Information and Knowledge Management
ISSN 2224-5758 (Paper) ISSN 2224-896X (Online)
Vol.3, No.5, 2013

Exploring the Trend of ICT Adoption in Tertiary Institutions in Ghana: A Case Study at Kwame Nkrumah University Of Science And Technology (KNUST)

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Abstract
The integration of ICT in tertiary institutions is critically important, if Ghana is to produce graduates equipped to for knowledge and technological based economy and also to bridge the gaps between itself and the rest of the world. This research examines the trend and use of ICT adoption in Ghana, and its effect on teaching, research and learning in tertiary institutions in Ghana. Mixed data collection method was used. Data was collected on the trend of ICT infrastructure within the past 10 years. There are many technology infrastructures available but it is not fully integrated in teaching, research and learning. While the practice of equipping institutions with ICT infrastructure and using them to teach computer literacy to augment teaching, research and learning is useful, the goal of fully integrating ICT in educational, research, and administrative processes seems very slow. Another issue is lack of affordable and dependable connectivity with sufficient bandwidth. The unwillingness to use ICT coupled with unreliable electric supply complicates the matter. To make these methods ready for practical, industrial use, they need further work, especially the creation of supports and investment in infrastructure. The full potential of technology will only be unlocked by effective approaches to other essential IT challenges to Ghanaian education.
Keywords: ICT, Infrastructure, Tertiary Institutions, and Ghana.

1. Introduction

According to Afshari (2006), the proliferation of technology has complicated the teaching, research and learning process and finding the best ways of adopting technology into teaching and research is one of the challenges the 21st century teachers face. Research studies in the past decade have shown that ICT is an effective means for widening educational opportunities, but most lecturers and students do not use it as a method in lecturing nor in their teaching and learning (Askar et al., 2006), the reason why they do not adopt it has received diverse views. The integration of ICT in tertiary institutions is critically important, if Ghana is to reduce the knowledge, technological, and economic gaps between itself and the rest of the world and to reduce the pressure on the limited infrastructure in Higher Institutions.

Blurton (1999) argues that, as access to ICT infrastructure (hardware, software, telecommunication and networks) continues to grow worldwide, ICT-use in education can be expected to increase dramatically. Therefore, if ICT is well integrated in institutions, it will help address assertion by World Education Report (UNESCO, 1998b) that, education worldwide is facing a significant challenge in preparing students and teachers for future knowledge-based. This is because most teachers are not prepared to use ICT and "the majority of existing school buildings, even in the most developed countries, are not equipped to integrate the new ICT" (Blurton, 1999). Blurton acknowledges the difficulties in implementing such innovations, and is sensitive to the fact that whatever is said about ICT in education now will quickly become out-dated as the technologies and educational applications continue to rapidly evolve as supported by Christensen (1997) in his sequel "the Innovation Dilemma"

The ACMA's (2008) research clearly shows that change, connectivity and innovation are occurring at a rapid rate in Australia. It suggests that the current trends in ICT are:

- the accelerating pace of change
- diversity in the development of physical infrastructure
- the spread of distributed connectivity
- enhanced content and network management capabilities
- the emerging Social Web, and
- continuing scientific and technological innovation

These trends raise questions about the ICT facilities that are available in tertiary institutions in Ghana and the need to be explored. It also adds emphasis to the need for research into the nature and extent of ICT adoption and use, its

effect on teaching, research and learning. From this, it is evident that there is the need to improve access to ICT facilities in order to effectively deploy them in tertiary institutions. Today's lecture theatre need Internet access for research, distributed multimedia curriculum on-line, access to digital libraries, distance education courses and remote collaborative tools. Information on demand for students like: video, live video broadcast, desktop and lecture notes on internet.

From the above review, the capacity of ICT infrastructure for African universities to lead the process of integrating ICT in education, as has been the case in most of the developed world, is woefully inadequate. They lack access to infrastructure, affordable and sufficient bandwidth, and the human resource capacity to exploit the technology. This makes African universities lagging behind in the global ICT context.

2. Literature Review

Information and Communications Technology (ICT) is a diverse set of technological tools and resources used to communicate, create, disseminate, store, and manage information. ICT is regarded as heart of education because of the role it played in formal and non-formal settings and public and private educational institutions (Blurton, 1999). Several researchers (Iqbal and Ahmed, 2010; Shaikh, 2009; Amjad, 2006) argued that, this century demands confidence and efficiency in ICT use in all fields, at both the academic and industry levels. Shaikh and Khoja (2011) supported this assertion that, to achieve success in education, employment, and everyday life, ICT should be seen as a key contributing factor in getting the right impact of education.

Where IT infrastructure is available, ICT users are often unwilling to use available technology that, if used, would generate significant performance gains (Swanson, 1988). In our environment, it is not so, the infrastructure is not adequate compared to other countries. This makes institutional investments in computer-based tools to support teaching, learning, and research risky and pertinent respectively. The adoption of ICT in tertiary institutions has progressively changed, and developed the learning and teaching processes in a direct way.

2.1 ICT Infrastructure in Tertiary Institutions

With the exception of South Africa, Mauritius, and most of North Africa, African universities are seriously constrained in the use of ICT by a lack of computer stations and a lack of access to affordable high-speed Internet connectivity. Indeed, the 2006 African Tertiary Institutions Connectivity Survey (ATICS) summed up the situation as "too little, too expensive, and poorly managed." The survey revealed that "the average African university has bandwidth capacity equivalent to a broadband residential connection available in Europe, pays 50 times more for their bandwidth than their educational counterparts in the rest of the world" (Gakio, 2006).

These challenges are being addressed through the development of *national research and education networks* (NRENs) that, at national levels, will enable connectivity among universities and, eventually all educational institutions. The NREN linking initiative is also being led by the UbuntuNet Alliance that has been established to provide a research and education backbone for Africa based on the emergence of optical fibre and other terrestrial infrastructure opportunities (UbuntuNet Alliance).

The expectation is that by linking these networks via regional networks, global connectivity will be a reality and costs can be reduced to sustainable levels. Universities are also developing their own internal ICT policies. Many of the South African universities are examples, with several having policies on the manner in which ICT is expected to be integrated into the teaching/learning process. Others have policies on the management of ICT functions.

Research by Malcolm and Godwyll (2008) reveals that the use of other ICT tools such as video conferencing; emailing and the Internet are rarely used. ICT Infrastructure issues are availability of ICT hardware (computers, Internet), availability of ICT software and infrastructure needs and issues. At the tertiary level, most ICT literate educators own their own computers and use the Internet for searching for teaching and learning materials which they use to enrich the contents of their lessons (Mereku et al. 2009). Another study conducted by Laff (2007) states that, online training, blended learning and other upstart methods may be the way for the future as many organizations move away from traditional classroom instruction, but in the IT field, instructor- led training remains the preferred method for many applications. Van Belle and Soetaert (1998) were of the view that, "information technology in the classroom is used in an ineffective way and it has proven difficult to integrate within traditional curriculum settings".

In a conference of Vice-Chancellors, Provosts and Deans of Science and Technology faculties from several Universities across Africa (ANSTI, 2005), low investment in ICT infrastructure, high cost of connectivity and bandwidth, poor online access (to journals) and Internet services were identified as major problems that hinder effective use of ICT for teaching, research and learning. Malcolm and Godwyll (2008) further reveal the lack of ICT infrastructure as one of the factors for non-usage of those tools. Another studies show that, limited resources

within schools are a great impediment to the take-up of ICT. Lack of computers and software in the classroom can seriously limit what teachers are able to do with ICT (Hadley and Sheingold, 1993).
A mix of on-site and distance programmes seems to be a possibility for the students of the future looking at the number of students who seek admission into tertiary institutions annually. Teachers need to be provided with adequate facilities and training to be able to use those facilities in order to progress in this technological age.
Study by Omwenga (2003) showed remarkable disparities in the number of computers in each of the 20 universities surveyed from across the African continent. On average the analysis showed that there are about 6.5 computers per basic science course and about 9.1 computers per engineering science course. It was also noted that in general, very few departments provide computers to all of their staff. In fact only 1 out of 3 departments across disciplines had more than half of their staff who has computers in their offices.

2.2 Effect of ICT Adoption and Use on Teaching, Research and Learning
A study by Neset, et al. (2008) concluded that, before investing heavily in ICT infrastructure, administrators should understand that the nature of 'productivity' in learning is elusive. They assert that, the specific needs and expectations of students, teachers, researchers and administrators who adopt ICT for use in education should be studied as the outcomes of investments in ICT. A study by Mereku, et al. (2009) highlight the following as the impact of ICT on students: the use of ICT had equipped them with skills to search for information and this had helped them gain more knowledge of some of the things they study in many subjects, increasing their confidence in making contributions during class discussions, helped in understanding abstract ideas and concepts. The grammatical and typographical errors in completed assignments had also reduced because of the ability to use the spell and grammar check functions of the word processing programme on the computer. Their findings indicates that, at the tertiary level, some impact of ICT use was observed in educators and learners, particularly from those involved in department-based ICT courses. This study will throw more light on this study by looking at the nature and extent of ICT adoption and use and its trend. Malcolm and Godwyll (2008) also states that, ICT has impacted on students, administrators and teachers respectively in the following ways: serve as extra reference materials to deepen understanding of the subjects taught in classrooms, computer software is used to track progress of students' performance and record grades, it changes pedagogical approaches, help to motivate and improve teacher-student interactions, increased self-confidence and increased excitement about teaching. This study has contributed towards knowledge on the impact of ICT on teaching, research and learning, but was done in different environment and setting. This study will throw more light into this in Ghanaian settings, furthering it into its challenges.
From this, it can be said that ICT has positive impact on students' and lecturers access to knowledge. As asserted by Goyal et al. (2010) that, ICT on education improve overall learning, increase in efficiency, increase in quality of projects and reducing the cost of education. It is also clear that ICT enhance learning process and its introduction in institutions has had beneficial impact on administrators, students and lecturers. It should also be note that these studies concentrated on second cycle institutions. This study will further these findings into tertiary institutions. Also Cox and Abbot (2004) carried out a study examining the factors relating to the uptake of ICT in teaching. 44 male and 28 female computer-using teachers with a mean age of 42 years were sampled. The results showed that, teachers who are already normal users of ICT have confidence in using ICT, perceive it to be useful for their personal work and for their teaching and plan to extend their use in future. Factors that were most significant to these teachers were: making the lessons more interesting, easier, more fun for them and students, more diverse, more motivating and more enjoyable. Additional personal factors were: improving presentation of materials, allowing greater access to computers for personal use, giving more power to the teacher in the school, giving the teacher more prestige, making the teachers' administration more efficient and providing professional support through the Internet (Mumtaz, 2000). It can be said that, the study focused on old male teachers (mean age is too high). The study should have taken age and gender issues into consideration to erode any biases in terms of age and gender. It was also limited in elementary school setting. Regardless of this shortfall, the importance of their study should not be underrated.

3. Methodology
The research approach was chosen based on the research purpose and questions set to be answered. This study adopted mixed method approach, thus both qualitative and quantitative approach were used. Combining qualitative and quantitative approaches within the same piece of research ensures the overall effectiveness of the research process as one can enhance the findings of the other. Also qualitative and quantitative data were combine because, it helps the study in revealing unanticipated results and also lead into confidence in the results. Combining qualitative and quantitative approaches within the same piece of research enables the researcher to

provide richer detailed analysis. This study adopted a case study strategy to explore the trend of ICT adoption and use in tertiary institution. This helps to gain a rich understanding of the trend of ICT adoption in tertiary institutions. Questionnaires and semi structured interviews were used to collect data from respondents.

The targeted population for this study was lecturers, students and ICT personnel from KNUST, Kumasi in Ashanti Region. Data was collected on the trend of ICT infrastructure within the past 10 years. A sampling size of 212 was targeted in the study. There were a total of 190 respondents consisting of 30 lecturers, 150 students, and 10 ICT officers all from different colleges on campus. Purposive and convenience sampling (haphazard sampling) technique was used in selecting the sample.

4. Analysis and Discussion of Data

4.1 ICT Infrastructure at KNUST

Table 1 ICT Infrastructure at KNUST

ICT Infrastructure	*Frequency*	*Mark (√)*
Lecture notes on internet(Course website)	70(46.7%)	√*
Providing library reserves electronically	50(33.3%)	√
Mandatory ICT courses	84(56.0%)	√
Technical support to use ICT at department level	49(32.7%)	√
Online discussion boards after lectures	9(6.0%)	√*
Access to computers and Internet for teaching and learning materials	92(61.3%)	√
Internet access in Lecture Theatre for research	38(25.3%)	√
Access to digital libraries always	27(18.0%)	√
Distributed multimedia curriculum on line	-	*
Distance education courses and remote collaborative tools	49(32.7%)	√*
Online training for students (from traditional to modern method)	20(13.3%)	*
A mix of on-site and distance programmes	28(18.7%)	√
Video conferencing and live video broadcast	-	*

Source: Field Study, 2012

√ = mean the facility is offered, *= Mean the facility is not offered

√*= mean the facility is offered but is not operational.

Table 1 indicates that, the facilities provided by KNUST include: lecture notes on internet (Course website), providing library reserves electronically, mandatory ICT courses, technical support to use ICT, online discussion boards after lectures, access to computers and Internet for teaching and learning materials, internet access in lecture theatre for research, access to digital libraries always, distance education courses and remote collaborative tools and mix of on-site and distance programmes. This means that, KNUST offered a lot of facilities though not adequate as compared to the total number of students and lecturers. This is consistent with the findings by (Mereku et al. 2009), Laff (2007) and Hadley and Sheingold (1993), that these facilities are offered by universities to help tertiary institutions to adopt and use ICT to improve teaching, research and learning. From observation and interviews it came out that, many of these facilities offered by the university are not accessible or in good working condition. The findings that video conferencing and live video broadcast, distributed multimedia curriculum on line and online training for students as some of the facilities offered in tertiary institutions were not supported in the study; this is because Ghana is still developing into integrating ICT in teaching, research and learning and such facilities are not common here. The little facilities offered are not used efficiently as revealed in the interview. From the interviews, the services offered by the ICT centre are: Internet service, Management and technical support for users, Maintenance and repair and webmail for students and lecturers.

The interview revealed that the following facilities are set up and should be available soon: lecture notes on internet (Course website), providing library services electronically, mandatory ICT course, technical support to use ICT, online discussion boards after lectures, access to computers and Internet for searching for teaching and learning materials, internet access in lecture theatre for research, access to digital libraries always, distance education courses and remote collaborative tools, distributed multimedia curriculum on line and mix of on-site and distance programmes.

Lecture notes on internet (Course website) - this facility is provided by the university but it is not operational. This is because; lecturers are not ready to use it. According to the interviewee, some of the reason why they do not use it is that, their lecture notes are dabbed from the internet and do not want to paste it there, others do not upgrade their lecture notes and want to prevent external people to have access to it before lecture, some do not trust the system,

others too are not ready to change etc. Online discussion boards after lectures – it is there but not effective, we now use Facebook forum for that since this is not operational. Distance education courses and remote collaborative tools – this services is offered on campus but it is owned by an Indian university. This facility can be used by KNUST lecturers but has never been use by any lecturer. Effort is in place to get our own multimedia platform for lectures as mention earlier.

It can be conclude that, the following ICT facilities are provided by KNUST for users: lecture notes on internet, providing library reserves electronically, mandatory ICT courses, technical support to use ICT, online discussion boards after lectures, access to computers and internet for teaching and learning materials, internet access in lecture theatre for research, access to digital libraries always, distance education courses and remote collaborative tools, distributed multimedia curriculum on line and a mix of on-site and distance programmes. Respondents agreed that, ICT facilities have increased tremendously.

4.2 The Trend of ICT Infrastructure at KNUST

There was a limited infrastructure in terms of computers, internet services, internet speed, high rate of down time and limited accessibility. From the IT Officers, there has been a significant improvement in ICT facilities as compared to the past 10 years. Things were worse in the past, but now it is quite normal, even though there is still much room for improvement. According to them, there has been tremendous change in ICT infrastructure in the university; the bandwidth was below 10 mbps (Megabyte per second) which was even upgrade version, very low internet speed, high internet down-time and low up-time, there was no ICT lap to serve the whole university until the establishment of the current ICT directorate in 2006.

The bandwidth has been improved from 10 mbps to 155 mbps, ICT centres are being constructed all over campus - colleges, schools, faculties, hall of residence, GRASAG, SRC, increase in wireless access all over campus through hot spots, there has been decrease in internet down-times and increased up-time. Now there is better internet speed with low down-time, better bandwidth, and more wireless networks available and expansion is also in progress.

Measure to Improve ICT Infrastructure at KNUST

The IT Officers listed the following as some of the measures to increase the ICT infrastructure:

There is negotiation to set up multimedia centre on campus - the multimedia will be established at every college. Every college will have its own multimedia classroom. This is being done in collaboration with Chinese partners. There are measures to increase computer facilities in the university (3000 computers have been ordered). The University's plan of installing wireless services all over campus within a certain radius through Wi-Fi hot spot is on-going. While waiting for these wireless services to be completed, there are negotiations to use broadband to increase internet facilities across campus to provide hot spot at every sector of the university to give easy access to stakeholders (lecturers, students and administrative staff). To make computers available at all place for users (Colleges, Hall of residence, Schools, Faculties, department and vantage positions).

4.3 Rating of ICT Infrastructure at KNUST

Table 2 Trend Of ICT Infrastructure at KNUST

Trend Of ICT Infrastructure	Frequency	Per cent
Increasing	68	45.3
Decreasing	9	6.0
Stable	46	30.7
Not Aware	27	18.0
Total	150	100.0

Source: Field Study, 2012

Table 2 shows that ICT facilities are increasing 68 (45.3%), which is consistent with the responses from the IT officers interviewed. Despite the fact that the facilities have increase significantly, there is still room for improvement. This is because, looking at the rate and the effect of ICT on higher education, it is pertinent to integrate ICT in teaching, research and learning fully. Again from the total number of our population and the number of higher education in the country, ICT is the only way out to increase access to higher education by majority of the people which is a backbone to national development.

Additional ICT infrastructure that respondents expect KNUST to introduce to enhance teaching, research and learning but are not available in the institution are:

- A modern e-learning centre stocked with state of the art computers with programmes to aid research and learning such as Excel, Minitab, SAS, SPSS, Sage etc.;
- A bigger ICT building to increase access and accommodate more students at a time;
- Reliable wireless networks accessible everywhere on campus for use by students, researchers and lecturers;
- Easy access to computers, Internet, Public Address System (PAS) and projectors at Halls of residents, Colleges, Departments and Lecture halls to enable practical learning, for research and group studies;
- Access to electronic library always and everywhere on campus;
- Online training for students;
- Provision of Electronic/Virtual classroom via Internet;
- Extending time of work of ICT labs at department level to weekends;
- Provision of laptops for students and lecturers;
- There should be facilities that will enable lectures to be able to sit, write and display workings through a projector for students as part of e-teaching process and;
- Video conferencing: where professors in other institution can lecture without physical presence in Ghana.

This result shows how respondents are ready and expecting to integrate ICT into teaching, research and learning. This is because, they have come to the knowledge of the effect of ICT on higher education and how it can reduce many of the challenges facing tertiary institutions in Ghana.

4.4 The Effect of ICT on Teaching, Research and Learning in KNUST

Table 3 The Effect of ICT on Teaching, Research and Learning (N=150)

The Effect of ICT on Teaching, Research and Learning	N	Mean	Std. Deviation
Makes the lessons more interesting, easier and fun	150	4.09	1.016
Improves presentation of material	150	4.19	.814
Increase efficiency and quality of teaching and learning	150	4.04	.826
Equipped with skills to search for information	150	4.10	.995
Increases confidence in class contributions and discussion	150	3.78	.947
Helped in understanding abstract ideas and concepts	150	3.73	1.121
Serves as extra reference materials to deepen understanding	150	4.23	.804
It changes teaches approaches	150	3.59	1.112
Help to motivate and improve teacher-student interactions	150	3.47	1.079
Using ICT increased effectiveness	150	3.81	.937
Using ICT saves time	150	3.93	.991

Scale: 1= Very Low, 2 = Low 3 = Moderate, 4 = High and 5 = Very High
Source: Field Study, 2012

From the table 3, it can be observed that respondents perceived that, there is a positive impact of ICT on teaching, research and learning at KNUST. The factors used to measure the effect of ICT shows that, ICT really have a positive effect on teaching, research and learning.
Results indicated that, ICT serves as extra reference materials to deepen understanding (mean=4.23), improves presentation of material (mean=4.19), equipped with skills to search for information (mean=4.04) and increase efficiency and quality of teaching and learning (mean=4.04) were rated high as the effect of ICT on teaching, research and learning while ICT helps to motivate and improve teacher-student interactions ICT (mean=2.31) was the least benefit for the use of ICT.
From the interviews it came out that, ICT makes teaching, research and learning easier, it give access to books that are not available in Ghana, it increase materials that a lecturer can use to prepare lecture notes for students and research, it makes communication easier, it establish relationship between lecturers to students, students to students and lecturers to lecturers and makes teaching, research and learning at KNUST effective and efficient.
It can be conclude that, ICT makes the lessons more interesting, easier and fun, changes teachers' approach and improves presentation of material, increase efficiency, effectiveness, scope and improves quality of teaching,

research and learning, equipped with skills to search for information which serves as extra reference materials to deepen understanding, increases confidence in class contributions and discussion, helped in understanding abstract ideas and concepts in a stimulated manner, it gives wide access of education to many people, enhance interaction and communication between student and lecturers which build relationship and exchange of ideas, helps finish courses and assignment on time and facilitates group work and discussions, it enables students to become conversant with ICT which are very much needed in the job market (improves marketability of student), reduces the operational cost of the university and enrich the quality of teaching and research materials. This means that ICT helps in teaching research and learning. This is consisted with the responses from the interview. It also supports research findings that ICT have impacted positively on teaching research and learning immensely (Mereku et al., 2009, Goyal et al., 2010, Cox and Abbot, 2004).

This benefits or usefulness of ICT drive the users to adopt and use ICT in tertiary institutions as proposed by scholars which have been supported in this study. It should be noted that, usefulness are very diverse, therefore management should find what users perceived as usefulness and provide ICT that will deliver that benefit to increase its adoption and use.

4.5 Challenges of the ICT Directorate

Inadequate ICT infrastructure in terms of human ware and facilities: Ideally servers need to be change every three years, but some of our servers are about 8 years which does not help our operations. Inadequate staff to attend to users' needs, support and train them, inadequate computers for students- (when you take the ratio of student to compute, it is far below average).

Time for students to use the lab is not adequate: There should be 24/7 ICT services but access is given to student for only 8 hours (9:00 am – 5: 00 pm) which is not adequate; Interrupted power supply: A times there is power fluctuation which affect our activities, though we have standby power supply, it is very expensive to use it.

From the data and observation, there are a lot challenges that prevent the directorate to increase ICT infrastructure. As indicated, management support is low, people attitude toward ICT is low and the desire to use it is also low. The building that is used now does not belong to them but for the library. This also makes their activities challenging. It is the desire of the directorate to have its own ICT building.

5. Conclusion

At this juncture, it is evident that ICT infrastructure is not sufficiently equipped to change teaching pedagogy in Tertiary Institutions, and may require a revisit to the field of requirement engineering. However, to make these methods ready for practical, industrial use, they need further work, especially the creation of supports and infrastructure. This study has demonstrated that the progress being made in diffusion of ICT in Ghanaian institutions is remarkable. In terms of broad impact on teaching and learning, the process is just beginning.

Investment in information communication technology (ICT) does not necessarily bring improvement in teaching and learning. One important cause of this is the divorce between the design of the ICT infrastructure, users, management support and institutional objectives. An approach of Institution ICT analysis, based on the understanding of ICT social norms emphasizes the central role of the people, their responsibility and the Institution in the analysis and design of IT applications. To make ICT ready for practical, Institutional use, they need further work, especially the creation of management support and the infrastructure. The base of ICT infrastructure in Institutions has the potential to contribute to a more effective educational system.

KNUST provides an ICT platform to its staffs and students such as access to computers and the Internet for teaching and learning materials, electronic library reserves, and mandatory ICT courses to students. Technical support for ICT usage, online discussion boards after lectures, internet access in lecture theatre for research. Several colleges and schools have major technology implementations in process or nearing completion.

The full potential of technology will only be unlocked by effective approach to other essential ICT challenges to Ghanaian education. Changes to national curricula and assessment to increase the relevance and effectiveness of student learning will present opportunities to link computer use to real-world productivity skills, dynamic sources of information on the World Wide Web, and collaboration infrastructure. The institutions should also change some of their policies to create the environment for full integration of ICT in their programmes. Increasing professionalism among lecturers, especially in relation to active-learning pedagogies, will increase computer use among a wider segment of faculty members. In reality, increasing the relevance and effectiveness of Ghanaian education will increase the relevance of ICT use in schools.

6. Recommendations

What follows are some suggestions and comments regarding actions in key areas of ICT in education that will be

important to attend to as the adoption process continues.

While the practice of equipping Institutions with ICT infrastructure and using them to teach computer literacy to augment teaching, research and learning is useful, the goal of fully integrating ICT in educational administrative and pedagogical processes will continue to be constrained by the lack of access to ICT infrastructure. That is affordable connectivity with sufficient bandwidth, unwillingness to use ICT, trust and a reliable supply of electricity. This is because these are major challenges facing Ghanaian education which will be difficult to deal away with, looking at our investment toward ICT infrastructure from both the government and donors, including Non- Government Organizations (NGOs).

User training needs to involve much more than the development of computer literacy skills. Users need to be able to design and adapt ICT to suit their needs, for example to search and manage information, teach and to be aware of the ethics, morals and dangers inherent in the use of ICT. These are some of the ways in which ICT need to be integrated into development and training programmes for users.

KNUST must endeavour to provide adequate ICT infrastructure. Installation of efficient and up to date ICT facilities at vantage points on campus, frequent maintenance of the facilities to avoid untimed breakdown, virtual classrooms to increase access to education, and supply of free or affordable laptops to students and lectures. This will encourage the use of ICT. Also there should be provision of alternate power supply system to supplement the national electricity supply especially in times of load scheduling and power outage.

The University must increase accessibility of ICT facilities and Internet. ICT facilities should be provided in all the colleges, departments, hall of residents and lecture halls. The down time of the internet connection need to motivate users. Modern computer labs and Internet services should also be provided in the colleges and halls of residence.

There should be research into the current trend of ICT facilities in tertiary institution and what students want before any ICT facility is provided. This will help to provide facility that users need.

They should automate academic registration to deal away with queues and resources. This will save time, struggles, quality of service and resources. It will also increase the weeks for lectures and revision. A modern e-learning centre stocked with act of the state computers with all the current programmes with experts to aid research and learning such as Excel, Minitab, SAS, SPSS, and Sage for research analysis and online training for students. This will help increase research and learning at KNUST.

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