] In 2011, NOC plans to debut a web platform to support distance education next year.

**Instructor Access to Technology**

CHS instructors often have desktop computers in their offices. Teaching staff often have their own printers in their offices and, if not, have departmental printers. Many, if not all, also own personal laptops that they occasionally use for work as well. There is a teaching lab reserved for teaching staff called the Staff Learning Center, which is located on the third floor of the ICTD building. [61] The majority of classrooms at the Korle Bu campus do not have Internet access. The only exceptions are Anatomy, Surgery, Pharmacology, which

have Ethernet, and Gynecology, Dentistry, and Surgery, which have wifi. There are several shared computers and cameras available to CHS instructors involved in OER production.

**Instructor Attitudes Toward Technology**

Technology adoption among instructors for teaching and research is low. There are no formal incentives (e.g. academic recognition, awards) for instructors to use technology in their teaching, learning and research. Assignments are largely paper-driven. Students occasionally have papers to write, which are normally done in Microsoft Word, printed, and then turned in in-person or less often through email. Most interaction with students is face-to-face and, less often, via email. Currently mobile phones are not being used in classroom settings or in clinical settings. In a 2006 paper, UG Professor of Political Science Kwame Boafo-Arthur argued that many lecturers at the university are not computer or email literate.[62] Those with ICT skills have gained them through informal self-teaching during visits abroad.[63] ICTD offers campus email to all in the UG community, but most instructors and other staff use personal webmail accounts, such as Yahoo, Gmail, and Hotmail.

**Student Access to Technology**

In 2003, UG installed its first computer labs for students.[64] There are now multiple computer labs spread across Legon, including the ICTD building, five residence halls, Balme library, and some of the colleges have their own computer labs. Within the CHS, there is one community computer for every 50 students. There are computers for student use at the CHS computer lab, the CHS library, Anatomy, Pharmacology, Community Health, Public Health, and Dentistry.

Table 3. Student Computer Labs, University of Ghana (March 2010)

| *Campus* | *Unit* | *Number of Computers* |
|---|---|---|
| Legon | ICT Directorate | 450 |
| | Residence Halls (4 of 5) | 25 |
| | Residence Halls (1 of 5) | 50 |
| | Balme Library | 30 – 40, with another 200 to be added soon |
| | Department of Community Health | 10 |
| | School of Public Health | Unknown |
| Korle Bu | CHS Computer Assisted Learning Centre | 100 computers, 12-24 of which are connected to the Internet, depending on power and connectivity |
| | CHS Library | 2 |
| | Department of Anatomy | 4 |
| | Deparment of Pharmacology | 6 |
| | Dental School | 6 |

The students who choose not to live in the residence halls often stay at privately owned hostels on or near campus. Some of these hostels have their computer labs and Internet service, which are privately maintained and not connected to the campus network. The

private hostels near Korle Bu campus contract private ISPs for their wireless networks. In March 2010, a CHS librarian commented that the router hardware alone is US$ 70, and the subscription rate varies with the bandwidth. Roughly 10% of students at Korle Bu have Internet access from their residence.

Little research has been done regarding student ownership or access to computers. The ICTD Webmaster provided a rough estimate that less than 10% of all UG students own computers. After wifi has been installed, ICTD will be able to get a better estimate of students with computer access, as the wireless will require users to authenticate. Computer ownership is believed to be higher within CHS than many other colleges and faculties at UG. A CHS librarian offered a rough estimate that 40% of CHS students own laptops. Four second-year medical students interviewed estimate that 80% – 95% of fellow medical students own laptops. In a small survey conducted by U-M Internal Medicine Professor Cary Engleberg and UG Professor of Obstetrics and Gynecology Richard Adanu in 2009, 10 of 10 ob/gyn students owned either a laptop or a desktop. Laptop ownership is purportedly higher among medical students than students in other health disciplines.

**Student Attitudes Toward Technology**

Instructors most often assign paper textbooks, but many students use electronic or web-based textbooks that they find them on their own to replace or supplement the assigned textbooks. Students exchange lecture notes with their peers, but this is done largely through paper and photocopies and less often through Word processing applications distributed via USB.

The students who own desktops or laptops usually have Windows XP. Piracy is common among students and some upgrade to Vista or 7 using fake license keys. Students often use removable media to transfer files. CDs are much more common than DVDs as they cost significantly less (US$ 0.35 – US$ 0.70 per blank CDs vs. US$ 4.90 – US$ 7.00 for DVDs). USB drives are also commonly used.

Several medical students interviewed remarked that they use eMedicine[65] and Wikipedia, oftentimes from their mobile phones, to supplement their studies. Social networking websites are also popular among students. Most students are avid users of Facebook. YouTube is also popular, but streaming video is used less often because of bandwidth constraints. One of the CHS librarians conducted a survey with students and found that the most commonly used social networking site is Facebook. He discovered that students use Facebook to connect with friends outside CHS rather than to connect locally with peers in their own discipline. In response, the CHS library adjusted its ICT literacy programs to encourage students to use Facebook to connect with their CHS classmates.

## Kwame Nkrumah University of Science Technology

**Network Backbone**

KNUST has a fiber-supported network managed by the Network Operations Centre (NOC) within the University Information Technology Services (UITS).[66] In addition, there is a VSAT that is used as backup. In order to moderate bandwidth during business hours, the

network administrators place student traffic on the VSAT and reserve the fiber for teaching and other support staff. The campus has an Intranet connecting the various academic buildings and university residence halls. All of the residence halls and some of the academic buildings have wifi access.

Power outages are common with up to four power outages a day, each ranging from several minutes to several hours. There is a standby generator at Network Operations Center which acts as secondary power for web servers, mail servers, application severs and other servers. The ICT Center in the library also has a generator, which can power the lab for up to half an hour.

**Bandwidth**

In early 2010, the campus network had a 13 Mbps uplink and same for the downlink. The Webmaster labeled this level as "woefully inadequate" and overly expensive, costing the university US$ 45,000 per month. For this reason, KNUST collaborated with Vodafone to upgrade its bandwidth. In May 2010, Vodafone announced a partnership with KNUST authorities to install a 45 Mbps network on campus.[67] Vodafone will offer the bandwidth at a highly subsidized rate of 50%[68] for six years.[69] Vodafone has honored its promise: KNUST currently has 45 Mbps dedicated bandwidth at 50% of its original cost. In November 2010, the CEO of Vodafone-Ghana added that the company will offer discounts on Vodafone services to KNUST instructors and staff and will donate 80 lamp poles to light the campus.[70]

Although local bandwidth has improved for the KNUST community, it is difficult for users outside campus to access the KNUST website. For this reason, UITS usually hosts its higher traffic websites outside Ghana, such as with Codero Hosting Solutions. The department uses Squid to manage the 13 proxy servers on the campus network.

**ICT Policy**

In mid-2010, the government of Ghana donated US $250,000 to KNUST to advance ICT activities on campus.[71] The funds will be used to enhance the KNUST website, to develop and deploy software for finance, human resources, and research, and to increase the library's digital collections.[72] The university ratified an ICT policy three years ago. The Webmaster relayed that the university is gradually implementing the policy, with the greater proportion of it yet to be put into practice.

KNUST has also explored partnerships with HP and Microsoft. KNUST had a previous agreement with HP for purchasing network switches, but that was recently discontinued. KNUST is currently in conversations with the Gates Foundation for an agreement on subsidized Windows licensing. The Webmaster speculates that Microsoft has been reluctant to expand in Ghana and that the Ghanaian government needs to do more to enforce software licenses and to reduce piracy.

KNUST uses Windows clients and servers as well as a number of open source applications: the proxy servers are all Linux servers (Ubuntu, Suzi, Fedora). In general, UITS staff tries to use open source or develop applications locally before relying on proprietary software.

**ICT Support Staff**

UITS oversees the deployment of ICT at KNUST. There are 25 full-time staff members in addition to 15 - 20 full-time National Service students from computer science, engineering, and communication design. Currently students, instructors, and other staff casually drop-in the UITS office with questions, which can be distracting to UITS staff. In response, UITS staff members are exploring setting up an official helpdesk system.

In late 2008, the College of Health Sciences launched an OER project. The following year, CHS enlisted the multimedia expertise of the Department of Communication Design. A number of staff members (three professors, several teaching assistants, a media specialist, and a group of final year students) provide part-time media support for OER.

**ICT Services**

ICT services include network and lab maintenance, campus email, library databases (including HINARI),[73] online registration, open source software development, ICT literacy, social networking platforms, learning management systems, video conferencing, and distance education.

*ICT Literacy Classes*

UITS staff members conduct training workshops in web design, database, networking basics, basic computer hardware and repairs, graphic design, statistical software, internet skills, the Microsoft Office Suite, and the Linux operating system. UITS charges a fee for their workshops.

*Social Networking*

UITS has created two social networking groups to connect KNUST students and alumni with their peers around the world. The office maintains an active Facebook page with over 9,800 fans.[74] There is also a custom website called Friends @ KNUST with over 28,500 registered users.[75]

*Learning Management Systems and Electronic Repositories*

There is a university-wide open-source learning management called Moodle, but few instructors use it. KNUST has an open access digital institutional repository called KNUST Space,[76] which is based on the open source archive software dSpace.[77] KNUST Space is used to store conference papers, pre-print research articles and book chapters, student theses and dissertations, and the university journal.[78] University librarians maintain KNUST Space. UITS has created a second Moodle instance for OER publication.[79] Like UG, KNUST is a member of the African Health OER Network, and OER created by KNUST instructors and support staff is also available on servers in South Africa[80] and Michigan.[81]

*Video Conferencing*

The high-end multimedia studio donated by the Indian government through the Pan African e-Network for Tele-education and Telemedicine project remained dormant until 2010. UITS now plans to offer it to teaching staff for video conferencing.

*Distance Education*

In 2005, KNUST launched the Institute of Distance Learning Programs, which offers paper-based distance education. One health related program, a Masters degree in clinical and social pharmacy, is offered through the institute. In mid-2010, KNUST began recruiting students for eLearning-enabled distance learning programs using the multimedia studio from the Indian government. There are currently 3,032 students enrolled under the Institute of Distance Learning Programs and 475 students under the Indian–KNUST eLearning Program.[82] In October 2010, Vice Chancellor Otoo Ellis, announced his plan to grow the distance education and eLearning programs at the university.[83] UITS is currently converting some of the paper-based distance education classes to its eLearning platform for online enrollment for the next academic year.

**Instructor Access to Technology**

Most classrooms have an Ethernet port to which the instructor can connect, as do most staff offices. Each department has a projector, which instructors may borrow for classroom use. Each block at Komfo Anokye Teaching Hospital (KATH), the teaching hospital associated with KNUST, has a small library with two Windows desktop computers with Internet access. Vodafone offers a 50% discount on residential broadband to KNUST employees. The Webmaster estimates that 95% of instructors own personal laptops. The teaching staff participating in OER production often do so on their personal laptops with some assistance from students and staff at the Department of Communication Design (DCD).

**Instructor Attitudes Toward Technology**

Many instructors give lectures using PowerPoint and handouts. Students take notes by pen and paper on what is presented. A few instructors, however, are exceptionally tech-savvy. One participating professor in Internal Medicine carries his Flip camera in his lab coat while on service at KATH. He uses it to take pictures or videos during ward rounds or to visits to rural clinics. He saves the photos of rare or common illnesses to use later in developing OER modules.

**Student Access to Technology**

There are 2,000 – 3,000 publicly available computers on campus, most of which are desktops with Windows XP. On average, each department has 20 – 30 computers. Students may print in black and white at the ICT Center at the library for a fee.[84] The ICT Center does not have photocopiers but there are independent entrepreneurs with photocopiers scattered around campus. As part their investment in KNUST, Vodafone plans to open a 146 seat high-speed Internet café on campus in February 2011.[85]

The Webmaster estimates that 60% of all students across disciplines own a personal laptop. Student personal access to and ownership of technology varies with social class. For example, medical students tend to come from wealthier backgrounds than nursing students. A group of five recent medical graduates from KNUST estimated that nearly all of their fellow medical students own either a laptop or a desktop. In a 2009 survey of KNUST medical students, Engleberg found that 74 of 110 (67%) medical students owned a laptop or a desktop, an additional 26 students (24%) co-owned a computer with someone else,

and the remaining 10 (9%) had access to a computer from their residence. Many students who live in residence halls or hostels have Internet access.

Forty percent of all students live in university residence halls, each of which has wifi. Most of the remaining students live outside campus at private hostels, many of which offer private Internet access.

| Table 4. Student Computer Labs, Kwame Nkrumah University of Science and Technology (March 2010) | |
|---|---|
| *Unit* | *Number of Computers* |
| Total | 2000 - 3000 |
| Average per department | 20 - 30 |
| ICT Center, Main Library | 300 |
| School of Medical Sciences | 2 - 6 |
| School of Pharmacy | 20 |
| Faculty of Allied Health Sciences | 60 |

**Student Attitudes Toward Technology**

Students have various brands of laptops and removable media. Students who own computers tend to have Windows 7 or Vista on their personal machines. Some of the more tech-savvy students (e.g. engineers) have Windows laptops with virtual machines with Linux. Students most often use USB drives, usually ranging from 2GB – 8GB, to share media. The second most common storage media is external hard drives, usually ranging from 200 – 300 GB.

Student textbooks often come with CDs. Students prefer digital versions of articles and textbooks for ease of searching. The library has approximately 25 databases but students must be on campus in order to access them. Many students on campus prefer to access materials in a digital medium rather than pay for printing. Students tend to print more during exam time. Five recent medical school graduates commented that many students share lecture notes and other electronic media (e.g. videos, images) via USB drives. These are often passed down from one class to the next via the class presidents.

## Challenges and Gaps

The 2007 University of Cape Town Centre for Educational Technology report identified a number of obstacles to the growth of ICT in Ghanaian universities, including a lack of enabling policy, uncoordinated ICT programs, high bandwidth subscription costs, lack of publicity about existing programs and services, identification of information sources relevant to the intended users, poor Internet connectivity, and ineffective management of network infrastructure and traffic.[86] Three years later some of the challenges identified in the report persist. There have, however, been significant advancements in ICT infrastructure and services at both institutions since then. Given the recent network improvement projects at both universities and the price reduction of bandwidth, the bandwidth and hardware constraints will be reduced significantly in the near future. At UG, the transition of CHS to Legon could dramatically improve connectivity for the college.

Construction on the new medical school block at Legon began in March 2011, but the move may not happen for several years.[87]

**Lack of awareness of existing ICT services**

Both universities offer a rich assortment of ICT services. There, however, seems to be little awareness among students and especially among teaching staff of the breadth of technology services available to them. For example, a couple instructors at KNUST commented that they were under the impression that Moodle was a service available only to the School of Medical Sciences when in fact it is available campus-wide. None of KNUST instructors or teaching staff interviewed, for example, associated the multimedia studio from the Indian government with a telemedicine initiative.

**Lack of coordination across campuses and departments**

At UG, coordination across campuses and across colleges seems to be rare. For example, there are separate websites for the university,[88] CHS,[89] and the Medical School.[90] Each website was designed by different developers and has different designs and does not cross-reference the others. The Department of Biomedical Engineering within the Faculty of Engineering offers a medical imaging course, but there appears to be little collaboration between the Faculty of Engineering and the CHS regarding medical imaging.

**Lack of instructor incentives to integrate technology with teaching and research**

ICTD at UG and UITS at KNUST both offer ICT training for teaching staff. In addition to the hurdle of instructor awareness, there is also little incentive for teaching staff to devote time to altering their teaching methods from chalkboard or PowerPoint handouts to online learning systems. The drastic improvements in upload and download speed may decrease instructor reluctance, but only in part.

**Frequent power outages and fluctuations**

The power outages and fluctuations dampen the potential impact of the network improvement projects at both universities. Several staff and students interviewed shared anecdotes about personal or work computers that were severely damaged due to power surges. There are projects within the government of Ghana to improve the electricity, such as the Bui Hydropower Dam Project,[91] but the universities could also take small, local precautions as well.

## Concluding Remarks and Recommendations

Over the past year, both institutions have made substantial investments to improve computer and Internet access for students, instructors, and support staff. The effects of the network improvement projects and the price reduction of bandwidth will be dramatic, freeing up time that was previously spent waiting on uploads and downloads for more productive activities. In order to further advance ICT support for health science education at both institutions, I recommend the following:

**Increase publicity about existing ICT services**

A publicity campaign would go a long way to improve the impact of the comprehensive ICT training and services already in place. The campaign could be integrated with existing events (e.g. student orientation, departmental meetings) or existing platforms. For example, KNUST already has a dynamic community on Facebook. UITS could use its fan

page to announce training seminars and distance education opportunities. Within the medical schools, it seems that the class president is the point person for distributing files and information from the instructors to the other students. The class president could also share guides or other resources from the ICT staff.

**Install more surge protectors and backup power supplies**

Both universities would greatly benefit from additional standby generators to address frequent power outages. Generators are quite costly, but there are less expensive alternatives that would also be beneficial. Uninterruptible power supplies (UPS) are less costly than traditional standby generators and provide, on average, 15 minutes of backup power during an outage, which is enough time to allow people to save their work to prevent data loss. Power strips with built-in surge protectors are low-cost and, though they would not address the power outages, could prevent power surges that damage equipment.

**Integrate more information literacy topics into ICT training**

U-M, UG, and KNUST have collaborated on ob/gyn education for over twenty decades, with U-M medical students traveling to Ghana for their clinical rotations and vice versa. The Global Health Librarian at U-M conducts a library services orientation for all Ghanaian medical students who come to U-M. She observed that even though both universities cover a wide array of *technology* literacy skills, she identified a need for more *information* literacy skills, such as how to search health science databases, an introduction to relevant open access journals and OER available, and how to evaluate research articles and papers.

**UG: Conduct pilot projects with the Medical Illustrations Unit and the Department of Biomedical Engineering**

Both universities have staff and students who are highly skilled in technology, but the lack of coordination among departments leads to inefficiencies. At KNUST, the College of Health Sciences has chosen to partner with the Department of Communication Design (DCD) on multimedia production for OER. UG may benefit from a similar approach. The Medical Illustrations Unit appears to be under-utilized but its staff members possess skills that could be quite useful to developing teaching materials, such as OER. Likewise, the Biomedical Engineering medical imaging course seems like an untapped resource for enhancing medical teaching materials and publications.

**Establish arrangements for bulk educational discounts**

At both institutions, ICT procurement is done on a case-by-case basis and often at the college or department level. KNUST has arranged for staff discounts on bandwidth and mobile phone service through the agreement with Vodafone, but there is no similar arrangement for equipment or software. By collectively bargaining for hardware and software, both universities could drastically reduce the amount that the institutions, employees, and students spend on ICT.

## Appendix: Framework and Interview Protocol for ICT Analysis

### Student Access to Technology

1. Describe the type of common computing facilities available to students, if any. (e.g. number of labs, number of computers, number of printers, number copiers, cost of printing, ratio of computers to students, hours)
2. What percentage students own personal computers? What percentage of students has access to a computer at their home or hostel (e.g. family computer)?
3. What kind of computers (e.g. laptop, desktop, netbook), brand, and operating systems do most students use?
4. Do personal and/or lab computers have CD and/or DVD drives? Any other preferred media (e.g. flash drive, external hard drive)?
5. What quality of Internet access do students have from home, hostel, library, hospital, and classroom?
6. What are student tendencies to use print media vs. electronic?
7. Does student access to technology vary by department or school?

### Instructor Access to Technology

1. Personal computers (% w/ own, % with access)
2. Do teaching staff have Internet access at home? Do they receive any subsidies or discounts based on their association with the university?
3. What equipment is available to teaching staff in developing learning materials (e.g. video cameras)?
4. What access do instructors have to printing services?
5. What are instructors' tendencies to use print media vs. electronic?
6. In what ways do instructors use technology to enhance classroom learning (e.g. PowerPoint, projectors, eLearning, open educational resources)?

### Classroom

1. Are there network access and electrical outlets in classrooms?
2. How do students complete homework assignments and return them to instructors?
3. How are mobile phones used in the university or classroom setting?
4. How are mobile phones used in clinical environments?
5. Do students use digital versions of the textbooks? How?

### Network Infrastructure

1. What is the type of network (e.g. wireless, Ethernet, dialup, VSAT)?
2. What are the institutional bandwidth limits?
3. Does the campus have a local area network?
4. Do students and instructors have remote access to university servers, data, and applications (e.g. email, networked file storage)?
5. Are power outages and power limitations common problems? What is the extent (e.g. duration)? Do you have generators? What, if any, workarounds are in place to handle these interruptions and limitations?
6. Are there other technical constraints (e.g. software and hardware compatibility)?

**ICT Support Staff**

1. Is the ICT support centralized for the university or disbursed among departments?
2. What is ratio of support staff to instructors? To students?
3. Does the institution have a technology policy? Does it include bulk licenses or equipment agreements with manufacturers?
4. What are the components of the ICT budget (e.g. hardware procurement, software procurement, system maintenance, licensing fees, technical staff training, product development)? How is this decided?
5. What sorts of ICT literacy programs are available for students and teaching staff?
6. Does the campus implement any university-wide security software (e.g. antivirus)?
7. Does the institution have a learning management system? How widely is it used?
8. Which administrative activities are done electronically? Are any of those online? (e.g. registration, academic records/grades)
9. Does the institution coordinate any distance education or eLearning activities?
10. Does the institution offer any advancing telecommunication services, such as videoconferencing, medical imaging, multicast, cellular modems, satellite, or ISDN?

**Attitudes**

1. What software (e.g. social networking technologies) and computing devices are popular among students? Among teaching staff?
2. Do students take, and share, lecture notes? If yes, through what methods?
3. Does the institution engage in advocacy efforts or partnerships to improve Internet connectivity?
4. Does the institution offer any technology-related degrees (e.g. library science, computer science, engineering, management information systems, graphic design)?
5. What are the incentives (e.g. academic recognition, awards) for instructors and students to use technology in their teaching, learning and research?

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