CAMBRIDGE EDUCATION

A Survey of ICT Capacity in Ghana's Public Colleges of Education

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Cambridge Education
22 Station Road
Cambridge CB1 2JD
United Kingdom

T +44 (0)1223 463500
F +44 (0)1223 461007
camb-ed.com

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Region	Location	College of Education
Ashanti	Agogo	Agogo Presbyterian College of Education
	Akrokerri	Akrokerri College of Education
	Offinso	Offinso College of Education
	Kumasi	Wesley College of Education
	Kumasi	St. Louis College of Education
	Mampong	Mampong Technical College of Education
	Mampong	St. Monica's College of Education
Brong Ahafo	Atebubu	Atebubu College of Education
	Berekum	Berekum College of Education
	Dormaa Akwamu	St. Ambrose College of Education
	Bechem	St. Joseph's College of Education
Central	Assin Foso	Foso College of Education
	Komenda	Komenda College of Education
	Cape Coast	Our Lady of Apostles (OLA) College of Education
Eastern	Asokore	Seventh Day Adventist (SDA) College of Education
	Abetifi	Abetifi Presbyterian College of Education
	Kibi	Kibi Presbyterian College of Education
	Somanya	Mount Mary College of Education
	Akropong- Akuapem	Presbyterian College of Education
	Aburi	Presbyterian Women's College of Education
Greater Accra	Accra	Accra College of Education
	Ada	Ada College of Education
Northern	Tamale	Bagabaga College of Education
	Bimbilla	Evangelical Presbyterian College of Education
	Gambaga	Gambaga College of Education
	Tamale	Tamale College of Education
Upper East	Bwaku	Gbewaa College of Education

Region	Location	College of Education
	Navorongo	St. John Bosco's College of Education
Upper West	Wa	Nusrat Jahan Ahmadiyya College of Education
	Tuma	Tumu College of Education
Volta	Akatsi	Akatsi College of Education
	Jasikan	Jasikan College of Education
	Peki	Peki College of Education
	Hohoe	St. Francis' College of Education
	Hohoe	St. Teresa's College of Education
	Dambai	Dambai College of Education
	Amedzofe	Evangelical Presbyterian College of Education
Western	Enchi	Enchi College of Education
	Sekondi Takoradi	Holy Child College of Education
	Wiaso	Wiawso College of Education

Acronyms and Abbreviations

CEMIS – College Education Management Information System

CiC - Consumer Insights Consult (www.cic-africa.com)

CoE — College of Education

CPD – Continual Professional Development

DFID – Department for International Development (UKaid)

EMIS - Education Management Information System

GET Fund — Ghana Education Trust Fund (www.getfund.gov.gh)

GIFEC — Ghana Investment Fund for Electronic Communications (gifec.gov.gh)

ICT — Information and communications technology

ISP — Internet service provider

JHS — Junior High School

LAN — Local area network

MCSP — Ghanaian Maternal and Child Survival Program

MOOCS – Massive Open Online Course

NCTE — National Council for Tertiary Education (ncte.edu.gh)

NITA — National Information Technology Agency (www.nita.gov.gh)

ODEL – Open and Distance e-Learning

PRINCOF — National Conference of Principals of Colleges of Education

SCL — Senior college leader (in our context a principal or vice-principal)

ST — Student teacher

TELBEL — Teacher Education and Learning Basic eLibrary; a device based on the OLE Ghana BeLL system, utilising a Raspberry Pi single-board to provide offline resources for up to 40 users

T-TEL — Transforming Teacher Education and Learning (www.t-tel.org)

WAN — Wide Area Network

WiFi — A technology for wireless local area networking with devices based on the IEEE 802.11 standards

WLAN — Wireless local area network

WPA — WiFi Protected Access

Executive summary

This report presents the findings of a Survey of ICT Capacity in 40 public Colleges of Education (CoE). The survey of ICT capacity in Colleges of Education was commissioned and managed by the National Council for Tertiary Education (NCTE) and implemented by Consumer Insights Consult (CiC) with support from Transforming Teaching and Learning in Ghana (T-TEL) which is funded by UKaid.

The report confirms that CoEs are on a journey towards the full integration of ICT in both the management and delivery of teacher education but that their progress is uneven. Indeed, **ICT capacity in most CoE falls far short of what is required to prepare new teachers to deliver a modern education in schools.**

The report delivers this finding just as the Minister of Education announces his intention to reform the education curriculum in schools, in 'ICT will be prioritised'. Achieving this vision will not only require more, well-skilled ICT teachers, it will require that all teachers can integrate ICT within their teaching.

This survey shows that very few CoEs (if any) already have the ICT capacity they need to deliver on this promise.

The report finds:

- Low levels of ICT capacity in most CoEs, and across a range of domains: infrastructure, human resources, and policy. (ICT capacity index results on page 9 of the exec summary)
- Only one CoE has a basic level of policy capacity required to manage an ICT system. In all others, the policy capacity is weak.
- Only 8 CoE (20 percent) have appointed a non-teaching staff member responsible for managing the ICT system (ICT technician), an essential staff post for any institution wishing to have a functioning ICT infrastructure serving hundreds of users.
- Only 20 percent of CoEs rated their power supply (including backup generators) as very reliable.
- Whilst most CoEs (67 percent) claimed to provide internet connectivity for staff on the day of the survey, internet connectivity was only available at 13 CoEs (33 percent).
- The nominal average download speed per student teacher is low (0.0025 MB/s (or 0.05 Mb/s at 1:20 contention).
- Only 27.5 percent of CoEs have functioning servers with appropriate specifications for local network management.
- Few student teachers have access to a larger screen device (i.e. a laptop or tablet), and rely on ICT labs to access such a device on campus. Although 75 percent of CoEs permit ICT lab use by student teachers in their own time, the average time that a student can access a computer in a CoE is about an hour a week.
- Smartphone ownership by student teachers is high; on average, 78 percent of student teachers own a smartphone but significantly fewer in Northern Ghana than in the South.
- The ICT in Education specialist role is almost completely absent across CoE at present, but is urgently needed to lead ICT integration in education, and to support other tutors in developing these skills.

Based on the findings, the following recommendations are made:

1) CoEs would benefit from guidance on how to improve their ICT capacity

Although there is scope for CoEs to improve the use of ICT with existing resources, this will be achieved only with guidance that supports informed and effective decision-making on ICT policies, staffing requirements, and infrastructure.

It is recommended that T-TEL support the NCTE to develop a national CoE Roadmap/ICT Capacity Development Pathway to guide CoE investments in all areas of ICT infrastructure and to guide the establishment of the policy and human resource environment required for efficient use of ICT infrastructure. The Roadmap should build from the findings of the NCTE survey, and include the critical milestones outlined in the ICT Capacity Development Pathway (Section 9). The roadmap must identify cost-effective directions for the development of CoE infrastructure.

It is recommended that T-TEL support the NCTE to identify an appropriate vehicle through which CoEs can be guided to implement the ICT Capacity Development Pathway in their own context. Advice must be customised and based on the current level of ICT capacity at the CoE, as measured in this survey, and address specific challenges, to support CoEs to achieve the critical milestones in the ICT Capacity Development Pathway / NCTE Road Map.

2) A CoE sector strategy for integrating ICT in education could provide efficiencies for all CoE

With increasing attention on ICT within both the school curriculum and the teacher education curriculum there is now an urgent need to integrate ICT within teaching and learning in CoE. As this survey demonstrates, however, the sector is starting from a low level of current ICT capacity. Meeting the demands of the new curricula in schools and CoEs will require a sector-wide response that encourages efficiencies for all CoE.

It is recommended that a CoE Sector Strategy for Integration of ICT in Education be developed through a partnership of CoE stakeholders led by PRINCOF. A small action group should be established to draft the strategy for review by the stakeholder group.

The strategy could consider shared concerns such as:

- Access to affordable internet connectivity (sector wide)
- Buy-to-rent scheme for student teachers to access mobile phones and laptops
- Piloting affordable ICT innovations in CoE to support:
    - Communication and information/materials delivery
    - Teaching and learning strategies within specific subject disciplines
    - Student-run clubs to increase access to ICT labs
- Professional development for ICT in education specialists in CoE
- Professional development for tutors on integrating ICT in education
- Open access resources for colleges
- Professional development for ICT technicians (in managing ICT in tertiary institutions; CEMIS requirements etc)
- The role of NITA in the CoE sector

3) The proposed CEMIS system must respond to the actual ICT capacity of most CoEs

The ICT capacity of CoEs to engage with the proposed College Education Management Information System (CEMIS) is limited.

It is recommended that the CEMIS system be hosted at a central secure location, given the weak policy environment at most CoEs (including data protection and backup).

It is recommended that the CEMIS is based on low bandwidth requirements, with mechanisms of data exchange appropriate to the setting (compression; resuming; integrity).

It is recommended that the CEMIS data is managed at CoEs by managers/staff that already have appropriate levels of skills in the use of ICT.

It is recommended that college leaders be provided with orientation to the CEMIS and the ICT capacity demands it will make on CoEs. The orientation should take into consideration the low levels of ICT expertise amongst college leaders.

Table 1: ICT capacity index results for all CoEs

	Capacity Domain				Index value
	Infrastructure	Policy	Human Resource	Indiv access to ICT devices	Total
Total Possible Score	**44**	**10**	**6**	**12**	**72**
Ada College of Education	20	0	2	6	**28**
Akrokerri College of Education	21	0	2	11	**34**
Accra College of Education	31	2	2	10	**45**
Presbyterian Women's College of Education, Aburi	31	9	4	11	**55**
St. Monica's College of Education	27	2	5	11	**45**
St. Louis College of Education	28	2	2	11	**43**
Mampong Technical College of Education	30	4	2	11	**47**
St. Francis College of Education	27	4	2	11	**44**
Holy Child College of Education	30	2	4	11	**47**
Foso College of Education	19	0	2	11	**32**
Gambaga College of Education	15	0	1	2	**18**
Enchi College of Education	21	0	2	11	**34**
Komenda College of Education	24	4	3	11	**42**
Wiaso College of Education	24	4	4	11	**43**
Evangelical Presbyterian College of Education, Bimbilla	15	2	5	11	**33**
Agogo Presbyterian College of Education	31	2	3	11	**47**
Evangelical Presbyterian College of Education, Amedz	11	0	1	10	**22**
St. John Bosco's College of Education	19	2	3	5	**29**
Bagabaga College of Education	20	2	1	5	**28**
Jasikan College of Education	30	4	2	11	**47**
Tumu College of Education	20	0	1	5	**26**
Tamale College of Education	27	2	2	11	**42**
St. Joseph's College of Education	27	2	2	6	**37**
Abetifi Presbyterian College of Education	16	0	3	5	**24**
Nusrat Jahan Ahmadiyya College of Education	26	4	6	3	**39**
Offinso College of Education	27	2	3	11	**43**
St. Theresa's College of Education	21	0	2	11	**34**
Gbewaa College of Education	22	2	2	5	**31**
Mount Mary College of Education	19	0	2	6	**27**
Kibi Presbyterian College of Education	30	4	2	5	**41**
Our Lady of Apostles College of Education	23	2	5	10	**40**
Atebubu College of Education	21	0	2	6	**29**
St. Ambrose College of Education	19	0	1	11	**31**
Akatsi College of Education	28	4	1	11	**44**
Seventh Day Adventist College of Education	16	0	2	6	**24**
Berekum College of Education	30	4	5	6	**45**
Presbyterian College of Education, Akropong	20	0	3	6	**29**
Dambai College of Education	11	0	1	11	**23**
Peki College of Education	37	2	3	11	**53**
Wesley College of Education	21	2	2	11	**36**

1 Introduction

This report presents the findings of a survey of ICT capacity in public Colleges of Education carried out by the National Council for Tertiary Education (NCTE) with support from the Transforming Teacher Education and Learning (T-TEL) in Ghana programme. T-TEL is a four-year Government of Ghana programme supported by UKAid to transform the delivery of pre-service teacher education by improving the quality of teaching and learning in Ghana's 40 public Colleges of Education (CoEs). The NCTE is the agency of the Ministry of Education mandated to regulate the tertiary education sector, and is responsible for the transition of CoEsto full tertiary status.

Advances in digital technology and ICT have led to an increased interest in considering potential applications of ICT in education. Increased affordability of low-cost mobile technology has sparked intense interest and experimentation in its use in classrooms. When used well, ICT can provide effective tools for teaching and learning, and particularly when combined with student-centred approaches. The T-TEL programme included resources to pilot innovations in educational technology to improve the quality of teaching and learning in colleges. In the first quarter of implementation, these included piloting Raspberry Pis to provide low-cost local intranet services and access to a library of digital learning materials, and the intention to procure tablets to CoEs.

1.1 Need for a survey of ICT capacity in Colleges

The need for the ICT capacity survey emerged through two developments.

First, DFID's Annual Review of T-TEL in November 2015 pointed to the need to review and finalise T-TEL's ICT strategy, particularly with respect to the plans to procure tablets and Raspberry Pis to support learning in colleges. Consequently, T-TEL invited a review of the ICT strategy by 'critical friends', Dr. David Hollow and Prof. Tim Unwin. Their report[1] recommended a baseline survey of ICT capacity to provide the evidence from which T-TEL and its programme partners could agree on appropriate support to CoEs to strengthen their efforts to integrate ICT in teacher education. The report also pointed to the increased demand that T-TEL support to an EMIS would create for internet connectivity.

Second, NCTE's support to tertiary institutions includes several activities that are dependent on ICT capacity in the Colleges, but are currently not coordinated with this capacity in mind. For example, the NCTE asked for support from T-TEL to develop an education management information system (EMIS) for CoEs, to improve planning, monitoring and evaluation, policy- and decision-making. NCTE has also invested substantial resources in subscription to journals that can only be accessed through digital portals.

1.2 Purpose of the survey of ICT capacity in CoEs

The purpose of the ICT baseline survey was to:

- Measure ICT capacity of every public CoE, using indicators of capacity in four domains:
  - Infrastructure
  - Policy
  - Human Resources
  - Access to ICT devises

[1] Hollow and Unwin (2016) T-TEL ICT Strategy Review, Jigsaw Consult Ltd.

- Identify relevant ICT-related needs of CoEs

NCTE and T-TEL will use the collected information to:

- Identify the critical gaps in ICT capacity on a college by college basis;
- Identify the types of support that are most urgently needed by individual CoEs and the sector as whole;
- Inform the development of the NCTE's ICT strategy for the college sector; and
- Identify areas of support to the NCTE strategy where T-TEL resources would be used most appropriately, effectively, and sustainably.

1.3 The uses of ICT capacity by Colleges

ICTs perform many important functions in education institutions. The effective use of ICT by CoEs includes:

- Efficient management of institutions

Today, ICT is essential to the efficient management of institutions. Information is collected, collated, processed, reported, communicated, and archived in digital/electronic formats, through information technologies. And even though some colleges still use ledgers for their financial management systems, this is a situation that cannot last. The demand for accountability to national agencies will bring a requirement for digital reporting.

- Student teachers' learning

Student teachers may use ICT within their pre-service teacher education programme, and then continue to use ICT to support their ongoing professional development. ICTs can support learning in any subject, and for teachers at all levels of the system. Using ICT to help student teachers learn does not depend on the availability or use of ICT in school classrooms, but it does depend on student teachers' access to ICT devices and internet connectivity during lectures and in their own study time.

- Staff development

ICT can support tutors' professional development in colleges. This can include access to:

- New information required for work, for example new government regulations, or curriculum updates,
- Resources that accompany off line programmes of learning (e.g. materials to support tutor professional development sessions, or background reading for university seminars).
- Online professional development e.g. through open and distance e-learning (ODEL) or massive open online courses (MOOCs).

1.4 Training student teachers to use ICT in education

CoEs exist to train teachers for the basic education system. As the school curriculum evolves to prioritise ICT, it will not only include ICT as a *subject* in the school curriculum, but ICT-based activities will also be used increasingly to support pupils' *learning* across the curriculum. CoEs must become institutions that train teachers who are skilled in using ICT within their teaching, and to support pupil learning.

- *Training teachers that can use ICT to support pupil learning and assessment*

Student teachers must learn how to use ICT to support **pupil learning** in any subject at any level of education. Although the present DBE includes units on ICT in the second year, 'learning about ICT" is different from "learning how to use ICT for effective student learning". Ghana's National Curriculum Framework for Teacher Education prioritises ICT in teacher education, as a cross-cutting issue to be integrated throughout the curriculum. Student teachers are soon going to be required to learn how to use ICT to further pupil learning in any subject. Student teachers will also need to learn how to **assess** pupils' learning, *and* to **evaluate** if their own use of ICT in teaching is effective. Student teachers will need to learn about relevant ICTs for primary and JHS education in Ghana, for example OLE Ghana BeLL.

- *Training teachers that can teach the subject 'ICT/computing'*

Teachers who teach ICT/computing need to learn the subject 'ICT/computing', as well as how to teach it, and how to use ICTs when teaching it. They will need a strong foundation in the subject, particularly since their own prior experience with ICT/computing may be limited. As for all subjects, interactive pedagogies and ICT can be used effectively (or not) when teaching ICT/computing.

1.5 Recent ICT initiatives with CoE

There are several recent initiatives seeking to enhance the use of ICT and digital resources at the CoEs.

- *The Elsevier ScienceDirect eBooks programme*

In August 2016, the NCTE entered into a collaboration with Elsevier, to provide all student teachers with access to 2000 ebooks through ScienceDirect College Edition, Elsevier's full-text platform for research literature, tailored towards institutes of higher education[2]. The cost of the three-year subscription is USD 340,000[3].

[2] http://www.ghana.gov.gh/index.php/media-center/news/3036-ghana-s-colleges-of-education-to-benefit-from-e-book-services-under-three-year-ncte-reed-elsevier-contract , https://www.elsevier.com/about/press-releases/science-and-technology/elsevier-announces-collaboration-with-national-council-for-tertiary-education

[3] http://ncte.edu.gh/index.php/44-collaboration-with-national-council-for-tertiary-education

Figure 1: Awareness of the Elsevier book programme

At the time of this survey 79 percent of college leaders were aware of the ScienceDirect eBook programme. Some college leaders thought that the programme would be beneficial, and save cost of hard copy books. However, others pointed out drawbacks, such that the contents of the book offered is not tailored for the CoE curriculum, that the programme is expensive, and that the eBook will be hard to access, given limited or no internet access at CoEs.

- *Desktop PCs, laptops and smartboards*

Through the Ghana Education Trust Fund (GETFund), 25 desktop PCs, laptops and a small number of smartboards (Interactive whiteboards) are being supplied to some CoEs.

2 Methodology

The survey of ICT capacity in the public CoEs was implemented between October 2016 and May 2017. It was jointly managed by the NCTE ICT department and T-TEL (T-TEL ICT Adviser). A survey company (CiC) was contracted by T-TEL to implement data collection, and basic analysis. The NCTE team carried out advanced analysis of data, and construction of a Capacity Index, with support from T-TEL. The final report was written by T-TEL advisers and the NCTE's Head of ICT.

2.1 Developing the survey tool: Capacity domains

The survey tool was developed by the NCTE ICT team, T-TEL ICT Adviser, and CiC researchers. The main areas of ICT capacity to be measured were laid out in the Terms of Reference.

2.1.1 Infrastructure Capacity

Broadly speaking, the elements of ICT infrastructure capacity are:

- *Power.* Power is an essential ingredient to any ICT use, whether that power is mains electricity, generated or stored on-site (e.g. generator, solar-power, deep-cycle batteries).
- *Devices.* Digital devices need to be available, which can be of various types (computers, laptops, tablets, smartphones; "Internet of Things" -type devices) and have different owners (the institutions vs. individuals).
- *LAN, WLAN, servers.* Local area networks (LAN) and wireless local area networks (WLAN) connect devices to each other; servers provide services on those networks.
- *Internet.* The Internet is the global system of interconnected computer networks that links devices worldwide. The internet enables services that facilitate information exchange, including, for instance, web searching and browsing, e-mail, messaging, and "voice over IP".

Internet access must be tightly managed, for instance imposing restrictions on usage (using routers and servers for "bandwidth management and optimisation"[4], "traffic shaping"[5], "web caching"[6], etc.). Without investment in maintenance of LAN, WLAN and servers, any investment in devices or Internet access will not work efficiently and will be very expensive /poor Value for Money. The "cost of ICT" is therefore much more than the "initial purchase cost of devices". The "total cost of ownership"[7] includes all the costs occurring over the lifetime of ICT infrastructure, including recurring costs and costs of maintenance.

2.1.2 ICT policy

Failing ICT infrastructure and poor connectivity can have serious consequences for an institution's operation and effectiveness. Common goods such as infrastructure and internet connectivity must be regulated through institutional policy. Users need to be made aware of the policies, and policies need to be monitored, to ensure that users comply. Moreover, the institution will have certain responsibilities, not least under Ghana's data protection legislation to safeguard personal data.

[4] https://en.wikipedia.org/wiki/Bandwidth_management. Flickenger, R. (ed.) (2006). "How To Accelerate Your Internet — A practical guide to Bandwidth Management and Optimisation using Open Source Software" http://bwmo.net/.

[5] https://en.wikipedia.org/wiki/Traffic_shaping

[6] https://en.wikipedia.org/wiki/Web_cache

[7] https://en.wikipedia.org/wiki/Total_cost_of_ownership

2.1.3 Human Resource Capacity

Human resource capacity is essential for effective use of ICT. This includes staff responsible for:

- maintaining ICT infrastructure and installations
- developing and monitoring ICT policies
- training leadership and tutors to use ICT in their management roles
- training tutors to use ICT in teaching/learning
- teaching ICT to student teachers

2.1.4 Access to ICT devices

The survey examined the availability and use of ICT devices provided by the College (e.g. ICT labs out of hours use), and the incidence of laptops/tablets (large screen devices), and smart phones amongst student teachers.

2.2 Developing the survey tool: Survey questions

The survey tool is available on request[8]. In the design of the instrument, an existing questionnaire for ICT infrastructure in secondary schools by the National Information Technology Agency (NITA) was considered.

Some of the key questions organised by capacity domain are summarised below:

Infrastructure capacity

- Does the CoE have reliable access to power (mains power and operational backup generator/fuel)?
- College connectivity: Internet access and reliability
- State of the LAN and WLAN/WiFi: Reliability and coverage.
- What ICT facilities for different user groups? Includes: computers, smartboards, projectors, etc.
- What facilities exist outside of lab? E.g. in tutors offices, administrative offices, etc.

ICT Policy capacity

- What does each CoE have in place regulating and controlling aspects such as secure access, system upgrades, adding software, adding users, licensing, backups etc.?
- What security features such as firewalls, user groups etc. exist to protect sensitive data networks such as exam result from public networks?
- What policies exist covering granting access, and authentication of remote users?
- Do colleges have a website (on their own domain)? Do colleges have dedicated email systems?
- Is there a data recovery plan or policy?

Human resources capacity

- What are the ICT skills set or competency level of college leadership, ICT tutors, tutors, and technical staff?
- What training needs of college leadership, ICT tutors, tutors, and technical staff can be identified?
- What is the level of willingness amongst college leadership to support the adoption of ICT in their colleges?

[8] The ICT survey tool is available from the ICT Manager, National Council of Tertiary Education, Accra.

- What is the technical capacity within CoEs to maintain the system?

Access to ICT devices

- When can users access ICT facilities?
- What do college students personally have access to? E.g. personally owned ICT, such as smartphones, tablets, or laptops.

Field work was carried out in October 2016 with visits to all 40 public Colleges of Education (CoEs) across the 10 regions of Ghana. The 40 CoEs were divided among 6 teams, who were allocated between 6 and 8 CoEs each. The teams conducted structured interviews with an College Leaders (principal or vice-principal), ICT tutors, as well as student teachers. CoE facilities, including ICT labs and other infrastructure, were also assessed.

2.3 Testing the survey tool

The survey team (NCTE ICT team, T-TEL ICT Adviser, CiC) carried out a two day pilot of the instruments at two CoEs close to the Accra offices (Accra Colleges of Education and Presbyterian Women's College of Education, Aburi). After testing the survey tool at the two colleges, the survey team returned to the T-TEL office to discuss their findings and made changes to the instrument.

2.4 Enumerator training

A four-day workshop was held in Kumasi to train the CiC enumerators. T-TEL's ICT adviser led the training, supported by the NCTE ICT team. The training covered the survey instruments, focusing on the underlying concepts and terminologies, as well as the objectives of the survey. The enumerator training was in the form of discussions in which enumerators initially discussed the instrument in pairs, before a general discussion on any outstanding issues.

Two days of the training took place in two CoEs (Wesley College of Education and St. Louis College of Education). This enabled enumerators to practice using the survey tool and helped standardise the survey use across the enumerator team.

2.5 Data collection

The NCTE informed every CoE Principal in advance of the survey team's visit to each College. The NCTE explained the purpose of the survey and provided information about the impending visit of the enumerators.

Six teams of enumerators were formed, with two enumerators per team. In each team, one enumerator was provided by CiC, the other provided by the NCTE. The teams visited all 40 CoE during a two-week period beginning 11th October.

Every CoE visit consisted of face-to-face interaction between enumerators and the senior college leader, ICT tutors and the student teachers. This included structured interviews with college leaders and ICT tutors, collecting both quantitative and qualitative data. There was a questionnaire and group discussion with the student teachers using a semi-structured questionnaire.

Initially it was planned that enumerators would either input the data directly into tablets ("mobile Computed Assisted Personal Interview"; mCAPI), with questions scripted using ROMITY[9].

[9] http://cognatesystems.com/index.php/romity

However, given the time constraints and workload, it was decided that enumerators initially collected the data on paper, to be entered later.

2.6 Ensuring data quality

A de-briefing event was held following the field work, which raised several important issues (including Internet connections for administrative reasons; CoEs aspirations to develop ICT specialisms). A debriefing event was held to moderate data quality prior to data entry.

2.7 Data entry

To ensure data quality all enumerators entered their own data based on notes made in the field. Data entry was completed at CiC offices and supervised by the project field coordinator. The data entered was checked and cleaned by the CiC field coordinator and the data manager. A comprehensive dataset of all variables, measured at every College was provided to the NCTE and T-TEL.

2.8 Data Analysis

Analysis of data is presented in three ways:

- ICT Capacity across the CoEs
- CoE ICT Capacity Scorecards
- CoE ICT Capacity Index

First, data from all 40 public colleges were analysed to reveal the levels of ICT capacity across the CoE, and to identify where most colleges face the greatest challenges. This analysis is presented in Sections 3,4, and 5 of this report.

Second, a College of Education Scorecard was designed by the NCTE. The most important indicators of ICT capacity in each domain were selected for inclusion in the card. The indicators selected for inclusion in the **CoE ICT Capacity Scorecard** are presented in Table 2 below.

A scorecard was generated for every public College of Education using data collected by this survey. The CoE ICT Capacity Scorecards for every college are presented in Annex 2. The CoE ICT Capacity Scorecards provide valuable data that the NCTE and Colleges can use to identify specific areas where capacity gaps need to be addressed.

Table 2: The College of Education ICT Capacity Scorecard

COLLEGE OF EDUCATION ICT CAPACITY SCORECARD		
Name of College		
Number of students		
Number of Tutors		
Zone		
#	**INDICATOR**	**VALUES**
INFRASTRUCTURE CAPACITY		
Power		
1	Reliability of national power supply to the CoE	Unreliable / Moderately reliable / Very reliable
2	Availability of backup power	Yes/No
3	Power in admin offices	Yes/No
4	% classrooms with power	% of all classrooms in COE with power. (Number of classrooms with power / total number of classrooms in CoE * 100%)
5	Power in college hall	Yes/No
6	Power in student accommodation	Yes/No
7	Power in tutor accommodation	Yes/No
8	Power in ICT labs	Yes/No
LAN/WLAN		
9	There is LAN/WLAN infrastructure on campus and working	Working/Not working
10	Network Connectivity measured through Ping Test on day of survey in mbps	Average Download MBPS
11	% ICT labs with LAN /WLAN connectivity	% of ICT labs with LAN/WLAN
12	% classrooms with WLAN connectivity	%
13	Access to LAN/WLAN connectivity in admin block	Yes/ Not working / No / No data
14	number of admin blocks with WLAN connectivity	Number
Internet		
15	The college has access to internet	Yes /No
16	Name of internet provider	*Name*

17	Internet Stability and Reliable Monthly average	Unreliable / Moderately reliable/ Very reliable
18	Mode of connectivity to ISP	4G/3G/ASDL /Microwave /Fibre /Satellite /other
19	Speed of internet as measured via speedtest tool on the day of visit (mbps)	Poor / Average / Good / No data
20	Cost of internet to College per month Gh ₵	GHS
21	Wireless LAN in the Student Accommodation	Yes / No
22	Internet access is available in administration block	Yes / No
ICT Labs		
23	Number of ICT labs	Number
24	% of functioning computers and/or laptops (across all labs)	%
25	Number of functioning computers and/or laptops per lab (average across labs)	Number
26	Ratio of functioning computers to seats (average across labs)	Number of seats/functioning computer
27	Condition of ICT labs	excellent/requires refurbishment, requites extensive refurbishment
28	ICT Lab security Status	*Description*
Server		
29	The college has a server	Yes / No
30	Server functioning	Yes /No
31	Uses of the server by the CoE	Network protection / content filtering / offline content
ICT devices		
32	Number of functioning computers in the administration block	Number
33	The principal's office has a computer	Yes / No
34	Number of functioning projectors available in the College	Number
35	Number of functioning whiteboards in the College	Number
36	Number of functioning (pairs of) speakers in the College	Number
Website		

37	College has a website or social media presence	Yes / No
38	If yes, what is the website name	Domain name
POLICY CAPACITY		
Policy		
39	The CoE has an ICT policy	Yes / No
40	Level of regulation and control of system maintenance	None / secure access, content filtering, system upgrades, adding software, adding users, licensing, backups/data recovering
41	Students can access the internet on their own devices	Yes / No
42	Tutors can access internet on their own devices	Yes / No
43	Network usage is monitored	Yes / No
44	There is a policy for the use of college network	Yes / No
HUMAN RESOURCE CAPACITY		
ICT Tutors		
45	ICT tutors (actual number)	Number
46	Highest Qualification in ICT (of all the ICT tutors)	1st Degree / M Ed /PhD
47	% ICT tutors that are female	%
Technicians		
48	Actual number of technicians	Number
49	Highest Qualification held by a Technician	
ACCESS TO ICT DEVICES		
Personal Access to ICT devices		
50	% tutors that own smart phone or tablet (ICT tutor estimate)	%
51	% tutors that own laptop (ICT tutor estimate)	%
52	% students that smart phone or tablet	%
53	% students that own a laptop or computer	%
54	% of laptop/computer owners that are Female	%
Student Tutors Access		

55	Students are allowed to use the ICT lab	Yes / No
56	If yes, how many hours per week	Number
COLLEGE OF EDUCATION PRIORITIES		
57	College Priorities for capacity development, as stated by CoE	

2.8.1 College of Education ICT Capacity Index

The NCTE developed the **''College of Education ICT Capacity Index''** in order to:

- Identify stages in a development pathway towards establishing sufficient ICT capacity to integrate ICT in education
- Identify the stage of ICT Capacity development for each CoE
- Identify priorities for NCTE support to CoEs for ICT capacity development.

The **College of Education ICT Capacity Index** is based on most, but not all, of the indicators in the CoE ICT Capacity Scorecard. All indicators selected for inclusion in the index were allocated numeric values for scoring. Based the analysis of the sector and college pathway data, the NCTE selected indicators of ''critical points'' in the development pathway, and these were weighted more heavily in the index.

The indicators of critical points on the development pathway, selected by the NCTE for heavier weighting were:

- Availability of backup power
- The college has access to internet
- The CoE has an ICT policy
- % students that have a smart phone or tablet
- Students are allowed to use the ICT lab after lecture hours
- If yes, how many hours per week per student

The maximum scores possible for each domain of the index are presented in Table 3.

Table 3: Maximum scores for each capacity domain of the ICT Capacity Index

Capacity domain	Max score possible in the NCTE Index
Infrastructure	44
Policy	10
Human Resources	10
Access to ICT devices	11

Values for indicators of each capacity domain were categorised into three bands using threshold boundary values. The three bands developed were:

- very weak capacity
- low capacity
- basic capacity

The bands were described in these terms because the variables used to measure ICT capacity represent a minimum of ICT capacity required to integrate ICT within teaching and learning. CoEs reaching the upper ends of the index still only reaching a basic level of ICT capacity for integration.

The construction of the ICT Capacity Index is described in Annex 1.

3 Findings on ICT Capacity: ICT Infrastructure

This section presents findings about the capacity of ICT infrastructure across the Colleges of Education sector.

Figure 3: Holy Child CoE Computer Lab

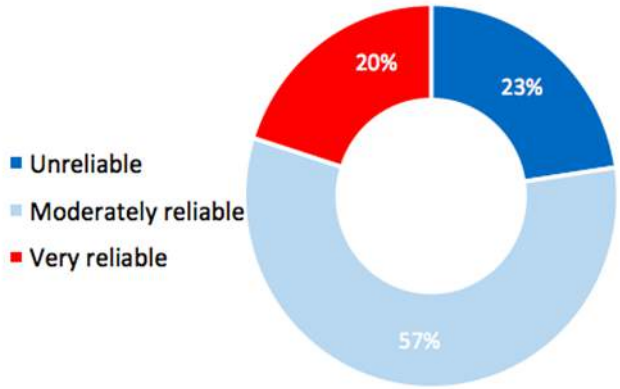
3.1 Power

ICT Capacity is dependent on the availability and reliability of electrical power.

3.1.1 Reliability of electrical power supply

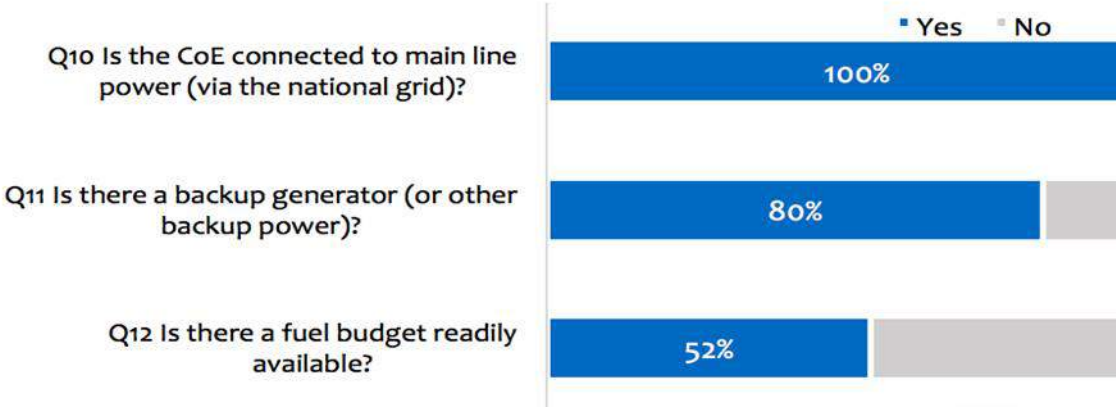
Although all 40 public CoEs are connected to the main national electricity grid, only 20 percent of college leaders confirmed that their CoE has a reliable power supply.

Figure 4: Reliability of electric power (main line and generator combined)



Although 80 percent of colleges have back-up generators, only 52 percent of college leaders confirmed they have budget for fuel. Consequently, only 57 percent of colleges have moderately reliable power supply. 23 percent view their power supply as unreliable. As a majority of Colleges of Education do not have reliable power, full integration of ICT into teaching and learning will be challenging and ICT solutions must take this into account.

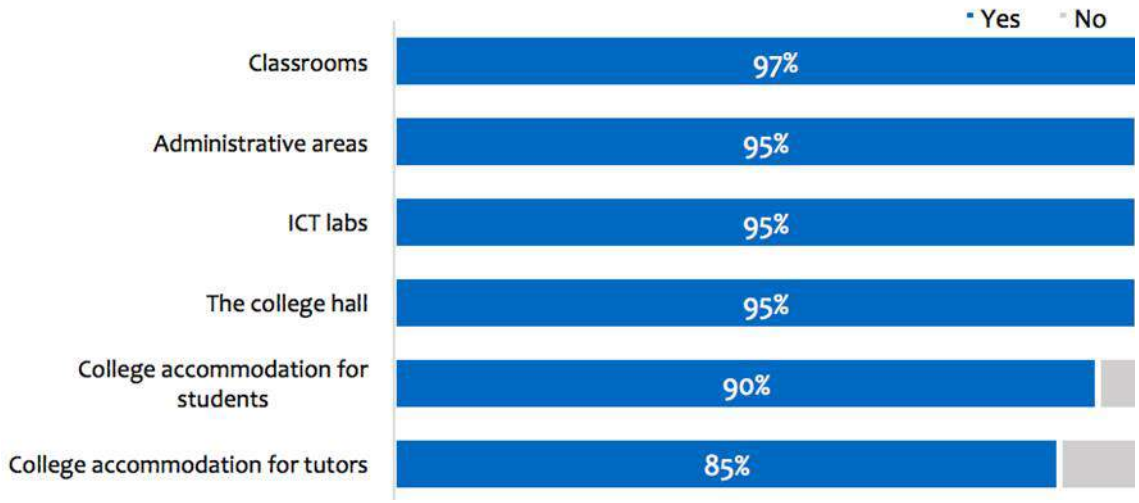
Figure 5: Availability and budget for power



3.1.2 Areas served by power

Most areas of college campuses are served by power. Only one CoE does not have power for the classrooms, and two do not have power to the administration block. 90 percent of CoEs have power to the student accommodation halls. As Figure 3 notes, 2 Colleges have ICT labs without a power supply.

Figure 6: Areas of the college with a power supply



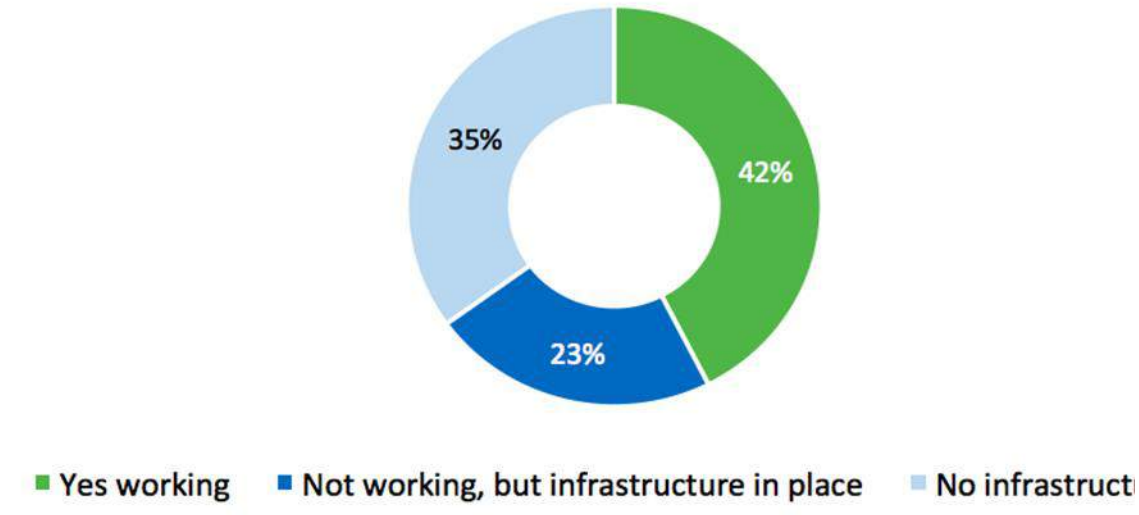
3.2 Networking

CoEs access the internet through Wired or Wireless LAN. Most colleges have both Wired and Wireless LAN. As different areas of the college are served by different technologies, it seems that by using both technologies, the CoEs increase the reach for internet connectivity.

3.2.1 Wired local area network (LAN)

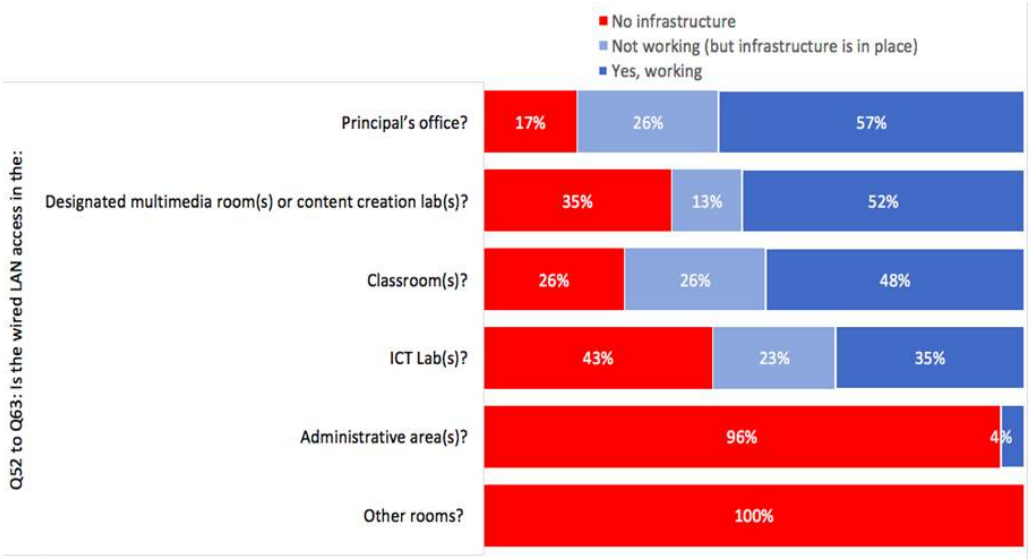
No college has wired LAN only. 42 percent of CoEs have a working wired LAN network. A further 23 percent have wired LAN infrastructure in place, but the wired LAN is not currently working. This is almost always due to unreliable or non-existent internet connectivity, rather than the condition of the wired LAN infrastructure.

Figure 7: Wired LAN infrastructure



Colleges vary in how they use wired LAN. As Figure 6 illustrates, almost all (96 percent) colleges with LAN use this technology for connectivity for administration areas, and the principals office (57 percent). Whilst 64 percent of colleges with LAN have connected their classrooms, the LAN to the classrooms is only functioning in 48 per cent of colleges. Only 57 percent of Colleges with LAN use it to connect ICT labs, and in most of those with LAN, it is not functional (only 35 percent of CoEs with LAN have functioning connection to the ICT labs).

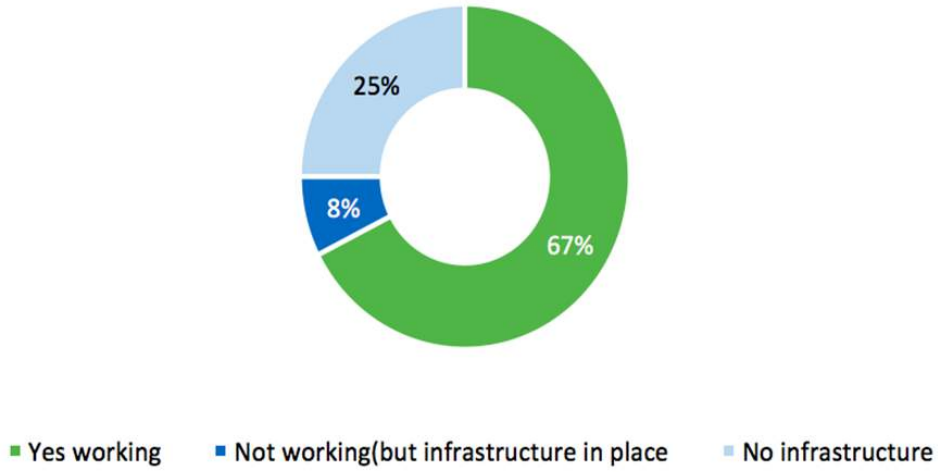
Figure 8: Areas of CoE served by LAN



3.2.2 Wireless LAN

More colleges use wireless LAN for internet connectivity. Three quarters of colleges have wireless LAN infrastructure in place, although in 8 percent the infrastructure is not working, so only 67 percent of CoEs state have a working wireless LAN infrastructure.

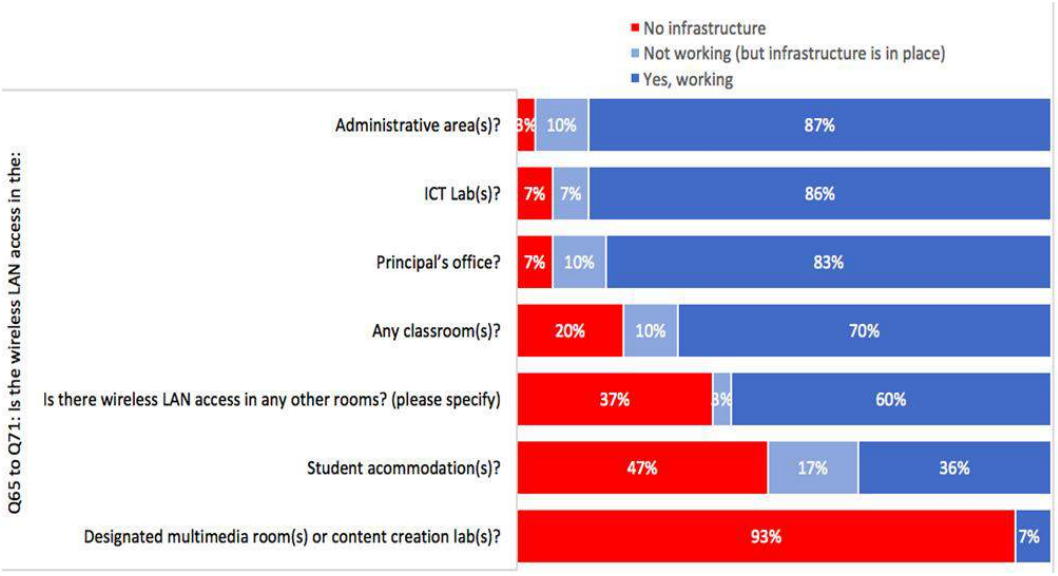
Figure 9: Availability of wireless LAN in CoE



As with wired LAN, most colleges (97 percent) use wireless LAN to serve the administration areas, although in 10 percent of these colleges, the wireless LAN is not working. The use of wireless LAN to extend internet access across the CoE campus is evident. But the lack of internet service means that the technology may not be functioning.

93 percent of colleges with wireless LAN use this technology to reach their ICT labs (7 percent of these not functioning); 80 percent have reached their classrooms (10 percent not functioning), and attempts to provide students with internet access is evident in the 53 percent of colleges with wireless LAN that have extended this technology to student accommodation. Unsurprisingly, student accommodation is most affected by lack of an internet provider, with 17 percent of colleges that have extended wireless LAN to student accommodation, not being in a position to service this with internet connectivity.

Figure 10: Areas of CoE served by wireless LAN



3.2.3 Combining LAN and WLAN to increase access

If both LAN/WLAN are considered, the percentage of CoEs where classrooms are connected to the internet reaches 75 percent, while the percentage of CoEs where ICT labs are connected to the internet reaches 87 percent.

3.2.4 Functional assessment of LAN/WLAN infrastructure

Although 87 percent of Colleges have LAN/WLAN infrastructure, only 45 percent of colleges had functioning connectivity on the day of the NCTE survey visit. Only 15 percent had good connectivity.

Enumerators attempted a basic test of the LAN/WLAN using the "ping" protocol. In only 23 CoEs the infrastructure was available and working to at least a basic level needed for the test to be conducted. In 5 of these colleges, the enumerators were unable to collect conclusive data, with the result that only 18 CoEs (45 per cent of CoE in Ghana) had functioning connectivity. As Table 4 shows, only 6 of these colleges had ''good connectivity. Thus, on the day of the survey, only 15% of CoEs in Ghana had good internet connectivity.

Table 4: Ping test outcome for the 18 CoE with connectivity

PING Test Outcome	Number of CoEs
Good (packet loss < 10%, round trip time < 100ms)	6
Average (packet loss < 20%, round trip time < 200ms)	3
Poor (packet loss > 20%, round trip time > 200ms; not usable)	9
Total number of colleges with sufficient connectivity to test quality	18

3.2.5 Number of CoE with Servers

Computers acting as servers are an essential part of an institution's ICT infrastructure. This survey found that 28 CoEs (70 percent) have at least one server; 12 CoE (30 percent) do not have a server. Most CoEs with a server, only have one. Only 3 CoEs have 2 servers.

However, in only about half of CoEs that have servers, is the server functioning (15 CoE); 13 CoEs have a server that is not functional, and 2 of these have boxed GIFEC servers that have never been used.

Of those CoEs with working servers, 11 were of a good or adequate specification (e.g. 4GB RAM, 3.20Ghz, 4 years old), and 4 were of a lower specification (e.g. 2Gb RAM, 2.00Ghz).

The operating systems used on the servers were mainly Windows (65 percent) and Linux (35 percent; mainly Ubuntu).

3.2.6 How servers are used by CoE

The most frequent uses of the server are for network management and local user accounts. A small number of CoEs use the server for school management software.

Table 5: Use of servers by CoE

Use of server	Number or CoEs
Network management	12
Local user accounts	8
School management software	4
Backup	2
Intranet applications	1
Offline content	1
Active directory	1
Enterprise resource planning/ accounting	1
Website	1
Email	0

3.2.7 Server maintenance

In CoE with a working server (15 CoEs), the server is typically maintained by a technician (4) or ICT tutor (6). Thus in 67 percent of those with a working server, a CoE staff member is responsible for server maintenance. One CoE uses a contractor, and in 3 CoEs no one is responsible for server maintenance.

3.3 Internet

Figure 11: Wiawso CoE ISP internet radio and College wireless access point

3.3.1 Availability of internet at CoEs

All CoEs have a working low-capacity internet connection (e.g. 3G) available to college leaders, that can be used for CoE administration by a limited number of users.

A majority of CoEs aim to provide internet access to tutors (70 percent of CoEs) and student teachers (65 percent of CoEs). Even so, this means that at 30 percent of Colleges, tutors do not have access to the internet.

3.3.2 Internet connection types used by CoEs

Most Colleges with internet access rely on more than one type of internet connection. The most common forms of internet connection type are ADSL and 3G. Only 6 percent of CoEs with internet use 4G, and only 6 percent use fibre optic connections. Even fewer (a mere 3 percent) are served by NITA, in spite of its national mandate to connect all tertiary institutions.

Table 6: Types of internet connect used by CoEs

Connection type	% of CoEs with internet that use this type
ADSL	33%
3G	28%
Satellite	14%
Microwave	11%
4G/LTE	6%
Fibre	6%
NITA	3%

Figure 12: Komenda CoE ISP Connection Point

3.3.3 Internet Service Provider (ISP)

Many ICT tutors were not able to provide the name of the Internet Service Provider (ISP) at their CoE. Of those named, Vodafone was by far the most frequent (34 percent of Colleges), K-Net was named by 8 percent, with MTN and NITA providing for only one connection each. CoEs sometimes use more than one ISP.

3.3.4 Cost of internet

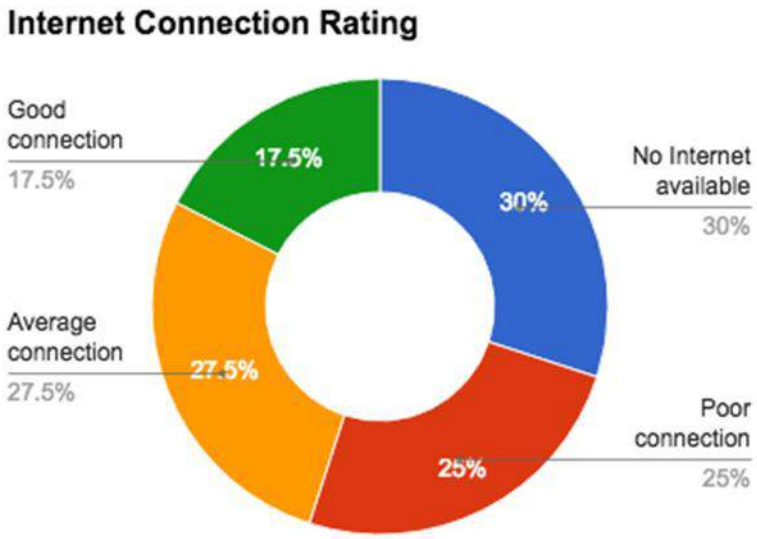
According to college leaders, the average amount that CoEs pay for internet is GHS 1,350 per month (range GHS 100–3500). In colleges with no internet, or poor quality internet, the cost of internet is generally considered unaffordable.

3.3.5 Quality of internet connectivity

Although 70 percent of CoEs intend to provide internet access to tutors, the ICT tutor survey found that most do not have access to good quality internet connectivity in practice. The survey found that good quality of internet provision is only available to tutors at 17.5 percent of CoEs.

The survey enumerators tested the download speed at all CoEs with internet on the day of the visit. The download speed obtained in the test was the same as the service promised by the provider in only 33 percent of the CoEs tested. On average, download speed was 3.2 Mb/s but the range of speeds was wide, from 0.1 Mb/s to 12 Mb/s.

Figure 13: ICT tutors' views on the quality of the internet connection at their CoE



Taking into account the different sizes of CoE student population, the average download speed per student teacher is estimated at 0.0025 MB/s.

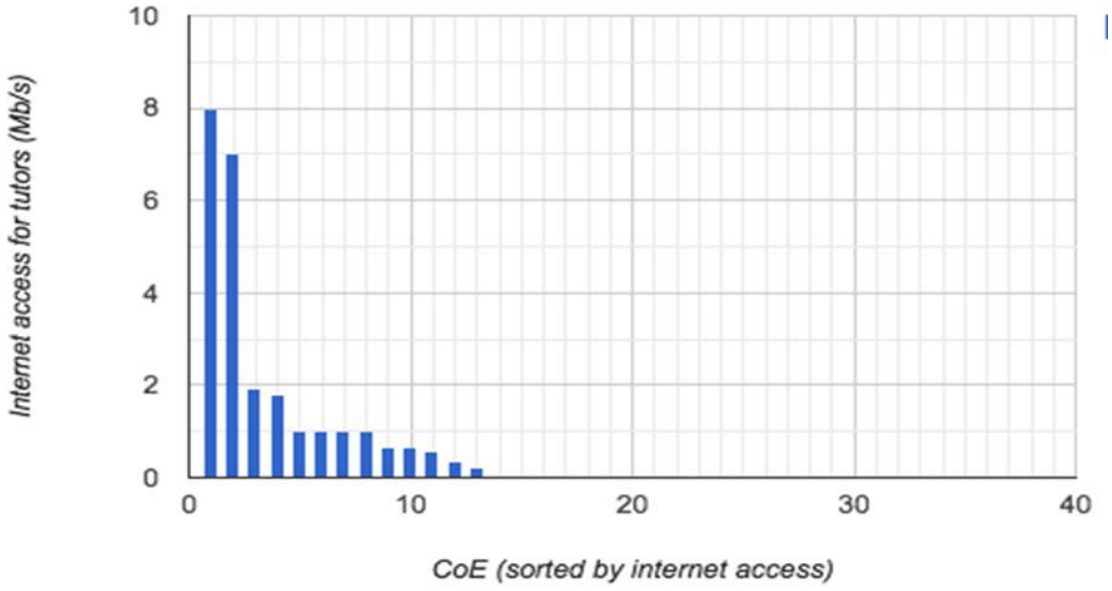
3.3.6 Measured Internet bandwidth

Tutors and student teachers have access to limited bandwidth of internet. The internet bandwidth was measured by enumerators using the speedtest.net app for Android while connected to the

CoE WiFi network. This test measures the bandwidth available to the user at the time of the test, rather than the total bandwidth available to the institution[10].

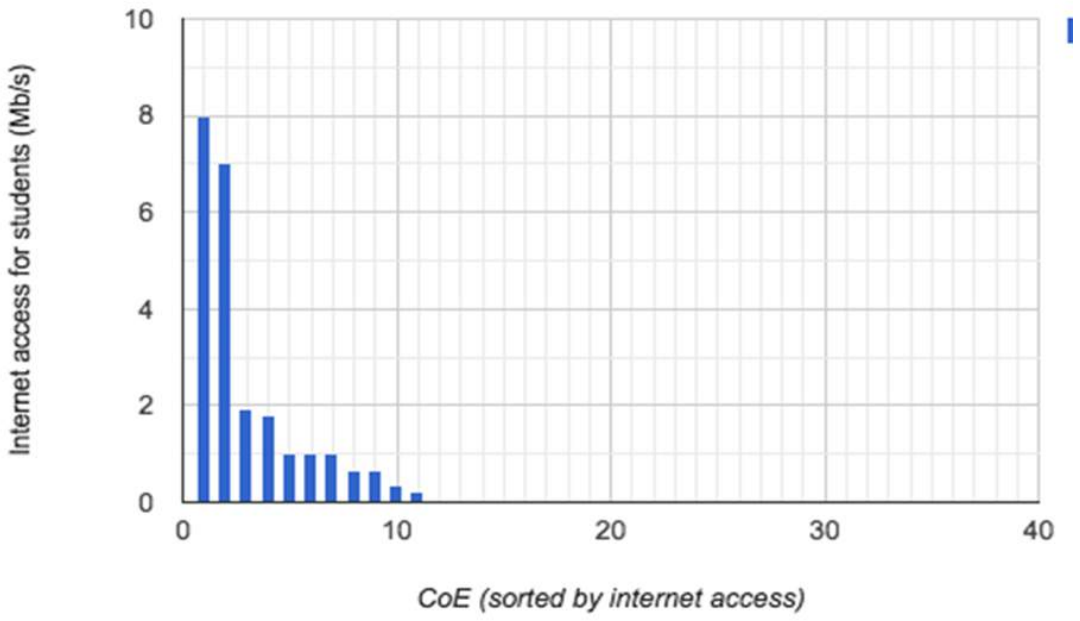
On the day of the survey, only 13 CoEs (33 percent) were found to have working internet access for tutors, and 11 CoE (27 percent) had working internet for student teachers. The slowest speed measured was 200kb/s. Figures 10 and 11 below illustrate the small proportion of CoE that provide significant bandwidth to tutors and students.

Figure 14: Internet bandwidth available to tutors



[10] Additionally, testing the bandwidth of the institution would have been possible by connecting directly to the Internet modem, while momentarily disconnecting the rest of the CoE. Given the one-off nature of the test we judged this to be un-necessary at this stage.

Figure 15: Internet bandwidth available to student teachers



Unsurprisingly, students consider internet access at their CoE to be 'non-existent'. In focus group interviews with students as part of this survey, some students described the colleges' WiFi as 'useless'. Student teachers mainly access the internet through mobile internet services, buying credit individually and bundling. Most student teachers spend around GHS 10 per month on data, with some spending up to GHS 60 per month.

Student teachers use internet for communication, mostly by WhatsApp where information such as assignment, examination results, news and entertainment-related items are shared. Unsurprisingly given the poor access at CoE, and the personal data costs, students rarely use ICT and the internet to support their learning.

3.4 ICT labs

3.4.1 Number of ICT labs

All CoEs have at least one ICT lab,35 percent have a second ICT lab, and one CoE has 3 ICT labs.

3.4.2 Condition of the ICT labs

Most ICT labs require refurbishment, with a third needing extensive refurbishment. The overall condition of the labs is summarised in Table 7 below.

Table 7: Condition of ICT labs in CoEs

	Excellent	Requires moderate refurbishment	Needs extensive refurbishment /replacement
Condition of the ICT lab	10%	57%	33%
Condition of the furniture	27%	40%	33%

85 percent of ICT labs have air-conditioning, which is necessary for maintaining ICT equipment. 87 percent of the ICT labs were judged to be secure (burglar proof locks, strong doors, bars on windows).

3.4.3 ICT equipment in the ICT labs

ICT equipment available in the ICT labs is mainly desktop computers; 60 percent of labs have desktops only, and 40 percent have a mix of desktops and laptops.

Where both desktops and laptops are available, labs typically have around 80 percent desktops and 20 percent laptops. However, there are a 4 labs that have more laptops, including only lab that is almost exclusively laptops (at St. Ambrose CoE).

There are no ICT labs that have tablets available for use.

On average, there are 59 computers per CoE, across all labs if the CoE has more than one lab. However, the total number of computers within a College varies considerably from 15 to 109.

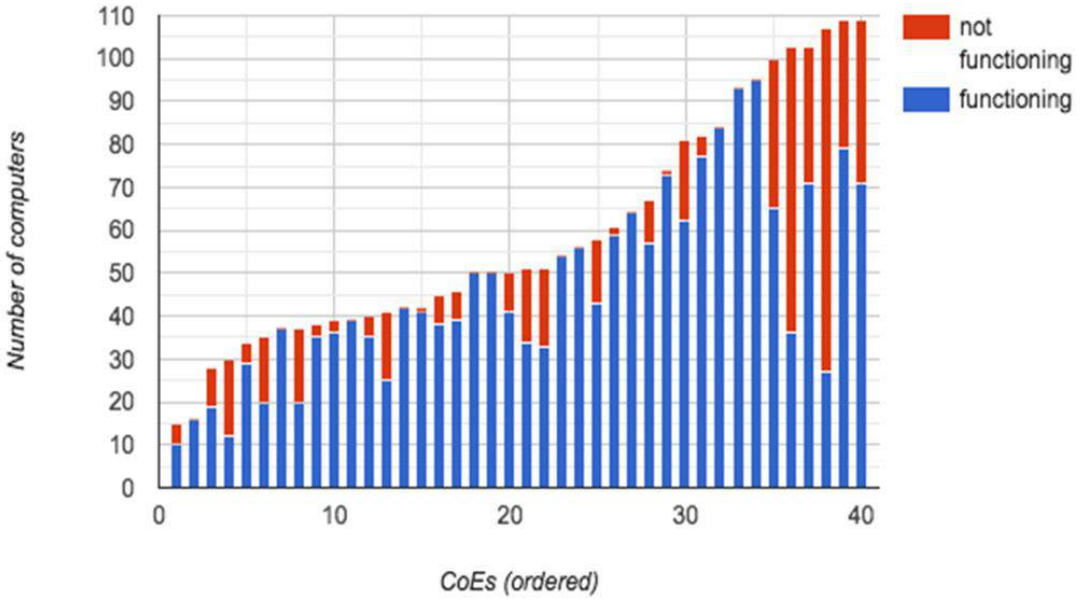
Figure 16: Sewhi Wiawso CoE faulty ICT equipment

The proportion of computers in ICT labs that are functioning

On average about 81 percent of the computers at a CoE are functioning, and the average number of functioning computers in a lab is 34.

Figure 17 below shows the total number of functioning and non-functioning computers in a CoE. It provides a general sense of the range in the total number of computers at CoE, and the general level of depreciation and/or maintenance. Unfortunately, there are two CoE with many more non-functioning computers than functioning computers.

Figure 17: Proportions of functioning and non-functioning devices in ICT labs

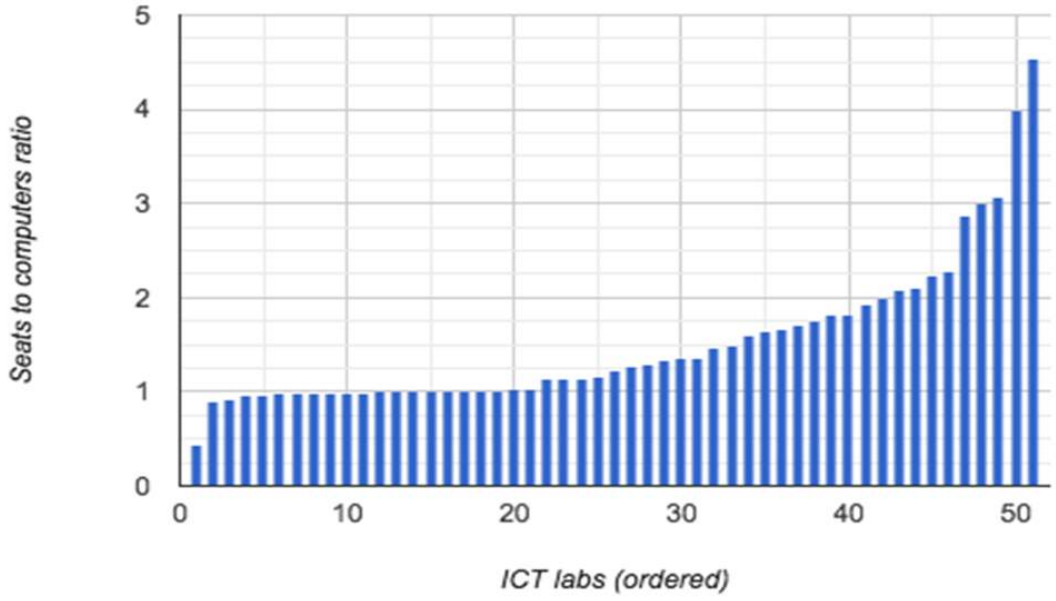


3.4.4 Capacity of ICT labs for lessons - functioning computers and seating

In most CoEs, the capacity of ICT labs is appropriate for learning. The average number of functioning computers per ICT lab is 34. The average number of seats in an ICT lab is 45 which corresponds to a typical class size. The average ratio of seats to functioning computers is 1.5 (between 1–2 seats per computer), but ranges from 0.4 (i.e more than 2 computers per seat) to 4.5 (4.5 seats per computers).

The number of seats per functioning computer in every ICT lab is shown in Figure 18 below.

Figure 18: The number of seats available in an ICT lab per functioning computer



3.4.5 Facilities in the ICT labs

In addition to computer for student use, most ICT labs have a projector (90 percent). Only a few ICT labs have audio speakers (13 percent), and only two CoEs (5percent), have interactive whiteboards in the ICT labs.

3.4.6 ICT Labs open for lessons

The use of ICT labs for lessons varies considerably across CoE. On average, CoE use the labs 18.8 hours per week, although this ranges from 0 to 45 hours per week.

3.4.7 Capacity and access to ICT labs outside of lesson hours

CoEs increase student access to ICT through opening ICT labs outside of lessons. 75 per cent of CoE allow student teachers to use the ICT lab outside of lessons. Several colleges reported that the ICT lab can only be used by student teachers under ICT tutor supervision. This section reviews the number of computers per student, the hours ICT labs are open, and the number of students this still offers little access per student teacher – less than two hours access per student per week. Unsurprisingly, therefore, focus interviews with students indicated that students do not make much use of the ICT lab outside of lessons, and report that labs are not that busy.

- Number of functioning computers per student

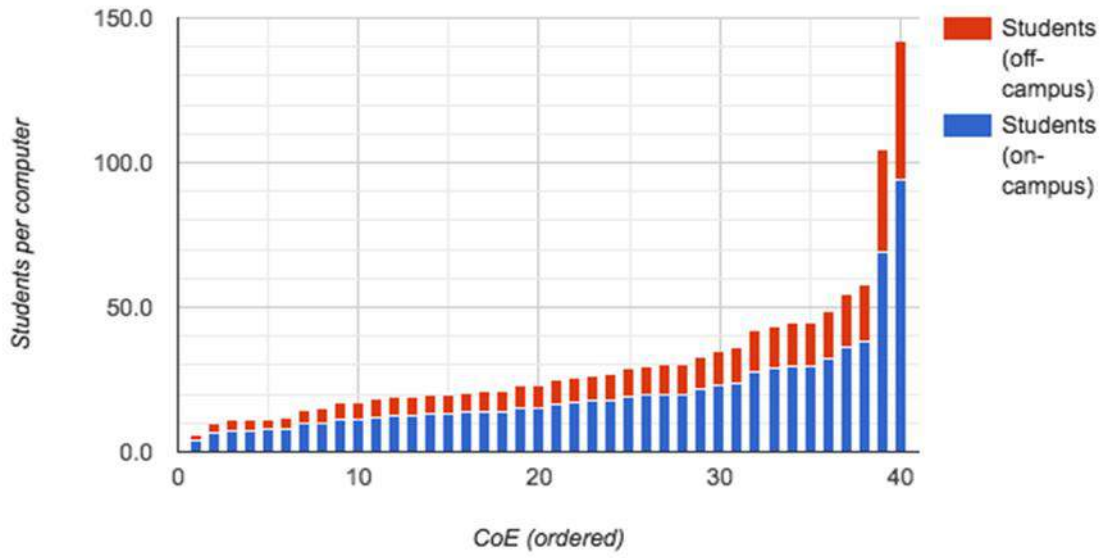
The average number of students to a functioning computer varies across CoEs.

Table 8 below presents the range, considering a) all student teachers (which includes students who are off campus on teaching practice – about one third of the student population) b) only the students on campus.

Table 8: Number of student teachers per functioning computer

	a. Student teachers (incl. off-campus) per functioning computer	b. Student teachers (excl. off-campus) per functioning computer
Maximum	142	94
Minimum	6	4
Average	31	20
Standard Deviation	25	17

Figure 19: Ratio of students to functioning computers



- Number of hours ICT labs are open for student use

Opening hours for ICT labs vary considerably. The “free” hours, i.e. the hours where the lab is open, but not being used for lessons ranges from 5 to 60 hours per week. On average, ICT labs are open for ‘’free use’’ for 27.4 hours per week. Based on the fact that the students cannot always access the lab (e.g. ICT tutors are not available to supervise; changes to timetables etc), we estimated that on average, ICT labs are open for student use for 20 hours per week.

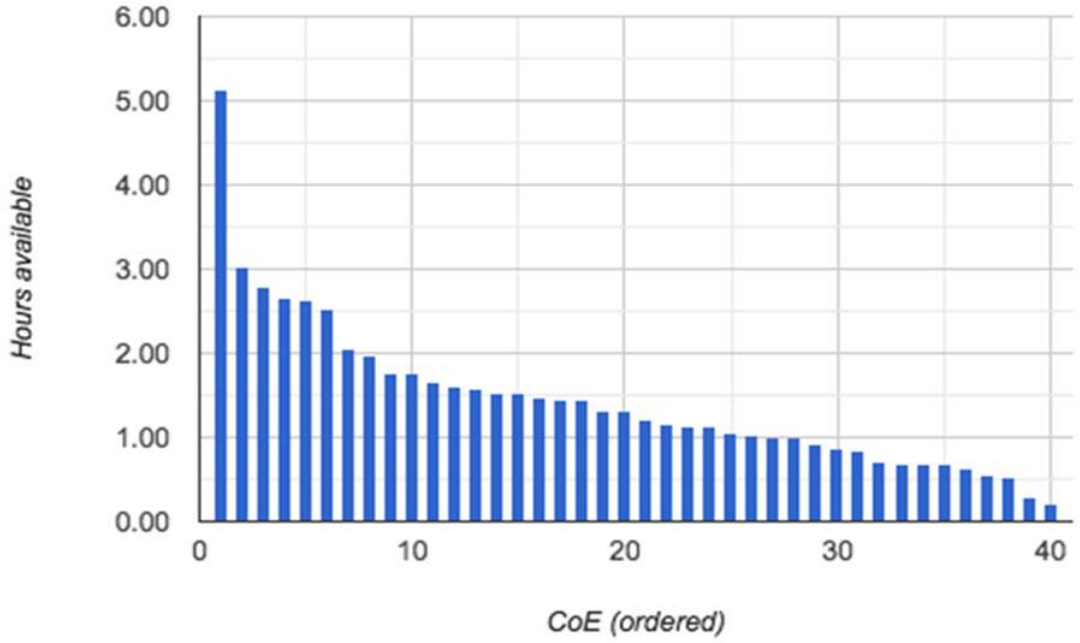
- Estimate of hours per functioning computer per student teacher

Based on the ICT labs being open for an average of 20 hours per week, and using the total number of functioning computers in ICT labs, we estimated that on average, a student teacher has approximately one hour of computer use per week. However, the range across CoEs is wide- from less than 10 minutes per week to five hours per week. Only one college provides 5 hours of access to the ICT labs per student per week.

Figure 15 shows the distribution of access to ICT labs per student, per CoE, but based on the assumption that the students have access for 20 hours per week. At most CoE, students have

less than two hours access to the ICT labs per week. At 11 Colleges (27 percent) students have less than one hour of access to a functioning computer per week.

Figure 20: Hours per week a computer in the ICT lab is available for an individual student



3.4.8 Gender differences in ICT lab usage

During the survey, ICT tutors at the CoEs that allow student teachers to access the ICT lab outside of lessons were asked if they observed differences in ICT lab use by male and female students. At most of these CoEs (57 percent) ICT tutors had not observed a difference; at 43 percent the ICT tutors thought there was more use by male students. When asked to explain the difference, the most frequent reason mentioned was that 'men are more interested in exploring ICT'. However, (and not insignificantly), other less frequently mentioned reasons were that the women's dormitories are far from the lab; and women have less free time as they have to cook.

3.5 ICT devices in CoE classrooms

There are few ICT devices in CoE classrooms outside of the ICT labs. None of the CoE classrooms have a computer or a tablet. Only one CoE has interactive whiteboards, within it's classrooms. Four CoEs also have interactive whiteboards in a lab-type space or an ICT lab (Enchi and Wesley; Holy Child, OLA, Wesley).

Half of the CoEs own at least one projector. Onaverage these CoEs have 5 projectors. However, the projectors are only installed/available in classrooms in half of the CoEs; in other CoEs the projectors are kept in the administration or department offices which tutors can borrow as required. Thus, only 23 percent of CoEs have at least one classroom with a projector already installed in the classroom. On average, CoEs have four classrooms with an available projector.

15 percent of CoEs have speakers that may be used with ICT devices. Only 2 CoEs have a classroom equipped with speakers, the others store the speakers in safe keeping.

2 CoEs have classrooms with a flat screen TV (number of classrooms: 1, 3).

Some colleges have other lab-type spaces, which can contain additional computers. St. John Bosco has an annex to the lab which is open to college tutors, and functions as a room for staff professional development.

Figure 21: OLA CoE Classroom

3.6 ICT devices in CoE administration offices

Almost all CoEs have at least some ICT available for college administration tasks, except the Evangelical Presbyterian College of Education, Bimbilla which does not have any CoE-owned computers available for administrative tasks. On average, a CoE has 11 devices (desktops, laptops, tablets) available for administration. The range is between 0 and 28 devices per CoE.

Most principals' offices are equipped with either a desktop computer or laptop, although there are 7 Principals (18 percent) whose offices do not have any ICT device. 13 percent of Principals' Offices have at least one tablets (13%).

Tutor staff rooms generally do not have ICT devices and neither does the room selected for T-TEL tutor professional development sessions.

4 Findings on ICT Capacity: ICT Policy

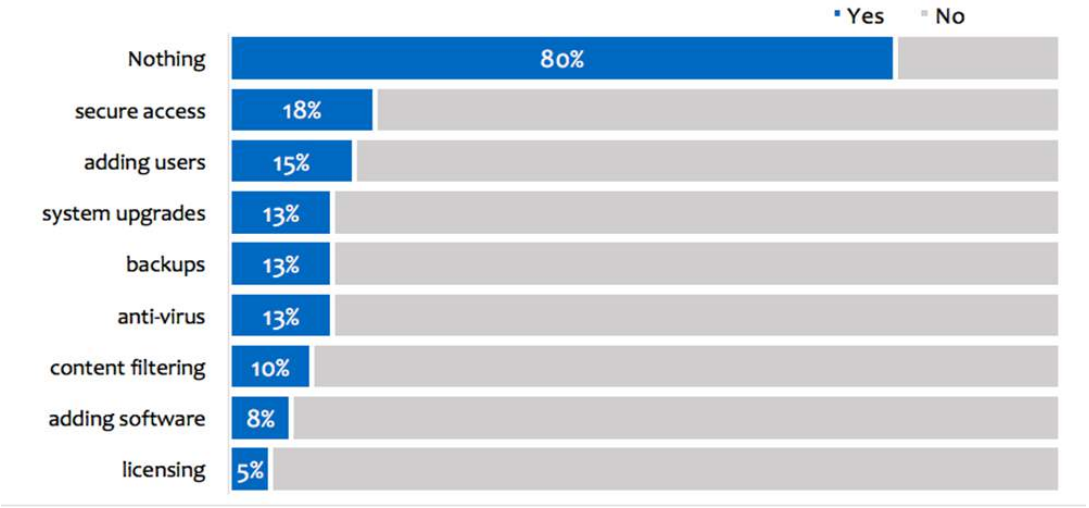
4.1 Policies available for regulating and controlling aspects of ICT systems

This section reports on the prevalence of policy and regulations to control aspects of the CoE-owned ICT systems. ICT tutors were asked about ICT policies or frameworks for regulating and controlling aspects of systems maintenance such as secure access, content filtering, system upgrades, adding software, adding users, licensing and backups.

- *ICT Policy*

Most Colleges (80 percent) do not have an ICT policy in place. Figure 16 illustrates the prevalence of different forms of ICT practice for regulating and controlling the ICT system.

Figure 22: Percentage of CoEs with policies in place regulating and controlling aspects of ICT systems



ICT tutors are concerned about the weak ICT policy environment. 87 percent of ICT tutors in CoEs without ICT policies stated that there should be policies. They prioritised the following areas: user behaviour; protect the WLAN; regulate the usage of ICT infrastructure; and student teacher and staff access.

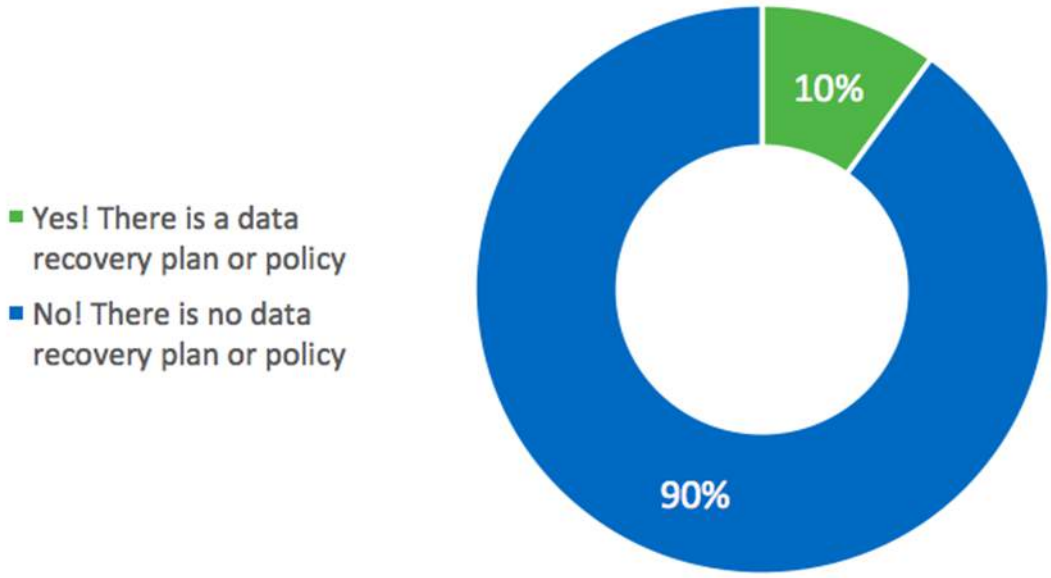
- *Anti - virus*

Only 13 percent of CoEs have policies on anti-virus software. However, ICT tutors suggested slightly higher levels of protection in practice. They indicated that 38 percent of CoEs are using anti-virus software even though only 13 percent have a policy that requires this. About half of the CoEs with anti-virus software use a free software, and half use commercial software but commented that funding for commercial software is a struggle.

- *Data recovery plan or policy*

A data recovery plan is any process or procedure that allows the recovery from data loss through technical failure, user error or theft. Only 10 percent of CoEs had such a data recovery plan, e.g. making backups at the end of every working week. External drives are used for backups.

Figure 23: Proportion of CoEs with a data recovery plan or policy



- *Security features protecting sensitive data*

Security features such as firewalls, user groups etc, protect networks holding sensitive data (such as exam results) from public networks. About half of the CoEs stated that they have some basic provision for security features. This typically included the default router firewall, as well as passwords.

- *General ICT usage policy*

ICT usage policies define who can access the network systems, which parts they may access, and how they access the system.

Only one CoE (Presbyterian Women's College of Education, Aburi) has policy that sets general usage. The policy prohibits remote access.

- *Secure access to the network*

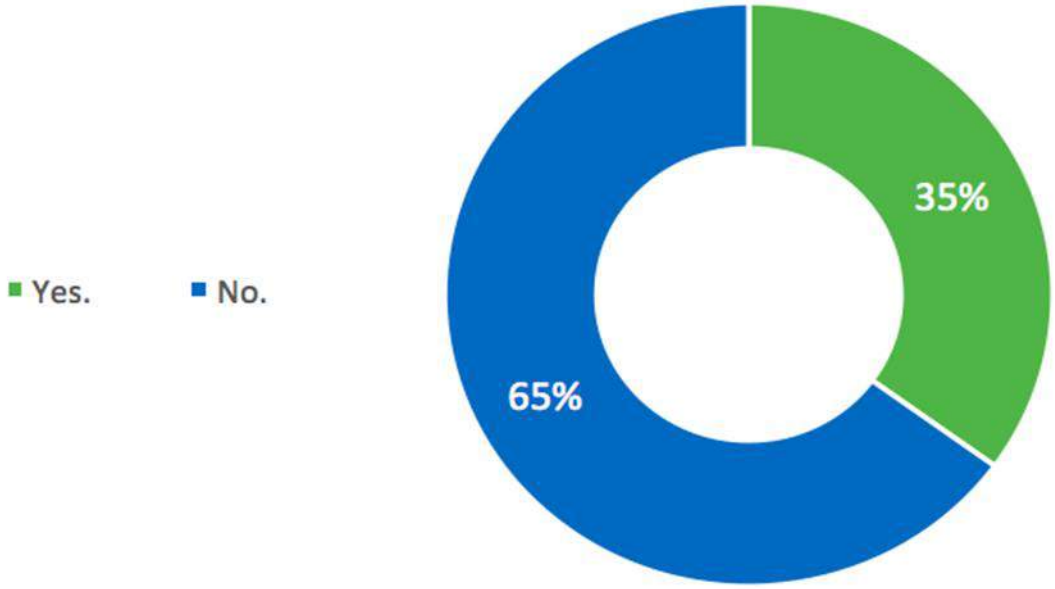
Only 18 percent of CoEs have policies in place to secure access.

Regarding access to the WiFi network, some colleges employ a WPA password (i.e. the same password for all users). Two CoEs regulate access per user through a captive portal, and one of these limits student access to 10 hours per term.

- *Monitoring network usage monitoring*

35 percent of CoEs monitor the usage of their network.

Figure 24: Proportion of CoEs that implement network monitoring



4.2 College communication through a website and social media

Although 45 percent of the CoEs state that they have a website, at the time of the survey only 30 percent had a working website. Few Colleges have a presence on social media: about 27 percent of CoEs are using social media such as Facebook or Twitter.

5 Findings on ICT Capacity: Human Resources Capacity

This section describes the human resources capacity to use ICT in the CoE. This includes the posts allocated to manage and teach ICT, the ICT skills available amongst CoE leaders, ICT tutors, and tutors, and each groups' perceptions of their ICT skills development needs.

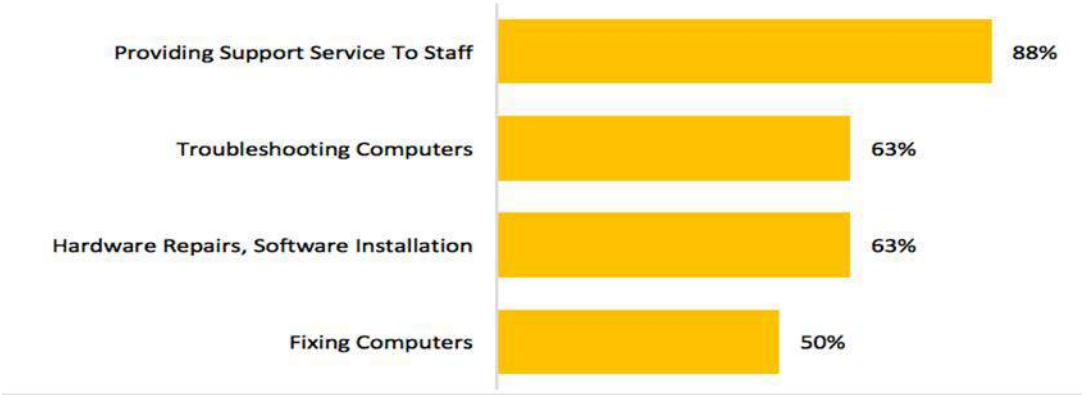
5.1 ICT Technicians

5.1.1 Number of ICT technicians in the CoE sector

Only 20 percent of CoE (8) have an ICT technician.

An ICT technician plays a vital role in the efficient and effective running of ICT infrastructure in an institution. The current duties of the ICT technicians at the eight colleges are presented in Figure 25 below.

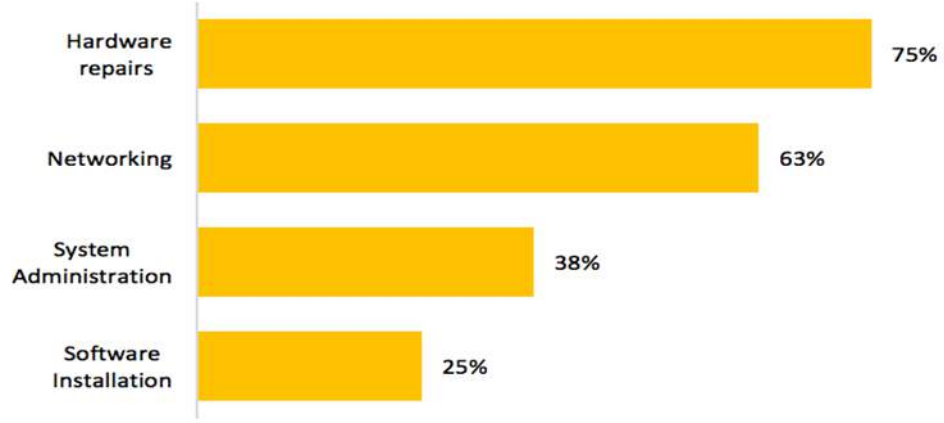
Figure 25: Current duties of ICT technicians at 8 CoEs



5.1.2 Required Competencies for ICT Technicians

The most important competencies of technicians at the 8 CoEs that have ICT technicians are shown in Figure 20 . Inevitably, these competencies reflect the current roles of ICT technicians as currently understood within CoEs, and the level of integration evident at this time.

Figure 26: Prioritised competencies of ICT technicians at 8 CoEs



5.2 ICT Tutors

5.2.1 Number of ICT tutors

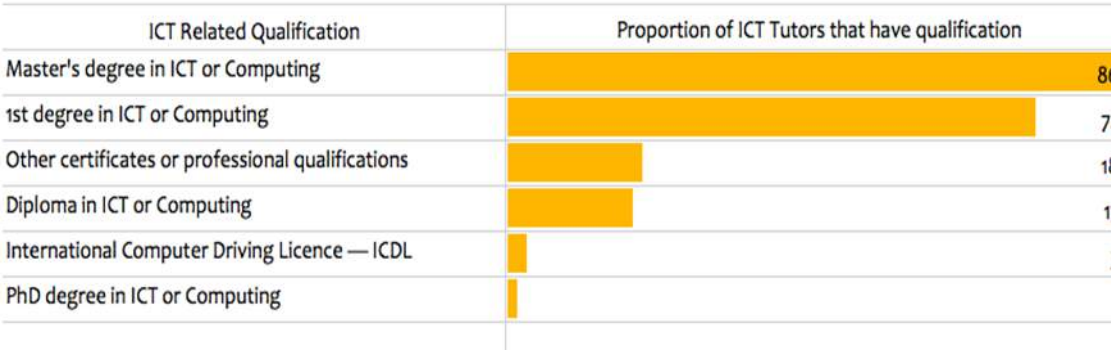
ICT tutors are teaching staff that teach student teachers who will become ICT teachers at secondary school.

All CoEs have at least one ICT tutor: the average number of ICT tutors is just under 2 tutors. The total number of ICT tutors in the CoEs is 76. As is the case globally, the majority of ICT specialists are male with only 14 percent of ICT tutors in CoEs being female.

5.2.2 Qualifications and skills of ICT tutors

ICT tutors in CoEs are well qualified. 86 percent of ICT tutors have a Masters Degree in ICT or Computing for Education. Over two thirds have a first degree in Computing.

Figure 27: Qualification level of ICT tutors in CoEs



Other ICT qualifications of tutors include certificates in hardware, microsoft office, NVTI business system, certificates by CISCO, MCSE, and Microsoft, as well as certificates in Linux system administration.

The tutors undergoing PhD programmes provided the following topics:

- Integrating instructional technology in teaching and learning practice in CoEs;
- End users satisfaction of cyber counselling programme in selected universities in Ghana;
- Evaluating the effect of blended learning in CoEs;
- Automatic discovery of fallacies in legislative processes.

Whilst the majority of ICT tutors (about 70 percent) have 4 or more years of experience as ICT tutors, a significant minority are still relatively new in their career as a tutor: just under one third (28 percent) have less than four years of experience.

Figure 28: Years of experience of ICT tutors

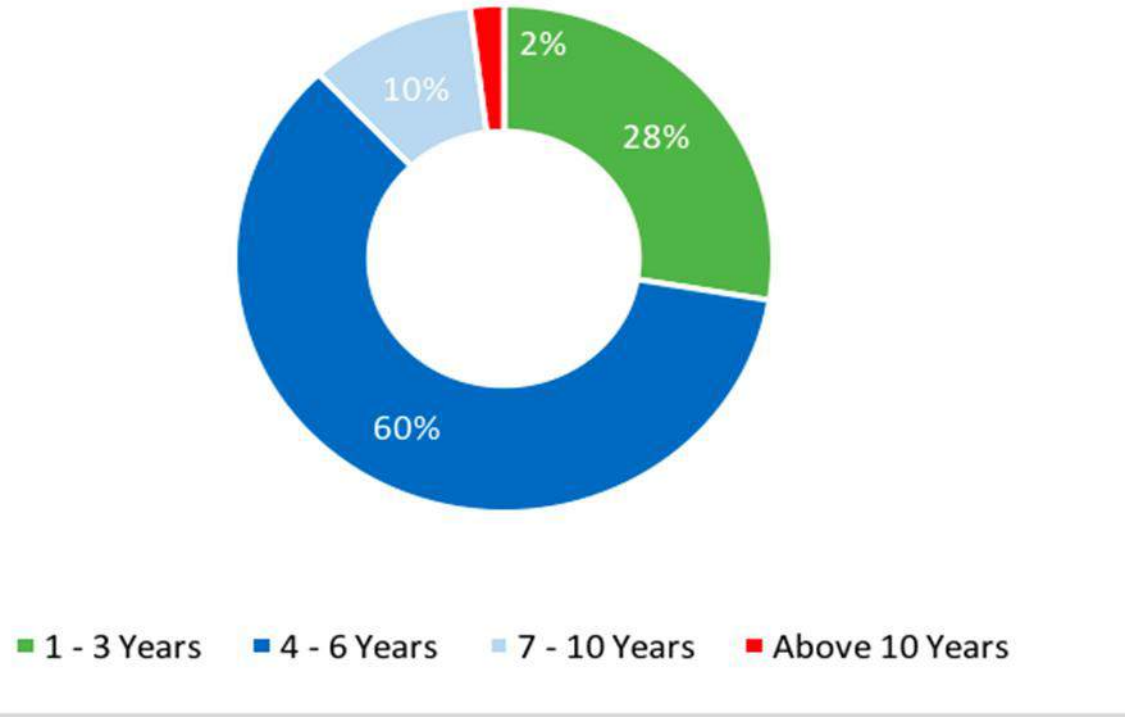


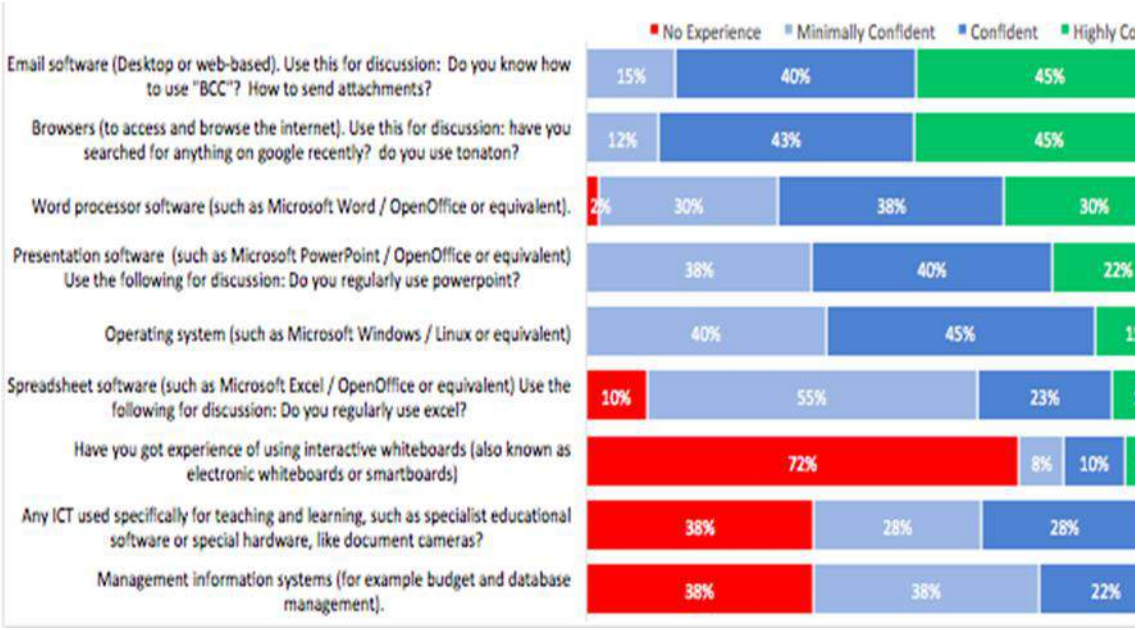
Figure 29: Fossa CoE ICT Tutor interview

5.3 CoE Staff Professional Development needs in ICT

5.3.1 Professional Development needs in ICT - College Leaders

College leaders reported their confidence, experience and skills in using ICT to perform their daily duties. As Figure 23 shows, 85 percent of College leaders say they are confident in basic ICT functions, such as how to use email, or using browsers. Confidence falls with office software such as Word (68 percent are confident) or Powerpoint (62 percent are confident). Confidence in use of excel (a key management tool) is low; only 35 percent of college leaders feel confident and 10 percent have no experience in using spreadsheets.

Figure 30: ICT skills of senior college leaders



College leaders emphasised their need for professional development in the use of ICT in management – see Table 9. Specific areas include management of student data, accounting, budgeting. The use of an EMIS is mentioned frequently both as a custom "CoE EMIS", as well as "any software that can be used for CoE management" (e.g. use of Excel). The use of office/productivity apps (word processing, spreadsheets, presentations) was also frequently mentioned.

Table 9: College leader's priorities for their own continual professional development (CPD) in ICT

Area for CPD	% of CoEs
MS Excel	40%
EMIS (inc. student data)	30%
Interactive whiteboards	28%
Accounting/budgeting (inc. EMIS)	28%
Powerpoint	25%
Office apps	23%
ICT for teaching and learning; educational software	23%
MS Word	18%
Basic ICT skills / OS, email, keyboard shortcuts	18%
Online research	18%
Database	10%
SPSS	8%
Website content management	5%
Online shopping	3%

5.3.2 Professional Development needs in ICT – ICT Tutors

ICT tutors are confident about their expertise in the use of ICT in education, with only 14 percent stating that they needed professional development in this area. A much greater proportion of ICT tutors identified networking and programming as priority areas for their development.

Table 10: Tutors' priorities for their own CPD

Area of professional development	% of ICT tutors that identified this need
Networking	45%
Programming	28%
Hardware	22%
Database	16%
Education related	14%
Security	13%

5.3.3 Professional Development needs in ICT – Tutors

As the survey did not involve data collection from tutors, perceptions of tutors' CPD needs were gathered from College leaders and ICT tutors.

Table 11: Perceptions of the ICT CPD needs of Tutors

Area for CPD	% [College Leaders]	% [ICT tutors]
Office applications	48%	35%
ICT for Teaching and learning	45%	20%
Internet (information searching, research)	43%	35%
Powerpoint	38%	43%
Basic literacy in ICT (incl. email and hardware)	23%	
Smartboards	20%	8%
Assessment / Monitoring &Evaluation / EMIS	20%	
Projectors	13%	18%
Resource searching (subject-specific)	10%	
ST/T communication	10%	
Content creation / TLMs	10%	5%
ebooks, eLibrary	5%	
Database	3%	
Professional development tools	3%	
Basic ICT, anti-virus, networking, fixing small problems		43%
Excel / data analysis		20%
School management		5%

College leaders and ICT tutors share a view that Office/productivity applications (such as Powerpoint) and the use of ICT for teaching and learning are priorities for tutor CPD.

Unsurprisingly, ICT tutors are aware of the need for tutors to develop basic skills required to maintain their ICT devices, function within a regulated ICT environment, and fix small problems with hardware.

5.3.4 Professional development needs in ICT - student teachers

College leaders were asked about ICT professional development needs of student teachers. Office productivity software and skills for online searching are priorities, followed by ICT in teaching and learning. The use of ICT in management is not recognised to be a priority, and possibly reflects the weak use of ICT-based recordkeeping in CoEs.

Table 12: Perceptions of the ICT CPD needs of student teachers

Topic	% of CoEs [College leaders]
Office	58%
Online search skills	55%
Basic ICT literacy (incl. hardware, emails)	38%
ICT for T&L	33%
Online assignments; teaching and learning management systems	15%
Projectors	10%
Access resources	10%
Data analysis / SPSS	8%
eBooks	5%
ICT for data management	3%
ST-ST communication	3%

Student teachers interviewed in focus groups as part of this survey estimated that about 50 percent of students enter the CoE with some prior knowledge of ICT with some basic practical experience, perhaps with Microsoft Word, gained in SHS.

Students' experiences of using ICT within the DBE Curriculum is mainly confined to the L200 ICT lessons. ICT is rarely used to aid teaching and learning in the curriculum more broadly, although students reported that some subjects (such as French and mathematics) may also use ICT in this way. Student's reported a lack of confidence in their own skills to integrate ICT within their teaching.

6 Findings ICT Capacity: Access to ICT devices (Tutors and Students)

6.1 Tutors' access to ICT devices

The survey did not attempt to collect information from all tutors on their access to ICT devices such as laptops, computers, mobile phones, whether personally owned or provided by the CoE. However, to estimate access, the survey enumerators asked ICT tutors to estimate the proportion of tutors with access to a device. Table 13 below presents the findings. Whilst the range is wide, the figures indicate more widespread access to smartphones (87 percent) and laptops (70 percent), than to tablets (27 percent) and desktops (6 percent).

Table 13: ICT tutors' estimates for tutors' access to devices (personal and CoE owned devices)

	Tutors' offices: Desktop computers	Tutors' laptops (work or personal)	Tutors' tablets (work or personal)	Tutors' smartphones (work or personal)
Average	6%	70%	27%	87%
St. dev.	9%	25%	24%	20%

6.2 Tutors access to ICT facilities outside the college

ICT tutors were also asked if tutors access ICT facilities outside the college. The survey suggests that many tutors do so (63 per cent of tutors), and the average distance of the nearest internet café/access point is 5.5 km. However, for some CoE, the nearerst internet café is 47 km away.

6.3 Student teachers' access through their own ICT devices

The survey investigated student teachers' access to ICT through their own devices ("Bring your own device", BYOD[11]). Two survey methods were used: ICT tutors were asked about student ownership, and a sample of students (class prefects) were interviewed and asked to complete a survey form. When data from the ICT tutors were compared to data from the student teacher survey a large standard deviation (st. dev. 20%) and a large range (-47% to 57%) in the differences suggests that ICT tutors' estimates may not be as reliable.

- *ICT Tutor estimates of student ownership of ICT devices*

ICT tutors were asked to estimate the devices owned by student teachers, for laptops, tablets and smartphones. Their responses suggest that many students (76 percent) own a smartphone, but few own a laptop or tablet.

[11] Bring your own device (BYOD)[...] refers to the policy of permitting employees to bring personally owned devices (laptops, tablets and smartphones) to their workplace, and to use those devices to access privileged company information and applications. [...] The term is also used to describe the same practice applied to students using personally owned devices in education settings [...]. https://en.wikipedia.org/wiki/Bring_your_own_device

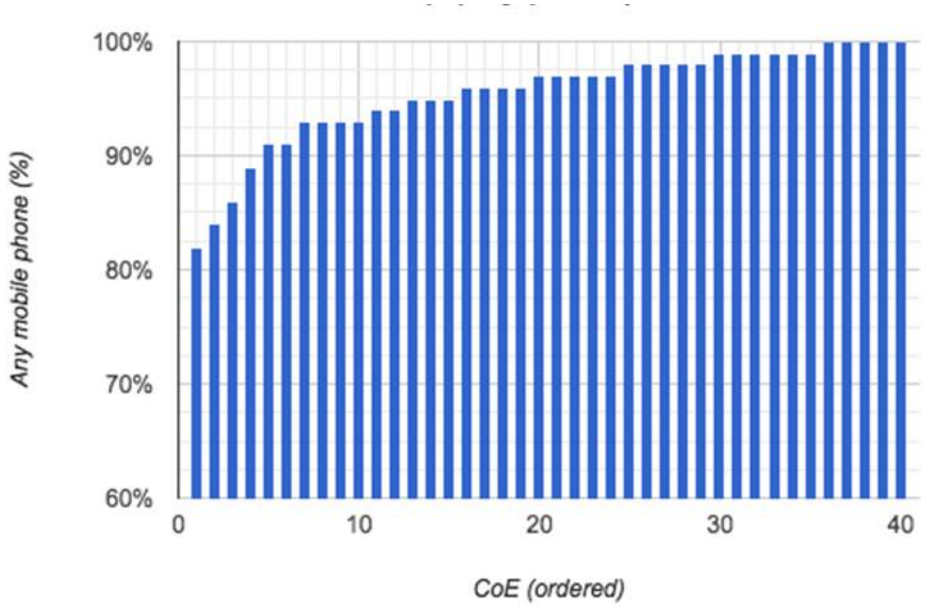
Table 14: ICT Tutors' estimates of student ownership of ICT devices

	Laptop ownership by student teachers	Tablet ownership by student teachers	Smartphone ownership by student teachers
Average	15%	12%	76%
St. dev.	14%	13%	21%
Min	0%	0%	0%
Max	60%	50%	98%

- *Class prefect estimates of student ownership of ICT devices*

Class prefect estimates suggest that mobile phone ownership (any type of phone) amongst student teachers is high; at most CoEs, over 90 percent of students own a mobile phone, with the average ownership being 95 percent.

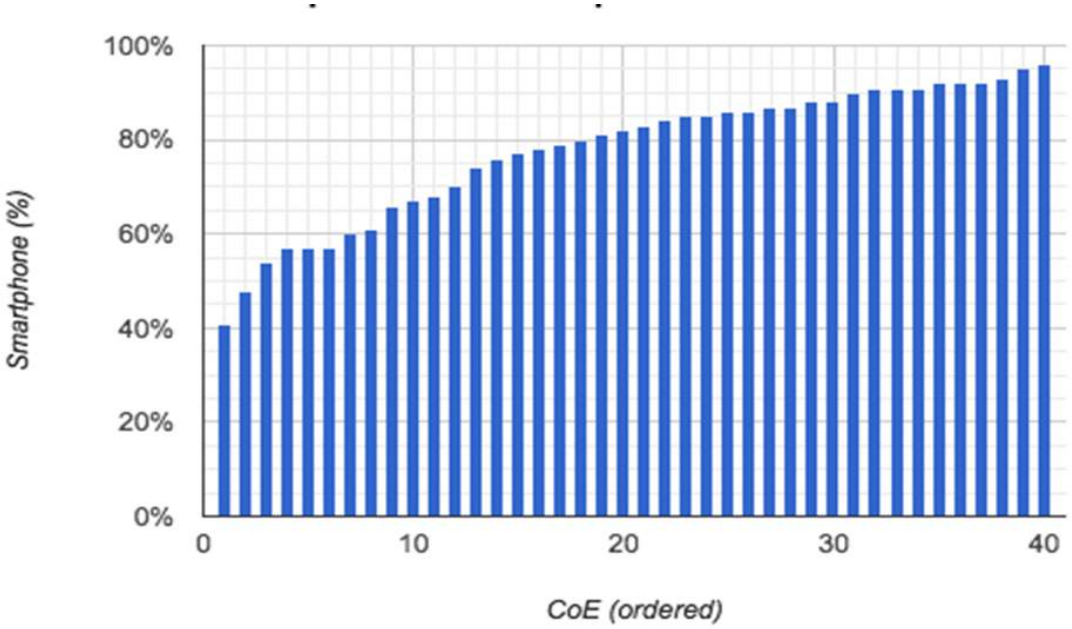
Figure 31: Phone owenership among student teachers (any mobile phone)



6.3.1 Smartphone ownership by students

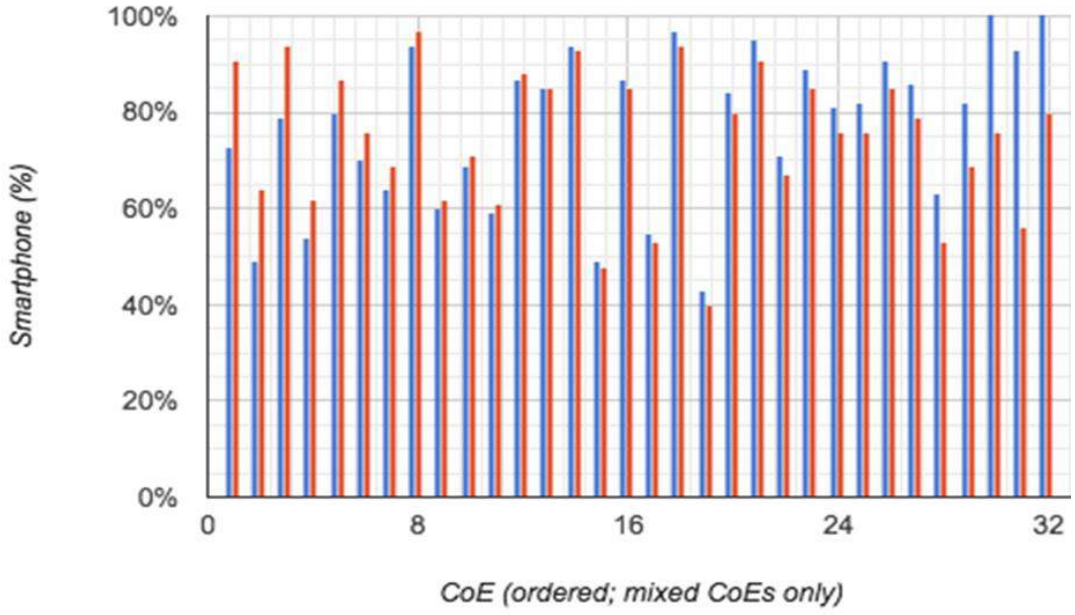
In most Colleges (70 percent), at least 70 percent of students have a smart phone. In only 6 CoEs does smartphone ownership fall below 60 percent of students.

Figure 32: Smartphone ownership among student teachers



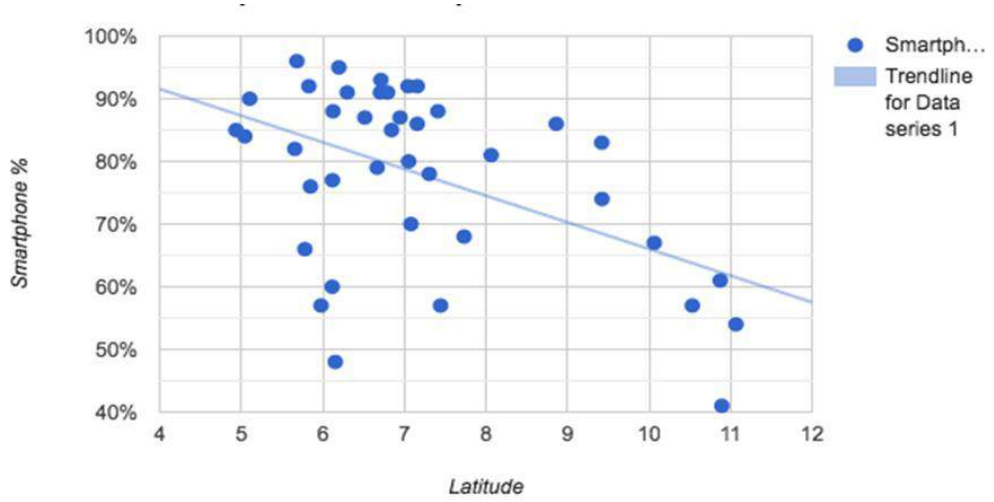
Although smartphone ownership differs between male and female students in many CoEs, no significant systematic difference could be found in ownership by gender. In some CoEs females own more phones than males, and in others vice versa.

Figure 33: Smartphone ownership female (red) vs. male (blue)



Significant differences in smartphone ownership were found between student teachers from the north and south of Ghana. Smartphone ownership was correlated with latitude, and a statistically significant relation was found, as illustrated in the following graph.

Figure 34: Smartphone ownership by student teachers at CoEs in the North and South of Ghana



The graph shows very clearly that at more northern CoEs, student teachers have fewer smartphones. One of the outliers in the north (i.e. a northern CoE with higher levels of smartphone ownership) is Tamale CoE, which is located in an urban centre. We were unable to determine a possible explanation for the outliers in the south (CoEs with lower rates of smartphone ownership compared to the rest of the region).

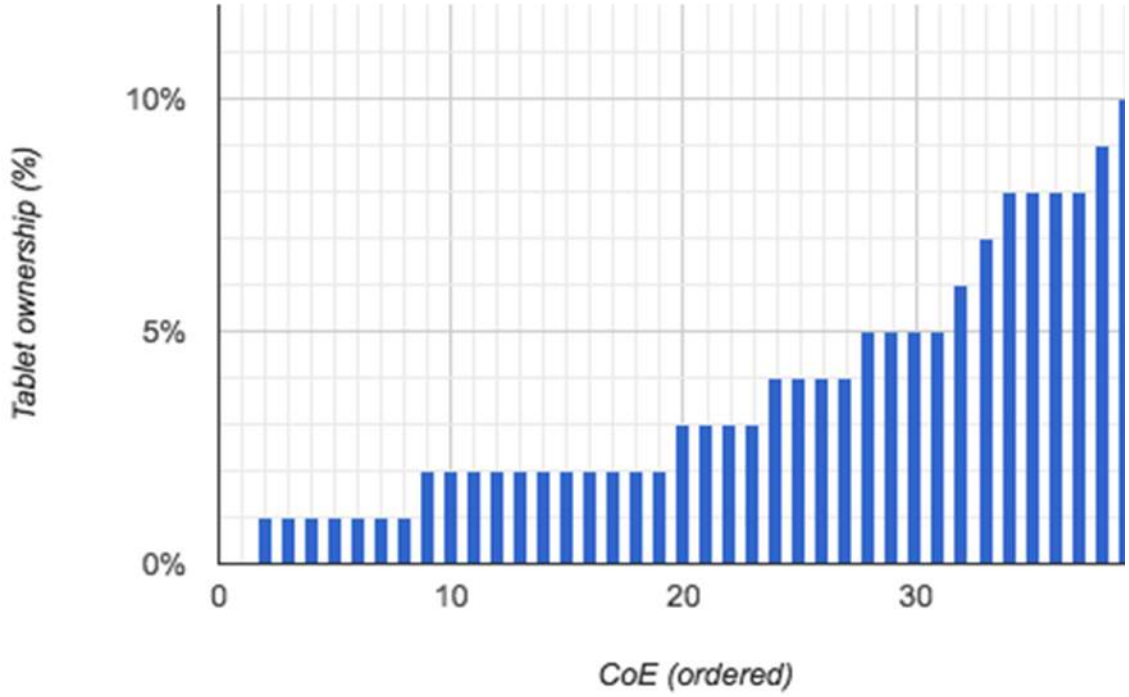
- *Reasons for not owning a phone or smartphone*

Most students own a phone, and many own smartphones. During focus group interviews, the survey team asked about the reasons why some students do not own phones. The reasons provided largely related to affordability, as well as theft. On occasion, student teachers claimed that phone ownership was not a priority because it is not directly linked to a purpose at their CoE. Indeed, some student teachers considered that a phone or smartphone may hinder learning. For smartphones, some student teachers gave difficulty in using the phone's features, low battery life, and the cost of data as reasons for not owning a phone

6.3.2 Tablet ownership by student teachers

Tablet ownership among student teachers is low; on average 3.8 percent of student teachers own a tablet, and tablet ownership only reached 10 percent in one CoE.

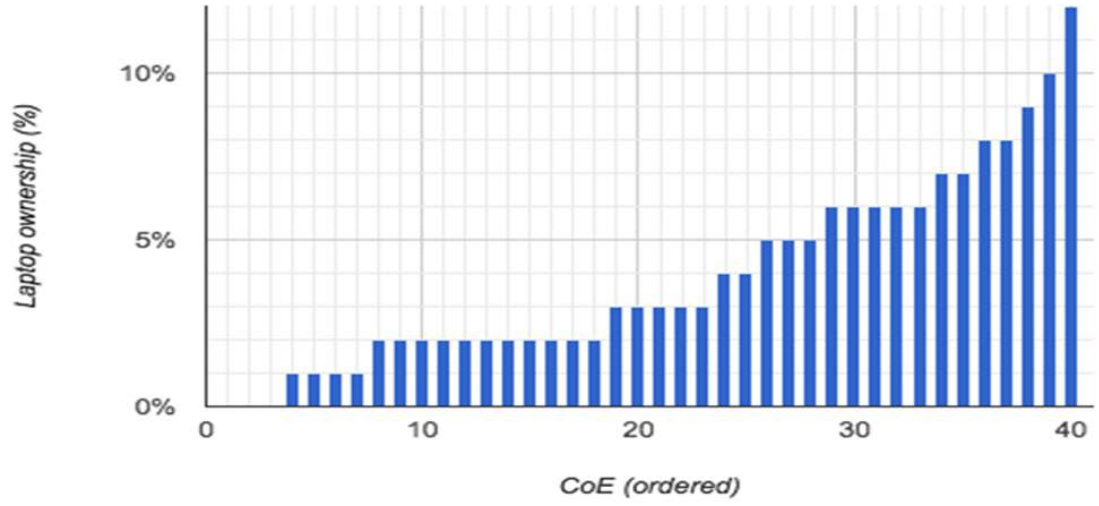
Figure 35: Tablet ownership among student teachers at CoEs



6.3.3 Laptop ownership by student teachers

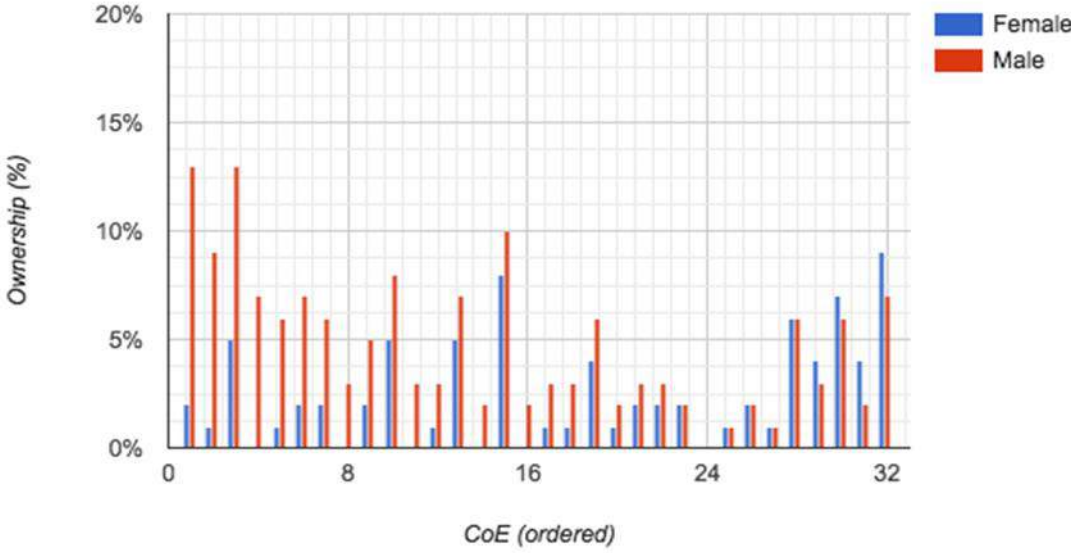
Laptop ownership among student teachers is low. On average 3.8% of student teachers at CoE own their own laptop. Laptop ownership was over 10% in only one CoE.

Figure 36: Laptop ownership by student teachers



A small but statistically significant was found with gender. Laptop ownership is slightly higher among male (5%) than female student teachers (2.5%).

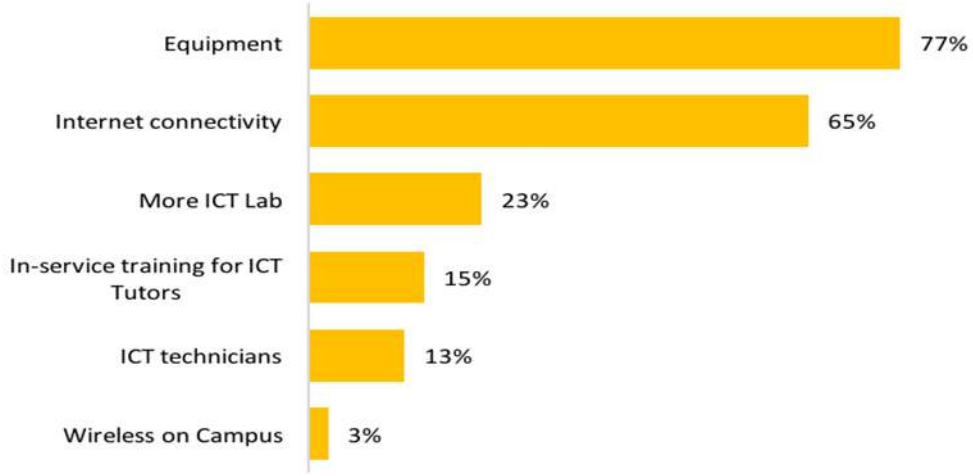
Figure 37: Laptop ownership by male and female student teachers



7 Findings on ICT Capacity: College Leaders' Priorities

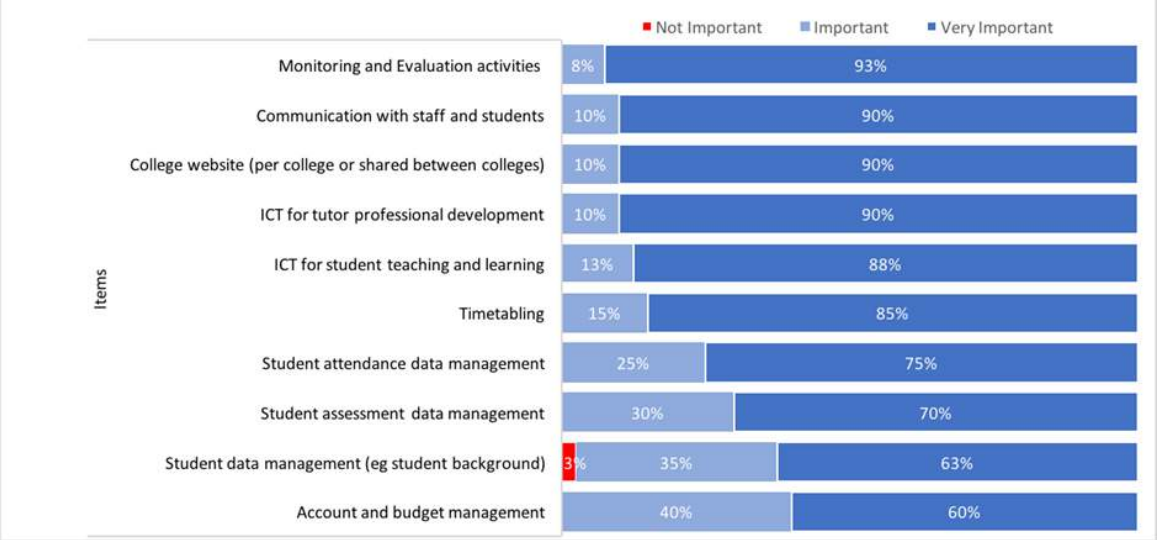
As part of the survey, college leaders were asked about their priority needs with regards to ICT. As Figure 31 illustrates, most college leaders share a priority concern with ICT equipment and internet connectivity.

Figure 38: College Leaders' priorities for ICT



When College Leaders were given a list of areas in which ICT could be useful, and were asked to rate its importance, a wider range of areas for intervention were supported.

Figure 39: Areas considered important for improving the use of ICT by CoE



8 Findings: CoE ICT Capacity Scorecards and ICT Capacity Index

8.1 CoE ICT Capacity Scorecard Results

ICT capacity at all 40 public CoE was measured using the CoE ICT Capacity Scorecard. The findings are presented in Annex 2: CoE ICT Capacity Scorecards. The implications of the individual college findings are discussed in Section 9 of this report.

8.2 ICT Capacity Index Results

The calculation of the value of the ICT Capacity Index per CoE is provided in Annex 1. The value of the sub-indicator for each area of capacity was categorized into three bands

- very weak capacity – red
- low capacity – orange
- basic capacity - green.

As noted in the methodology section, the bands have been given these terms as the indicators used to measure ICT capacity are considered to be a minimum for ICT integration within education.

The values of each sub-indicator, and total index value for every CoE are presented in Table 15.

Table 15: ICT Capacity index results for all CoEs

	Capacity Domain				Index value
	Infrastructure	Policy	Human Resource	Indiv access to ICT devices	Total
Total Possible Score	**44**	**10**	**6**	**12**	**72**
Ada College of Education	20	0	2	6	**28**
Akrokerri College of Education	21	0	2	11	**34**
Accra College of Education	31	2	2	10	**45**
Presbyterian Women's College of Education, Aburi	31	9	4	11	**55**
St. Monica's College of Education	27	2	5	11	**45**
St. Louis College of Education	28	2	2	11	**43**
Mampong Technical College of Education	30	4	2	11	**47**
St. Francis College of Education	27	4	2	11	**44**
Holy Child College of Education	30	2	4	11	**47**
Foso College of Education	19	0	2	11	**32**
Gambaga College of Education	15	0	1	2	**18**
Enchi College of Education	21	0	2	11	**34**
Komenda College of Education	24	4	3	11	**42**
Wiaso College of Education	24	4	4	11	**43**
Evangelical Presbyterian College of Education, Bimbilla	15	2	5	11	**33**
Agogo Presbyterian College of Education	31	2	3	11	**47**
Evangelical Presbyterian College of Education, Amedz	11	0	1	10	**22**
St. John Bosco's College of Education	19	2	3	5	**29**
Bagabaga College of Education	20	2	1	5	**28**
Jasikan College of Education	30	4	2	11	**47**
Tumu College of Education	20	0	1	5	**26**
Tamale College of Education	27	2	2	11	**42**
St. Joseph's College of Education	27	2	2	6	**37**
Abetifi Presbyterian College of Education	16	0	3	5	**24**
Nusrat Jahan Ahmadiyya College of Education	26	4	6	3	**39**
Offinso College of Education	27	2	3	11	**43**
St. Theresa's College of Education	21	0	2	11	**34**
Gbewaa College of Education	22	2	2	5	**31**
Mount Mary College of Education	19	0	2	6	**27**
Kibi Presbyterian College of Education	30	4	2	5	**41**
Our Lady of Apostles College of Education	23	2	5	10	**40**
Atebubu College of Education	21	0	2	6	**29**
St. Ambrose College of Education	19	0	1	11	**31**
Akatsi College of Education	28	4	1	11	**44**
Seventh Day Adventist College of Education	16	0	2	6	**24**
Berekum College of Education	30	4	5	6	**45**
Presbyterian College of Education, Akropong	20	0	3	6	**29**
Dambai College of Education	11	0	1	11	**23**
Peki College of Education	37	2	3	11	**53**
Wesley College of Education	21	2	2	11	**36**

The CoE Index results confirm extremely weak policy capacity to manage ICT across the CoEs, with one exception.

Human resource capacity is also weak in the majority of CoEs, which largely reflects the lack the appointment of ICT technicians by CoEs to manage and maintain the ICT environment. Seven CoEs have weak human resources capacity in ICT.

No CoEs were found to have very weak infrastructure capacity, although 6 CoE are close to the boundary score. Almost half of the CoEs achieved the status of basic ICT infrastructure capacity. This means that over half of the CoE do not have even a basic level of ICT infrastructure required to use ICT in education.

In contrast, at half the CoEs (21), students and tutors do have access to ICT through personal devices. In the remaining CoEs, access is lower with 8 CoEs where student access lies toward the weaker end of the capacity spectrum.

9 Discussion of findings

This section discusses the findings, before conclusions and recommendations are presented in the final section.

9.1 Low ICT Capacity in CoE across a range of capacity domains

The variables measured by the NCTE ICT Survey represent a basic level of institutional capacity in ICT required to begin to integrate ICT into institutional management systems, teaching and learning, and staff development. Thus, CoEs that score relatively well on the CoE ICT Capacity Scorecard have only achieved a basic level of ICT capacity required for initial levels of integration.

This survey revealed low levels of ICT capacity in most CoEs, and across a range of domains: infrastructure, human resources, and policy. This finding is of significant concern for institutions aiming to become fully fledged tertiary education institutions with robust management systems and providing a quality of teaching and learning appropriate for the 21st century. It is particularly disturbing given the new Minister of Education's focus on ICT in schools in Ghana. New teachers must be equipped to integrate ICT appropriately into their teaching, whatever the subject and level of schooling. At present, CoEs do not have the ICT capacity to provide a teacher education curriculum that prepares teachers with the knowledge and skills to integrate ICT within their own teaching.

9.2 Weak ICT policy capacity in CoEs

Only one CoE has achieved a basic level of capacity in the ICT policy environment. In most CoEs, capacity to regulate and manage the ICT environment is very weak. Most CoEs remain exposed to risk of significant losses (both data, and financial) through virus attacks, lost data, compromised data, and unapproved access to networks. Internet connectivity is an expensive resource with high demand, and must be managed effectively. Some CoEs are implementing good practices even without a formal policy in place, but all CoEs need to develop, implement and monitor the policies through which they manage their ICT.

9.3 Inadequate technical support to manage ICT systems in CoEs

Most Colleges of Education do not have a non-teaching staff member responsible for managing the ICT environment (the ICT technician). This is an essential staff post for any institution wishing to have a functioning ICT infrastructure serving hundreds of users. On a day-to-day basis ICT technicians are responsible for implementing ICT policies and providing appropriate feedback on the systems' performance to college leaders. All CoEs will require at least one ICT technician.

To increase ICT staff capacity, some CoEs have National Service Scheme[12] persons (e.g. computer science graduates) successfully assisting with the technical aspects of the ICT infrastructure. This may well be a possible approach to increase technical capacity further. In the next round of National Service Scheme allocation, each CoE could take on two such persons, with a background in computer science. Under the guidance of the existing technician these could collaboratively (across CoEs) support the maintenance of the infrastructure.

It is important to take note of the professional development priorities that ICT tutors and technicians have *identified as their most pressing needs*, namely **network management**. The

[12] http://nss.gov.gh

findings support their view that this is an urgent need for capacity development across CoEs. There is also a need to raise awareness amongst college leaders of the critical importance of this area of activity, and skill.

9.4 Irregular power supply

Unreliable power is a significant deterrent to using ICT in general and particularly to using ICT as an aid to learning and teaching when some degree of predictability about power supply is required. It is gravely concerning that only 20 percent of CoEs rated their power supply (including backup generators) as reliable.

All CoEs wishing to integrate ICT within teaching and learning will need to identify reliable power supplies for ICT technologies. Colleges with different levels of financial resources may select different power solutions, ranging from back-up generators with fuel, to solar battery packs to support specific low-cost ICT resources.

9.5 Poor internet connectivity

Whilst internet connectivity is not required for all forms of ICT integration in education, it is essential to digital inclusion in the 21st century. Most CoEs (67 percent) provide internet connectivity for staff in principle, but on the day of the survey, internet connectivity was only available at 13 CoEs (33 percent). Across CoEs there is great variation in terms of the amount paid for internet, and quality of service. The nominal average download speed per student teacher is low (0.0025 MB/s (or 0.05 Mb/s at 1:20 contention). CoEs tend to provide the level of internet provision that they consider affordable, even if this is not sufficient – or even no internet at all. Understandably, internet connectivity was cited as a priority by college leaders.

Offline content can be provided in environments with limited Internet connectivity. However, only one CoE provides offline content to staff and students. CoE tutors are likely to need support in finding ways to integrate ICT within teacher education in low resource environments.

Given the limited access to working internet, and low connectivity, it is unclear how the eBook programme will benefit the CoEs. It has been suggested that tutors and student teachers may be willing to use their own data. However, T-TEL's experience suggests that tutors are not willing to use large amounts of personal data for work purposes (downloading an eBook requires multiple MB and expires after a few days, requiring re-downloading the eBook).

9.6 Inadequate management of internet provision

In addition to providing internet connectivity, it is essential that CoEs manage the internet service internally. Internet provision consists of the overall connection (WAN; provided by the ISP), as well as how the connection is managed (LAN; managed locally). Bandwidth management of the (wired and wireless) LAN is paramount. This includes using routers and servers for bandwidth management and optimisation, traffic shaping, web caching, etc. There are significant opportunities to maximise the WAN connectivity through "aggressive" bandwidth management. But only 27.5 percent of CoEs have functioning servers with appropriate specifications. Most CoEs need urgent support to make most cost-effective use of their internet through LAN management.

Infrastructure improvements are also required to improve the reliability of internal networks (LAN/WLAN), given that only 15 percent of CoEs were found to have a LAN/WLAN confirmed as good.

Few CoE manage access to the network effectively. Where WiFi access is just by a single (WPA) password (potentially for hundreds of users), once this password is compromised, the entire network is compromised. Accordingly, some CoEs face problems with non-CoE members accessing their networks. Only two CoEs use captive portals, that enable user access with individual passwords; these are also by one of the CoEs to restrict internet access by duration, i.e. 10 hours per semester.

9.7 Limited access to larger screen ICT devices for student teachers outside of ICT lessons

Few student teachers have access to a larger screen device (i.e. a laptop or tablet). For many student teachers, the ICT labs are the only way of accessing a large screen device on campus.

Although 75 percent of CoEs permit ICT lab use by student teachers in their own time, once the number of students to computers, and opening hours are considered, the average time that each student could access a computer is about an hour a week. This is not sufficient for developing significant ICT competence. CoEs need to find strategies for improving student teachers' access to ICT larger screen devices.

One factor limiting students' free access to labs is the requirement that an ICT tutor must be present. An alternative may be to initiate student teacher-led ICT clubs that utilise the lab after hours. At least one CoE draws on "ICT prefects" representing and monitoring student teachers' ICT-related interests.

9.8 Limited range of ICT infrastructure used in teaching and learning

The use of ICT in education is almost entirely limited to ICT lessons, and activities in ICT labs.

All colleges have ICT labs which are primarily used for teaching ICT lessons. Most labs have an appropriate ratio of computers to seats, (one computer to two seats) and in most cases, the ICT devices are working. For use during lessons some labs are configured with between 3 to 4.5 seats per computer, which makes it difficult to conduct lessons where all student teachers gain practical experience, and in these cases more computers are needed. While the desktop PCs recently procured for CoEs increase the number of devices, they are comparatively expensive and have a comparatively high power consumption. It should be possible to utilise alternative technologies that are functionally equivalent, but better Value-for-Money, have lower power requirements and reduced need for maintenance. This could include low-cost solutions (similar to the Pi-top CEED, "all-in-one" PCs, "PC sticks"; either stand-alone or as thin clients), as well as utilising existing PCs in multi-seat configurations

In some CoEs, existing resources could be used more effectively for learning. In many labs, the ratio is one seat per computer. However, research on ICT in education[13] indicates that a ratio of 2 seats per computer may encourage more effective learning, through peer interactions.

At present, ICT infrastructure for teaching and learning is limited to ICT labs. The survey found very little use of ICT in general classrooms. If CoEs are to train teachers capable of teaching the new basic education curriculum, significant improvements in the integration of ICT across the teacher education curriculum will be required. Colleges may require support to identify and set up appropriate, low-cost ICT solutions for teaching and learning.

[13] Haßler, Major, Hennessy, 2015

9.9 Student teachers' mobile devices – an untapped resource?

Smartphone ownership by student teachers is high; on average, student teachers estimate that 78%, of their peers own their own smartphone. There is significant variation in ownership between CoEs (standard deviation 14percent from the average, range 41percent to 96percent), and significantly fewer student teachers owning their own phone in Northern Ghana than in the South.

Even though many smartphones will be basic models, with limited storage capacity for educational resources, students' smartphones could be used fruitfully as part of classroom activity. Intranet options could be used within classrooms. Security at CoEs may need to be addressed so that students can keep their devices securely. CoE tutors are likely to need professional development in order to introduce new teaching and learning strategies with ICT.

It may be possible for the College sector to develop a scheme to enable students to acquire their own devices ('rent-to-buy' scheme). The Ministry of Health/Samsung laptop scheme (see MCSP-CHNTS report) seems to have been effective, and Winneba University runs a tablet scheme for distance students, where the cost of the tablet is included in the registration fee.

9.10 Professional development in ICT is required for college leaders and tutors

Staff at all levels of the CoEs acknowledged their professional development needs in ICT.

College leaders prioritised improving their skills in the use of ICT tools in management. They also expressed a significant lack of confidence and experience in the use of ICT in education and acknowledged that this limits their capacity to provide leadership in this area.

Similar professional development needs were identified for tutors, with the use of MS Office software, and ICT in education being priorities. ICT tutors' concern that tutors also need to develop basic ICT skills, the ability to fix minor problems, and to use the internet, appear to suggest low levels of ICT skill among tutors. Appropriate models for CPD need to be found, and could include regular sessions at which tutors work collaboratively to build strategies for using ICT in their teaching, whilst also developing their own ICT skills.

9.11 CoE sector has limited expertise in 'how to use ICT in teaching and learning'

Unsurprisingly given the nature of the DBE curriculum, the capacity amongst tutors to integrate ICT in education (using ICT to learn effectively) is extremely low. As the DBE curriculum is revised in line with the basic education curriculum, and the emphasis on ICT increases, all tutors will need to improve their own competence in using ICT in teaching. This in turn requires a cadre of tutors across the CoEs with particular expertise in this curriculum area. At present, some ICT tutors have Masters Degrees in ICT and education. These tutors could provide the foundation from which a community of practice in ICT in education could be built.

In many CoEs, the ICT tutor currently has to maintain the CoE ICT system, as well as teaching the curriculum subject of ICT. Perhaps reflecting this, more ICT tutors expressed a need for professional development in system-related areas such as networking than asked for development in ICT in teaching and learning (where they are arguably already considered to be 'expert').

However, if ICT is to be fully integrated within CoE, three distinct roles will need to be defined:

- ICT Technician - a non-teaching post, responsible for ICT system maintenance across the CoE.
- ICT Tutor - a tutor that teaches ICT

- ICT in education specialist - a tutor who promotes the use of ICT in teaching and learning across the curriculum, and provides internal professional development to other tutors

The ICT in education specialist role is almost completely absent across CoEs at present. It is urgently needed to support others in developing these skills. Some ICT tutors may wish to become experts in the area of ICT in education, but not all will want or be appropriately skilled to perform this role. The ICT in education specialists must be competent in the use of ICT, but have a passion for teaching and learning.

9.12 CoEs are at different points on a development pathway to ICT integration

The survey suggests that CoEs are travelling along a pathway towards the integration of ICT in their institutions, and that CoEs are at different points along this trajectory. The variables surveyed by the NCTE, the CoE ICT Capacity Scorecards, and the ICT Capacity Index point to a set of key moments in this journey. These moments need to be conceptualised and supported by, strategies that scaffold the integration of ICT in low cost environments.

Table 16: Key Milestones in a CoE ICT Capacity Development Pathway

Milestone	Success criteria
ICT Policy developed	• ICT policy written and disseminated to all CoE staff • ICT policy includes decisions on network management, data backup, data security, firewalls • Senior manager is nominated to be responsible for the implementation of the policy. • Implementation of ICT policy is monitored by the college management team
ICT technician	• Non-teaching ICT technician appointed to manage ICT system • ICT technician receives professional development in management of ICT for tertiary institutions
Reliable power	• ICT system set up is suited to availability of power • ICT solutions using solar batteries and backup power packs are provided in classrooms and administration blocks without generators
Server and WLAN/LAN infrastructure	• Server is installed and used • Server is used to manage network • WLAN/LAN infrastructure is maintained and managed • Infrastructure extends to student study spaces (e.g. library, dormitories, study areas)
Internet connectivity	• Internet connectivity is available for college leaders, tutors and students • LAN is managed through bandwidth and access portals • Internet service is affordable for the CoE
Use of mobile devices	• CoE security supports students to bring devices into classrooms • Student schemes (such as rent to buy) increase access to mobile devices and affordable data

Milestone	Success criteria
	• Tutors include use of ICT devices (low cost ICT solutions) in teaching and learning in their lessons
ICT in Education specialist	• A tutor is nominated to lead ICT in teaching and learning • ICT in education specialist receives specialist training • ICT in education specialist runs CPD for tutors
CoE Management Team	• College management team includes a manager responsible for promoting ICT in Education • College management team includes manager responsible for implementation of CEMIS • CPD for college management includes basic ICT skills • Recruitment of new college managers requires basic ICT competence
CoE Tutors	• Tutor career path progression requires basic competence in ICT • Tutors attend professional development on integrating ICT in education

10 Conclusions and Recommendations

Public CoE in Ghana are on a journey towards the integration of ICT, but progress is unequal. Most CoEs have weak ICT capacity across three domains and also lack the internal capacity required to improve this situation by themselves.

The NCTE, as the institution responsible for the quality of tertiary institutions, is mandated to support CoEs to progress towards ICT integration, and to achieve the minimum level of ICT capacity required by functioning tertiary institutions in the 21st century.

Based on the findings, the following conclusions with recommendations are made:

1. *CoEs would benefit from guidance on how to improve their ICT capacity*

Although there is scope for CoEs to improve the use of ICT with existing resources, this will only be achieved with guidance that supports informed and effective decision-making on ICT policies, staffing requirements, and infrastructure.

It is recommended that T-TEL supports the NCTE to develop a national CoE Roadmap/ICT Capacity Development Pathway to guide CoE investments in all areas of ICT infrastructure and to guide the establishment of the policy and human resource environment required for efficient use of ICT infrastructure. The Roadmap should build from the findings of the NCTE survey, and include the critical milestones outlined in the ICT Capacity Development Pathway. It must identify cost-effective directions for infrastructure development.

It is recommended that T-TEL supports the NCTE to identify an appropriate vehicle through which CoEs can be guided to implement the ICT Capacity Development Pathway in their own context. Advice must be customised, and based its current level of ICT capacity of the CoE, as measured in this survey, and address specific challenges, in order to support CoEs to achieve, and move through the critical milestones in the ICT Capacity Development Pathway / NCTE Road Map.

2. *A CoE sector strategy for integrating ICT in education could provide efficiencies for all CoEs*

With increasing attention on ICT within both the school curriculum and teacher education curriculum there is now an urgent need to integrate ICT within teaching and learning in CoE. As this survey demonstrates, however, the sector is starting from a low level of ICT capacity. Meeting the demands of the new curricula in schools and CoEs will require a sector-wide response that encourages efficiencies for all CoEs.

It is recommended that a CoE sector strategy for Integration of ICT in education should be developed through a partnership of CoE stakeholders led by PRINCOF. A small action group should be established to draft the strategy for review.

The strategy could consider shared concerns such as:

- Access to affordable internet connectivity
- Buy-to-rent scheme for student teachers to access mobile phones and laptops
- Piloting affordable ICT innovations in CoE to support:
    - Communication and information/materials delivery
    - Teaching and learning strategies within subject disciplines
    - Student-run clubs to increase access to ICT labs

- Professional development for ICT in education specialists in CoEs
- Professional development for tutors on integrating ICT in education
- Open access resources for CoEs
- Professional development for ICT technicians (in managing ICT in tertiary institutions; CEMIS requirements etc)
- The role of NITA in the CoE sector

3. The proposed CEMIS system must respond to CoEs present ICT capacity

The ICT capacity of CoEs to engage with the proposed College Education Management Information System (CEMIS) is limited.

It is recommended that the CEMIS system is hosted at a central secure location, given the weak policy environment at most CoEs (including data protection and backup).

It is recommended that the CEMIS is based on low bandwidth requirements, with mechanisms of data exchange appropriate to the setting (compression; resuming; integrity).

It is recommended that the CEMIS data is managed at CoEs by managers/staff that already have appropriate levels of skills in the use of ICT.

It is recommended that college leaders are provided with orientation to the CEMIS, and the ICT capacity demands it will make on CoEs, and that the orientation takes into consideration low levels of ICT expertise amongst college leaders.

Annex 1: Colleges of Education ICT Capacity Index

COLLEGES OF EDUCATION ICT CAPACITY INDEX				
Name of College				
Number of students				
Number of Tutors				
Zone				
#	**INDICATOR**	**VALUES**	**WEIGHTINGS**	**SCORE**
INFRASTRUCTURE CAPACITY				**52**
Power				12
1	Reliability of national power supply to the CoE	Unreliable / Moderately reliable / Very reliable	Unreliable =0, Moderately Reliable =1, Reliable =2	2
2	Availability of backup power	Yes/No	Yes = 5	5
3	Power in admin offices	Yes/No	Yes = 1	1
4	% classrooms with power	% of all classrooms in COE with power. (Number of classrooms with power / total number of classrooms in CoE * 100%)	less than 80% = 0 above that is 1	1
5	Power in college hall	Yes/No	Yes = 1	1
6	Power in student accommodation	Yes/No	Yes = 1	1
7	Power in tutor accommodation	Yes/No	Yes = 1	1
8	Power in ICT labs	Yes/No		
LAN/WLAN				*7*

9	There is LAN/WLAN infrastructure on campus and working	Working/Not working	Yes = 1	1
10	Network Connectivity measured through Ping Test on day of survey in mbps	Average Download MBPS	no connection = 0; reading is zero=1, above 0 = 2	2
11	% ICT labs with LAN /WLAN connectivity	% of ICT labs with LAN/WLAN	less than 80% = 0 above that is 1	1
12	% classrooms with WLAN connectivity	%	less than 80% = 0 above that is 1	1
13	Access to LAN/WLAN connectivity in admin block	Yes/ Not working / No / No data	Yes = 1	1
14	number of admin blocks with WLAN connectivity	Number	less than 1 is 0, 1 and above is 1	1
Internet				19
15	The college has access to internet	Yes /No	no=0, yes=10	10
16	Name of internet provider	*Name*		
17	Internet Stability and Reliable Monthly average	Unreliable / Moderately reliable/ Very reliable		
18	Mode of connectivity to ISP	4G/3G/ASDL /Microwave /Fibre /Satellite /other	satelite,3G, other =1, 4G, ADSL, Microwave =2, fibre = 3	3
19	Speed of internet as measured via speedtest tool on the day of visit (mbps)	Poor / Average / Good / No data	No internet, No data =0, anything else = 1	1
20	Cost of internet to College per month Gh ₵	GHS		
21	Students can access the Wifi on their own devices	Yes / No	1= yes, 0=no	1
22	Tutors can access internet on their own devices	Yes / No	1= yes, 0=no	1

23	Wireless LAN in the Student Accommodation	Yes / No	1= yes, 0=no	1
24	Network usage is monitored	-	1= yes, 0=no	1
25	Internet access is available in administration block	Yes / No	1=yes, 0=no	1
ICT Labs				7
26	Number of ICT labs	Number		
27	% of functioning computers and/or laptops (across all labs)	%	less than 80% = 0 above that is 1	1
28	Number of functioning computers and/or laptops per lab (average across labs)	Number	less or equal to 5 computers is 0, from 5 to 25 is 1,above that is 2	2
29	Ratio of functioning computers to seats (average across labs)	Number of seats/functioning computer	less than 0.5 is 0, 0.5 is 1, above 0.5 is 2	2
30	Condition of ICT labs	excellent/requires refurbishment, requites extensive refurbishment	requires extensive refurbishment = 0, moderate =1 and good condition is 2	2
31	ICT Lab security Status	*Description*		
Server				2
34	The college has a server	Yes / No	yes=1, no=0	1
35	Server functioning	Yes /No	yes=1, no=0	1
36	Uses of the server by the CoE	Network protection / content filtering / offline content		
ICT devices				5
37	Number of functioning computers in the administration block	Number	1 and above is 1, less than 1 is 0	1

38	The principal's office has a computer	Yes / No	1 and above is 1, less than 1 is 0	1
39	Number of functioning projectors available in the College	Number	1 and above is 1, less than 1 is 0	1
40	Number of functioning whiteboards in the College	Number	1 and above is 1, less than 1 is 0	1
41	Number of functioning (pairs of) speakers in the College	Number	1 and above is 1, less than 1 is 0	1
POLICY CAPACITY				**8**
Policy				
42	The CoE has an ICT policy	Yes / No	5=yes, 0=no	5
43	Level of regulation and control of system maintenance	None / secure access, content filtering, system upgrades, adding software, adding users, licensing, backups/data recovering	yes=1, no=0	1
44	There is a policy for the use of college network.	Yes / No	Yes=1, no = 0	1
Website				
45	College has a website or social media presence	Yes / No	Yes = 1, no=0	1
46	If yes, what is website domain name	*Domain name*		
HUMAN RESOURCE CAPACITY				**4**
ICT Tutors				
47	ICT tutors (actual number)	Number	More than 1 = 1; Three and more =2	2
48	Highest Qualification in ICT (of all the ICT tutors)	1st Degree / M Ed /PhD	1st degree is 0, anything else above is 1	1

49	% ICT tutors that are female	%		
Technicians				
50	Actual number of technicians	Number	1 and above is 1, less than 1 is 0	1
51	Highest Qualification held by a Technician			
ACCESS TO ICT DEVICES				**18**
Personal Access to ICT devices				
52	% tutors that own smart phone or tablet (ICT tutor estimate)	%	less than 80% = 0 above that is 1	1
53	% tutors that own laptop (ICT tutor estimate)	%	less than 80% = 0 above that is 1	1
54	% students that smart phone or tablet	%	less than 80% = 0 above that is 5	5
55	% students that own a laptop or computer	%	less than 50% =0 above is 1	1
56	% of laptop/computer owners that are Female	%		
Student Out of Hours Access to Labs				
32	Students are allowed to use the ICT lab after lecture hours	Yes / No	yes=5, no=0	5
33	If yes, how many hours per week per student	*Hours*	less than 3 hours a week is 0, above 3 is 1, 5 or above is 5	5

Source: <Insert Notes or Source>

Annex 2: CoE ICT Capacity Scorecards for Every College

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