# DIGITISING UNIVERSITY LIBRARIES IN GHANA: HOW TECHNOLOGY IS FACILITATING ACCESS TO DIGITAL CONTENT AND SERVICES

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## ABSTRACT

The study investigated the extent to which technological advances are affecting the development of digital libraries in universities in Ghana. Using the case study approach, interviews were conducted with university librarians and information technology (IT) officers of three public universities in Ghana. In all, six staff members (i.e., two representatives each from the three libraries at the University of Ghana (UG), the Kwame Nkrumah University of Science and Technology

(KNUST), and the University of Cape Coast (UCC)) were interviewed. Their views on the available information communications technology (ICT) infrastructure which would enable access to digital content and services, such as online databases, institutional repositories, online public access catalogues (OPACs) and World Wide Web (www) resources, were obtained. The findings revealed that all three universities have the basic ICT infrastructure to enable users to access digital content. However, there was restricted access to the OPAC; lack of visibility of the library website; and inadequate use of Web 2.0 tools in some of the libraries. Therefore, the study recommends the hiring of more multi-skilled librarians who would provide the necessary support for digital resources and services.

**Keywords:** digital libraries, digitisation, information communications technology, universities, Ghana

# 1.   INTRODUCTION

The application of new technologies in libraries has brought significant changes in the way information is processed, stored, retrieved and disseminated to patrons. These new technologies, known as information communications technologies (ICTs), encompass several areas, such as telecommunication and networking information delivery, office systems, expert systems, digitisation, speech recognition, hardware and software, data formats, and data systems (Ingersoll and Culshaw 2004, xiii). With the rapid deployment of ICTs, libraries worldwide are moving from places to spaces; redesigning their services and information products; adding value to their services; and satisfying the changing information needs of the user community. Libraries are providing digital collections and services, such as online databases, e-books, e-journals, institutional repositories, library websites, online public access catalogues (OPACs), the Internet and the Intranet. The increasing application of technology to library processes, especially in the current 'Information Age', has led to the emergence of digital libraries which are facilitating cooperation and collaboration, resource sharing, bibliographic control, information access and information dissemination.

In the view of Athanasopoulos, Candela and Castelli (2010, 18), digital libraries are 'organizations which might be virtual, that comprehensively collects, manages and preserves for the long term rich digital content, and offers to its user communities specialised functionality on that content, of measurable quality and according to codified policies'. They depend on sophisticated technological infrastructure which may include different machineries, software programmes and procedures including digital multimedia technologies, web-based hypermedia and hypertext, Internet/Intranet, user and system interfaces, OPACs, full text search engines, relational

databases, electronic document management systems, and so on (Dahl, Banerjee and Spalti 2006; Roknuzzam, Kanai and Umemoto 2009).

This article examines the extent to which the rapid advances in technology have, firstly, influenced the development of digital libraries in Ghana and, secondly, how they have affected access to digitised resources in selected Ghanaian universities. The specific objectives of the study were to:

1.  examine the availability of the ICT infrastructure in selected Ghanaian university libraries;

2.  assess the content and services supporting the development of digital libraries in selected Ghanaian university libraries.

Various studies have examined the use of ICT in Ghanaian libraries and have come up with different findings. Studies by Afari-Kumah and Tanye (2009), Badu and Markwei (2005), Hinson and Amidu (2006), Hinson, Atuguba and Ofori (2007), and Boateng, Sanka Laar and Molla (2009) have focused on the use of the Internet by various segments of the Ghanaian society. Generally, the authors have concluded that the use of the Internet has become popular with Ghanaians. Corletey (2011), Borteye, Teye and Asare-Kyire (2010) and Buer (2009) have examined the awareness and use of e-resources in Ghanaian academic libraries and have indicated that the e-resources are not utilised effectively. Additionally, studies by Rosenburg (2005), Koelen and Quaye-Ballard (2009), Boamah (2009), Tritt (2010) and Asamoah-Hassan (2010) have recognised the gradual progress being made towards the development of digital libraries and the digitisation of content by Ghanaian libraries.

The problem that the study sought to investigate was the extent to which the availability or non-availability of ICT infrastructure in Ghana is affecting the effective use of digital libraries and digitalised resources in Ghana.

The study findings were significant as they will provide an insight into the current status of ICT infrastructure supporting the development of digital libraries in Ghana. They will draw the attention of policy makers to opinions and attitudes towards technology and the development of digital libraries for teaching, research and learning. Although technological requirements for digital libraries and digitalised resources have been well researched in developed countries, most empirical studies on the subject in developing countries, particularly in Africa, are inadequate. The article will bridge the gap and contribute to the discourse on ICT and its role in the development of digital libraries.

The second section presents a review of the literature on technological developments in libraries worldwide and in Ghana; the third section describes the methodology of the study; the fourth section presents the findings and discussions of the study; and the fifth section dwells on the conclusion of the study and recommendations for future research.

## 2.   TECHNOLOGICAL ADVANCEMENT IN LIBRARIES

Appropriate technological infrastructure facilitates access to and use of digital content and services. A review of the hardware status in some public sector university libraries in Pakistan revealed that the majority of libraries lacked sufficient computers and Internet connectivity and had low bandwidth (Jan and Sheikh 2011; Walmiki and Ramakrishnegowda 2009). Similar views are shared by Krubu and Osawaru (2011), who mention several factors that are hindering the impact of ICTs on Nigerian academic libraries, including: a lack of capital investment to buy hardware, software and standby generators for the library; a lack of search skills; automation at infancy level; an epileptic power supply; and technical know-how. In Ghana, in spite of recently updated ICT policies, expanded ICT services, improved network backbone, and increased bandwidth, Omollo (2011) argues that the Kwame Nkrumah University of Science and Technology (KNUST) in Kumasi and the University of Ghana (UG) still face major obstacles in terms of the 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 addition to hardware, the choice of appropriate software or use of standard library software/management systems in automation is of utmost importance. Jan and Sheikh (2011), report that libraries in some public sector university libraries in Pakistan are using a variety of library management software, such as LIMS, LAMP, Koha, Virtua and WINISIS. A similar situation is prevalent in Ghana where libraries are using different software for library management resulting in the lack of user groups being created for resolving software challenges.

The availability of the Internet is an important network infrastructure and in the view of Adomi, Omodeko and Otolo (2004), academic institutions cannot do without Internet services especially in this era of information globalisation, explosion and superhighway where Internet connectivity enhances teaching, studying, research, publishing and communication. In spite of this conviction, Internet penetration in Africa as at 31 December 2014, was low (10.3%), as compared to other continents, such as Asia (45.6 %), Europe (18.9 %), North America (10.1%), and Latin America/ Caribbean (10.1%) (Internet World Stats 2014). The low penetration is reflected in studies by Chigbu and Dim (2012) and Echezona and Ugwuanyi (2010) who attribute it to a number of obstacles, such as: unsteady power supply; low bandwidth; low speed Internet infrastructures, such as VSAT; and lease line wire connection. A possible solution could be the use of a fibre optic network which has improved bandwidth access to electronic resources in university libraries in Malawi (Mapulanga 2012).

Despite the numerous challenges, academic libraries in Africa have created institutional repositories (IR) where scholarly works are digitally published, accessed and stored for teaching, research and scholarly communication. Corletey (2011) observes that four academic libraries in Ghana, namely, the University of

Cape Coast (UCC), the University of Education, Winneba, the Ghana Institute of Management and Public Administration and the Methodist University College have met the challenges of technical support, content provision, qualified personnel and institutional backing with the establishment of their IRs. However, he asserts that the absence of policy legalising the operation of the repositories has made it difficult for the managers to request equipment, content and qualified staff to run the repositories.

In the view of Nyambi and Maynard (2012), the current state of IRs in Zimbabwe has largely been influenced by the political and economic situation in the country. Partnerships forged between the libraries and INASP are playing a significant role in supporting research and setting up of the repositories. They conclude that the issue of repositories in Zimbabwe requires much attention and financial assistance from the government and from the universities themselves. In a similar vein, Dorner and Revell (2012) report that subject librarians in New Zealand have varying levels of knowledge about IRs as an information resource and hold both positive and negative perceptions. The librarians perceive IRs to be still underdeveloped, with greatest value for humanities clients and least value for science clients, offering little value to undergraduates, but being a good resource for accessing theses.

In addition to IRs, libraries worldwide are offering Library 2.0 services which are more personalised, interactive, collaborative, web-based and driven by community needs. Services, such as Wiki, Blog, Really Simple Syndication (RSS), Podcasting, Instant Messaging, Short Message Service (SMS), Multimedia Messaging Service (MMS) and Social networking are readily accessible through libraries (Holmberg, Huvila and Kronqvist-Berg 2009, 668). Ruppel and Vecchione (2012) in their study on chat and SMS reference concur that college students value the availability of high-quality, quick, convenient, personalised reference assistance, regardless of the medium used. It is, therefore, unsurprising that 90 per cent of students from the Boise State University, Idaho, United States, indicated that they like to use the Chat reference and that the motivating factor for using it is the speed at which questions are answered and the quality of help they receive from the librarians.

Other technological advancements, such as OPAC and the library websites, are facilitating access to content and services. OPAC serves as a gateway to the resources not only held by a particular library but also by other linked libraries and to regional, national and international resources (Islam and Ahmed 2011). Denholm, Kauler and Lavelle (2009) contend that with mass digitisation and the availability of web-based delivery systems and other search services, such as Google and others, libraries are forced to develop new search interfaces to replace existing OPACs. The new OPAC needs to provide clients with a seamless tool that will deliver the ability to both find and obtain the desired item. Garza (2009) supports the earlier view and describes how the library at Tecnológico de Monterrey, Monterrey Campus, Mexico, migrated from the OPAC to the open source Drupal with other freely available tools

as the basis for an extensible platform for current and future information discovery gateways.

Furthermore, the library website or its link on an academic institution's home page is essential as it helps with the library's visibility and the effective use of the library's online, web-based resources (Bao 2000). In the opinion of Turner (2010), the library website is a key point of access to the online information and must thus be attractive to the user, offering a dynamic presentation and effective distribution of the contents. The library website should be used to provide digital reference or online reference services which should help patrons to access information in a virtual environment, using various methods, such as e-mail, Webforms, chat or instant messaging, SMS, VOIP, video conferences and web-based services.

Although access to digital content is being facilitated by a number of ICT infrastructures and services, the awareness and use of content and services vary from institution to institution. For example, Chigbu (2012) reports on the high awareness and use of e-journals among academics in the University of Nigeria, Nsukka, while Tyagi's (2012) findings show a growing interest in online journals among the users at the Indian Institute of Technology's, P. K. Library and reports that awareness among the users was found to be satisfactory. Similar high awareness and use of online journals were reported by Thanuskodi (2012) when investigating Faculty of Education members in Coimbatore District in India. Sethi and Panda (2012), in their study of e-resources used by life scientists at Sambalpur University, India, reported among others, that 'e-journals' and 'e-books' are more popular among the life scientists. However, low patronage and underutilisation of electronic journals/ information in the Electronic Information Department (EID) of KNUST library, Ghana, was reported by Borteye et al. (2010).

With all these transformations, there is the concern for the management of libraries and their staff to reposition themselves in order to manage the changing modes of knowledge creation and dissemination and the information needs of the communities they serve. A number of authors have discussed the competencies and different skills that this new crop of librarians should possess, among them skills, such as negotiation, navigation, facilitation, entrepreneurship (Choi and Ramussen 2009; Fourie 2004; Gerolimos and Konsta 2008; Kumar 2009; Sreenivasulu 2000).

## 3.   RESEARCH METHODOLOGY

The study adopted an exploratory comparative case study design to find out the extent to which technological infrastructure is supporting the development of digital libraries in three universities in Ghana. This design was suitable for understanding the social process of ICT adoption and use in a developing country's context. In particular, it enabled the researcher to grapple with relationships and social processes in a way that would not have been possible if the survey approach had been used.

The main instrument for data collection was the interview. The interview process allowed the researcher to probe in depth and to examine at first hand the role of ICT infrastructure in the development of digital libraries in Ghana. For the purposes of the current research, the population consisted of officers who could address the issue of ICT infrastructure, namely, the university librarians and the IT officers in each of the three public universities in Ghana. In all, six staff members (i.e., two representatives each from the three libraries at UG, Legon, Accra, KNUST, Kumasi, and UCC were interrogated). The three universities are the oldest public universities in Ghana; have the largest number of students; and house the largest collections of resources in their libraries.

The university librarians were selected for the study because they are ultimately responsible for the development of their libraries and have a fairly good idea of the status of the library. The IT officers were also selected because they are important stakeholders as they advise and provide technological infrastructure for digital access.

Structured interviews with respondents were all taped with their permission. The interviews lasted for three hours each and were held in different locations in Accra, Kumasi and Cape Coast. The interviewing process explored core areas of technological infrastructure, such as hardware, software and other ICT infrastructure. Regarding digital content and services, the interviews focused on digital resources, such online databases, institutional repositories, e-theses, e-books and e-journals, OPAC and the Internet.

The interviews started with the UG librarian. The results were transcribed and analysed before the interviews with the KNUST and UCC librarians, respectively, were held. This iterative process of data collection, analysis, comparison and revision during the entire study was used and this process, referred to as the 'constant-comparative' method, was supported by Strauss and Corbin (in Zach 2006, 13).

A different set of structured interviews were also prepared for the IT personnel of the three universities using the one-to-one interview style. They were interviewed on the same day as the librarians from the respective institutions. For the IT officers, the interviewing process focused solely on the ICT infrastructure in the library. This was either to confirm or disprove any patterns relating to the ICT support given to the development of digital libraries in Ghana.

## 4.   FINDINGS OF THE STUDY

### 4.1.  ICT infrastructure

ICTs provide a wide range of tools and services for the development of digital libraries in the context of acquisition, technical processes, storage, retrieval and dissemination of knowledge and information. The tools include telecommunication technologies

(e.g., telephone, cable satellite, TV and radio), computer-mediated conferencing and video conferencing, as well as digital technologies, such as computers, information networks (Internet, Web and Intranet) and software applications (Walmiki and Ramakrishregowda 2009, 236). To determine the ICT status of the university libraries, the librarians and the IT officers were asked to indicate the hardware, software, Internet and other ICT infrastructure available in the libraries.

## 4.2.  Internet

Both the UG librarian and IT officer confirmed the existence of Internet connectivity through a leased line. The shared bandwidth with the university was 300 Mbps. The IT officer described access to the Internet as reliable, while the librarian mentioned that it was quite slow. In a similar vein, both the librarian and IT officer at KNUST mentioned that the library accessed the Internet through a fibre optic connection to the university backbone. The shared bandwidth with the university was 256 Mbps and both interviewees described the speed of access as moderately fast and reliable. A similar situation was encountered at UCC, where the library was connected to the Internet through a leased line and Broadband (ADSL). The shared bandwidth with the university, according to the IT officer, was 290 Mbps. Both the librarian and IT officer confirmed that the Internet connectivity was reasonably fast.

## 4.3.  Hardware

According to the UG librarian and IT officer, there were 350 personal computers (PCs) in the library with virtually all being linked to the Internet. Seventy of these PCs had been reserved for library staff only. The library network was part of a network accessible by all the libraries within the university library system. At KNUST, the IT officer described the hardware infrastructure as including 'computers, book scanners, fax machines, photocopiers, VoIP, servers, switches, wireless routers and barcode scanners. The operating systems were Windows, Linux, DSPACE, Winisis, J-Man'. There were, however, differences in the number of PCs reported in the library. Whereas the librarian indicated that there were 64 PCs with 56 connected to the Internet, the IT officer indicated that there were 50 PCs and all were connected to the Internet. Both respondents agreed that the number of PCs available for staff use was 26. The PCs in the library were linked to the university-wide network which made it possible to access information from other faculty libraries within the university library system.

At UCC, both the librarian and IT officer mentioned that the library had 155 workstations with 102 connected to the Internet. They further indicated that 24 of these had been dedicated for administrative work. The IT officer also stated that the library's network was part of a LAN and served as proxy for the Network Operating

Centre. This enabled the library to access information from other faculty libraries within the university library system.

## 4.4.  Hardware performance

Commenting on the system performance, capability and functionality, the IT officer at UG explained that 'the system was monitored to ensure server availability and server load, authorized access and related security issues'. These were recorded in a library log. A similar log book was available at KNUST, where maintenance dates, server availability as well as electricity supply and network connectivity were recorded. However, at UCC, the network performance was not recorded.

While UG users were given prior information of system downtime through notices on notice boards and the website, this did not happen at KNUST and UCC. The UG systems team recorded the time taken for actual downtime and was responsible for system maintenance or upgrade when the software was to be upgraded. At KNUST, the IT officer indicated that the systems analyst in consultation with the librarian determined when system maintenance or upgrading was due and this was mainly for the upgrade of software. At UCC, the system maintenance or upgrade was done when staff was available.

All the IT officers at the three universities acknowledged that users were encouraged to report faults or problems through email or at the reference desk. As a standard practice, these common faults were logged; however, the time it took to repair the faults was not recorded and neither were students given feedback. While UCC provided 24/7 IT support to digital resources, UG and KNUST did not do so.

The IT officers reported that the library network was linked to the digital resources and that no interoperability problems were experienced as the system complied and used Z39.50 which is a protocol that allows the sharing and use of information and other resources with other institutions worldwide. All the libraries did not provide federated searching where users could search and obtain results of information at a go from different formats.

Commenting on the commitment of management to the provision of adequate infrastructure, the UG IT officer reiterated that 'management was very supportive by ensuring that enough budgetary allocation was made. This had been the situation for the past three years where adequate funds had been provided to maintain the system and subscribe to databases'. In the opinion of the IT officer, the sustainability of infrastructure for digital library resources and services was assured. Similar sentiments were expressed by the IT officers of KNUST and UCC. The KNUST IT officer indicated that management felt that the provision of adequate infrastructure was a 'sure way of increasing the visibility of scholarly output internationally'.

## 4.5.   Software

On the subject of automation, the UG librarian mentioned that 'the library started its automation activities as far back as 1987. It was completed in 2007 and went live in 2008. Until recently, the Millennium software was being used but now the library had migrated to SIERRA. Virtually all modules had been completed'. According to the librarian, OPAC could be accessed over the Internet without any challenges.

On the same subject, the KNUST librarian mentioned that digitisation activities started in 1997 with the automation of the catalogue. Initially, CDS ISIS was used, but the data was later migrated into Alexandria software. So far, the acquisition, cataloguing and circulation modules were in use. Other modules were still being developed as the automation of systems was ongoing. According to the librarian, OPAC could be accessed over the Internet.

The UCC librarian pointed out that library automation started in the late 1990s with cataloguing and was fully completed in 2011. The cataloguing, acquisitions and circulation modules had been activated. KOHA software was being used and users needed to register with the library in order to access OPAC with their PIN and password.

## 4.6.   Digital content and services

Digital content and services may consist of materials already in digital format, such as e-journals, Internet resources, databases, e-books and other materials, which were not originally created in digital form, but have been digitised in order to provide access to and to preserve unique materials in the collections (Chowdhury and Chowdhury 2003, 90).

### 4.6.1. Digital content

The university librarians confirmed the availability of digital resources and services in their libraries. The UG librarian indicated that the available digital resources included online databases, e-journals, e-books, OPAC, heritage materials, research publications and access to Web resources. In addition to some of the digital resources mentioned earlier, the KNUST librarian added access to digitised current and back issues of the university's peer-reviewed journals and OERs. The UCC librarian also included CD ROM databases, theses, and faculty and university publications. According to the UG librarian, most of these resources were purchased, while others were digitised and some were freely available on the Internet.

The UG librarian highlighted 'the digitalization of rare books in the Africana collection, a project which was supported by the Royal Tropical Institute of the Netherlands (KIT)'. These collections were hosted on the university's IR and were designed to provide 'wide access to Ghanaian heritage materials and other African

arts and cultural artefacts'. These materials consisted of books, notes and manuscripts from the colonial era (1470–1958), including Dutch publications, Folio and Furley collections.

Commenting on the Open Education Resources (OERs), the KNUST librarian intimated that 'although these were important digital resources, the library had very little input in these resources. OER was the outcome of initiatives by the Medical Schools in Kumasi and Accra with OER Africa and the University of Michigan. What the partners of the OER domain did was to create a link to the library website'. OERs are teaching, learning and research resources that reside in the public domain or have been released under an intellectual property license that permits their free use or re-purposing by others. Some of the OERs include full courses, course materials, modules, textbooks, streaming videos, tests, software, and any other tools, materials, or techniques used to support access to knowledge.

Subscription to online databases through the Consortium of Academic Libraries in Ghana (CARLIGH) was confirmed by all the librarians. CARLIGH is open to all academics – universities, polytechnics, colleges of education and research libraries in Ghana – and it is estimated that faculty and students have access to about 19 000 journals, of which several thousand are in full text.

### 4.6.2. Digital services

IRs were available in all three public universities to promote the international visibility of research originating from the universities. At UG, the librarian indicated that the IR policy was ratified in 2014 and the aim was

> to maintain a digital archive of all PhD theses and dissertations produced in Ghana in order to promote the intellectual output of the University. It was also to host publications of staff and faculty in the university, records created by or relating to the University of Ghana in order to permanently preserve and make accessible the University's corporate memory.

The KNUST librarian stated that KNUSTspace was 'the first live university institutional repository in Ghana'. As at 2010, it had 685 entries consisting of abstracts and full text materials of digital theses/dissertations, research articles and all other forms of papers fit for dissemination.

At UCC, IR content was facilitated by a policy which ensured that students submitted e-copies of their theses. According to the university librarians, the software used for the repository was DSPACE, an open source software used to convert conventional media into digital media. The library scanned the materials and used the XML and PDF formats. Other materials which were already in digital format were also accepted into the repository. Regarding metadata in the repository, the university librarians pointed out that the Dublin Core was used as this was already incorporated into the DSPACE software. According to all the librarians, no challenges had as yet arisen with the implementation of the metadata. However,

the KNUST librarian cited some technical challenges affecting user access to the repository and other e-resources. Another significant challenge that the KNUST IT officer cited was the inability of users to log in from outside the university's network: 'Attempts were now being made to set up a Virtual Private Network (VPN) to help users log in from outside the university's network.' Similarly, the UCC IT officer mentioned access to public IP making it difficult for users to access digital resources off-campus. The library had overcome these difficulties by installing EZproxy.

All three public universities had library websites. Both the UG librarian and IT officer stated that the library's website provided general information, such as the history of the library, e-resources, services offered by the library and the OPAC. In addition to the above content at UG, the KNUST library website had the bio data of heads of the library departments. UCC also featured similar operational activities and services available. In the opinion of all the librarians, information on the websites was well organised and fairly easy to access. Interviewees from UG and UCC affirmed that the design of their websites was good and attractive; however, the KNUST librarian added that 'there was more room for improvement especially with the attractiveness of the website'. Regarding the interactive nature of the website, the UG librarian intimated that 'patrons were given the opportunity to communicate with librarians through its "Ask a librarian", "Chat with a librarian", use Facebook and Twitter links'. Unfortunately, no such interactive links were provided by the KNUST and UCC library websites. Additionally, the UG and UCC library websites had direct links from their universities main homepage. At KNUST, the library's link was placed under 'Academics' which may not be too obvious for any user. There was also a separate link provided for the IR on the university's homepage.

OPACs were available in all three university libraries to provide information on books and other materials available in the library. AT UG and KNUST, they were accessible over the Internet without any restrictions. However, at UCC, it was password-protected to prevent overuse of the bandwidth.

### 4.6.3. IT skills

The extent of use of digital resources is enhanced by committed and well trained staff who promote them to create the necessary awareness. According to the UG librarian, staff whose main responsibility for the development of digital resources at UG included network administrators and HCI specialists with BSc and MSc Computer science qualifications, as well as BA Information Studies qualifications. At KNUST and UCC well qualified staff were equally available. At KNUST, the library had three network administrators, one Web and Software developer and two Human-Computer Interaction (HCI) specialists. The UCC librarian pointed out that the library had four network administrators, three web and software developers and six HCI specialists. According to the university librarians, staff had also benefited from a number of training sessions. The UG librarian mentioned attending

workshops in relation to digitisation activities from 2009 to 2011 such as the training on DSPACE, IR seminars provided by KIT, Netherlands and other courses offered by CARLIGH. The KNUST librarian also mentioned that although the library had not directly funded staff development training in relation to digitisation activities, staff had benefited from the training provided by CARLIGH, which was established to ensure the sharing of electronic resources. Staff who participated in these training sessions also retrained other staff on their return. At UCC, the librarian indicated that staff members worked as a team and they were constantly sponsored to attend training, workshops and conferences.

With regard to user support for digital resources and services, the KNUST librarian indicated that this was facilitated through information literacy sessions or instructional sessions where faculty and researchers received training in accessing/ searching the Internet. The UG librarian, on the other hand, indicated that 'though the library was yet to introduce a formal information literacy programme, it provided instruction on online databases to postgraduate students every year'. For all other students, a one-week orientation was done. The UCC librarian intimated that senior members and some senior staff taught some users in using digital services and resources. On the level of awareness of and use of digital resources, the responses from all librarians were mostly encouraging. The UG librarian indicated that 'there was relatively high level of awareness of and use of digital resources', while the KNUST librarian stated that the very high level of awareness had impacted positively on patrons. In the view of the UCC librarian, the 'awareness level of the digital library and its resources was not very high among the academic staff, however, the postgraduate students were very conversant with them'. He further reiterated that the feedback from postgraduate students indicated that they were satisfied with the digital resources available in the library.

# 5.   DISCUSSION OF FINDINGS

## 5.1.  ICT infrastructure

The ICT infrastructure involves the enabling technology which integrates computing, storage and communication technologies together with many other tools to operate and maintain networked digital information system. Digital libraries are built on sophisticated technological infrastructure which may include different machineries, software programs and procedures including digital multimedia technologies, web-based hypermedia and hypertext, Internet/Intranet, user and system interface, PAC, full text search engines, relational databases, electronic document management system, and so on (Dahl et al. 2006; Roknuzzam et al. 2009). Technology promotes the systems functions, such as acquisition, conversion, processing, storing and providing universal access to digital information. The technical infrastructure can

support the construction of online information services for research, teaching and learning including services that enable the libraries to effectively share materials and provide greater access to digital content. For the purposes of this discussion, technological infrastructure will be based on views proffered by librarians and IT officers on the availability of hardware, software and high speed Internet connectivity.

The study findings revealed that all three university libraries have the basic infrastructure to enable accessibility to the Internet. With the exception of the UG librarian, who described access to the Internet as slow, the other librarians and IT staff described access to the Internet as moderately fast and reliable, satisfactory and reliable. UG had the highest bandwidth of 300 Mbps, followed by UCC with 290 Mbps and KNUST with 256 Mbps. Even though the bandwidths seem to be adequate, university authorities should explore the use of fibre optic network as recommended by Mapulanga (2012).

In terms of hardware, the availability of computers in the three universities seems to be quite adequate with UG providing the greatest number of PCs both for staff and patron use. However, KNUST needs to increase the number of PCs in the library to at least 300 to cater for students who do not have personal laptops. In spite of KNUST's situation, university libraries are better equipped than some public university libraries in Pakistan, where computers were found to be inadequate (Jan and Sheikh 2011).

With regard to library automation, the study found that all three university libraries have completed this process. This finding clearly provides an update to Rosenberg's (2005) study, which observed that many libraries in Africa were not automated and were still using manual systems in their library operations and services.

To ensure the functionality of digital libraries, all university libraries complied with universally accepted standards and protocols. The IT officers mentioned compliance with Z39.50 (an information retrieval protocol) which allowed the library to share its information with other institutions and also allowed its patrons to use other resources worldwide. This finding is consistent with the significant transformatory changes in the 2000s which ensure the integration of technologies and independent systems to ensure harmony.

## 5.2. Digital content and services

Digital content and services represent information made available to users, whether it is 'born digital' or 'made digital'. It may include virtually any kind of electronic material, such as library catalogues, digital collections, subscription databases, electronic journals, electronic reserves, document delivery and the creation of local digital content (IR). Discussions on the above are based on the views proffered by the participating university librarians and IT officers.

The study found that all three universities had IRs. The common software DSPACE was used by all three universities and Dublin Core was used for the description of the metadata. In Jain's (2011) view, IRs are helping to curb the scholarly communication crisis owing to high serial subscriptions.

In the era of technology, the basic access point for any library is its electronic catalogue, which would enable patrons to find out what information exists in the library without walking to the library. The findings showed that the universities were using a variety of software to create their OPACs. KNUST was using Alexandria software, while UG was using Millennium (now SIERRA) and UCC was using KOHA, reflecting a similar situation in libraries in Pakistan where libraries were using different library management software (Jan and Sheikh 2011). Ideally, if libraries cooperate and purchase one integrated library software package, it would facilitate the sharing of information and increase cooperation among the libraries (Rubin, 2004). The creation of a union catalogue may help to resolve some software technical challenges as the participating libraries would constitute themselves into a user group. The purchase of the integrated software package may also reduce the cost of software and future updates as the libraries could negotiate as a group with the vendors.

Patrons' access to OPACs was also varied. UG and KNUST's OPACs were accessible over the Internet without any restrictions, while that of UCC had to be accessed by registered users of the library. This finding is worrisome in this digital era where users want information easily and quickly without the challenge of remembering passwords. The reasons attributed to this were to protect the bandwidth from excessive use by outsiders and also to track the number of users to the site.

If university libraries were to collaborate in having a union catalogue, access to OPAC would have to be over the Internet without any restrictions. Thus, the universities would be required to have adequate bandwidth and infrastructure in place.

A major challenge which the research revealed was the lack of seamless integration of digital resources and services in all the libraries. This implies that users have to access the library catalogue, IR and e-resources separately and at times with different passwords. This finding seems to be at variance with the findings of Garza (2009) where the library at Tecnológico de Monterrey, Monterrey Campus, Mexico, provides seamless access to information.

The availability of the library website was confirmed by all the university librarians and IT staff. They all agreed that the information was well organised on the website to facilitate retrieval. However, an indictment on the KNUST library websites had to do with its visibility. The library's link from the KNUST homepage could be found under 'Academics' which would certainly not be obvious to many users. As reiterated by Bao (2000), the location of a library home page link on its parent institution's home page determines the visibility of a library and affects the

effective use of the library's online, Web-based resources. In addition, the KNUST and UCC library websites did not provide any Web 2.0 facilities. Web 2.0 is one of the significant transformatory changes in the 2000s which gave rise to digital libraries. The UG library website has to be commended for being up to date in providing services, such as Live Chat, Ask a Librarian, Facebook and Twitter links. Ruppel and Vecchione (2012) note that the use of such facilities enhances the speed and quality of reference services offered by libraries.

The study findings also showed that the library personnel in the three universities have the basic IT skills. However, the researcher observed that more multi-skilled librarians are needed to ensure that the necessary competencies are available to assist patrons (Choi and Ramussen 2009).

With regard to library cooperation and resource sharing networks, all three university libraries belong to CARLIGH and share cost of e-resources. The libraries do not only benefit from online database training but also benefit from staff visits through consortium arrangements.

# 6.   CONCLUSION AND RECOMMENDATIONS

The article has examined in detail the two main objectives set out for the study which focus on the availability of IT infrastructure and the types of digital content and services provided in Ghanaian university libraries. The study concludes that all the three libraries have the basic ICT infrastructure to ensure the development of digital libraries in Ghana. They have adequate computers and Internet access with reasonable bandwidth. Automation is at advanced stages and the libraries have basic library websites which, however, do not provide seamless access to library resources and services. All the libraries have IRs and also have some staff members who possess basic IT skills to ensure the development of digital libraries. Library cooperation is carried out through CARLIGH where the cost of e-resources is shared. In spite of the positive findings, the study recommends that the library which provides restricted access to its OPAC should endeavour to make it accessible over the Internet without any restrictions. This would ensure that users could access it on and off campus.

Though all the libraries had websites, one library's website was not visible from the university's homepage. This had to do with the design of the webpage and the librarian and IT officer would have to engage the university administrators for a change in this situation.

Furthermore, two of the libraries need to make their websites interactive. The use of Web 2.0 tools, such as social networking tools and chat services, is highly recommended as many students are comfortable using these tools for communication. Finally, all three libraries need to engage more multi-skilled librarians who would be able to provide the necessary support for digital resources and services.

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