Assessing the available ICT infrastructure for collaborative web technologies in a blended learning environment in Tanzania: A mixed methods research

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ABSTRACT

This paper is about the use of a Mixed Methods approach in an investigation that sought to assess the available Information and Communication Technologies (ICT) infrastructure capable of supporting Collaborative Web Technologies (CWTs) in a Blended Learning (BL) environment in Tanzanian Higher Education Institutions (HEIs). We first used questionnaires to collect information about available ICT infrastructure from a sample of 1,068 respondents in six different higher education institutions in Tanzania. The sample was made up of students, faculty, and ICT staff in these institutions. Interviews were then used to either clarify some points from the completed questionnaires or to seek in-depth information. Data were also collected from observations and review of documents from the Government of Tanzania. We present the results of our investigation, which suggest strongly the availability of good and growing ICT infrastructure capable of supporting the use of Collaborative Web Technologies (CWTs) BL in HEIs in Tanzania.

Keywords: *Mixed Methods Approach, Blended Learning, Collaborative Web Technologies, Higher Education, Tanzania*

INTRODUCTION

This paper aims to assess the current Information and Communication Technologies (ICT) infrastructure in higher education institutions (HEIs) whether it can support the use of collaborative web technologies (CWTs) in a blended learning (BL) environment. Our review of the literature shows that a good ICT infrastructure is an essential element when considering for the use and adoption of CWT-enabled BL in learning and teaching (Mtebe & Raphael, 2013; Toro & Joshi, 2012; Sife, et al., 2007; and Omidinia, et al., 2012). In the light of BL's potentials for learning and teaching, this study was motivated in one way, by the need to assess the current ICT infrastructure capable of supporting CWT-enabled BL (Lwoga, 2012) in Higher Education Institutions (HEIs) in Tanzania. Equally important, the study is attributed by the fact that, the use of CWTs and the BL is increasingly becoming a common instructional model (Graham, et al., 2013) in higher education. Thus, it is timely and relevant, to assess whether the available ICT infrastructure in Tanzania can support the use of Collaborative Web Technologies (CWTs) in a BL environment in HEIs. This paper also reviews briefly the literature in both Mixed Methods approach and CWTs in higher education in order to advance its application in this context. The study findings and the reviewed literature discussed in sections two through six of this paper, provide enough evidence that, the study is a timely contribution to assess the available ICT infrastructure's capability for supporting the use of CWTs in a BL instructional model.

In view of the above introductory discussion, in this paper, we adopt a definition used by Graham, et al., (2013) and Lomas, et al., (2008) that BL is a combination of face-to-face and online learning instructional models. Not withstanding the current debate about the definition of BL (Chew (2009), contextually, the current practice of BL in Tanzania is limited to the combination of face-to-face and e-learning technologies such as Moodle and Compact Discs (Mtebe & Raphael, 2013). Consequently, the current practice is yet to consider the use of CWTs such as Wikis, podcasts, blogs, and social networks (Rosbotom & Lecarpentier, 2010). A closer look at the current practice reveals that BL in Tanzania HEIs is at its infancy level (Lwoga, 2012; and Mtebe, 2015). Along similar lines, we are of the view that, one of the main reasons why CWTs have not been widely used in Tanzania for BL is the lack of information about the available ICT infrastructure to support CWTs in learning and teaching. As far as we are aware, there is little research to establish the available ICT infrastructure in HEI in Tanzania capable of supporting BL (Lwoga, 2012; and Dahms & Zakaria, 2015). Scoring from study motivation discussed above, these empirical evidences (Dahms & Zakaria, 2015; Lwoga, 2012; Mtebe & Raphael, 2013; and Hennessy, et al., 2010) insist on the rationale for the study.

At the international research level, generally, Omollo (2011); Toro & Joshi (2012); and Dahms & Zakaria (2015) suggest that HEIs in developing countries have good ICT infrastructure to support learning and teaching. However, some challenges exist, such as lack of awareness among ICT users of the available services in HEIs, poor coordination across campuses, demotivated faculties, and lack of top management support (Omollo, 2011). Nevertheless, the challenges facing HEIs have been widely resolved and some efforts are underway to improve the situation (Omollo, 2011). For example, heavy investment in telecommunications, and high rate of electricity penetration in Africa, have reduced the impacts of the challenges faced by HEIs (Hennessy, et al., 2010) and (Wainaina *et al.,* 2014). Additionally, the ICT infrastructural components such as internet connection, availability and affordability of hardware and software, ICT skills among students and the faculty, and national ICT projects such as the national fiber optic backbone in East, Central, and Southern Africa have improved the state-of the art of the ICT infrastructure (Toro & Joshi, 2012; Mtebe, 2015); Lwoga, 2012; and TCRA, 2015).

Moreover, there must be a supporting ICT infrastructure in order to use the CWTs in BL for enhanced learning and teaching (Boulos, et al., 2006). Empirically Lwoga (2012) used a Mixed Methods approach to assess the extent to which CWTs support learning and teaching in Tanzania. Lwoga (2012) assessed the ICT infrastructure through semi-structured interviews, in which the results show the presence of fiber optics, wireless internet, internet bandwidth and devices at a basic level. Furthermore, the ICT infrastructure was investigated using interviews administered to ICT staff only. In our opinion, using a sample that includes students, academic staff and ICT staff enabled us to assess in depth, and contribute timely knowledge about the available ICT infrastructure's capabilities in supporting CWTs in BL in Tanzania.

THEORETICAL REVIEW OF THE MIXED METHODS APPROACH

Our review of the Mixed Methods approach revealed that, MM has grown over time (Bryman & Bell, 2007) and offers an alternative to qualitative or quantitative only inquiries (Johnson, et al., 2007). The review shows five areas of the research process in which MM approach has been used. For example, Johnson, et al., (2007) identified the five areas as being, first, "what was being mixed (e.g. methods, methodologies, or type of research). Secondly, the point in the research process in which mixing occurred (e.g. data collection, data analysis). Thirdly, the scope of the mixing (e.g. from data to worldviews). Fourthly, the purpose or rationale of mixing (e.g. breadth, corroboration); and fifthly, the elements driving the research (e.g. bottom-up, top-down, a core component)" (Creswell & Plano Clark, 2011:p.3-4). The MM approach combines both qualitative and quantitative research (Greene, 2007; and Creswell & Plano Clark, 2011), and it is

viewed as both a method and philosophy with multiple ways of seeing, hearing, and making sense of the social world (Turner, 2008). Additionally, further review reveals that the MM approach allows for the generalization of the findings to other related organizations (Saunders, et al., 2009:p.127).

From the foregoing, our review of literature on MM approach shows that the MM approach has been used in a number of higher education studies (Saunders, et al., 2009; and Creswell & Plano Clark, 2011). For example, Vaughan (2010) used MM approach to the design of an "Inquiry Through Blended Learning (ITBL)". Likewise, Georgouli *et al.,* (2008) used the MM approach to design a Framework for adopting Learning Management System (LMS) to introduce e-Learning in a Traditional Course (Georgouli, et al., 2008). Finally, Graham *et al.,* (2013) used MM approach to design "A framework for institutional adoption and implementation of blended learning in higher education" (Graham, et al., 2013). In all the three studies, the MM approach was meant to offset the disadvantages of either qualitative or quantitative when used alone. In addition, the use of multiple methods for data collection and analysis eliminates the problems that may arise due to generalization of the findings (Shenton, 2004).

Moreover, in the current study, there three factors, which motivated the adoption of a MM approach in our study:
• The study involved an assessment of the available ICT infrastructure in terms of its capabilities to support the use of CWTs in learning and teaching. We believe that a mixed data collection method and analysis are best suited for collecting data about broadband networks, Learning Management Information systems, Internet connectivity, CWTs usage, the internet Service Providers (ISPs), and internet enabled devices.
• The study involved a case study of six HEIs - a complex population of students, lecturers, and ICT staff with obviously varied technical skills in CWTs. In this regard, a MM approach is relevant to enhance the comprehensiveness of the collected data and their analyses.
• The use of the MM approach overcomes the weaknesses of either qualitative or quantitative as single design.

The approach also helped to minimise the risk of conflicting data that could be generated by a single approach (unequal evidence) due to the nature of the higher education population (Creswell & Plano Clark, 2011). For example, in higher education, the computer literacy varies greatly from among students and academic staff.

IMPORTANCE OF ICT INFRASTRUCTURE FOR CWTS IN BLENDED LEARNING

The ICT infrastructure required to support the use of CWTs in a BL environment consists of Audio/Visual equipment, network facilities, software, hardware and people (Johnson, et al., 2014). In other words, a typical online enabling ICT infrastructure consists of broadband networks, Learning Management Information Systems, Internet Connection, Collaborative Web Technologies, Internet Service Provider (ISPs), personal and institutional mobile phones and PDAs, e-resources, and power supply (Omidinia, et al., 2012; and Johnson, et al., 2014). We strongly argue that a good ICT infrastructure is essential for the use of CWTs in a BL environment (Ramakrisnana, et al., 2012). We also argue that the ICT infrastructure for BL in HEIs, at least in Tanzania, requires a combined effort of the government and private partners in the area of ICTs. In particular, a combined effort of the Internet Service Providers, Data Service Providers, Cellular Network Operators, government agencies, and the HEIs.

CWTs have been defined as web technologies designed with features capable of facilitating work, which involves more than one person (Lomas, et al., 2008; and Cheung & Hew, 2011). In other words, the CWTs are referred to as Web 2.0 tools (Köse, 2010; and Rosbotom & Lecarpentier,

2010). Examples of CWTs include the Wikis, Blogs, Podcasts, Social Networking, RSS, mashups, virtual societies, and folksonomy. Consequently, the ICT infrastructure enables CWTs to provide opportunities for active, engaged, and collaborative learning or study in HEIs to meet learner's needs. Thus, ICT infrastructure acts as a hub to meet a learner's needs through flexible and open learning via CWTs enabled BL (Johnson, et al., 2014). Therefore, a good knowledge of the ICT infrastructure would provide better information for decision makers and teaching staff to embrace CWTs-enabled BL. This is because, CWTs-enabled BL offer benefits to learners and lecturers such as: (1) enhanced effective communication between student and lecturers; (2) enhanced effective collaboration among students; (3) enhanced student-centred generation of new knowledge and engagement; and (4) an appropriate mix of technologies and learning process (Garrison & Kanuka, 2004; Garrison & Vaughan, 2008); Chew, 2009; Köse, 2010; Graham, et al., 2013). Along similar lines, in section 4, we contextualize our case study by exploring the Tanzanian higher education in the light of its available ICT Infrastructure. We further argue that the Tanzanian HEIs unique ICT infrastructure calls for a unique CWTs-enabled BL framework and our argument is supported by the (Commonwealth of Learning, 2004; Tarhini, et al., 2013; World Bank, 2013; and Chew, 2009) about reflecting the unique environment and learners' needs in the design and use of technologies in learning and teaching.

HIGHER EDUCATION IN TANZANIA

Higher education in Tanzania encompasses all post-advanced level secondary education leading to the award of an ordinary diploma or a professional level I certificate and above (TCU, 2012). The University Qualifications Framework 2012 (UQF) classified non-higher education awards as ranging from certificate of primary education to advanced certificate of secondary education and technical certificate at national technical awards (NTA) level 5 (TCU, 2012). Thus, higher education consists of universities, university colleges, and non-university institutions such as institutes and colleges (TCU, 2012) and (MSTHE, 1999). By June 2015, Tanzania had 37 full-fledged universities, 15 university colleges (TCU, 2015) and 343 colleges and institutions – under the category of non-university higher education institutions (NACTE, 2015). All universities and university colleges are under the jurisdiction of the Tanzania Commission for Universities (TCU) while all non-university higher education institutions are under the jurisdiction of the National Accreditation Council for Technical Education (NACTE). Moreover, the TCU and NACTE coordinate admissions into higher education through two separate central admissions systems. With the objectives, TCU deals with admissions into various degree programmes, while the NACTE deals with admissions into technical diploma and certificate programmes (UNESCO, 2011). All higher education students from the bachelor degree level to postgraduate programmes are eligible to access student loan facilities (HESLB, 2015). The instructional model is face-to-face and with some distance learning modes (Komba, 2009; and Lwoga, 2012).

In the context of the ICT infrastructure, the uniqueness of Tanzanian HEIs is on the following main areas: the level of ICT advancement in the country, investment projects in ICT, access level of individual students and teaching staff to affordable internet, power supply, and computer literacy (Hennessy, et al., 2010; Lwoga, 2012; and Mtebe & Raphael, 2013). We assess these factors in relation to the available ICT infrastructure through the methods discussed in section 5. In our view, based on experiences in the ICT infrastructure management, the five factors mentioned above, provide a justifiable possibility to uniquely distinguish the ICT infrastructure in HEIs in Tanzania and those in other countries (Hennessy, et al., 2010; and Omollo, 2011).

METHODS

Research design

Drawing its rationale from the theoretical and literature review of MM in section 2 above, the assessment of the available ICT infrastructure was carried out using the Mixed Methods (MM) approach (Creswell & Plano Clark, 2011). In this approach, a multilevel mixed design was implemented in parallel or sequentially (Teddlie & Tashakkori, 2009). It should be noted that, multilevel mixed design (Teddlie & Tashakkori, 2009:p.156) could be used in the same way as the multiphase mixed design (Creswell & Plano Clark, 2011:220). In the current study, the researchers designed a case study of Six Higher Education Institutions. The participating HEIs were taken from both Tanzania Commission for Universities - TCU and the National Accreditation Council for Technical Education - NACTE. That is, three HEIs from TCU, and another three HEIs from NACTE. The choice was also based on the geographical locations of these institutions countrywide. Other factors that influenced the choice of the six HEIs were based on logistics regarding the cost of the research and ease of access as well as the need to find data that is representative of HEIs in Tanzania (Saunders, et al., 2009).

Participants and sampling

As discussed above about a multilevel mixed design (Teddlie & Tashakkori, 2009), first, the researchers selected six HEIs in Tanzania, using purposive sampling. The composition and rationale of the six HEIs sampled is provided above too. Secondly, we employed a stratified sampling strategy to group participants into students, lecturers, and ICT staff. The students' group was further divided into postgraduate and undergraduate. This was meant to draw a representative sample of participants capable of answering our research questions from all students' main groups. Then, a simple random sampling strategy was used to get participants from each group. In this case, we managed to distribute 1,461 questionnaires and 1,068 were returned (about 73%). For the returned questionnaires: first, 900 came from students (out of 1200), 120 (out of 177) were received from lecturers, and 48 (out of 84) ICT staff.

In order to supplement the questionnaire, interviews were conducted on 178 selected interviewees to clarify some of their answers or to seek more in-depth information from them. They were made up of 150 students (25 from each of the six HEIs), 20 academic staff randomly selected from the six HEIs, and 8 ICT staff randomly sampled from the six HEIs. Furthermore, a review of institutional documents was used to supplement the questionnaires too. This included a review of the government reports on ICT infrastructure and projects to ascertain the current state of the art in Tanzania. The data collected from these sources were then triangulated (Saunders, et al., 2009) and analysed together.

Instruments of the study and data gathering procedures

A questionnaire was the main data collection tool. This used points likert scale questions and a few open ended questions. Three sets of questionnaire were designed each for the students, lecturers, and the ICT staff. Additionally, an interview protocol was devised to complement the questionnaire.
Prior to the data collection process, the researchers sought and obtained access to the six HEIs. In addition, every participant signed a consent form which also ensured them for data confidentiality and privacy. The data collected was only used for the purposes of the research.
The data gathering was done in both parallel and sequential approach. The questionnaires were distributed in all six HEIs, and at the same time, we conducted documentary reviews to answer some of the research questions. Sequentially, in the end, the questionnaires were collected, meanwhile, some interviews were carried out based on the preliminary analysis of the collected

data. Finally, the data collected was analysed sequentially or in parallel from all data collection instruments (Teddlie & Tashakkori, 2009:p.151,156) and (Creswell & Plano Clark, 2011:p.220). The analysis of the interviews – qualitative data, was grouped into respective research question and then quantified and integrated with the quantitative data. That is, the data was qualitatively analysed at the respondent's level, quantitatively at the strata (students, lecturers, and ICT staff) level to answer the research questions. The integration stage of qualitative and quantitative data was done during the analysis and interpretation stages (Teddlie & Tashakkori, 2009:p.279). Using concurrent triangulation methods, each objective measured was analysed, discussed and interpreted using both qualitative and quantitative data and techniques (Teddlie & Tashakkori, 2009; and Creswell & Plano Clark, 2011).

RESULTS AND DISCUSSION

We successfully used the MM approach to collect, analyse, and interpret data from participants and using instruments and procedures discussed in sections 5.1 through 5.3. Equally important, the way the research was designed, and implemented in the HEIs context, this study advances new knowledge of MM approach application as reviewed in section 2 above. The methods were designed to fit the HEIs contexts and the nested population, such that, future research could use this approach. Creswell & Plano Clark (2011) argue that MM approach is increasingly becoming an alternative when either qualitative or quantitative approach pose risks. This is evidenced by the presence of many international journals publishing papers of mixed methods studies. Some of these journals include the Journal of Mixed Methods Research, International Journal of Multiple Research Approaches. In addition, there are international scholarly conferences on MM research signify the presence of mixed methods movement which this study advances too. This includes the Mixed Methods International Research Association (MMIRA) (Durham University, 2016), and the International Conference on Social Science Methodology (The University of Leicester, 2016). The results presented below are the outcomes of the application of the MM approach in HEIs in Tanzania. Thus, this is a reproducible approach and a contribution to the MM research.

The results presented in this section are about the available ICT infrastructural components (Broadband Networks, ISP, Learning Management Information Systems, Internet Connection, Mobile and Desktop Devices, and Power Supply) in Tanzania (Kerres & Witt 2003; and Johnson, et al., 2014). These components form the ICT infrastructure required to support the use of CWTs. For the first component of the ICT infrastructure, we present and discuss results of the available Broadband Networks and the available Internet Service Provider (ISP). We use the data from the questionnaires, interviews, and review of institutional documents. We submit that the data collected and analysed from the above methods revealed that broadband network at 3G LTE and 4G LTE (Long Term Evolution) technologies are available from all major cellular network operators and Internet Services Providers (ISP) in Tanzania. For example, our document review found out that Vodacom launched 4G LTE in 2013 (PESATIMES, 2013), SMILE launched it in 2013 (SMILE, 2013), and Airtel launched it in 2012 (Kanzota, 2012). The TTCL (Tanzania Telecommunications Ltd (TTCL) launched 4G LTE in November 2015 (TeleGeography, 2015) and TiGo (Tigo, 2015) launched 4G LTE in October 2015 in all the Tanzanian major cities. To regulate this, the TCRA has issued licenses to mobile and data operators in the country to provide reliable and fast internet connection (TCRA, 2015). The presence and operations of these operators seem to suggest that there are broadband networks in Tanzania providing internet connection.

The survey results, supplemented by documentary review results above, show about 17 network service operators (TCRA, 2015) and about 80 applications services providers licensed to operate in Tanzania. Our results concur with the report published in July 2015 by BuddeComm, which affirms that the broadband networks are reliable (Lancaster, 2015). The current use of broadband

networks extends to data and voice services nationwide. Since all HEIs are located in urban areas where internet service providers operate, our results of the interviews and observations suggest that both students and lecturers have access to broadband network services. For example, from our survey about 85.9% of lecturers were either satisfied or "very satisfied" with broadband services while about 55% of students were either satisfied or "very satisfied" with the broadband services. Additionally, the internet reliability was also ranked highly by students. About 92% of the students said the internet is either reliable or somehow reliable. The assessment was carried out for both home and campus accesses on the internet. The findings suggest, first the availability, and capability of broadband networks to provide reliable internet connection to all HEIs in Tanzania. As a result, the available broadband networks are capable of supporting the use of CWTs in HEIs in order to enhance learning and teaching.

The second component of ICT infrastructure assessed was the availability of Learning Management Information Systems (LMIS). The interview results reveal that the use of these systems provides an opportunity for users to acquire some skills that are required for the effective use of CWTs. Examples of technical skills that could be acquired include internet search technique skills, interpretation skills, internet navigational techniques, familiarization with internet common terms, and creating favourites and personal preferences. Our results further reveal that the experiences gained by students and lecturers from using the LMIS provided them with practical skills to use the CWTs in a better way. Therefore, our results show the use of LMIS such as Moodle, Blackboard, Academic Records Management Systems, and Library Management Systems improve the users' skills and enhance the reuse of such skills in CWTs when used for learning and teaching. Furthermore, our findings link to the literature (Mtebe, 2015) by highlighting that, the increased use of LMS in HEIs is an evidence of available ICT infrastructure capable of supporting the use of CWTs. According to Mtebe (2015), the LMS are accessed through stable Local Area Networks (LAN) or Wide Area Network (WAN) which are present in HEIs in Tanzania.

Regarding how to access the LMIS, Tanzanian HEIs provide access from within and outside campuses to registered students and staff. Additionally, our results collected through the questionnaires and supplemented by the interviews reveal that the HEIs' LMIS contain relevant and updated information. Although the frequency of access to the LMIS varied from each user, majority of lecturers (52%) said in the interviews, that they used them for furthering their teaching, research and consultancy. This is depicted in figure 1 which shows the frequency of accessing these LMIS by lecturers from the six HEIs in Tanzania. The frequency of accessing LMIS was divided into a 6 point scale; namely daily, 1-3 days a week, once a week, 1-3 weeks a month, very rarely, and never accessed. The results in figure 1 reveal that faculty members access the LMIS on demand basis and other systems on a daily basis. For example, the LMS, Students Portal and SAR systems were frequently accessed on weekly or monthly basis. In a follow up interview and observations, the results revealed that uploading results in the SAR systems happen often, when coursework and semester results are published. Additionally, access to Staff Portal and LMIS was often more frequent since students and staff visit it as a link to all other LMIS, and to upload and access daily announcements and information. On the basis of the above evidence on the availability of LMIS, both students and staff agreed the likelihood that, the use of LMIS helped them to gain technical skills useful for the use of CWTs in a BL environment. Additionally, the available LMIS form an important component of the ICT infrastructure required for the use of the CWTs for enhanced learning and teaching. In his study, Mtebe (2015) found out that HEIs in Sub-Saharan Africa uses LMIS to supplement face-to-face teaching via LAN/WAN and the internet. That is, access to the LMIS is both from within and outside HEI campuses. However, the literature was a generalization of all sub-Saharan Africa, which is hereby comprehended by a close look involving one country. Our results confirm frequent access to LMIS and the Student Portal by the lecturers for the reasons stated above.
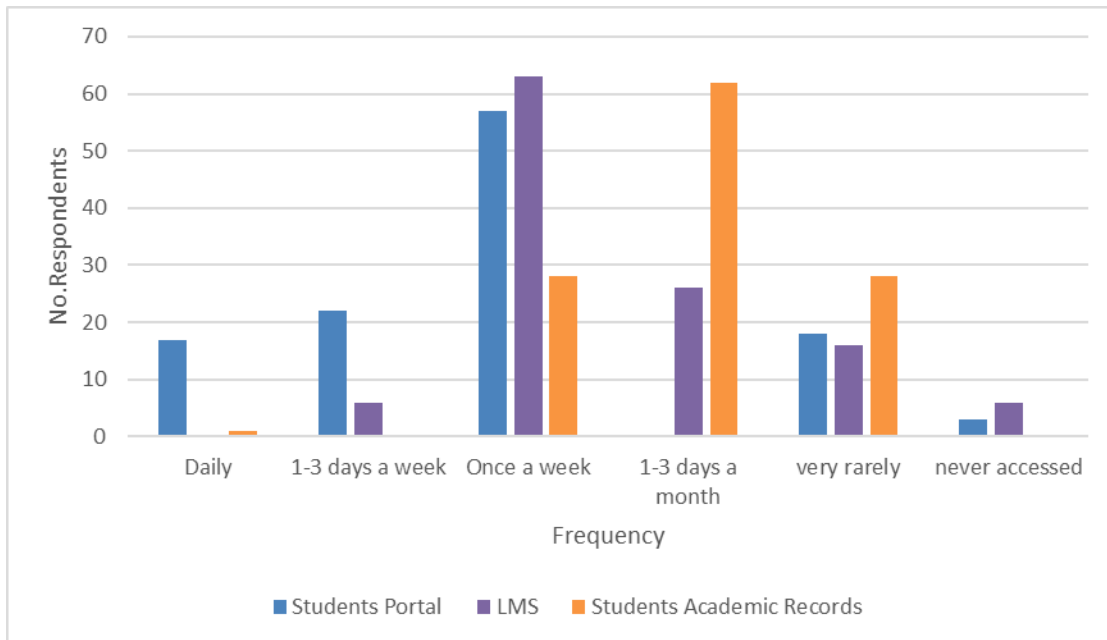
Figure 1: Frequency of access to University Information Systems by academic staff

Along with the first two ICT components discussed (network broadband, and LMIS) above, the third component of the ICT infrastructure assessed was the internet connection and the Internet Service Provider (ISP). We assessed the internet connection in terms of its reliability and availability for supporting the use of CWTs in learning and teaching. The results show that the internet connections at the HEI campuses and the students' hostels or houses (in which students live while pursuing their programmes) are reliable. For example, the results show that HEIs have a strong Local Area Network (LAN) some of which provide both cable and Wi-Fi connectivity. Likewise, our results from both observation and interview show that, in halls of residence and private accommodation, internet connection is mostly provided through mobile broadband and mobile modem dongle. In an attempt to establish causes of such disparities between campus and residential areas in Wi-Fi and network broadband internet connectivity, we found out three causes. First the complexity of Wi-Fi infrastructure setups; secondly, investing costs and thirdly, the presence of widespread cellular transmission cells in the country. On the other hand, university campuses enjoy government funding for their ICT infrastructure setups and maintenance. For example, the government of Tanzania links all public HEIs to the internet and e-resources through the Higher Education Research Institutes (HERIs) and the Commission for Science and Technology (COSTECH) projects. Previous study show challenges of internet connection like high cost, poor supporting infrastructure, and lack of technical support (Lwoga, 2012). However, our results do not conform to Lwoga's findings. Such variations could be due to the difference in time and the scope of the study. Since we interviewed students, lecturers, and the ICT staff, we believe our results present the current situation. Additionally, while Lwoga (2012) interviewed the ICT staff only in two institutions and our study used six institutions; and given some government projects in ICT, the current study advances the knowledge of the previous findings.

In order to assess the internet connectivity in these institutions, students were asked (using a questionnaire) to rate its availability and reliability at both halls of residence and private accommodation. We used four point parameters: major problem, a minor problem, not a problem,

and I do not know. For the purpose of this paper, we use "Major problem" to refer to a situation/occurrence which prevents the use of the internet. We also use "Minor problem" to mean a situation/occurrence which needs some improvement, but cannot prevent the use or access to the internet. The "Not a problem" means that a situation/occurrence which allows the use of internet; and finally, "I don't know" means that the person has not used the internet or has no idea how the internet is accessed or used in a certain locality. The analysis of the 900 responses shows that over 42% of respondents did not see this as a problem and 41% saw it as a minor problem (see figure 2). Given the meaning of the "minor problem", and the "not a problem" adopted in this paper, and the sum (42% + 41% = 83%) derived from the evidence gathered, provides a strong evidence to suggest that internet connectivity meets the basic internet needs of the students to use with CWTs. Consequently, it is not surprising, therefore, that, in the interviews, students reported that they were happy with the services they get from their providers.
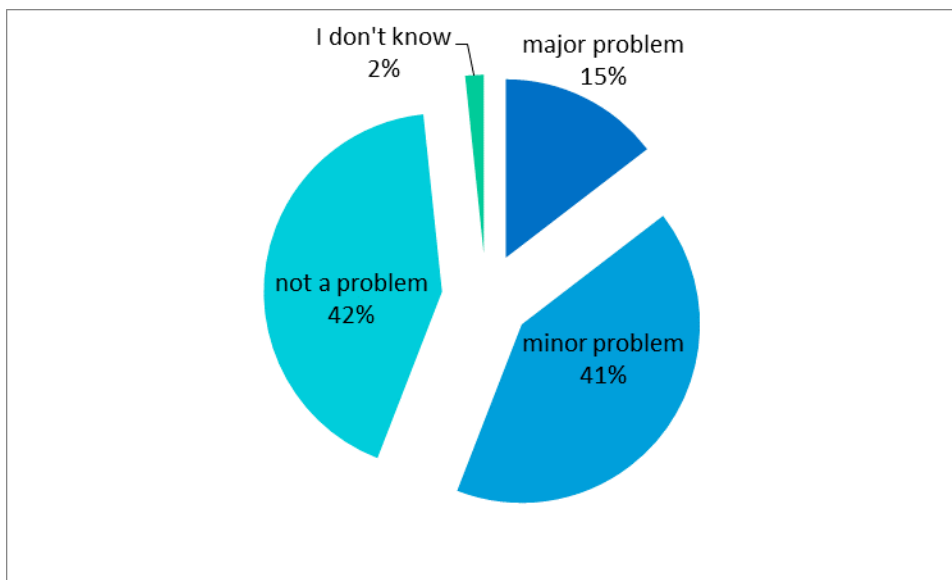
Figure 2: *Reliability of Internet connection at students' residences in Tanzania*

Likewise, academic staff (n=120), and ICT (48) staff were asked similar questions through questionnaires and interviews. The results were integrated and thus show 64% of academic staff who said that the reliability of internet connectivity was a minor problem and about 22% did not see it as a problem; only 14% saw it as a major problem. For the ICT staff, the results show about 54% of respondents said internet problems at home was a minor problem, and about 46% said it was not a problem. Apart from internet reliability at residences, respondents were also asked about the internet reliability at university campuses. The results from students show about 23% rated it as a major problem; about 49% as a minor problem; about 27% rated it as not a problem and about 1% said they did not know. For the academic staff, the results show that about 40% said it was a minor problem and about 60% said it was not a problem.

Given the above results, some follow up interviews were conducted to identify the effects of the "minor problems" on the capability of the internet connectivity to support the use of CWTs in teaching and learning. The interviews also sought to assess whether the minor problems could adversely affect the use of CWTs in teaching and learning. Out of the 178 interviewees, 92% said that such minor problems could not affect adversely the use of CWTs in learning and teaching.

Without prejudice to the meaning of "minor problem" above, examples of minor problem include internet connection signals during pick hours and weekends; power cuts in some hours of the day; bandwidth selection versus costs for better bundles; and costs of better devices such as smart devices. Most of these problems, if not all, are very temporary and their solutions are readily available. For example, a power cut problem has a solution such as using alternative power backup solutions and charging devices from a neighbouring house or from a power charging/resell kiosk.

Additionally, the results show 47% of students and about 64% of academic staff viewed internet costs as a minor problem. As defined above, students viewed the cost of the internet as "minor problem" since majority of them can afford at least a daily, weekly, and monthly or special internet tariffs. Besides, a number of projects are being carried out nationally which are expected to improve internet connectivity in Tanzania. They include the final phase of the national backbone network; TiGo and Vodacom launch M-Pesa interoperability scheme; 3G services by Zante extended in mainland Tanzania; 4G LTE launched by TiGo and TTCL in November 2015; about TZS 17.5 billion commitment by the URT of rural telecom infrastructure expansion project; the review of the National ICT Policy and TTCL expansion scheme (Lancaster, 2015). These major commitments will have positive impacts on the availability of the internet and are expected to increase access to the internet in the country (MST, 2015).
In this regard, there is scarce of data on this theme in the Tanzania HE contexts. Given the above findings and discussion, we are of the view that the present and future internet connectivity is strong and growing stronger, hence capable to support BL with CWTs.

Apart from the first three components of an ICT infrastructure for supporting CWTs-enabled BL (namely: Network Broadband, LMIS, and Internet Connection), our paper presents results and discussion of the fourth component - Mobile and Desktop Devices. The assessment was based on the ownership of these devices and whether they are used to access the internet. The Mobile and Desktop Devices form an essential part of the use of CWTs in a BL environment. That is, students, lecturers, and ICT staff use either mobile or and desktop devices to connect to the internet. In whichever case, the new knowledge is essential to help scholars, practitioners, and decision makers to make informed and good decisions on the use of these devices for enhanced learning and teaching. In table 3, results presented include only personally owned devices. The university's devices were not assessed. This is because, all HEIs surveyed had computer laboratories and internet services for students and staff. From the questionnaires, the results show about 84.3% of students and about 84.2% of academic staff have at least an active account in one of the CWTs. Respondents also indicated the ICT devices with which they use to connect to the internet include desktop computers, laptops, and smart devices. We present results in fig. 3 from students' responses on the devices they use to connect to the internet.

The use of the devices in figure 3, depend on the internet connectivity and the availability of broadband networks. Our further investigation through questionnaires and interviews revealed that both students and lecturers have mobile and desktop devices to use for CWTs-enabled BL. In figure 3, majority of students do not use desktop computers at home and in some cases at the university campuses, instead, they use smart devices followed by laptops. That means, the results do not include computers owned by HEIs. The reviewed literature does not provide enough evidence of similar studies on internet enabled devices. It is only a study by Mtebe (2015) who assessed the use of computers, CD, and DVD facilities for e-learning in HEIs. However, the hardware and software requirements for e-learning and CWTs may vary greatly.
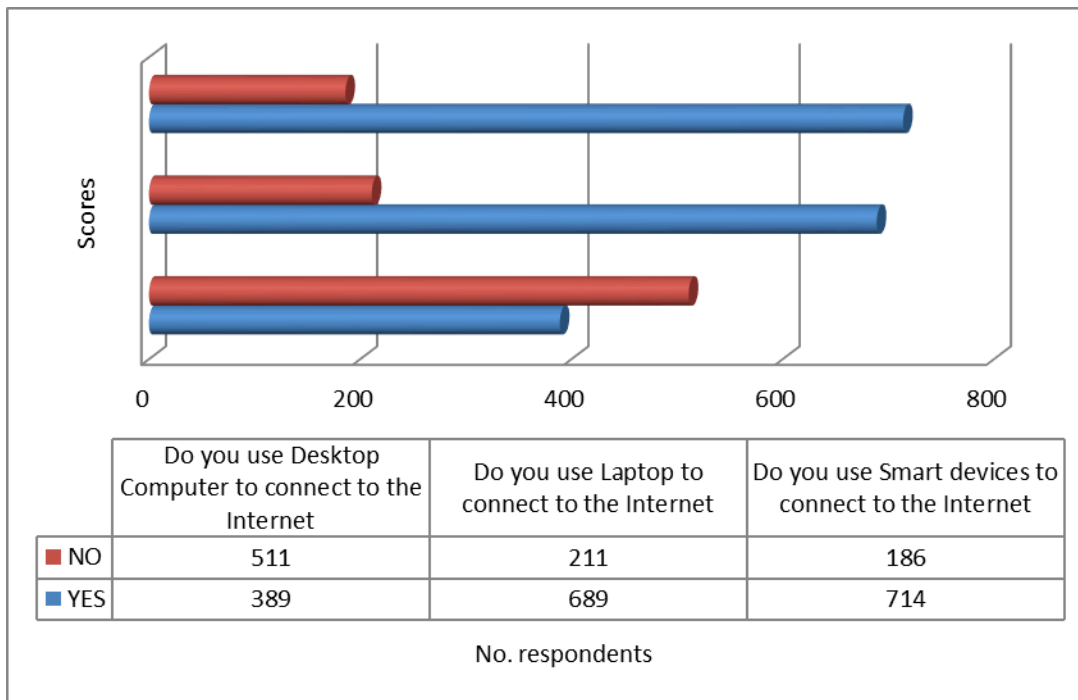
Figure 3: *Devices used for internet connection*

We also assessed the fifth ICT component called Power Supply. In this component, our questionnaire and interview results show that power supply posed some challenges to majority of interviewees. Our results also show that all surveyed HEIs operate power generators as a solution to power cuts. Furthermore, the interview and observation results show that, although generators do not run all the time during power cuts, there are specified and known times in which they operate. For off campus activities, at individual usage level, the results show the presence of portable power bank devices for the mobile devices and some portable solar power supply solutions. Additionally, the electricity penetration rate was about 14.8% with a 92kWh/capita Electricity use by December 2012 Wainaina, et al., (2014). On September 2015, an additional 90MW generated from natural gas was added and 335MW more added by the end of October 2015 (Kamagi, 2015). On the basis of the available evidence, it seems appropriate to suggest that both students and lecturers in HEIs have devices to use for CWTs-enabled BL. It is also reasonable to suggest that the current state of power supply meets the basic power requirements, and that, at the completion of the power generation national projects in Tanzania, the power outages could be minimised. Furthermore, our results provide overwhelming evidences to suggest that the current ICT infrastructure in Tanzania is capable of supporting the use of CWTs in a BL environment.

Our results also show that the current literature does not provide enough evidence on the infrastructure for CWTs. The current literature on the ICT infrastructure show only components for e-learning (Lwoga, 2012; and Mtebe, 2015). In line of the data reviewed, we strongly argue that there is a difference between the e-learning systems and the CWTs requirements. Thus, the current study is timely and contributes to the existing body of knowledge to inform the emergent blended learning instructional model in the context of HEI in Tanzania.

Apart from the results and discussions above, we highlight that our study may be limited in regard to generalization. This could be caused by external validity, such as technical skills gained through experiences of using LMIS and prior knowledge of web services for some of the participants. We assume that the technical skills gained from the use of LMIS might have influenced the responses given and any similar study to the same population or similar population may or may not yield similar results. For the internal validity, any internal politics in HEIs may have influenced students' and lecturers' responses in favour of any side. However, this study is a contribution since it:

- Adopts a reproducible MM scientific approach in higher education research as discussed in section 2, 5, and 6 above.
- Generates new knowledge about the availability and capability of ICT infrastructure, in the developing country's contexts, specifically in Tanzania, capable of supporting CWTs-enabled BL in higher education. This informs decision makers on the hardware and software requirements of CWTs-enabled BL and when planning for and implementing CWTs-enabled BL in Tanzania.
- Reveals new information about how the gained technical skills from legacy systems such as LMIS, could be useful in the use of new technology such as CWTs in HEIs contexts. In this case, through the experience gained, students and lecturers can use CWTs in a better way.
- Provides a critical review and discussion of the ICT infrastructural components which are capable of supporting CWTs in HEIs in developing countries.
- Provides a stepping stone for further research in the ICT infrastructure in relation to the use of CWTs in a BL environment in higher education in Tanzania.

CONCLUSION AND REFLECTIONS

We believe that the results from this study are of value in the context of the ICT infrastructure for CWTs-enabled BL in HEIs in developing countries such as Tanzania as stated above. The paper has shown that there is a stable and capable ICT infrastructure in Tanzanian HEIs to support the adoption and use of CWTs for BL environment. The MM approach was used to enhance the quality and comprehensiveness of our data and results. Additionally, the MM approach helped to collect enough evidence and interpretation to state the current status of the ICT infrastructure in Tanzania. In summary, through questionnaire, interview, observation, and review of organisational documents, the MM approach helped to show that Tanzania has a stable and fast growing broadband network service. The paper has also shown that the ISPs competition in Tanzania has resulted in lowering of the internet costs and increased the qualities of services offered. As well as more internet bundle options and coverage. Furthermore, the paper shows that, by December 2015, all major cities and some municipals were covered by 3G LTE and 4G LTE. As a result, internet connection is strong in all urban areas and hence capable of supporting the use of CWTs in a BL environment. All HEIs in Tanzania have LMIS, most of which are accessible from anywhere with some exceptions.
Additionally, the paper has shown that both students and lecturers have and use smart devices and laptops more than desktop computers when accessing online services through the internet. The status of power supply as one of the core components of an ICT infrastructure for CWTs-enabled BL was assessed and discussed too. The paper shows that there are power supply problems caused by power outages. However, this challenge is solved through power backup solutions and mobile power chargers for the mobile devices.

We believe that our results and discussions show that the ICT infrastructure in Tanzania is capable of supporting the use of CWTs in a BL environment.

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