Towards adoption of information and communication technology in higher education – a structural equation model approach

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Abstract: The African higher education system has received several uncoordinated interventions towards the adoption of information and communication technology (ICT). Coordination of these interventions for determining the extent of ICT adoption is challenging. Thus, this research formulates an integrated ICT adoption model using the thematic analysis of the factors and elements of existing models. The confirmatory factor analysis of the generated structural equation model at a Nigerian north-central state university identifies ICT-infrastructure-readiness and ICT-use-intensity as the major impacting factors for ICT adoption. The preliminary result shows that a unit increment in the use-intensity raises the ICT adoption level by 0.73. Similarly, a unit increment in ICT-infrastructure-readiness and behavioural-intention respectively cause 0.88 and 0.50 raise in the use-intensity. The theories and aggregation techniques adopted for the model are confirmed to be operational for determining the factors and levels of ICT adoption in the institution, thereby providing the required instrument for guided academic and administrative decisions.

Keywords: ICT adoption level; ICT infrastructure readiness; unified theory of acceptance and use of technology; UTAUT; confirmatory factor analysis; analysis of model structure; AMOS; structural equation model.

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1 Introduction

Most countries in Africa continent missed the first and second industrial revolutions of mechanisation and mass production respectively. Many of them also performed very poorly in the third revolution of electronics and information technology (IT) automation. For these nations to be actively involved in the fourth revolution of cyber-physical systems, there is the need for the government and people of the continent to make deliberate efforts toward qualitative inclusive education for the citizens. In Nigeria, like other African countries, there is a high demand for higher education (HE), unfortunately, there is no complementary capacity in the existing higher institutions. The statistics show that in nine years (2007 to 2015), a trivial 1.9 million students from the over 12 million candidates were admitted by the Joint Admissions and Matriculation Board (JAMB) – a federal agency for coordination of admissions to all tertiary institutions in the country (Blueprint, 2017). As at May 2018, the approved carrying capacity of all tertiary institutions in Nigeria is still slightly above 600,000. Meanwhile, an average of 1.6 million candidates registered yearly for the Unified Tertiary Matriculation Examination (UTME) which is the national tertiary entrance examination (Adesulu, 2018).

This unpleasant situation can be ameliorated through ICT integration into the HE system. Such integration has been identified as an impetus for coping with the increasing demand for HE and an enabler for transformation towards functional education (Usluel et al., 2008). The literature is awash with the various factors militating against ICT enabled schooling in Africa. It is therefore instructive to identify the common factors

across Africa, the patterns and their consequential effects. Similarly, over the years, in an attempt to facilitate ICT adoption in higher institutions, several ICT for education models, initiatives and interventions have been conceived and implemented. Sadly, most of these are disjointed projects without adequate coordinated assessment or a general implementable framework.

A complete, integrated and implementable framework should specify the input, the processing and the output elements of a system. The existing models mostly handle a fraction of the whole adoption process. For instance, the International Telecommunication Union's (ITU) Information Technology Development Index (IDI), in the (ITU, 2019) release, identifies ICT readiness (infrastructure access), ICT use (intensity), and ICT capability (skills) as the IDI. This is just an input indicator, it requires component for the monitoring and a measure of attainment level which could be found in the United Nations Educational, Scientific and Cultural Organization (UNESCO) ICT adoption level (Jonathan, 2010). The levels of ICT adoption in schools identified by UNESCO are emerging, applying, infusing and transforming levels. The expectations for each of these levels are provided in narratives, thereby necessitating further processing. Similarly, the unified theory of acceptance and use of technology (UTAUT) and its extended version have been used by researchers globally to dissect the factors influencing the adoption of ICT in schools and other sectors (Attuquayefio and Addo, 2014; Venkatesh et al., 2003). Furthermore, Solar et al. (2013) identified information criteria, ICT resources, and leverage domains as the three elements supporting educational processes. The five leverage domains specified are educational management, infrastructure, administrators, teachers and students.

These models have their focus, constructs and strengths that need to be harmonised, integrated and made operational. The development of such an integrated framework that could be used for planning, monitoring and ranking ICT adoption levels in the schools is a challenging effort. To this end, this work aimed at filling these gaps by building an integrated operational framework for systematic implementation of ICT adoption in higher institutions. The objectives of the study are to:

1 Perform thematic analysis of the factors militating ICT adoption in African higher institutions and the components of existing ICT for education models.

2 Build an integrated ICT adoption model for the sector.

3 Perform the model exploration and evaluation.

In the remaining parts of this paper, an overview of referenced ICT adoption models is outlined in Section 2. The methodology is discussed in Section 3 and Section 4 has the results, the discussion and hypothesis testing. The conclusion is presented in Section 5.

2 Overview of ICT for education models and theories

Research has shown that several efforts have been made to model ICT integration in education. These models target diverse components of the educational system and built on different formats, thereby making their harmonisation and synchronisation a challenge. This work targets the integration of the various elements of these models to formulate a comprehensive integrated model that can be used to monitor the progress of ICT adoption in the tertiary institutions in Africa. The models can also be used to monitor

the progress of various operational units of the institutions. The referencing models as described in this section are the UNESCO's schools ICT level, the ITU, the IDI and specific implemented models from commonwealth regions of Asia, Australia and Africa. The initial two models are from international bodies, the remaining was selected based on the availability of their implementation details in the literature.

2.1 UNESCO's schools ICT development levels

The UNESCO identifies hierarchical and continuous approaches to ICT development in schools. The model illustrates ICT development in education as a continuum approach along which an educational system or institution can be mapped depending on the stages of ICT development. These broad stages have been termed as emerging, applying, infusing and transforming levels of ICT development. The stages can be useful in determining the phase of ICT development reached by a country, a district, or even an individual institution, (UNESCO, 2002). Summary of the major features of these stages is as shown in Table 1.

Table 1 UNESCO ICT development stages and their indices

Staff efficacy	*Facilities and resources*	*Pedagogical indication*
ICT development stages 1: emerging		
• Becoming aware of ICT • Develop curriculum for basic ICT skills	Acquisition of hardware, software and formulation of policy.	• Traditional, teacher-centred practices • Fixed timetable
ICT development stages 2: applying		
• Learning the usage of ICT • Proficiency ICT curriculum	Specialised ICT tools for teaching. Setting up of ICT labs and workstations.	• Integrating ICT into common teaching and administrative activities • A bit flexible timetable
ICT development stages 3: infusing		
• Understanding ICT usage and its applications • Professional ICT curriculum	Massive ICT tools in the classes, laboratory and the administration.	• Implementation of ICT-based learner-centred curriculum • Flexible timetable
ICT development stages 4: transforming		
• Specialising in ICT usage and application • Applied ICT curriculum	Broad and unrestricted access to technology.	• Open access, open content • Deep learner centres and community-driven curriculum

Institutions can be rated from the initial emerging level to the highest transforming level based on the indices. Furthermore, UNESCO identifies components of ICT intervention to include curriculum, pedagogy, assessment, required infrastructure and networking, and human resources.

2.2 ITU – ICT development framework

The ICT data and statistics division of ITU in February 2019, identified ICT readiness (infrastructure access), ICT use (intensity), and ICT capability (skills) as the IDI. The IDI is a composite index with 14 indicators, 5 for readiness, 5 for use and 4 for capability. There are three data sources for the IDI; firstly, the telecommunication data that is usually collected locally by the regulator from operators and internationally through the ITU-World Telecommunication Index (ITU-WTI) questionnaire. Secondly, the household/individual ICT data that is usually collected locally by the National Statistical Office (NSO) through a household survey and internationally through the ITU household questionnaire. Thirdly, the education data usually collected locally by the education ministry and internationally through the UNESCO Institute for Statistics (UIS).

Unlike the previous index that has 5:3:3 indicators for ICT access, ICT use and ICT skill sub-index respectively, the indices in the 2019 review has 5:5:4 indicators for the three components. The indicators for ICT access are 20% households with a computer, 20% households with internet, international internet bandwidth per internet user, 20% population covered by 3G/LTE mobile network and fixed-broadband (fbb) subscriptions by speed as a 20% total fbb. The indicators for ICT use are 20% individuals using the internet, active mobile-broadband subscriptions per 100 inhabitants, mobile broadband internet traffic per mobile-bb subscription and 20% individuals who own a mobile phone. The ICT skills indicators are mean years of schooling, gross enrolment ratio (secondary level), gross enrolment ratio (tertiary level) and proportion of individuals with ICT skills. The deduction from the ITU model is that ICT use is a function of ICT readiness/ infrastructure and ICT capability/skills.

2.3 ICT in school education maturity model – a case study from Chile

The ICT in school education maturity model (ICTE-MM) was developed in Chile. It describes an ICT-based and capability-driven model for assessing ICT in education capabilities and maturity of schools. The three identified elements for supporting educational processes in the model are information criteria, ICT resources, and leverage domains. The five leverage domains are defined as educational management, infrastructure, administrators, teachers and students (Solar et al., 2013). The leverage domains generate a hierarchical structure with a second level named key domain area. These areas are expected to be measurable and controllable, so they are related to a third hierarchical level, called critical variables, allowing the model's elements to be assessed qualitatively and quantitatively.

2.4 ICT-based education models – a case study from Australia

In the work of Webb et al. (2005) a scenario of over 400 e-learning grant applications from Australian primary schools was presented. They were analysed to determine the nature of the proposed ICT-based projects in literacy and numeracy. The three key dimensions that emerged from the teacher descriptions are ICT infrastructure, motivation and ICT use, and pedagogy and innovation.

The three dimensions, and the interactions between them, provide a means for understanding the complex factors within an individual school that determine the nature of ICT use and the potential for innovation. Several types, or levels, were identified within each dimension, together forming a framework that can be applied as both a research tool and a model for describing in detail the current status of ICT use in a school.

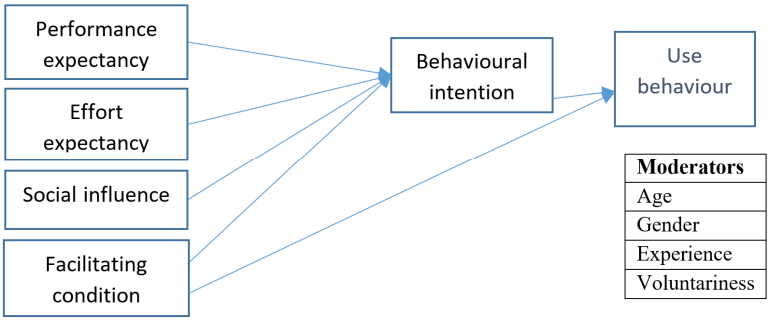
2.5 ICT adoption framework – a case study from Indonesia

The work of Nurjanah et al. (2017) presents preliminary research findings on the ICT adoption framework for education in Indonesia. The model identified a set of components that linked to ICT adoption in education based on works of literature and explorative analysis. The components are infrastructure, application, user skills, utilisation, finance, and policy. The components are used as a basis to develop a questionnaire to capture the current ICT adoption condition in schools. The data from the questionnaire are processed using structural equation modelling (SEM). The results show that each component contributes differently to the ICT adoption framework. Finance provides the strongest effect on infrastructure readiness, whilst a user skill provides the strongest effect on utilisation. The study concludes that the development of ICT adoption framework should consider components contribution weights among the components that can be used to guide the implementation of ICT adoption in education.

2.6 The UTAUT model

The UTAUT model is an aggregation of eight separate models (Venkatesh et al., 2003). The eight models considered are the theory of reasoned action (TRA) (Fishbein and Ajzen, 1975), the theory of planned behaviour (TPB) (Ajzen, 1991), the technology acceptance model (TAM) (Davis, 1989), the combined-TAM-TPB (Taylor and Todd, 1995), model of PC utilisation (MPCU) (Thompson et al., 1991), motivational model (MM) (Davis et al., 1992), social cognitive theory (SCT) (Bandura, 1986) and innovation diffusion theory (IDT) (Rogers, 1995). The UTAUT model is as shown in Figure 1.

Figure 1 UTAUT model (see online version for colours)



Source: Venkatesh et al. (2003)

The UTAUT model which explained seventy per cent (70%) of the variation in the user's intention to accept technology (Venkatesh et al., 2003), has four exogenous and two

endogenous variables. The exogenous are effort expectancy (EE), performance expectancy (PE), social influence (SI) and facilitating conditions (FCs). The behavioural intention (BI) and use behaviour (UB) are the endogenous variables in the model. The moderators are age, gender, experience and voluntariness of use.

2.7 Applicability of the UTAUT model – Ghana and South African

The UTAUT was used to analyse students' ICT adoption in Ghana as reported in (Attuquayefio and Addo, 2014). The work provides further understanding of issues surrounding the acceptance of ICT by students of tertiary institutions. Questionnaires were administered and analysed using analysis of model structure (AMOS) and Statistical Package for the Social Sciences (SPSS). The measurement and structure model was appraised using SEM. The EE (0.4, $p < 0.05$) significantly predicted BI to use ICT, while SI and PE were statistically insignificant, as was BI on UB. However, FCs ($\beta = 0.26$, $p < 0.01$) significantly influenced UB. The study recommends that future studies should include students from other faculties and multiple universities for more reliable results and conclusions.

Similarly, Liebenberg et al. (2018) also demonstrated the applicability of the UTAUT model within a South African HE setting. The work aimed at clarifying the factors that influence students' intentions to make use of digital technologies. The work sampled 738 ICT students via a questionnaire to measure their responses to PE (PEx), EE (EfEx), FCs, self-efficacy (SE), anxiety (Anx), attitude towards using technology (ATT) and BI. Statistical analysis was used to develop and assess a model of the factors that are affecting BI. SEM was used and the goodness-of-fit test indicated that the model was supported by the data. PEx, FC and EfEx showed high practically significant relationships with BI. SE and ATT as mediators of the model are confirmed, however, gender as a moderator did not reflect the original findings of UTAUT.

The UTAUT adopted in the two pieces of research have also been used in several other areas of human endeavours like health, politics and business.

3 Methodology

This section presents the methodology for the realisation of the objectives. It starts with the thematic analysis of the militating factors for ICT adoption in Africa and the elements of ICT in education models. This is followed by the formulation of the proposed integrated ICT adoption models, model validation and evaluation. The section is concluded with the hypotheses testing, results, discussion and recommendations.

3.1 Thematic analysis of the militating factors and models for ICT adoption in Africa

Thematic analysis is a robust method of identifying, analysing and reporting patterns within data (Braun and Clarks, 2006). The six steps in the thematic analysis are: familiarisation with the data; initial code generation; searching for the themes; themes reviewing; defining and naming themes, and report production. There exists a vast amount of literature on factors militating against ICT driven education in Africa. A thematic analysis of 15 relevant articles that explicitly identified factors affecting the

adoption of ICT from two countries each within the five regions of Africa. Three most cited articles from West Africa, East Africa, South Africa, North Africa and Central Africa were selected. The countries considered include Ghana, Nigeria, Ethiopia, Congo, South Africa, Botswana, Cameroon, Kenya, Sudan and Egypt. Thematic analysis method was used to extract the patterns and build the themes.

The articles were read to identify the coded data. Eleven initial codes were generated and mapped first to five themes and further reviewed to three themes. For simplicity, the table was used to form a subset of codes to form the themes. Other possible options for theme searching and reviewing are mind maps and flashcard. Shown in Table 2 is the article number for the code data that form the initial codes and the themes, the details are in Appendix.

Table 2 Thematic analysis of factors limiting the adoption of ICT in HE

S/N	*Articles serial number*	*Initial codes/(frequency)*	*Initial themes*	*Final themes*
1	1, 2, 3, 4, 7, 8, 10	Educational exposure/(7)	Staff efficacy	Staff skillset
2	1, 4, 7, 13, 15	Lack of competence/(5)	Staff efficacy	Staff skillset
3	1, 2, 3, 4, 7, 10, 12, 13, 14	Leadership support/(9)	Management efficacy	Facilitating condition
4	1, 2, 3, 4, 5, 6, 7, 8, 9, 11, 12, 13, 14, 15	Inadequate infrastructure/(15)	Facilities/ resources	Infrastructural factors
5	1, 3, 8	Gender imbalance/(3)	Management efficacy	Facilitating condition
6	3	Lack of content in local language/(1)	Facilities/ resources	Infrastructural factors
7	3, 8	Funding/(2)	Facilities/ resources	Infrastructural factors
8	4, 8	Lack of ICT policy/(2)	Policy issues	Facilitating condition
9	7, 10	Rigour in planning ICT curriculum/pedagogical issues/(2)	Pedagogical issues	Facilitating condition
10	8, 11, 14, 15	High cost of equipment/(4)	Facilities/ resources	Infrastructural factors
11	15	Security issues/(1)	Facilities/ resources	Infrastructural factors

From the review, several factors hindering the adoption of ICT tools in institutions were identified across the regions and tabulated as shown in Table 2. The 11 unifying factors which become the initial codes after harmonisation are educational exposure, lack of competence, leadership support, inadequate infrastructure, gender imbalance, lack of content in local language, funding, lack of ICT policy, rigor in planning ICT curriculum/ pedagogical issues, high cost of equipment and security issues.

It can be observed from Table 2, that, the most mentioned factor across the region is inadequate infrastructure, followed by leadership support and educational exposure. However, the lack of content in local language and security issues were rarely mentioned as a contributing factor discouraging the adoption of ICT tools. Implying that those two factors have little or no effect on the adoption. The contributing factors can further be narrowed down to staff skillset, infrastructural factors and facilitation condition. These

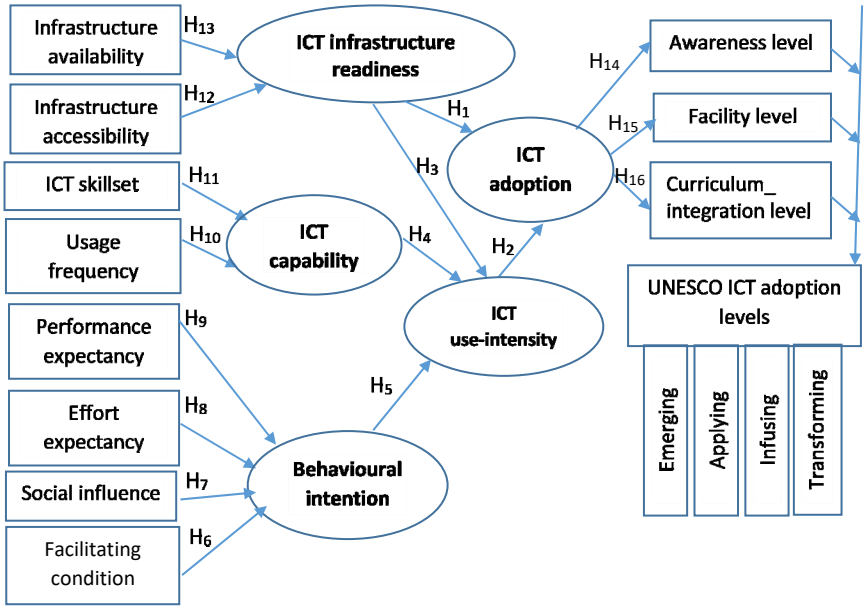
factors and those generated from the review of ICT for education models in Section 2 form the constructs for the developed integrated model for ICT adoption in this research.

Furthermore, the thematic analysis of the six ICT for education models reviewed shows that the elements considered are seven. The seven elements are infrastructure, policy and usability, and skills. Others are performance, perception, finance and administrator, and anxiety. The analysis shows that infrastructure is a major factor having been identified in each of the six models. The analysis further shows that skills, policy and usability are factors with high frequency, each cutting across four of the models, while performance was identified by three of the models. The perception was identified by two of the models while anxiety, finance and administrator were each identified by one of the models.

3.2 The proposed integrated ICT adoption model

The proposed ICT adoption model shown in Figure 2, is a conceptual model based on the themes and elements deduced from the thematic analysis of the militating factors and reviewed models.

Figure 2 Proposed integrated ICT adoption model (see online version for colours)



The model is built on the deductive proposition from the thematic analysis of the militating factors which identifies staff skillset, infrastructural and FCs as the main contributing factors for ICT adoption in higher institutions. These factors are harmonised with ITU's constructs to form ICT-infrastructure_readiness and ICT-use-intensity as the two common factors that impact ICT adoption in the institutions. The use-intensity is also impacted by the ICT-capability of the personnel and their BI. These five latent variables (derived variables) are endogenous. The ICT-use-intensity depends directly on the ICT-capability of the personnel, their BI and the ICT-infrastructure-readiness of the

institutions. The ICT capability of the staff is a function of their ICT-skill-set and their usage-frequency which are exogenous variable. The manifests variables that determine BI are the PE, EE, and SI with the FCs. The ICT-use-intensity replaces UB in the Venkatesh et al. (2003) UTAUT model. Furthermore, the indicator variables for the infrastructure-readiness of an institution are the infrastructure-availability and infrastructure-accessibility. Finally, the model provides the capability to classify the ICT adoption – level into the lowest 'emerging' level to the highest 'transforming' level using the levels of awareness, facility and the curriculum integration, as specified in the UNESCO ICT adoption level.

The conceptual structure provides a framework to guide the implementation of ICT adoption in educational institutions, especially at the tertiary level. It indicates the input, process and output (IPO) layers for the implementation. The input layer specifies the variables grouped by the process being targeted. Institutions can version out the approach and sequence of implementation as they may be considered appropriate. An institution that prioritises the processing of the 'ICT infrastructure readiness' component, for instance, needs to facilitate the acquisition of necessary equipment and make them accessible to the target users. This can be followed by or run concurrently with the 'ICT capacity' component which requires facilitating ICT skillset of the staff and their usage frequency of the ICT facilities. Progressively, as the Institution intensify efforts on each of the processes, their levels of attainment can be determined as output that could either be emerging, applying, infusing or transforming.

3.3 Model exploration and evaluation

Expectedly, formulated conceptual models are expected to be validated for the correctness and fitness. This is usually achieved by estimating the effects of indicators and the latent variables. Specifically in this model, it is essential to determine the extent to which ICT-infrastructure readiness and ICT-use-intensity impacted the ICT adoption in the institutions as postulated in the model. Similarly, the impact of the ICT-infrastructure_readiness, ICT-capability and BI on ICT-Use-Intensity need to be measured. Other relationships to be determined are the rate at which the BI are influenced by the PE, EE, SI and FCs. Consequently, every path in the model as shown in figure 2 can be used to generate a hypothesis, this will result in 16 hypotheses. However, the path represented with H_1, H_4 and H_8 in the figure together with the endogenous variable 'ICT-capability' were dropped during the model fitting. Also, to give the latent factor an interpretable scale as opined in Hox and Bechger (1998), one loading was fixed to value 1 for each of the factors. The fixed loads or path in Figure 2 are H_3, H_5, H_7, H_{10}, H_{12} and H_{14}. Seven null hypotheses renumbered as H_1 to H_7 below were formulated from the remaining seven paths. The result of the null hypothesis testing is reported in Section 4. The seven null hypotheses were generated to provide an approximate description of the phenomena under investigation. They provided the researchers with a relational statement that were directly tested in this study.

H_1 Use intensity does not have a direct positive effect on ICT adoption level. ICT use intensity has been observed to have a positive effect on the level of ICT adoption and there is an ordered logistic regression to allow predicting a discrete outcome like the adoption of ICTs in the presence of a set of variables that may be continuous, discrete, dichotomous, or a mix of these (Ulmanisa and Deniņs, 2012).

H_2 Infrastructure availability does not have positive impacts on ICT infrastructure readiness. The availability of ICT infrastructure is a basic requirement for the adoption of e-learning in learning institutions and indeed any organisation (Mulwa and Kyalo, 2011). Lumumba (2007), in their study on the challenges facing e-learning at public secondary schools, based on the NEPAD pilot project schools in Kenya established that the e-learning project was faced by many challenges. They singled out a lack of adequate e-learning facilities (infrastructure), as key obstacles to the success of the e-learning project.

H_3 Resources level does not have positive impacts on ICT adoption level. Many countries both in developed and developing economies have adopted ICT for different operations in their economies. However, the extent to which a country can participate and benefit from the electronic communication technology depends on the country's digital divide as well as the availability of e-infrastructure and technical knowledge in the country (UNESCO, 2004).

H_4 Curriculum integration level does not have positive impacts on ICT adoption level. Schiff and Solmon as cited in Lai and Pratt (2004) argued that for effective utilisation of ICT by teachers, there is the need for strong leadership to drive a well-designed technology plan in schools

H_5 ICT skill does not have positive impacts on use intensity. The extent to which a country can participate and benefit from ICT depends on the technical knowledge in the country (UNESCO, 2004).

H_6 Facilitation does not have a positive impact on behavioural intent. Successful e-pedagogy depends on effective e-facilitation, which can be made difficult or possible by various factors depending on how prepared the implementers are (Mulwa and Kyalo, 2011).

H_7 PE does not have positive impacts on behavioural intent. Evidence suggests that innovation attributes: relative advantage, compatibility, complexity, trialability and observability as perceived by individuals influence the rate of adoption (Rogers, 2003). Similarly, Smarkola (2007), confirmed that perceived usefulness is a predictor of user acceptance of computer technology.

These propositions were accomplished by collecting, processing and analysing data from the sample population within the case study.

3.3.1 Data collection and description

The data for this preliminary study is drawn from the sampled 154 academics from 248 staff across the seven colleges of a Nigerian North Central State University that responded to the questionnaire administered. The respondents are from the Colleges of Agriculture, College of Education and College of Engineering. Others are Colleges Humanities, Management and Social Sciences, College of Information and Communication Technology, College of Pure and Applied Sciences, and College of Law. The questionnaires received were cleaned, validated and tested for reliability.

3.3.1.1 Instruments for data collection

The instrument for collection of data was a questionnaire titled 'Enhancing the adoption of ICT for education in Nigeria Higher Institution'. The questionnaire was structured to harvest the eight input variables for the model. It was divided into four sections (A, B, C and D):

- Section A requested for demographic information of the respondents including the gender, age and academic position. Others are years in academics and categories of university.
- Section B elicited information on availability, accessibility and usability of ICT equipment in the university. This section was divided into three sub-sections of Subsections a, b and c. Subsection B(a) contained three items on available of ICT equipment/facilities/services and was scored using the three-points Likert type rating scale of not available = 1, available but rarely accessible = 2 and available and fully accessible = 3. Subsection B(b) contained three items on the frequency of ICT equipment usage and scored using the three-points Likert type rating scale of never = 1, rarely = 2 and often = 3. Subsection B(c) contained five items on ICT skills and versatility, three-points Likert type rating scale of fair = 1, good = 2 and excellent = 3 was used.
- Section C sought information on factors influencing the adoption of IT as postulated in the UTAUT. The three-points Likert type rating scale of not at all = 1, a little = 2 and a lot = 3 was used to extract the four UTAUT factors of PE, EE and SI. The fourth is FC.
- Section D was divided into three subsections (a–c). Subsection D(a) elicited information on staff awareness level of ICT in education in their institutions, Subsection D(b) extract information on levels of ICT facilities and resources in the institutions. Finally, Subsection D(c) contained information on institutions level of ICT integration in curriculum implementation.

3.3.1.2 Validity and reliability of the questionnaire

The questionnaire was given both face and content validity by the researchers' colleagues and five other senior academic staff from College of ICT, College of Education and College of Agriculture. After effecting all corrections, the experts adjudged that the instrument has content validity and therefore suitable for use in the study. Their suggestions were used for the final draft of the instrument.

Reliability, on the other hand, is one of the features of a valid questionnaire. The split-half reliability method was used to determine the reliability of the questionnaire. To ascertain the reliability, the instrument was administered to 40 lecturers randomly selected across the sampled colleges. The data obtained were split into two comparable halves of even and odd numbers subsets. The two sets of scores from the two halves of the instrument were correlated.

3.3.2 SEM of ICT adoption

SEM is a general statistical modelling technique that extends the general linear model (GLM). It consists of a series of statistical methods that allow complex relationships between one or several independent variables and one or more dependent variables. It has a capability for simultaneous evaluation of a series of dependent relations, especially where there are direct and indirect effects among the constructs within the model (Hair et al., 2010). It can also analyse relationships between latent and observed variables, model random errors in the observed variables and measure latent variables using multiple indicators and testing hypotheses at the construct instead of item level (Hoyle, 2011).

SEM is often visualised as a graphical path diagram. It uses traditional multivariate procedure such as factor analysis, regression analysis, discriminant analysis and canonical correlation. Common SEM software includes Amos, SAS PROC CALIS, R packages sem, lavaan, OpenMx, LISREL, EQS, and Mplus. These softwares can estimate parameters for traditional models and complex relationships and models. AMOS 23 software is used in this work to demonstrate the adequacy of the formulated model and to determine whether or not it is good for consideration.

3.3.3 Model identification

Traditionally, model identification requires a formal mathematical analysis. However, the advancements in computer applications for SEM have made it possible for automatic identification of a given model. The structural equation model and the standard output generated in AMOS 23 software for the proposed model in Figure 2 is as shown in Figure 3.

Figure 3 ICT adoption model specification and standard output (see online version for colours)

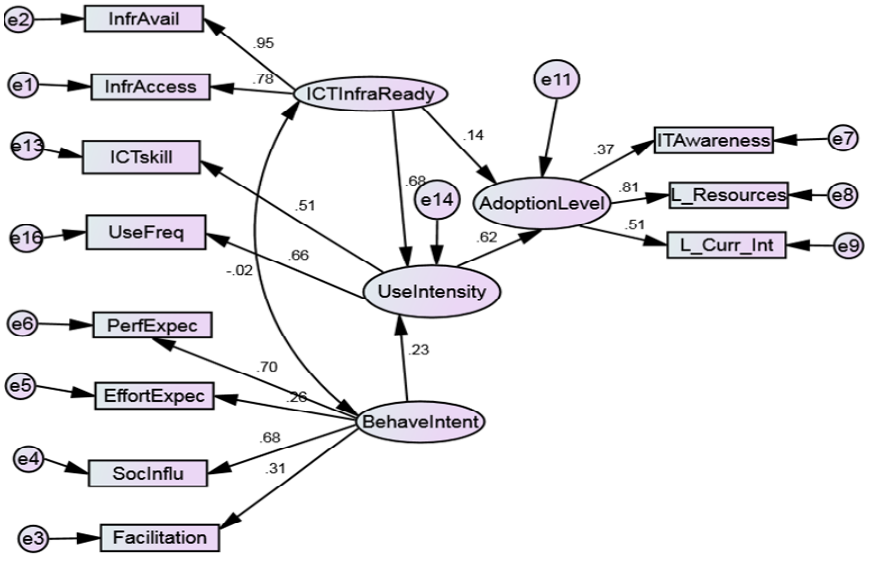


Figure 3 is a demonstration of confirmatory factor analysis (CFA) type of SEM. The two major purposes of CFA are to obtain the estimates of the parameters of the model and to assess the fit of the model. For the model to be 'identified' some factors loading was constrained or fixed to be zero. Also, for each factor, one loading was fixed to one, to give the latent factor an interpretable scale. Furthermore, the loading of each latent factor can be estimated when a fixed variance which standardises the scale of the factor to z-score is given. But, since, the loading factor and variance cannot be estimated simultaneously, being alternate functions of each other, common solution has opined in (Hox and Bechger, 1998) is to fix one loading for each factor to one, and estimate the factor variances. In SEM, the latent factors are assumed not to provide perfect prediction because there could be other unspecified or unidentified causes. To capture this uncertainty, measurement errors were also introduced. Measurement errors are specified for the entire observed variable and the endogenous variables. The measurement errors being unobserved variables like the latent variable are represented with oval shape in SEM, the observed variables are indicated with as rectangles. In SEM's parlance, the latent variables are impacted by the observed variable. For instance, ICT infrastructure readiness are impacted by observable infrastructure availability and infrastructure accessibility. Consequently, the model provides the capability to classify the ICT adoption level into the lowest 'emerging' level to the highest 'transforming' level as recommended by the UNESCO ICT adoption level.

The calculation of the model estimate is an indication that the default model is identified. As shown in Table 3, the degree of freedom (df) is equal to 40, hence, the model is not just identified, but over identified.

Table 3 Initial model results

Computation of degrees of freedom
Number of distinct sample moments: 66
Number of distinct parameters to be estimated: 26
Degrees of freedom (66–26): 40
Result: minimum was achieved
Chi-square =123.575
Degrees of freedom = 40
Probability level = 0.000

As shown in Table 3, the default model is considered satisfactory for a recommendation. This is because the Probability level is less than 0.05 (0.000) and the proportion of the chi-square value (123.575) to the degree of freedom is low. Table 4 reveals the unstandardised and standardised estimated values for the initial model.

Table 4 shows that all the estimated paths are significant because the p values are less than 0.05 except the AdoptionLevel ← ICTInfraReady. When p value is 0.00, AMOS 23 software represents it with three asterisks (***) as shown in the table. Though,, the model needs to be subjected to further evaluation to ascertain the level of 'goodness' and for possible modification for better accuracy and adequacy. However, this initial level of identification implies that the theories and aggregation techniques adopted for the model are confirmed to be operational for determining the factors and levels of ICT adoption in educational institutions.

Table 4 Unstandardised and standardised estimates for the initial model

			Estimate	*S.E*	*C.R*	*P*	*Label*	*Standard estimate*
UseIntensity	←	BehaveIntent	1.000					0.226
UseIntensity	←	ICTInfraReady	1.000					0.685
AdoptionLevel	←	ICTInfraReady	0.090	0.122	0.735	0.462	par_7	0.140
AdoptionLevel	←	UseIntensity	0.273	0.130	2.106	0.035	par_8	0.624
InfrAccess	←	ICTInfraReady	1.000					0.780
InfrAvail	←	ICTInfraReady	1.000	0.120	8.333	***	par_1	0.951
SocInflu	←	BehaveIntent	2.109	0.652	3.233	0.001	par_2	0.680
EffortExpec	←	BehaveIntent	0.830	0.376	2.205	0.027	par_3	0.260
PerfExpec	←	BehaveIntent	1.557	0.487	3.199	0.001	par_4	0.699
FacilityCon	←	BehaveIntent	1.000					0.314
ICTAwaren	←	AdoptionLevel	1.000					0.370
SchICTLeve	←	AdoptionLevel	2.037	0.556	3.666	***	par_5	0.811
CurrInteg	←	AdoptionLevel	1.427	0.409	3.490	***	par_6	0.515
ICTskill	←	UseIntensity	0.430	0.093	4.626	***	par_10	0.509
UseFreq	←	UseIntensity	0.504	0.086	5.871	***	par_11	0.664

3.3.4 Model validation and evaluation

The two steps SEM approach recommended in Hair et al. (2010) was used in this study. The measurement model assessment was used to estimates how well the observed indicators measure the unobserved latent variables (Gerbing and James, 1988). The structural model assessment was also used to estimate the relationships that exist between the endogenous and exogenous variables in the structural component of SEM. The former determines the convergent and discriminant validity of the model, thereby, testing the validity and the reliability of the constructs, while the latter provides the strengths and direction of the relationships among the constructs. The following are the analysis of the two measurements.

3.3.4.1 Test of the measurement model

The estimation of the measurement model, which entails model validity and reliability, was conducted using maximum likelihood estimation (MLE). The MLE is a method that estimates the parameters of a probability distribution by maximising a likelihood function, such that, the observed data is most probable under the assumed statistical model. Model validity examines the ability of an instrument to measure what is supposed to be measured for a construct. The convergent validity was considered for the model. It is achieved when all items in a measurement model are statistically significant ($p < 0.05$). Other possible validity measures are construct validity and discriminant validity (Zainudin, 2015). Reliability is the extent of the measurement model in measuring the intended latent constructs. The reliability metrics used in the study are the construct reliability (CR) which is expected to be ≥0.6 and average variance extracted (AVE) which supposed to be ≥0.5 (Hair et al., 2010). Furthermore, to obtain a reliable result in

SEM the Hoelter's critical N is commonly adopted by researchers. The Hoelter's critical N, refers to the sample size for which the hypothesis would be accepted at the 0.05 level of significance. The other popular assumptions are, that more than 200 observations or at least 50 more than 8 times the number of variables in the model are required. Furthermore, in Hair et al. (2010) and Ahmad et al. (2016), 100 samples were recommended for a model with five or less latent construct when each latent construct has more than three measuring items. In this study, 154 samples were used. Generally, the minimum thresholds value for factor loading is 0.5, that of CR is 0.7, the AVE for each CR should be equal or greater than 0.5 (Hair et al., 2010).

Table 5, has the CR and the validity result of the initial model, the equations used to measure the CR and the validity of the measurement instrument from the estimates in AMOS software are:

$$\mathrm{CR} = \left(\left(\sum \mathrm{k} \right)^2 \Big/ \left[\left(\sum \mathrm{k} \right)^2 + \sum 1 - \mathrm{k}^2 \right] \right) \tag{1}$$

$$\mathrm{AVE} = \left(\sum \mathrm{k} \right)^2 \Big/ \mathrm{n} \tag{2}$$

where k = factor loading of each item, n = number of items in a model and $1 - k^2$ = measurement error.

Expected: factor loading > 0.5, composite reliability ≥ 0.7, AVE ≥ 0.5 (Hair et al., 2010).

Table 5 Initial models CR and validity

Construct	*Indicator*	*Factor loadings*	*Composite reliability (CR)*	*Average variance extracted (AVE)*
ICT-infrastructure_readiness	Infrastructure-availability	0.95	0.89	0.68
	Infrastructure-accessibility	0.78		
ICT-use-intensity	ICT skill	0.51	0.51	0.35
	Usage frequency	0.66		
Behavioural intention	Performance expectancy	0.70	0.57	0.28
	Effort expectancy	0.26		
	Social influence	0.68		
	Facilitating conditions	0.31		
ICT adoption	Level of awareness	0.37	0.59	0.35
	Resources level	0.81		
	Level of curriculum integration	0.51		

The factor loadings in Figure 2 and Table 5 show that some items of the instrument are not valid for their construct in the dataset used. The loading factors for EE (0.26) and FCs (0.31) are below the expected minimum of 0.5. The implication of this in practice is that the respondents did not see the rate or the enormous efforts requires of them as an influencing factor towards their intention to adopt ICT. Also, they submitted that the domain in reference has not provided adequate FCs for ICT adoption. The reliability of

the model is satisfactory. All four CR values are more than 0.5. The recommended CR values in the literature are ≥0.50 (Teo and Zhou, 2014), ≥0.60 (Ahmad et al., 2016) and ≥0.7 (Hair et al., 2010). For now, only the ICT-infrastructure_readiness met the required AVE (≥0.50) value, which is the average percentage of variation explained by the items in a construct. Currently, the model to a large extent certify the convergent validity and CR. These values and that of AVE can be improved through model fitting and model modification.

3.3.4.2 Model fitting

Model fit measures in SEM provide information about the extent to which the model fits the underlying data. It is a measure of goodness of the model. The three types of measurements for determining model fit are absolute model fit (AMF), incremental model fit (IMF) and parsimonious model fit (PMF). For a model to have valid AMF, the chi-square (CMIN) value and the probability value (P-value) must be <0.05, the root mean square error of approximation (RMSEA) must be <0.08 and goodness of fit index (GFI) must be >0.9. Also, for a model to have valid IMF, the adjusted goodness of fit index (AGFI), comparative fit index (CFI), normal fit index (NFI) and Tucker Lewis index (TLI) must be >0.9. Furthermore, the PMF requires that the minimum discrepancy (CMIN/DF) must be <5.0. Table 6 shows the excerpt of the model fit summary generated in AMOS.

Table 6 Initial model fit summary

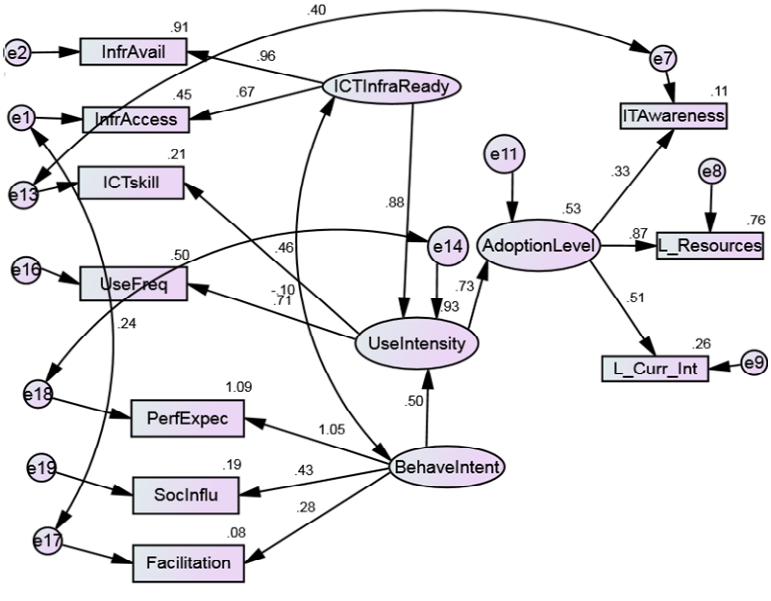
CMIN					
Model	*NPAR*	*CMIN*	*DF*	*P*	*CMIN/DF*
Default model	26	123.575	40	0.000	3.089
Saturated model	66	0.000	0		
Independence model	11	458.762	55	0.000	8.341
RMR, GFI					
Model	*RMR*	*GFI*		*AGFI*	*PGFI*
Default model	0.047	0.875		0.794	0.530
Saturated model	0.000	1.000			
Independence model	0.113	0.610		0.533	0.509
Parsimony-adjusted measures					
Model	*PRATIO*		*PNFI*		*PCFI*
Default model	0.727		0.531		0.577
Saturated model	0.000		0.000		0.000
Independence model	1.000		0.000		0.000
RMSEA					
Model	*RMSEA*	*LO 90*		*HI 90*	*PCLOSE*
Default model	0.117	0.094		0.141	0.000
Independence model	0.219	0.201		0.238	0.000

To test for the AMF, the table shows that the CMIN is 123.575, p-value is 0.000, RMSEA is 0.117 and GFI is 0.875 against the expected <0.05, <0.05, <0.08 and >0.9 respectively. It can be deduced that the AMF is only closely met. In practice, this model, though not perfect but good enough for consideration. This is because the p-value condition is met, RMSEA and GFI values are much closed and the CMIN value though high but of extremely low ratio with the degree of freedom (DF = 40). For the IMF, the AGFI is 0.794, CFI is 0.793, NFI is 0.731, and TLI is 0.715. All the four parameters of the IMF are expected to be >0.9, but, as shown, they are very close. This is also a pointer to the fact that the model is not presently perfect but, it is good enough for consideration and improvement. Furthermore, the expected minimum discrepancy value of the PMF which is expected to be <5.0, cannot be met because it is a derivative of CMIN/DF which is given as 3.089. All the model fit values are indicators that the model in its present form is considered satisfactory but can be enhanced through model modification.

3.3.5 Model modification

To achieve a more perfect fit, the model modification process is employed using the modification indices (MIs). MIs provide estimates of the most likely relationship between the variables that can be used to improve the fitness of a model. Hence, it flagged the potential changes that can be made to the model to attain a better fit. It is indicated by the changes in the chi-square (CMIN), GFI and minimum discrepancy values. Though in practice, modification is also expected to be guided by the base theories for the model. Also, by the rule of thumb, only three modification is allowed. The three highest MIs indicating the expected reductions in the chi-square (CMIN) values after implemented are $e_7 \leftrightarrow e_{13} = 20.442$, $e_{14} \leftrightarrow e_{18} = 13.082$ and $e_7 \leftrightarrow e_7 = 8.029$ respectively. The model after the third modification is as shown in Figure 4.

Figure 4 The final model after the third modification (see online version for colours)



3.3.6 Analysis of the structural model and revalidation of the model fit

After the modification the CMIN is now 82.417 lower from 123.575, p-value remains as 0.000, RMSEA is 0.107 from 0.117 and GFI is 0.915 from 0.875 against the expected <0.05, <0.05, <0.08 and >0.9 respectively. It can be deduced that the AMF is now more closely met because the CMIN is minimal, p-value correctly met, RMSEA is closer and GFI is perfectly met. All the metrics for the IMF are expected to be >0.9, now the AGFI is 0.845 from 0.794, CFI is 0.866 from 0.793, NFI is 0.811 from 0.731, and TLI is 0.799 from 0.715. All these values after approximation will be 0.9 of closer. Furthermore, the expected minimum discrepancy value of the PMF is expected to be <5.0, this is perfectly met, it now stands at 2.747 from 3.089. The new model fit values indicated that the modified model is a better version and good enough for consideration. Additionally, Figure 4 shows the relationships between the exogenous and endogenous variables and among the endogenous constructs of the model, thereby depicting the performance of the structural equation. Table 7 shows the estimated covariance values and the standardised regression coefficient of the variables. Also shown, are the standard error (S.E), the critical ratio (C.R) and the p-values for determining the statistical significance of the estimated values.

Table 7 Estimates of the relationship between variables and the path regression weight

			Estimate	*S.E*	*C.R*	*P*	*Standardised estimate*
UseIntensity	←	BehaveIntent	1.000				0.500
UseIntensity	←	ICTInfraReady	1.000				0.878
AdoptionLevel	←	UseIntensity	0.467	0.143	3.264	0.001	0.727
InfrAccess	←	ICTInfraReady	1.000				0.674
InfrAvail	←	ICTInfraReady	1.293	0.152	8.517	***	0.956
ITAwareness	←	AdoptionLevel	1.000				0.328
L_Resources	←	AdoptionLevel	2.515	0.725	3.470	***	0.874
L_Curr_Int	←	AdoptionLevel	1.611	0.476	3.382	***	0.513
ICTskill	←	UseIntensity	0.636	0.121	5.268	***	0.456
UseFreq	←	UseIntensity	1.000				0.706
Facilitation	←	BehaveIntent	0.663	0.182	3.643	***	0.277
PerfExpec	←	BehaveIntent	1.732	0.535	3.236	0.001	1.045
SocInflu	←	BehaveIntent	1.000				0.433

As shown by the p values (< 0.05), all the estimated values are statistically significant. The three asterisks (***) in the p value represents 0.00. Figure 4, therefore, illustrate the significant structural relationships among the variables to be used to validate the research hypothesis.

4 Results, hypothesis testing and discussion

The preliminary result from the case study indicates that ICT adoption is impacted by the use-intensity at $\beta = 0.73$ coefficient value. The use-intensity is also impacted by ICT

infrastructure readiness and BI at the rate β = 0.88 and β = 0.50 respectively. Furthermore, the exogenous variables; ICT infrastructure readiness is influenced by infrastructure availability (β = 0.96) and infrastructure access (β = 0.67), the use intensity is influenced by ICT skill (β = 0.46) and use frequency (β = 0.71). The third exogenous variable – BI is impacted by the PE (β = 1.05), SI (β = 0.43) and the FCs (β = 0.28). Finally, the level of ICT adoption can be determined by levels of IT awareness, facilities/ resources and curriculum integration at β = 0.33, 0.81 and 0.51 respectively.

The EE component of the behavioural intent was dropped for insignificancy in the model. This result is in line with the finding of Birch and Irvine (2009), but in contradiction with the postulation of Venkatesh et al. (2003). The findings that the FC has a positive impact on behavioural intent is in agreement with Venkatesh et al. (2003) and Azlina et al. (2013). Furthermore, the outcome here that shows PE and SI have a positive impact is supported by the finding of Venkatesh et al. (2003) but contradict the Birch and Irvine (2009) submission.

The result among others implies that, for every unit increment of the use-intensity, the ICT adoption level will rise by 0.73. Also, a unit increment in ICT infrastructure readiness and behavioural intent will cause 0.88 and 0.50 raise respectively in the use intensity. The acceptability or otherwise of the hypothesis are consequent on these generated values. The H_1 which states that the use intensity does not have a direct positive effect on ICT adoption level is rejected. This is because the regression coefficient (β) of the direct path is 0.73 and the P-value = 0.001. This finding is in agreement with that of Ulmanisa and Deniņs (2012). Also, the H_2 which states that Infrastructure availability does not have positive impacts on ICT Infrastructure readiness is rejected at β = 0.96 and the P-value = 0.000. This result conforms with that of Mulwa and Kyalo (2011) and Lumumba (2007). The H_3 and H_4 which hypotheses that level of resources and level of curriculum integration do not have positive effects on adoption level are rejected because their coefficient value β and the P-value respectively are β = 0.87; P-value = 0.00 and β = 0.51; P-value = 0.00. These results align with those of UNESCO (2004) and Schiff and Solmon in Lai and Pratt (2004). Similarly, the H_5 that ICT skill does not have positive impacts on use intensity is also rejected because the β = 0.46 and the P-value = 0.000. This result agrees with that of UNESCO (2004). Similarly, the H_6 and H_7 are rejected, H_6, which hat, the facilitation does not have a positive impact on behavioural intent is rejected because the β = 0.28 and the P-value = 0.000. The P-value of H_7 is = 0.001. These results are in alignment with the results of Mulwa and Kyalo (2011) and Smarkola (2007). The fact that the entire null propositions are rejected, is another pointer, that, all the constructs and interplays as reflected in the final model are significant and should be maintained.

The model reveals the factors, the weights and the logical relationships among the constructs for the adoption of ICT in tertiary institutions. It provides the input, the processes and the output operational framework as guidance for the implementation of ICT integration in the educational system. From the framework, Institutions can version out the approach and the most convenient sequence of implementing the components. The framework indicates that, for the management of educational institutions to enhance ICT adoption, there is the need for facilitating usage intensity by the staff and getting necessary ICT infrastructure ready. Infrastructure readiness requires both adequate infrastructure availability and accessibility. This is because, in this part of the world, infrastructure availability does not automatically translate to the accessibility. Sometimes,

ICT infrastructure might be kept unused for lack of technical skills, security issues, discouraging policy or lack of sustainability strategy after initial activations. The management also need to realise that aside from the provision of infrastructure, there is need for facilitation through adequate policies, performance recognition as indicators of SI and sensitisation on the benefits of the adoption to the staff and the institution. Furthermore, training and continuous training is required for improved staff ICT skills. Proper monitoring and controlling mechanism must be setup to track usage frequency.

The output of the efforts and progress made towards the attainment of emerging, applying, infusing and transforming levels of ICT adoption is measured by the degree of achievements on ICT infrastructure readiness, ICT capability, BI and ICT use intensity. The importance of determining the current ICT adoption levels of institutions is to guide the management, government and donor agencies on the peculiar needs of each school and to ensure adequate interventions are made. It is expected that the implementation of the findings of this study will to a high extent increase ICT adoption by educational institutions in Africa.

5 Conclusions

This research sought to develop a comprehensive framework for guided implementation of ICT adoption in educational institutions. The statistical evaluation of the model, though constraint by the size as available in the case study, satisfactorily confirmed the intent. The formulated model of aggregated and harmonise constructs from the thematic analysis result and the extracts from the referenced models are implementable and could serve the intended purpose. Also, the rejection of the entire null hypothesis is another indication that each of the exogenous and endogenous variables and the relationships are essential for the successful implementation of ICT adoption in educational institutions.

Consequently, it is recommended for school managers, policymakers, government and donor organisation to leverage the model to determine the needs and the ICT adoption level of the institutions which could either be emerging, applying, infusing or transforming. The attained levels are indicators of achievements, desires and required supports. The impacting figures of the variables can also be used to prioritise the areas of possible interventions.

Furthermore, the procedure could be repeated for expanded samples coverage and for generalisation of results. The model can also be abstracted to a functionally user-friendly platform for easy adoption and replication.

The developed framework, if properly implemented would provide the necessary measures for monitoring and controlling activities towards the adoption of ICT in teaching, research and community development.

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Appendix

Table A1 Factors affecting ICT adoption in higher institution

Africa region	*Country*	*References*	*S/no.*	*Discouraging factors*	*Unifying term/initial code*
West	Ghana	Charles (2012)	1	Level of education	1, 2 – educational exposure, 3, 4, 5 – lack of competence, 6 – leadership support, 7 – inadequate infrastructure and 8 – gender imbalance
			2	Educational experience	
			3	Attitude belief	
			4	Self-confidence	
			5	ICT competence	
			6	Leadership support	
			7	Accessibility of equipment	
			8	Age/gender	
		Kwabena et al. (2013)	1	Inadequate infrastructure	1, 3, 9 – inadequate infrastructure, 2, 4, 6, 7 – educational exposure and 5, 8, 10 – leadership support
			2	Poorly trained educators	
			3	Lack of internet connectivity	
			4	Lack of teaching experience with ICT	
			5	Lack of support for teachers using Technology	
			6	Lack of skilled specialist teachers	
			7	Lack of time to integrate ICT into curriculum	
			8	Lack of financial support	
			9	Lack of suitable educational software	
			10	Rigid traditional educational system	
	Nigeria	Musa et al. (2018)	1	Inconsistent electricity supply	3, 4 – high cost of equipment, 1, 5, 7 – inadequate infrastructure, 2, 6 – lack of competence and 8 – security issue
			2	Illiteracy in computer	
			3	High cost of internet	
			4	High cost of equipment purchase	
			5	Outdated hardware/software	
			6	Fear of change	
			7	Lack of facility	
			8	Security issue	

Table A1 Factors affecting ICT adoption in higher institution (continued)

Africa region	*Country*	*References*	*S/no.*	*Discouraging factors*	*Unifying term/initial code*
South	South Africa	Chigona and Chigona (2010)	1	Lack of confidence in usage of ICT	1, 4 – lack of competence, 2, 7 – educational exposure, 5 – rigor in planning ICT curriculum, 3 – leadership support and 6 – inadequate infrastructure
			2	Lack of skills in usage of ICT	
			3	Lack of support from institution council	
			4	Lack of personal development	
			5	Rigor in planning ICT curriculum	
		Chigona and Chigona (2010)	6	Lack of access to ICT equipment	1, 4 – lack of competence, 2, 7 – educational exposure, 5 – rigor in planning ICT curriculum, 3 – leadership support and 6 – inadequate infrastructure
			7	Lack of mentor	
	Botswana	Matyokurehwa (2013)	1	Lack of funding	2 – educational exposure, 3 – rigor in planning ICT curriculum and 1 – leadership support
			2	Late exposure to ICT technology	
			3	ICT curriculum design issues	
		Lekopanye and Mogwe (2014)	1	High cost of equipment	1, 3 – high cost of equipment and 2, 4 – inadequate infrastructure
			2	Lack of electricity supply	
			3	Expensive internet facility	
			4	Low computer to student ratio	
East	Ethiopia	Tibebu et al. (2009)	1	Inadequacy of essential skills	3 – lack of ICT policy, 4 – lack of competence, 5 – leadership support, 1, 2 – educational exposure and 6 – inadequate infrastructure
			2	Lack of skilled ICT support staff	
			3	Absence of institutional ICT policy	
			4	Low self-efficacy	
			5	Inadequate support for pedagogy	
			6	Inadequacy of ICT resources	

Table A1 Factors affecting ICT adoption in higher institution (continued)

Africa region	*Country*	*References*	*S/no.*	*Discouraging factors*	*Unifying term/initial code*
East	Ethiopia	Alemu (2015)	1	Inadequate access to ICT resources	1, 2, 3 – inadequate infrastructure
			2	Overcrowded classrooms	
			3	Lack of technical and support staff	
	Kenya	Ibrahim (2016)	1	High cost of equipment and infrastructure	2, 3, 4, 5 – inadequate infrastructure, 1 – high cost of equipment and 6 – leadership support
			2	Lack of manpower	
			3	Inadequate supply of ICT resources	
North	Sudan	Suliman et al. (2018)	1	Low level of diffusion and use of ICT infrastructure	7, 9 – inadequate infrastructure, 1, 4, 5 – educational exposure, 3 – gender imbalance, 2 – leadership support, 9 – lack of content in local language and 8 – funding
			2	Autocratic government	
			3	Age/gender/ethnic	
			4	Lack of knowledge on ICT usage	
			5	Lack of trained faculty	
			6	Inadequate infrastructure	
			7	High cost of accessing infrastructure	
			8	Lack of capital	
			9	Lack of content in local language	
	Egypt	Hafez (2013)	1	Inadequate pedagogical support	1 – leadership support and 2 – inadequate infrastructure
			2	Low quality of training for development	
		Genemo and Krishna (2016)	1	Insufficient ICT infrastructure	1, 2, 3 – inadequate infrastructure
			2	Insufficient funds to replace faulty components	
			3	Insufficient power supply	

Table A1 Factors affecting ICT adoption in higher institution (continued)

Africa region	*Country*	*References*	*S/no.*	*Discouraging factors*	*Unifying term/initial code*
Central	Congo	Fall (2007)	1	Lack of ICT Infrastructure	1, 4 – inadequate infrastructure, 6 – funding, 7 – high cost of equipment, 2 – lack of ICT policy, 3 – gender imbalance and 5 – educational exposure
			2	Lack of ICT policy	
			3	Gender inequality	
			4	Lack of power supply in rural areas	
			5	Lack of skilled personnel	
			6	Lack of funds	
			7	High cost of equipment	
		Ngoma (2010)	1	Poor internet connectivity	1, 2, 3, 4, 5, 6, 7 – inadequate infrastructure and 8 – high cost of equipment
			2	Unreliable electricity	
			3	Inadequate educational facilities	
			4	Scarcity of ICT qualified educators	
			5	Inadequate teacher education program	
			6	Large class	
			7	Lack of educational resource	
			8	High cost of infrastructure	
	Cameroon	Nsolly and Charlotte-Ngo (2016)	1	Lack of ICT resources	2, 3 – leadership support, 1 – inadequate infrastructure and 4 – lack of competence
			2	Limited knowledge and skills of administration	
			3	Absence of clear vision on ICT adoption	
			4	Attitude and believe of teachers on ICTs adoption	