

## A CLASSIFICATION OF INFORMATION COMMUNICATION TECHNOLOGIES (ICTS) USED FOR LEARNING IN HIGHER EDUCATION

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### ABSTRACT

This paper identified ICTs used in HEIs in Ghana for learning. A quantitative research technique was employed in this study. The study's sample were students of selected HEIs in the Greater Accra and Ashanti Regions of Ghana. The study involved a sample size of 3,199 students. A structured questionnaire was used to collect data. Principal Component Analysis was used to present findings. The study identified 21 ICTs that are used for learning in HEIs in Ghana. Among them, desktop PC, laptop PC, e-encyclopaedia, e-libraries, e-books and e-journals are the most frequently used ICTs. The ICTs retrieved are placed in three components. The first component accounts for the highest variation of 51.4% of the total variation of 100% and contains the most frequently used ICTs in the HEIs. The second component contributes 22.6% of the total variation and contains the second most frequently used ICTs for learning in HEIs. The third component accounts for 16.1% of the variation. It is recommended that HEIs focus on deploying ICTs contained in the three components.

**KEYWORDS:** Higher Educational Institutions (HEIs), learning, information

communications technologies (ICTs), Principal Component Analysis (PCA), Ghana.

### INTRODUCTION

Human beings have found their way towards the deployment and leveraging of technologies in learning and teaching, resulting in a remarkable change in the quality and impact of education in most jurisdictions in recent times [1], [2]. Additionally, the educational sector is gradually catching up with industry in terms of the use of technologies in facilitating the accomplishment of activities and minimising the cost of hiring labour. Moreover, there is the general belief that the renewable efficiency of technologies makes them deployable in teaching and learning now and in future [1]. This belief is rooted in the rapid advancement in the functions of educational technologies and the evolution of robust technologies that address specific issues in teaching and learning [3], [4]. Hence, institutions failing to incorporate technologies in learning and teaching are missing out on technological innovations that play a pivotal role in institutional management and societal building. This argument would better be understood when

the role and advantage of technologies in teaching and learning are acknowledged. It is admitted in practice and research that technologies have the basic role of maximising the efficiency of human skills and competencies [5], [6]. In terms of education, technology infusion is aimed at facilitating teaching, learning and the accomplishment of administrative activities [5], [6], [7]. This means that technologies are deployed in an academic institution at three levels: teaching, learning and accomplishment of administrative processes which involve research and communication. According to [8], the advantage of technological infusion in an academic institution is a reduction in costs and the accomplishment of tasks with much flexibility, speed, convenience and ease, regardless of what level of education is involved. Yet, the extent to which an institution savours a technology in this respect depends on the institution's dynamic capabilities in using it [6], [8], where dynamic capabilities in this context would depend on knowledge and experience with the specific technologies and their uses.

A research by [8] posits that many categories of technologies are deployable in an academic environment. They however add that the bulk of technologies are information systems used basically for disseminating information across stakeholders (i.e. university council, management, faculty, students, parents and potential students) in an academic institution. Many studies (e.g. [1], [9], [10] etc.) have identified the computer and its applications, internet, intranet, mobile phones and other e-learning systems as information systems centred on information dissemination across institutional stakeholders.

The higher educational sector in Ghana is growing quickly in terms of technological infusion in teaching and learning [9]. It is observed that virtually all higher educational institutions (HEIs) in Ghana use technologies, precisely information communications technologies (ICTs) to some extent [11]. For instance, universities and polytechnics in Ghana have subscribed to the use of Public Address Systems, projectors, computers and other devices in teaching. Unlike situation in the past, students and lecturers in Ghana now significantly use e-books, e-libraries and the internet in research [11]. Universities and polytechnics also use intranet, Microsoft office applications and other ICTs at the administrative level [9].

Though the use of ICTs in teaching and learning is fast growing in Ghana, research has made little contribution to knowledge on important subjects of ICTs deployment and use in HEIs [9]. Some of these subjects are the extent of use of ICTs, challenges associated with ICT application, cost-benefit impact of ICTs deployment and types of ICTs used. As a result, academic debate on these subjects in a Ghanaian perspective is weak. This hinders the productive and effective use of ICTs in HEIs in Ghana [12].

This study therefore contributes to academic debate and knowledge with respect to only one of these many subjects while leaving the remaining subjects for future research work. In this study, the objective is to identify ICTs used in HEIs in Ghana. This paper also examines the extent to which identified ICTs are used in teaching and learning in HEIs in Ghana. This paper seeks to contribute to knowledge on ICTs used in a tertiary educational environment in Ghana and the extent to which these ICTs are used. In the next section, the objective of this paper is presented.

## **OBJECTIVE OF THE STUDY**

This paper identifies ICTs used for learning in higher educational institutions in Ghana. This paper provides a classification of ICTs with respect to the extent to which they are used in learning in HEIs in Ghana. The specific research objectives of this study are: (1) to identify all individual ICTs used in learning in HEIs in Ghana; and (2) to find the most commonly used ICTs in HEIs in Ghana.

## **SIGNIFICANCE OF THE STUDY**

This paper contributes to academic debate and knowledge in terms of ICTs used for learning in some higher educational institutions in Ghana. Empirical evidences produced in this study would inform managements of emerging higher educational institutions in Ghana and other similar countries in Africa about ICTs which are basically needed for effective teaching and learning. The study would also enable managements of HEIs to prioritise the use of some ICTs when it cannot afford to use all needed ICTs in teaching and learning. The study's result would also reveal which ICTs are suitable for use at the early stage of ICTs deployment in HEIs.

## **LITERATURE REVIEW**

Information communication technologies (ICTs) are increasingly becoming major facilities in the provision of higher education in developing countries. While developed countries are known to have better savoured ICTs in higher education [10], developing countries are increasingly enhancing the impact of ICTs on quality teaching and

learning at the higher educational level [7], [13]. ICTs are believed to be used at three basic levels. Firstly, they are used at the administrative level basically for communicating among management members, faculties and sometimes students [1]. In this respect, ICTs constitute a platform for integrating management, faculty and students. Secondly, ICTs are used at the level of teaching among faculty members [1], [14]. At this level, ICTs are used by faculty members to research, prepare lessons, present lessons in class, and assess students. Last but not least, ICTs are used by students for research, doing assignments, and communicating with other students, lecturers and possibly management of the higher institution [7].

Various categories of ICTs are used at the three levels identified. For instance, management primarily depends on Management Information Systems (MISs) to communicate at the administrative level [15]. Lecturers may also use projectors and PA systems to present lessons to students in class. Students and lecturers alike use e-libraries and e-journals for their research work [1], [15]. There are several other ICTs used in a tertiary educational environment. Some of them, according to [1], include course-specific software, internet, intranet, wikis, blogs, e-forums, massively open online courses, to mention but a few.

Research by [6] contends that the above ICTs are used at varying degrees in a higher educational environment in developing countries like Ghana. For instance, the extent to which e-books and e-journals are used in a higher educational environment would be significantly higher than the extent to which the digital media is used in a developing country [2]. The computer and its peripherals are also very common ICTs used in higher

educational institutions in developing countries [13]. In developed countries however, all educational ICTs are used at almost the same extent since universities in these countries have reached the maturity stage of using ICTs [6]. This argument suggests that HEIs at their early stages of ICTs application such as HEIs in developing countries need to focus on deploying basic ICTs in learning and teaching as a basis of gradually adapting to the deployment of all forms of ICT in teaching and learning.

In this context, “basic ICTs” are technologies which satisfy two criteria [2], [6]: (1) facilitate the accomplishment of basic tasks among administrators, faculty members and students; and (2) adequately accessible within the financial capability of the higher educational institution. The fact is that ICTs that facilitate accomplishment of basic tasks and are adequately accessible are used at a higher extent in the HEI. Hence, basic ICTs in this context are technologies that are used at a higher extent in teaching and learning in HEIs in developing countries.

Therefore to better leverage ICTs in teaching and learning in developing countries, HEIs in their early and premature stages of ICTs deployment must know basic ICTs that suit their needs and financial capabilities. The problem is that little research has been conducted to identify ICTs applicable in HEIs in developing country contexts. Some studies (e.g. [5], [1], [6]) have identified some ICTs applied in HEIs, but these studies were not conducted to identify the extent of application of these ICTs as a basis of revealing basic ICTs needed by developing country HEIs which are at their early stages of ICTs deployment. Moreover, there is no identifiable study that used a robust statistical tool such as Principal Component Analysis

(PCA) to classify ICTs in terms of their extent of use in developing country HEIs.

This study therefore contributes to knowledge by using PCA to identify basic ICTs used by HEIs in Ghana and in a developing country context. As acknowledged earlier, the operational definition of “basic ICTs” has two facets: (1) ICTs that facilitate the accomplishment of basic tasks among students; and (2) ICTs that are adequately accessible within the financial capability of the higher educational institution. Moreover, basic ICTs are those frequently used, or ICTs that are used at a high extent in the HEIs. This study is conducted based on the assumption that HEIs in Ghana have not reached the stage of using advanced ICTs in teaching and learning. Thus HEIs are still at their early stages of ICTs deployment.

## METHODOLOGY

This study employed Principal Component Analysis (PCA) in identifying ICTs used in HEIs in Ghana. According to [16] and [17], studies in which PCA is used as the main statistical tool of data analysis are better conducted as quantitative studies. This is because PCA is an inferential statistical tool which best works in quantitative studies [16]. Hence, this study was basically implemented as a quantitative research. This research technique was used to ensure that findings could be rigorously generalised over the sampled population in the light of ample research validity and reliability.

Table 7 shows the sample sizes used from the 10 HEIs.

The simple random and stratified sampling techniques were used in this study. A

researcher [18], is of the view that these sampling methods are suitable for quantitative studies in which the researcher seeks to generalise findings. The Stratified sampling was used by researchers for appropriate categorizations. Since this study covered two regions of Ghana; Ashanti and Greater Accra Regions, the stratum included the HEIs in these regions. Subsequently, 10 HEIs were randomly selected with students therein forming the samples. A total of 3,119 students participated in this study.

A structured and self-administered questionnaire was the main instrument used in data collection. A self-administered questionnaire was used because it was equipped with features that allowed participants to respond at their convenient time or in the absence of the researchers. The ICTs used for learning were measured on a five-point likert scale [Strongly disagree (1); disagree (2); not sure (0); agree (4) and strongly agree (5)]. In the questionnaire, the extent of using each ICT was also measured by asking respondents to score from 1 to 5 the extent to which they used it in the higher educational environment.

Questionnaires were administered by hand delivery to students. An accidental approach was used in contacting students, since no information on them was accessible prior to data collection. Therefore, their response was instant. The researchers asked the students to indicate their levels before administering questionnaires to them. This was done to ensure that questionnaires were not administered to new or fresh students who knew little or nothing about the use of ICTs in the HEIs.

Before questionnaires were administered, formal notices were written to the authorities

of the participating HEIs. To ensure that it was reliable and valid, the design of the questionnaire was based on standard measures. It was also submitted to many research experts for scrutiny and suggestions, ensuring that errors were duly corrected. Moreover, the instrument's reliability coefficient was .923, which reflects a high reliability of the study's data. In total, there was a 100% return rate for Academic Registrars, 92.86% return rate for Faculty and 93.38% for students.

The Statistical Package for the Social Sciences (SPSS), Version 21, with its nested AMOS software was used in data analysis. The hypothesis is tested using Principal Component Analysis (PCA). Generally, the PCA was used to classify ICTs into groups based on the extent to which they are used in learning in HEIs. This statistical tool also identified individual ICTs that are generally used for learning in the HEIs in Ghana. This tool was used as a result of its robustness and its specialised function of classifying variables. It also provides statistical estimates (called extraction values) that can be used to create a hierarchy of the variables in terms of the strength of their influence. In the next section are the results of this study.

## RESULTS

In this section, results of the study are presented. Firstly, results are presented with respect to individual ICTs used in HEIs for learning. Secondly, components of ICTs are extracted, with each component expressing the extent to which its constituent ICTs are used for learning. This assessment is done using Principal Component Analysis (PCA). Tables 1 to 6 come with results of this statistical assessment.

**Table 1. Descriptive Statistics: ICTs used among Students**

Variable	Notation	Observations	Minimum	Std. deviation
Mobile Phone	X1	3199	0.000	1.271
Tablet	X2	3199	1.000	0.781
Desktop PC	X3	3199	0.000	0.998
Laptop PC	X4	3199	0.000	1.076
E-Books	X5	3199	0.000	2.462
e-Journals	X6	3199	0.000	2.462
E-Libraries	X7	3199	0.000	2.462
E-encyclopedia	X8	3199	0.000	2.462
Digital Media	X9	3199	1.000	1.155
E-mail	X10	3199	0.000	1.017
Video Calls	X11	3199	0.000	2.285
Search Engine	X12	3199	0.000	2.462
Online Data Storage	X13	3199	0.000	1.126
Wikis, Blogs & Forums	X14	3199	0.000	1.452
Massively Open Online Courses	X15	3199	0.000	1.274
Learning management Systems	X16	3199	0.000	1.276
Social Media	X17	3199	0.000	2.676
Course specific Software	X18	3199	0.000	1.985
Microsoft Office Suite	X19	3199	0.000	1.300
Projector	X20	3199	0.000	2.039
Scanners	X21	3199	0.000	3.114
Printers	X22	3199	0.000	1.005
Lab Instruments	X23	3199	0.000	2.084
PA Systems	X24	3199	0.000	2.462

Table 1 shows 24 ICTs (i.e. X<sub>1</sub>, X<sub>2</sub> ... X<sub>24</sub>) used for learning in HEIs. Mobile phones (M = 4.10, SD = 1.27) have the highest level of application, followed by tablets (M = 2.70, SD = 0.78) and desk top personal computer (M = 2.12, SD = 1.00). There is quite some level of consistency (with a mean score of 2.00) in the extent to which other ICTs are used in the HEIs. In the context of PCA, the strength of the correlations among the ICTs is the basis of whether all the ICTs are sufficiently used or not. Table 2 in the Appendix shows these correlations.

Table 2 shows the correlation matrix of the PCA. Correlation values in **bold** are significant at 5% significant level. By taking a close look at the distribution of these correlations, it is seen that most of them are significant (p < .05). This situation reflects the fact that most of the ICTs are significantly used among students. This situation also reflects the validity of the PCA. Yet, there are other indicators of the validity of this analysis. Table 3 comes with these remaining indicators.

**Table 3. KMO & Bartlett's Test of Sphericity**

KMO	.732
Bartlett Chi-square (Critical value)	67.321
df	78
Sig.	.001

Table 3 shows the KMO test and Bartlett's test of sphericity. These tests indicate the validity of the PCA. By principle, the KMO value must be .70 or more for the Component Analysis to be valid. Also, the Bartlett's test must be significant at 5% significance level.

Apparently, both conditions are satisfied. Hence, the PCA is sufficiently valid. This means that any conclusions made from results of this PCA would be valid. Table 4 shows variables (ICTs) that have been eliminated in the PCA.

**Table 4. Communalities**

Variable	Extraction
X1	0.897
X3	0.811
X4	0.897
X5	0.557
X6	0.557
X7	0.557
X8	0.557
X9	0.522
X10	0.601
X11	0.540
X12	0.557
X13	0.766
X14	0.621
X16	0.560
X17	0.513
X18	0.545
X19	0.578
X20	0.550
X22	0.600
X24	0.500

Table 4 shows the communalities of the Principal Component Analysis. In a single iteration, some of the ICTs are eliminated. These include X<sub>2</sub>, X<sub>15</sub>, and X<sub>21</sub>. These variables are *Tablet*, *Massively Open Online Courses* and *Scanners*. This means that these three ICTs are not significantly used among students relative to other ICTs. In Table 1, *Tablet* is found to have a relatively high mean score, but it is removed from the list of ICTs at the level of communalities because of its poor relationship with other ICTs. This scenario does not mean that the three ICTs removed are not used at all in learning. It

could mean that the extent to which they are used relative to other ICTs is insignificantly low. In Table 4, the value corresponding to each variable is called an *extraction*, which is usually equivalent to the R<sup>2</sup> value in linear regression analysis. The larger the communality value, the higher the need to retain its corresponding variable or ICT and the higher the extent to which the ICT is used for learning. Therefore, mobile phone, tablet, desktop PC and laptop PC are the most commonly used ICTs in for learning in HEIs of our study. Though other ICTs such as e-libraries, e-books and e-journals are used by

students, their extent of use is low, considering the cut-off point of .50 for their retention.

The validity and strength of the PCA is expressed in terms of the Eigen values of components formed. A component is a group

of ICTs or variables that are most correlated. While Table 4 comes with extraction values that express the extent of use of individual ICTs retained, Table 5 comes with components that express the extent of use of a group of ICTs.

**Table 5. Eigen Values**

	F1	F2	F3	F4
Eigenvalue	12.334	5.420	3.863	2.383
Variability (%)	51.391	22.582	16.098	9.930
Cumulative %	51.391	73.972	90.070	3199.000

Table 5 shows the Eigen values and variability of all components formed. By principle, the total variability accounted by components must be sufficiently large for the PCA and its model to be strong and valid. It can be seen that this condition is satisfied as the first three components contribute about

90.1% of the total variation of 100%. The first component accounts for 51.4% of variation, whereas the second component contributes 22.6% of the total variation. The third component accounts for 16.1% of the variation. Table 6 shows the components (ICTs) of each component.

**Table 6. Components of Components**

Variables	Component	Variability
Mobile Phone	F1	51.4%
Desktop PC		
Laptop PC		
E-encyclopaedia		
e-Journals		
E-Libraries		
E-Books		
E-mail	F2	22.6%
Search Engine		
Online Data Storage		
Learning management systems		
Microsoft Office Suite		
Course specific Software		
Digital Media	F3	16.1%
Video Calls		
Wikis, Blogs & Forums		
Social Media		
Projector		
Printers		
Lab Instruments		

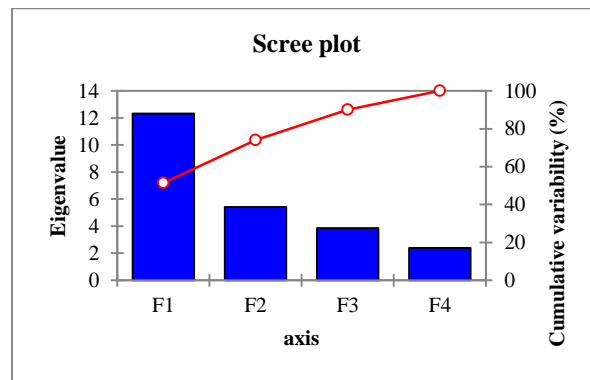


PA Systems		
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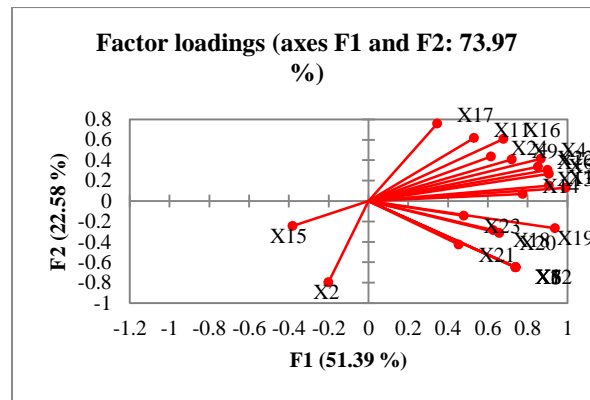
Table 6 shows components of each component extracted. It is worth saying that F4 is not a significant component, owing to its low variability contributed. So the total variability accounted by retained variables or ICTs is 90.1 (see Table 5). From Table 6, mobile phone, desktop pc, laptop pc, e-

encyclopaedia, e-libraries, e-books and e-journals have the highest level of use as a group of ICTs in terms of learning, with a variation of 51.4% accounted. Digital media and PA systems are among the ICTs least used among students. Figure 1 is a diagram that shows components extracted.

**Figure 1. Components Extracted**



**Figure 2. Component Loadings Plot**



**Figure 3. Component Loadings Plot 2**

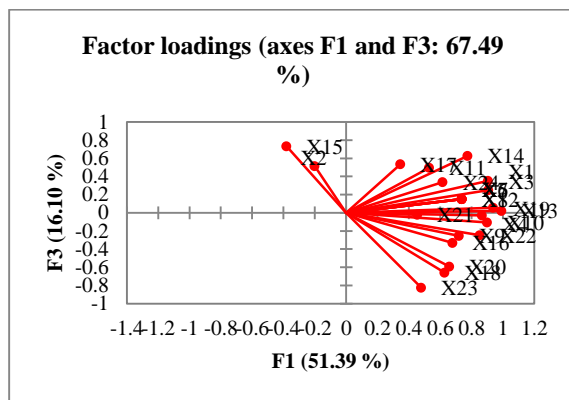


Figure 1 shows components extracted from the retained variables or ICTs. From the figure, the fourth component (F4) contributes a low variation (< 10%). Therefore, it has no components; all the variables are shared among the first three components. In Table 6, F<sub>1</sub> contributes the highest variation and therefore has components that are most largely used by relative to F<sub>2</sub> and F<sub>3</sub>. This means that the magnitude of the variation accounted represent the extent to which items that make up the component are used in learning. Figures 2 and 3 depict the significant correlations among variables. It is expected that variables are far off from the centre but are as close to each other as possible. This condition is largely satisfied and reflects the fact that most of the variables are significantly correlated. In both Figures 2 and 3, X<sub>2</sub> and X<sub>5</sub> stand far off in the opposite direction, a reason for which they are removed in the PCA. Also, X<sub>21</sub> is the closest to the centre. This indicates that this variable is highly related to X<sub>2</sub> and X<sub>15</sub>, a reason for which it is also removed. Figure 1 shows F<sub>1</sub> and F<sub>2</sub> on their axes, whereas Figure 3 shows F<sub>1</sub> and F<sub>3</sub> on their axes. There should have been a third chart that shows F<sub>2</sub> and F<sub>3</sub> on their axes, but this chart is relegated because the needed information is already expressed in Figures 2 and 3.

In view of the above results, all ICTs are significantly used in learning in HEIs, except three ICTs which are *tablet*, *massively open online courses*, and *scanners*. Moreover, mobile phone, desktop pc, laptop pc, e-encyclopaedia, e-libraries, e-books and e-journals have the highest level of use as a group of ICTs. In the next section, findings of the study are discussed.

## DISCUSSION

According to findings, twenty-one (21) of the 24 ICTs identified in the literature are significantly used for learning in higher educational institutions in Ghana. Some of these ICTs are digital media, e-mail, and mobile phone. The identification of these ICTs in Ghana is supported by several studies (e.g. [13], [7]). Contrary to this study's findings, scanners and tablets are major ICTs used in some developing countries [7]. Moreover, tablet, massively open online courses, and scanners have been confirmed as ICTs significantly used in developed country contexts [6]. In the literature therefore, "massively open online courses" is the only confirmed ICT that is not significantly used in developing country contexts. But as indicated by findings, scanners, tablets and *massively open online courses* are ICTs not significantly used in HEIs in Ghana.

The PCA used in data analysis places ICTs in three components. The variation accounted by each component suggests the degree to which ICTs are applied in the higher educational environment. The higher the variation accounted by a component, the more basic its ICTs and the higher the extent to which they are applied in the higher educational environment. Hence the first component comes with the most commonly used ICTs for learning in HEIs in Ghana. This component accounts for the highest variation of 51.4% of the total variation of 100%. Its items are mobile phone, desktop PC, laptop PC, e-encyclopaedia, e-libraries, e-books and e-journals. While some studies (e.g. [1], [6]) identified these ICTs as basic educational technologies in developed countries, no study could identify them as a component in the context of PCA neither in developed countries nor developing countries. Since the PCA is a more robust statistical tool in the context in which it is used in this study [16], this study better reveals the most basic ICTs used in HEIs.

In essence, mobile phone, desktop PC, laptop PC, e-encyclopaedia, e-libraries, e-books and e-journals have the highest extent of application in HEIs in Ghana. Nonetheless, some other ICTs are significantly applied, and these ICTs constitute the second and third components extracted in the PCA. The second component contributes 22.6% of the total variation and contains the second most frequently used ICTs for learning in HEIs. The third component accounts for 16.1% of the variation. The variations accounted express the extent to which ICTs in each component are used in HEIs in Ghana. This implies that items of the third component (i.e. digital media, video calls, wikis, blogs, forums, and social media, etc.) have the least frequency of application in HEIs in Ghana. In agreement, [7], [13] found that most of these

ICTs (e.g. digital media, video calls, wikis, blogs, forums, etc.) are applied in HEIs in developing country contexts at a relatively lower extent. As revealed in findings however, this supported evidence does not mean that these third-component ICTs are not used or are not significantly used.

Considering the operational definition of “basic ICTs” in this study, ICTs of the first component are the most basic and the most frequently applied technologies for learning in HEIs in Ghana, followed by ICTs in the second and third components, in that order. Since the use of PCA in this context is scarce in the literature, future researchers would have to conduct related studies using PCA to buttress or disprove this study’s evidences.

## CONCLUSION AND RECOMMENDATIONS

Out of 24 ICTs, 21 are significantly used for learning in higher educational institutions. The ICTs significantly used are found in Table 6. Some of these ICTs are digital media, e-mail, and mobile phone. The three ICTs not significantly used are *tablet*, *massively open online courses* and *scanners*. In essence, these three ICTs are not often used for learning in HEIs in Ghana. Of all the 21 ICTs used for learning, the most significantly used are mobile phone and laptop PC. Also, the least used ICT among the 21 ICTs retrieved is PA systems.

The ICTs retrieved are placed in three components. The first component comes with the most commonly used ICTs for learning in our study’s HEIs. This component accounts for the highest variation of 51.4% of the total variation of 100%. The second component contributes 22.6% of the total variation and contains the second most frequently used

ICTs for learning in HEIs. The third component accounts for 16.1% of the variation. The three components contribute about 90.1% of the total variation of 100%.

The first component is made up of ICTs such as mobile phone, desktop PC, laptop PC, e-encyclopaedia, e-libraries, e-books and e-journals. The fact that this component accounts for the highest variation implies that its ICTs are basically relevant to learning in HEIs. The second component is made up of ICTs such as e-mail, search engine, online data storage, learning management systems, Microsoft office suite, and course specific software. The third component is made up of digital media, video calls, wikis, blogs & forums, social media, projector, printers, lab instruments, and pa systems. Thus the third component contains ICTs that are least used for learning in HEIs.

It is therefore concluded that a majority of the ICTs are significantly used for learning in HEIs. However, the extent of use of the ICTs is not the same. Some ICTs such as mobile phone, desktop PC, laptop PC, e-encyclopaedia, e-libraries, e-books and e-journals are more frequently used. Hence, mobile phone, desktop PC, laptop PC, e-encyclopaedia, e-libraries, e-books and e-journals are some of the basic ICTs which HEIs can effectively deploy in the early stages of their ICTs deployment in a developing country context.

Though ICTs such as PA systems, printers and others are in the second and third components, they are also among basic ICTs used by HEIs, except those removed in the PCA such as *massively open online courses*. This suggests that some HEIs in Ghana have

not reached the stage where they can run massively open online courses. The removal of *scanners* and *tablets* in the PCA could be as a result of their low level of application. Tablets are really seldom used in HEIs as a result of their high cost, while scanners have unpopular uses.

It is therefore recommended that HEIs in Ghana focus on deploying the ICTs retained in the PCA, especially those in the first component. This is because the use of these ICTs yields higher effectiveness in the face of the financial capability of HEIs and the ability of students, administrators and lecturers to use ICTs.

#### **LIMITATIONS AND SUGGESTIONS FOR FUTURE RESEARCH**

This study could not provide a distinction between ICTs used in learning and ICTs used in teaching. Invariably, the study provides no specific evidence regarding ICTs used by lecturers in teaching, research, learning and student assessment, and ICTs used by students in learning. Thus this study only provides evidence on the list of ICTs used for learning in a HEI environment in Ghana. This study could also not classify ICTs in terms of which of them are best used for learning.

Future research must therefore address these limitations of the study. In this respect, the ICTs must be identified on the basis of lecturers' learning, research, teaching and student assessment, as well as students' learning and research. The ICTs must also be classified in terms of those more suitable for teaching and those more suitable for learning.

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**APPENDIX**

**Table 2. Correlation Matrix**

	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11	X12	X13	X14	X15	X16	X17	X18	X19	X20	X21	X22	X23	X24
X1	<b>1.00</b>	-0.16	<b>0.99</b>	<b>0.89</b>	<b>0.65</b>	<b>0.65</b>	<b>0.65</b>	<b>0.65</b>	<b>0.54</b>	<b>0.88</b>	<b>0.70</b>	<b>0.65</b>	<b>0.93</b>	<b>0.93</b>	-0.21	<b>0.55</b>	<b>0.59</b>	<b>0.24</b>	<b>0.87</b>	<b>0.28</b>	<b>0.20</b>	<b>0.79</b>	0.08	<b>0.65</b>
X2	-0.16	<b>1.00</b>	<b>-0.32</b>	<b>-0.59</b>	<b>0.42</b>	<b>0.42</b>	<b>0.42</b>	<b>0.42</b>	<b>-0.48</b>	<b>-0.55</b>	<b>-0.27</b>	<b>0.42</b>	<b>-0.30</b>	0.12	<b>0.77</b>	<b>-0.73</b>	<b>-0.37</b>	-0.16	0.00	-0.10	<b>0.43</b>	<b>-0.64</b>	<b>-0.34</b>	0.16
X3	<b>0.99</b>	<b>-0.32</b>	<b>1.00</b>	<b>0.95</b>	<b>0.56</b>	<b>0.56</b>	<b>0.56</b>	<b>0.56</b>	<b>0.59</b>	<b>0.93</b>	<b>0.71</b>	<b>0.56</b>	<b>0.95</b>	<b>0.87</b>	<b>-0.33</b>	<b>0.64</b>	<b>0.62</b>	<b>0.27</b>	<b>0.84</b>	<b>0.29</b>	0.13	<b>0.87</b>	0.14	<b>0.64</b>
X4	<b>0.89</b>	<b>-0.59</b>	<b>0.95</b>	<b>1.00</b>	<b>0.40</b>	<b>0.40</b>	<b>0.40</b>	<b>0.40</b>	<b>0.66</b>	<b>0.99</b>	<b>0.62</b>	<b>0.40</b>	<b>0.92</b>	<b>0.68</b>	<b>-0.59</b>	<b>0.78</b>	<b>0.56</b>	<b>0.36</b>	<b>0.76</b>	<b>0.36</b>	0.00	<b>0.97</b>	<b>0.31</b>	<b>0.55</b>
X5	<b>0.65</b>	<b>0.42</b>	<b>0.56</b>	<b>0.40</b>	<b>1.00</b>	<b>1.00</b>	<b>1.00</b>	<b>1.00</b>	0.18	<b>0.48</b>	0.04	<b>1.00</b>	<b>0.66</b>	<b>0.62</b>	-0.06	0.03	-0.17	<b>0.52</b>	<b>0.90</b>	<b>0.56</b>	<b>0.53</b>	<b>0.41</b>	<b>0.30</b>	0.17
X6	<b>0.65</b>	<b>0.42</b>	<b>0.56</b>	<b>0.40</b>	<b>1.00</b>	<b>1.00</b>	<b>1.00</b>	<b>1.00</b>	0.18	<b>0.48</b>	0.04	<b>1.00</b>	<b>0.66</b>	<b>0.62</b>	-0.06	0.03	-0.17	<b>0.52</b>	<b>0.90</b>	<b>0.56</b>	<b>0.53</b>	<b>0.41</b>	<b>0.30</b>	0.17
X7	<b>0.65</b>	<b>0.42</b>	<b>0.56</b>	<b>0.40</b>	<b>1.00</b>	<b>1.00</b>	<b>1.00</b>	<b>1.00</b>	0.18	<b>0.48</b>	0.04	<b>1.00</b>	<b>0.66</b>	<b>0.62</b>	-0.06	0.03	-0.17	<b>0.52</b>	<b>0.90</b>	<b>0.56</b>	<b>0.53</b>	<b>0.41</b>	<b>0.30</b>	0.17
X8	<b>0.65</b>	<b>0.42</b>	<b>0.56</b>	<b>0.40</b>	<b>1.00</b>	<b>1.00</b>	<b>1.00</b>	<b>1.00</b>	0.18	<b>0.48</b>	0.04	<b>1.00</b>	<b>0.66</b>	<b>0.62</b>	-0.06	0.03	-0.17	<b>0.52</b>	<b>0.90</b>	<b>0.56</b>	<b>0.53</b>	<b>0.41</b>	<b>0.30</b>	0.17
X9	<b>0.54</b>	<b>-0.48</b>	<b>0.59</b>	<b>0.66</b>	0.18	0.18	0.18	0.18	<b>1.00</b>	<b>0.65</b>	<b>0.66</b>	0.18	<b>0.74</b>	<b>0.44</b>	<b>-0.30</b>	<b>0.94</b>	<b>0.49</b>	<b>0.65</b>	<b>0.45</b>	<b>0.67</b>	<b>0.55</b>	<b>0.65</b>	<b>0.63</b>	<b>0.82</b>
X10	<b>0.88</b>	<b>-0.55</b>	<b>0.93</b>	<b>0.99</b>	<b>0.48</b>	<b>0.48</b>	<b>0.48</b>	<b>0.48</b>	<b>0.65</b>	<b>1.00</b>	<b>0.52</b>	<b>0.48</b>	<b>0.94</b>	<b>0.64</b>	<b>-0.65</b>	<b>0.76</b>	<b>0.45</b>	<b>0.46</b>	<b>0.82</b>	<b>0.46</b>	0.05	<b>0.99</b>	<b>0.40</b>	<b>0.48</b>
X11	<b>0.70</b>	<b>-0.27</b>	<b>0.71</b>	<b>0.62</b>	0.04	0.04	0.04	0.04	<b>0.66</b>	<b>0.52</b>	<b>1.00</b>	0.04	<b>0.61</b>	<b>0.77</b>	0.16	<b>0.65</b>	<b>0.96</b>	-0.08	<b>0.30</b>	-0.03	<b>0.20</b>	<b>0.44</b>	-0.17	<b>0.93</b>
X12	<b>0.65</b>	<b>0.42</b>	<b>0.56</b>	<b>0.40</b>	<b>1.00</b>	<b>1.00</b>	<b>1.00</b>	<b>1.00</b>	0.18	<b>0.48</b>	0.04	<b>1.00</b>	<b>0.66</b>	<b>0.62</b>	-0.06	0.03	-0.17	<b>0.52</b>	<b>0.90</b>	<b>0.56</b>	<b>0.53</b>	<b>0.41</b>	<b>0.30</b>	0.17
X13	<b>0.93</b>	<b>-0.30</b>	<b>0.95</b>	<b>0.92</b>	<b>0.66</b>	<b>0.66</b>	<b>0.66</b>	<b>0.66</b>	<b>0.74</b>	<b>0.94</b>	<b>0.61</b>	<b>0.66</b>	<b>1.00</b>	<b>0.79</b>	<b>-0.41</b>	<b>0.74</b>	<b>0.45</b>	<b>0.56</b>	<b>0.90</b>	<b>0.59</b>	<b>0.37</b>	<b>0.89</b>	<b>0.43</b>	<b>0.66</b>
X14	<b>0.93</b>	0.12	<b>0.87</b>	<b>0.68</b>	<b>0.62</b>	<b>0.62</b>	<b>0.62</b>	<b>0.62</b>	<b>0.44</b>	<b>0.64</b>	<b>0.77</b>	<b>0.62</b>	<b>0.79</b>	<b>1.00</b>	0.16	<b>0.37</b>	<b>0.66</b>	0.06	<b>0.74</b>	0.13	<b>0.33</b>	<b>0.52</b>	-0.15	<b>0.74</b>
X15	<b>-0.21</b>	<b>0.77</b>	<b>-0.33</b>	<b>-0.59</b>	-	-	-	-	<b>-0.30</b>	<b>-0.65</b>	0.16	-	<b>-0.41</b>	0.16	<b>1.00</b>	<b>-0.53</b>	0.14	<b>-0.50</b>	<b>-0.36</b>	<b>-0.43</b>	<b>0.32</b>	<b>-0.75</b>	<b>-0.62</b>	0.19
X16	<b>0.55</b>	<b>-0.73</b>	<b>0.64</b>	<b>0.78</b>	0.03	0.03	0.03	0.03	<b>0.94</b>	<b>0.76</b>	<b>0.65</b>	0.03	<b>0.74</b>	<b>0.37</b>	<b>-0.53</b>	<b>1.00</b>	<b>0.55</b>	<b>0.54</b>	<b>0.41</b>	<b>0.54</b>	<b>0.24</b>	<b>0.79</b>	<b>0.57</b>	<b>0.71</b>
X17	<b>0.59</b>	<b>-0.37</b>	<b>0.62</b>	<b>0.56</b>	-	-	-	-	<b>0.49</b>	<b>0.45</b>	<b>0.96</b>	-	<b>0.45</b>	<b>0.66</b>	0.14	<b>0.55</b>	<b>1.00</b>	<b>-0.32</b>	0.12	<b>-0.28</b>	-	<b>0.38</b>	<b>-0.35</b>	<b>0.80</b>
X18	<b>0.24</b>	-0.16	<b>0.27</b>	<b>0.36</b>	<b>0.52</b>	<b>0.52</b>	<b>0.52</b>	<b>0.52</b>	<b>0.65</b>	<b>0.46</b>	-0.08	<b>0.52</b>	<b>0.56</b>	0.06	<b>-0.50</b>	<b>0.54</b>	<b>-0.32</b>	<b>1.00</b>	<b>0.56</b>	<b>1.00</b>	<b>0.65</b>	<b>0.51</b>	<b>0.97</b>	<b>0.21</b>
X19	<b>0.87</b>	0.00	<b>0.84</b>	<b>0.76</b>	<b>0.90</b>	<b>0.90</b>	<b>0.90</b>	<b>0.90</b>	<b>0.45</b>	<b>0.82</b>	<b>0.30</b>	<b>0.90</b>	<b>0.90</b>	<b>0.74</b>	<b>-0.36</b>	<b>0.41</b>	0.12	<b>0.56</b>	<b>1.00</b>	<b>0.59</b>	<b>0.37</b>	<b>0.77</b>	<b>0.39</b>	<b>0.36</b>
X20	<b>0.28</b>	-0.10	<b>0.29</b>	<b>0.36</b>	<b>0.56</b>	<b>0.56</b>	<b>0.56</b>	<b>0.56</b>	<b>0.67</b>	<b>0.46</b>	-0.03	<b>0.56</b>	<b>0.59</b>	0.13	<b>-0.43</b>	<b>0.54</b>	<b>-0.28</b>	<b>1.00</b>	<b>0.59</b>	<b>1.00</b>	<b>0.71</b>	<b>0.49</b>	<b>0.94</b>	<b>0.26</b>
X21	<b>0.20</b>	<b>0.43</b>	0.13	0.00	<b>0.53</b>	<b>0.53</b>	<b>0.53</b>	<b>0.53</b>	<b>0.55</b>	0.05	<b>0.20</b>	<b>0.53</b>	<b>0.37</b>	<b>0.33</b>	<b>0.32</b>	<b>0.24</b>	-0.08	<b>0.65</b>	<b>0.37</b>	<b>0.71</b>	<b>1.00</b>	0.00	<b>0.50</b>	<b>0.53</b>
X22	<b>0.79</b>	<b>-0.64</b>	<b>0.87</b>	<b>0.97</b>	<b>0.41</b>	<b>0.41</b>	<b>0.41</b>	<b>0.41</b>	<b>0.65</b>	<b>0.99</b>	<b>0.44</b>	<b>0.41</b>	<b>0.89</b>	<b>0.52</b>	<b>-0.75</b>	<b>0.79</b>	<b>0.38</b>	<b>0.51</b>	<b>0.77</b>	<b>0.49</b>	0.00	<b>1.00</b>	<b>0.48</b>	<b>0.41</b>
X23	0.08	<b>-0.34</b>	0.14	<b>0.31</b>	<b>0.30</b>	<b>0.30</b>	<b>0.30</b>	<b>0.30</b>	<b>0.63</b>	<b>0.40</b>	-0.17	<b>0.30</b>	<b>0.43</b>	-	<b>-0.62</b>	<b>0.57</b>	<b>-0.35</b>	<b>0.97</b>	<b>0.39</b>	<b>0.94</b>	<b>0.50</b>	<b>0.48</b>	<b>1.00</b>	0.10
X24	<b>0.65</b>	-0.16	<b>0.64</b>	<b>0.55</b>	0.17	0.17	0.17	0.17	<b>0.82</b>	<b>0.48</b>	<b>0.93</b>	0.17	<b>0.66</b>	<b>0.74</b>	0.19	<b>0.71</b>	<b>0.80</b>	<b>0.21</b>	<b>0.36</b>	<b>0.26</b>	<b>0.53</b>	<b>0.41</b>	0.10	<b>1.00</b>

**Table 7. Sample Sizes by Region and HEI**

Region	Institution	Participating Sample Size	
			Students
Greater Accra Region	A		335
	B		331
	C		349
	D		343
	E		830
	F		319
Ashanti Region	A		351
	B		339
	C		323
	D		328
Total			3119