JYU DISSERTATIONS 170

Eloho Ifinedo

On Technology Integration: Perspective from Nigeria

UNIVERSITY OF JYVÄSKYLÄ
FACULTY OF INFORMATION TECHNOLOGY

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ABSTRACT

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Rapid technological advancement continues to influence various sectors and societies. Thus, much discussions have been documented and published on technology integration. In education, evaluations on the impact of Information and Communication Technology (ICT) on factors such as learning outcomes, methods, and learning environments towards improving quality of education, abound globally. Such evaluations have led to better planning of the implementation process and educational reforms. Developing countries' context have however been underrepresented or unequally evaluated by using the lenses from foreign contexts and this is one problem with the technology integration process. This study employs a mixed method research design to evaluate the perspectives of the Nigerian students and teachers and the effect of their context on the use of ICT in the pursuit of their educational goals. Survey (N =136) and focused interview (N= 19) responses from Nigerian teacher educators of three government owned colleges of education from the southern part of Nigeria were analysed. The Technological Pedagogical and Content Knowledge (TPACK) framework was adopted albeit with some adaptation. Thus, TPACK was extended to include interactions, teachers' characteristics and ICT practices.

In relation to the aim of this research, first the study provides information on the ownership of multiple mobile devices, positive disposition, and willingness to engage in learning and teaching activities using ICT. Thus, indicating that the teachers and students are prepared to integrate technology in their schools. Second, contextual constraints were found at all three levels considered in this study (that is, macro, meso and micro). Two factors that promoted the use of ICT were the school support and personal determination to innovatively teach with available ICT. Overall, the TPACK framework was found suitable and relevant in explaining technology integration in the Nigerian context. The findings of the study advance research in educational technology for planning, implementation, designing of practical applications and creating processes that are sustainable. In addition, it provides insights to governments, school administrators, researchers, policy makers and international organisations who fund and are associated with many of these educational technology projects in developing contexts.

Keywords: Technology Integration, Educational technology, Context, TPACK, Nigeria

TIIVISTELMÄ (ABSTRACT IN FINNISH)

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Nopea teknologian kehitys on lävistänyt yhteiskuntien eri osia vaikuttaen monilla alueilla. Teknologiaintegraatio onkin herättänyt laajaa keskustelua. Opetuksessa tapahtuvaa tieto- ja viestintäteknologian (TVT) hyödyntämistä ja sen vaikutuksia oppimistuloksiin, opetusmenetelmien ja oppimisympäristöjen kehittämiseen sekä opetuksen laadun parantamiseen on tutkittu kansainvälisesti yhä laajemmin. Tutkimukset ovat johtaneet toimintamallien ja prosessien parempaan suunnitteluun sekä koulutusuudistuksiin, mutta ne ovat luoneet myös haasteita teknologioiden integroimiseen kehittyvissä maissa, jotka ovat olleet tämän tyyppisessä tutkimuksessa aliedustettuna ja joissa keskeisenä haasteena on mallien ja prosessien sovittaminen erilaisten kulttuuristen linssien läpi. Tämän monimenetelmäisen tutkimuksen tarkoituksena on arvioida nigerialaisten opiskelijoiden ja opettajien TVT:n käyttöön liittyviä näkökulmia sekä kontekstin merkitystä oppimistavoitteiden saavuttamisen kannalta. Osana tutkimusta toteutettiin kysely (N=136) sekä teemahaastattelut (N=19) kolmen valtion omistaman opettajakorkeakoulun opettajankouluttajille Nigerian eteläosassa. Tutkimuksen taustalla vaikuttavaksi viitekehykseksi valittiin Technological Pedagogical Content Knowledge (TPACK) -malli muutamin mukautuksin. Elementit, jotka TPACK-malliin lisättiin, olivat vuorovaikutus, opettajan ominaisuudet sekä TVT-käytänteet. Tutkimuksessa kuvataan opettajien ja opiskelijoiden TVT:n koulukäyttöön liittyvien valmiuksien taustalla olevia tekijöitä, kuten useiden mobiililaitteiden omistaminen, positiiviset asenteet sekä halukkuus osallistua oppimis- ja opetustoimintaan TVT:n avulla. Tutkimuksessa tuodaan esiin teknologian käytön esteitä, joita tunnistettiin kolmella kontekstuaalisella tasolla (makro, meso ja mikro). Lisäksi löydettiin kaksi TVT:n käyttöä edistävää tekijää: 1) koulun tarjoama tuki sekä 2) opettajien päättäväisyys hyödyntää innovatiivisia opetuskäytänteitä TVT:n avulla. Johtopäätöksenä voidaan todeta, että TPACK-malli on käypä ja tarkoituksenmukainen viitekehys selittämään teknologian integroimista myös nigerialaisessa kontekstissa. Tuloksia voidaan hyödyntää opetusteknologioihin liittyvän tutkimuksen, suunnittelun sekä kestävien käytänteiden ja prosessien edistämiseen. Lisäksi tutkimus tarjoaa näkökulmia koulunjohtajille, tutkijoille, päätöksentekijöille sekä kansainvälisille järjestöille, jotka rahoittavat ja ovat osallisina opetusteknologiaan liittyvissä projekteissa kehittyvissä maissa.

Avainsanat: Teknologiaintegraatio, Koulutustekniikka, Konteksti, TPACK, Nigeria

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Jyväskylä, 01.10.2019
Eloho Ifinedo

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I. Ifinedo, E., Kankaanranta, M., Neittaanmäki, P. & Hämäläinen, T. (2017). Exploring Nigerian University Students' Perception towards Mobile Learning. In J. P. Johnston (Ed.), EdMedia 2017: *Proceedings of the World Conference on Educational Media and Technology* (pp. 833-842). Association for the Advancement of Computing in Education (AACE).

II. Ifinedo, E. & Kankaanranta, M. (2018). The Nigerian Education and the Opportunities ahead for Mobile Learning. In S. Carliner (Ed.), E-Learn 2018: *Proceedings of E-Learn: World Conference on E-Learning in Corporate, Government, Healthcare, and Higher Education* (pp. 246-251). Association for the Advancement of Computing in Education (AACE).

III. Ifinedo, E. & Kankaanranta, M. (2019). Understanding the influence of Context on Nigerian Teachers' Technology Integration. *Technology, Pedagogy and Education Journal* (Under second review).

IV. Ifinedo, E. & Rikala, J. (2019). TPACK and Educational Interactions – Pillars of Successful Technology Integration. In *Proceedings of E-Learn 2019: World Conference on E-Learning in Corporate, Government, Healthcare, and Higher Education*. (Forthcoming). Association for the Advancement of Computing in Education (AACE).

V. Ifinedo, E., Saarela, M. & Hämäläinen, T. (2019). Analysing the Nigerian Teacher's Readiness for Technology Integration. *International Journal of Education and Development using Information and Communication Technology*. (IJEDICT) 15(3), pages 34-52.

VI. Ifinedo, E. (2019). Comparing the Effect Size of School Level Support on Teachers' Technology Integration. In *Proceedings* of *Smart ICT Conference 2019.* (Forthcoming).

VII. Ifinedo, E., Rikala, J. & Hämäläinen, T. (2019). Factors affecting Nigerian teacher educators' technology integration: Considering characteristics, knowledge constructs, ICT practices and beliefs. (Accepted) *Computers & Education.*

1 INTRODUCTION

This chapter of the thesis begins with preliminary information on technology integration from a developing country perspective. Thus, contained in this chapter are: the background (Section 1.1) and the motivation for the study (Section 1.2), the research questions (Section 1.3), the scope (Section 1.4) and an overview of the structure of the thesis (Section 1.5).

1.1 Background

The developments in information technology have resulted in its increased usage in many sectors including education. However, the speed of technological developments cannot be compared with the speed of developments in education. This gap may have inspired the perceived globally waning emphasis on education, which affects objectives such as SDG 4[1]. For example, GEM[2] (2017/8) reports that in 2015, although sub-Saharan Africa is home to over 50% of the world's out-of-school children, the region received 26% basic education aid which in comparison was below 50% of the amount received in 2002. This study considers the influencing potentials of the constantly developing information technology in three aspects namely, improving the quality of education, future work skill and nation building. Saarela (2017) argues that the success of a country is a function of the educational achievement of its citizens. Information Communication and Technology (or ICT) is therefore a facilitator of success and if properly exploited, the combination of quality education and expected development of information technology can be used to strengthen societies (Asongu & Nwachukwu, 2018; Bankole, Osei-Bryson, & Brown, 2015; Oluwatobi, Olurinola & Taiwo, 2016; ITU, 2017).

---

1 Sustainable Development Goal 4 aspires 'to ensure inclusive and equitable quality education and promote lifelong learning opportunities for all'

2 Global Education Monitoring

In reality, countries in the developed world have applied the advantages of ICT for the development of their economies (Watanabe, Naveed & Neittaanmäki, 2017). It is perceived that investments in education yields positive and direct effect on human capital with evident economic and social developments (Oluwatobi et al., 2016). Information technology through technology integration in education (for example, mobile learning, electronic learning, online learning and other variants) has the potential to reshape learning experiences towards new skills such as computational thinking, problem solving, innovative product creation, collaborators and effective communicators otherwise referred to as 21st century skills (Scott, 2015).

However, a 50-year review of research on educational technology within the British Journal of Educational Technology attests to the fact that studies from the African continent compared to others were grossly under represented (Bond, Zawacki-Richter & Nichols, 2018). The fact is that developing countries continue to struggle with successful implementation of technology integration (Adedoja, Botha & Ogunleye, 2012; Byungura, Hansson, Masengesho, & Kaunaratne, 2016; Heeks, Gao & Ospina, 2010; Ifinedo, Saarela & Hämäläinen, 2019; Kozma, 2005; Oye, Salleh & Iahad, 2011; Tran & Stoilescu, 2016).

UIS[3] (2015) stresses four prevalent factors that challenge the ICT integration process; lack of formal policy, financial resources, basic infrastructure and competent teachers. Compared to developed countries, the technology adoption process in developing countries is slow (see Ifinedo 2005; UNESCO 2015, Vainikainen, Soriyan, Korpela & Saranto, 2014). For developing countries, the process is commonly associated with poor leadership and policies (Heeks, Gao & Ospina, 2010; Ololube, Agbor, Major, Agabi, & Wali, 2016; Oye, Salleh & Iahad, 2011; Tran & Stoilescu, 2016), and poor implementation strategies (Howie, 2010). As an example, from developed context, Kozma (2008) cites Finland and Singapore as examples of countries that created a vision for productivity through education reforms and who then implemented it by investing in education, technological infrastructure, research and development with evident result in economic growth. Nevertheless, Asongu and Nwachukwu (2018) assert that the policy issues, which are predominant in sub Saharan African countries can be tackled with the combining effect of quality education and information technology.

Of the earlier mentioned four-factor challenges of technology integration by UIS (2015), teacher competency appears common to both developing and developed countries (see Aduke, 2008; Kihoza, Zlotnikova, Bada & Kalegele, 2016; McCusker, 2017; Ololube, 2006; Rikala, 2015; Tran & Stoilescu, 2016). The pedagogical practices of teachers have a direct impact on learning activity, learning process, and learning experiences (Rikala, 2015; Shulman 1986; Willis, Lynch, Fradale, & Yeigh, 2019). Therefore, teachers play a significant role in the technology integration process (Heitink, Voogt, Verplanken, van Braak, & Fisser, 2016; Ifinedo & Rikala, forthcoming; Mishra & Koehler, 2006; Porras-Hernandez & Salinas-Amescua, 2013). To a large extent, they influence the integration process as key participants and are in turn influenced by the other three contextual

3 UNESCO Institute for Statistics

factors (i.e., formal policy, financial resources, basic infrastructure) therefore, teachers find themselves in a challenging position. Despite this common denominator of teacher competency, Pettersson (2017) emphasizes the significant impact that context has on digital competence as an aggregate and network of various related factors. For example, Finnish teachers have been exposed to information technology in their schools through the curriculum and the physical presence for over forty years (Mannila, 2018), which is contrary to the case of Nigerian teachers (Aduke, 2008; Ololube, 2006). Similarly, a level of autonomy is required for a teacher to become creative with the use of ICT, again this level of autonomy varies across contexts. Finnish teachers are said to carry a substantial weight in the decision-making processes in schools. These decisions include for instance, choice of course contents, methods for assessing the students, pedagogical strategies along with suitable materials (Rikala, 2015). Consequently, teachers should be active participants of the integration process (Cviko, McKenney, & Voogt, 2013) and teaching in such environments, allow for flexibility and inclusivity of multiple teaching strategies (Harris, Mishra & Koehler, 2009).

In this study, technology integration refers to the use of information technology in the educational context. Davies (2011, P.50) describes the objective of educational technology as *'the wise and competent use of technology to facilitate learning'*. This implies that the educational technology is used by the teacher and student for the purpose of achieving their educational objectives. (e.g., facilitate the understanding of a subject). Hereafter, *educational technology* may be used interchangeably with the term *technology integration* to connote the same thing.
The multiplicity of factors to be considered is often a challenge on how best to evaluate the technology integration process (Lai & Bower, 2019). Though the process and field of technology integration remains emerging, building a sustainable process requires perspectives of all contexts. In this study, the discourse centres on two major aspects of the technology integration process namely, the primary stakeholders (students and teachers) and the effect of their context on the use of ICT in the pursuit of their educational goals.

1.2 Motivation

The motivation for this study is threefold. First, the GSM association (2018) predicts that developing countries compared to their nearly saturated counterparts in the developed countries, will drive growth in the global mobile industry for the next seven years. This forecast prospects and further development possibilities in Africa for example. Consequently, research is needed to identify the gaps that exist and in turn, how these gaps can become opportunities for technology integration in learning environments within developing contexts.

Secondly, technology integration is one route towards achieving the United Nation's 2030 Sustainable Development Goals in effectively building human competence through education. At the global level in 2015, the UN Secretary General (2019) estimates that about 411.3 million children within the primary and lower secondary school bracket possibly dropped out of school. Likewise, according to UIS (2012), the Out Of School Children (OOSC) problem is the largest contributor to Nigeria's inability to achieve for example, Education for All (EFA) and Millennium Development Goal (MDG). National Bureau of Statistics (2015) maintains that almost 3 million Nigerian children (8.1%) between the age brackets of six and fourteen were out of school while 3.2 percent of this population dropped out of school in 2010. Further, Nigeria is ranked as one of the countries with the largest out of school population (UNESCO, 2015).

Thirdly, when considering the integration of ICT in education, attention should be drawn towards the context in which it is to be situated. As Traxler (2018) explains, the development of policies and the use of mobile technologies in developing country contexts are greatly influenced by countries on the other side of the divide such that the '*role and impact of research*' is distorted. For example, student-to-computer ratio and average percentage multimedia machines were used to measure ICT availability and quality (or ICT infrastructure) in schools of 24 countries (Pelgrum, 2001). The result from the two indicators showed that the developing countries were empirically disadvantaged. Such evaluations do not accommodate contextual factors such as infrastructural variances across the divide. Vainikainen, Soriyan, Korpela and Saranto (2014) distinguish the context of the African continent from the others along the lines of slow technological and infrastructural development, arising from precolonial dominance. These typical fundamental issues rarely apply to developed contexts and should therefore be accounted for during evaluation of innovative processes.

1.3 The research questions

The objective of this research is twofold. Firstly, to provide insight into technology integration within the Nigerian education context. Second, within the Nigerian context, to highlight practical technology integration opportunities as a channel for improving the quality of education. To achieve these objectives, the following research questions were addressed:

1. How prepared are students and teachers towards integrating technology in Nigerian schools?
2. What factors motivate or discourage teachers in applying technology for teaching?
3. What factors are not accounted for when considering technology integration?

1.4 Scope of the study

The boundaries and considerations defining this dissertation include:
Technology integration: Technology integration is discussed generally in this study. This means we consider all forms in which information technology is used for educational purposes as technology integration. Information technology is also used in informal education but it is however, beyond the scope of this study and therefore will not be addressed.

The focus of the study is on the education stakeholder perspectives – teachers and students: Previous research conducted outside and within the context of developing countries have considered individual stakeholder's view on educational technology.

Finally, the case of Nigeria is selected as representative of a developing country context: An increasing number of studies were found on the subject of technology integration in education with most of them being conducted in the USA, Asia, Britain, Scandinavia, and Australia but limited studies have been conducted within the context of developing countries (see Bond, Zawacki-Richter & Nichols, 2018; Durak & Çankaya, 2018).

1.5 Structure of the thesis

Figure 1 represents an overview of the study in relation to the research framework and how the research questions were addressed. Hereafter, the thesis is structured in the following way:
Chapter 2 elucidates the research context. Chapter 3 presents the theoretical foundation that guides the study. In chapter 4, the research method, data collection method, and data analysis techniques used are discussed. Chapter 5 presents a summary of the included papers along with their contributions. In conclusion, chapter 6 discusses the major findings of the study in relation to the research questions as well as the limitations and directions for future research.

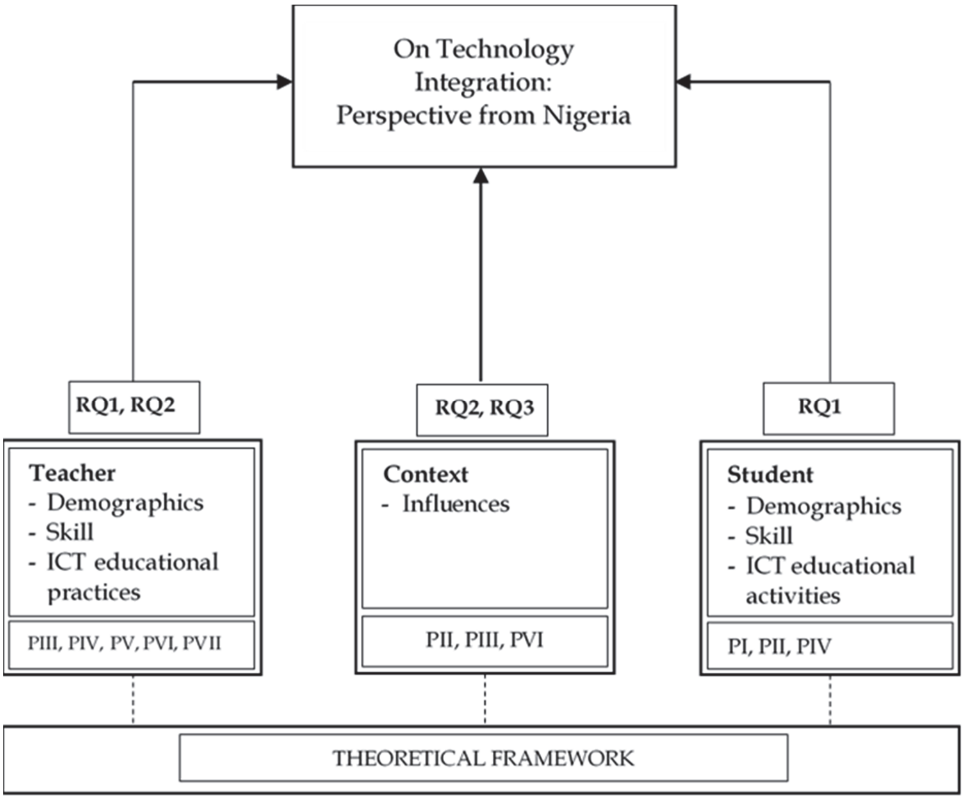

FIGURE 1 The research study's framework

In summary, the study answers three research questions using the perspectives of the Nigerian teachers and students. The context of the developing country in this case is perceived to have a strong influence that distinguishes the technology integration process from the developed countries' context. The theoretical framework is used as a guide in the study. Altogether, the thesis consists of seven articles that provided the answers to the research questions as represented in the Figure 1.

2 THE RESEARCH CONTEXT, NIGERIA

In order to provide a clear understanding of this study, this chapter discusses the subject of context. Information on Nigeria's profile (2.1) is presented first, followed by explanations on her education system (2.2) and contextual problems (2.3).

2.1 Country Profile

This study was conducted in Nigeria. The population of the country is about 197 million (World Bank, 2019) which accounts for 2.61% of the world's population (Worldometer, 2019), 47% of the West African population and about 20% of the Sub-Saharan Africa population. With a landmass of about 923, 770sqkm and about 274 ethnic groups (World Bank, 2019). Education is seen as an economic driver for the development of any nation but for Nigeria, on one hand is the struggle for more economical options of education. On the other hand is the continuously growing population while the national resources depreciate (World Education Services in WENR, 2017).

Nigeria is ranked 157 among 189 countries and classified as a low human development country from her 2017 Human Development Index (HDI) value of 0.532 (UNDP[4], 2018). Moreover, between 2010 and 2015, the completion rate according to the level of education (primary, lower secondary and upper secondary) in the country was estimated at 66%, 52% and 50% respectively (GEM report, 2017/8). In addition, GEM (2017/8) reports the country is recognized among the E9[5] but is lagging on providing the required information on indicators that enable the assessment of her quality of education despite her pledge towards the SDG4.

4 United Nations Development Programme.

5 E9 is a group of middle income countries constituting more than 50% of the world population. Others in the group are Brazil, Egypt, Indonesia, Mexico, Bangladesh, China, India and Pakistan.

According to the Global Information Technology report which used Networked Readiness Index (NRI) to measure countries leading in ICT related revolutions worldwide, Nigeria is said to score low on all indices (WEF[6], 2016). Nigeria has an aggregate of 3.2 (on a scale of 1-7) and therefore ranked 119th among 143 countries in NRI. The NRI currently consists of 53 indicators and is used to assess important capacities in economies where ICT can influence progress socioeconomically. It can be deduced from this NRI value that Nigeria is far behind on applying ICT for advancement.

2.2 Education in Nigeria

Although Nigeria is multi ethnic, the language of instruction is generally English. The federal, state, and local government, together with the communities and private organisations in Nigeria, all share the mandate for delivering the objectives in the education sector. Such a system of governance signifies the decentralisation of authority and responsibility which should ultimately result in equal opportunity in education for the populace (UNESCO, 2015). Basic education is mandatory and provided by the government. Generally, this begins when a child is five years and over a period of nine years. Formal education (see Figure 2) previously consisted of four levels: six years of primary school, three years of junior secondary school, three years of senior secondary school, and four years of university or undergraduate education leading to a degree award.

Currently, the first and second levels are merged and thus referred to as nine years compulsory basic education. The purpose of this strategy is to improve access to education and engender a creative workforce (FME[7], 2014). In addition, technical and vocational education is available. While the junior secondary school is both pre-vocational and academic, inclusive in the senior secondary school are technical, commercial, and vocational subjects designed to suit the labour market demands.

6 World Economic Forum
7 Federal Ministry of Education

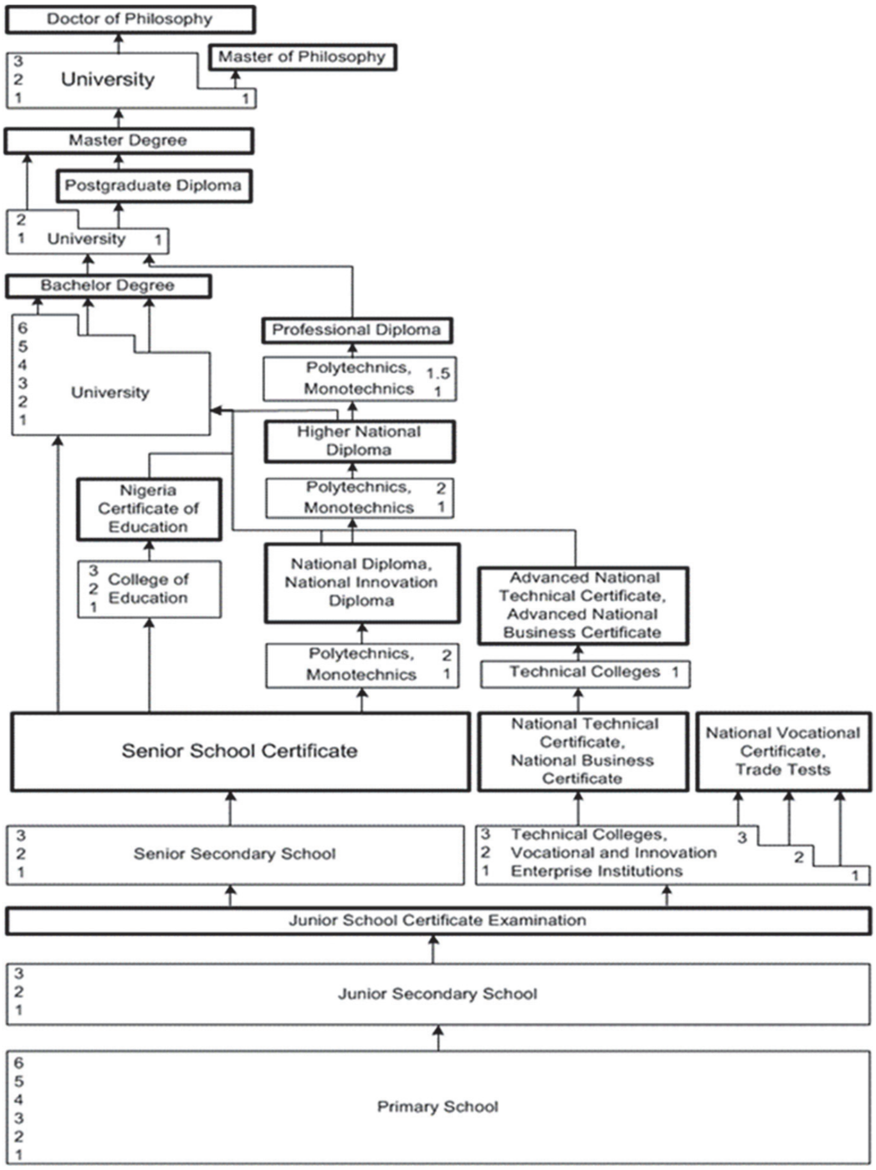

FIGURE 2 Education system in Nigeria by World Education News and Review (2017)

In addition, colleges of education are provided and devoted to training professional teachers. With a duration of three years, the training requirement is fulfilled and a Nigerian Certificate in Education is awarded. As an entrance requirement at university level, students are expected to pass the national test by the Joint Admissions Matriculation Board (JAMB) and have the minimum five credits in senior secondary school certificate (usually in English, Mathematics, and other subjects). The academic year in the country begins in September and ends in July (similar to countries like United Kingdom and Cameroun).

FME (2019a) reflects that presently, the country has 174 universities. Of the 174 universities, 43 are Federal universities, 52 are state universities while 79 are owned privately. In relation to tertiary institutions, there are 151 Colleges of Education, 188 Polytechnics and Monotechnics. The country's growing population has resulted in the noticeable oversubscription for higher level education (Ifinedo

& Kankaanranta, 2018; Oyewole, 2010). An example that validates this claim is that, as at 2017 and 2018, it was estimated that about 85,251 Nigerian students, study in foreign countries with the top three destinations being the UK, US, and Malaysia (UIS, n.d). In addition, acquiring an education in terms of degree qualification is perceived as a level of affluence among the populace. The notion is that the average educated person, specifically a graduate, has better prospects in life or better head start.

The aforementioned Nigerian tertiary institutions are regulated by the National Universities Commission (NUC), the National Board for Technical Education (NBTE) and the National Commission for Colleges of Education (NCCE). In Nigeria, the Colleges of Education (or CoE) trains future teachers in various programs such as Early Childhood Care and Education, Primary Education, Language Education, Secondary Education and Adult Non-formal Education. Thus, a graduate from CoE earns a Nigerian Certificate of Education which is the minimum educational qualification. Such a graduate is licensed to teach up to the junior secondary school level (i.e., grade 9) while a university graduate with a bachelor's degree in education (B.Ed. or B.Sc./Ed.) is licensed to teach at senior secondary school level (i.e., grade 12). Despite the large number of teacher training colleges and diverse programs offered, some authors (e.g., Barnes, Boyle, Zuilkowski & Bello, 2019; Ofoegbu, Okaro, & Okafor, 2018) have lamented the low level of content knowledge of the Nigerian teacher educators. Among others, this problem was ascribed to the lack of teaching equipment, internet access and poor policy.

2.3 Comparing disadvantaged learners across context

A study related to disadvantaged learners who dropout of schools within the context of OECD countries was conducted by Kozma and Wagner (2006). The study identified the need to provide national education policies that cater to this part of the population. The authors proposed that efforts should be directed towards the root cause of the dropout problem, which in their study was associated mainly with social factors. As a result of the social factors that were established in their study, they proposed solutions that are ICT based as well as to *'support social engagement with learning'*. The two main factors they enumerated as the root causes of student dropout are as follows:

Individual level: this group consists of factors that are associated with the student's early school experience and or, poor academic performance which leads to academic failure. However, they claim that this level could also be influenced by the other level (i.e. contextual).

Contextual level: this level can further be decomposed into social economic factors (such as economic status, parents' level of education) and sociocultural factors (which account for differences in culture, values, and influence from the parents, community, peers, and school).

Similarly, UIS (2012) from their perspective categorized the root cause of the out-of-school children problem in Nigeria into four major groups:

The socio-cultural demand barriers: for example, circumstances where education is not perceived as significant, as a result, parents view the children as too young and thus, may rather favour early marriage or non-formal education, gender disparity, etc.

Economic demand side barriers: These are as a result of the socio-economic status of the family. For example, in the case of poverty, parents may choose child labour or children may seek material wealth or both parents and children may be discouraged by the lack of employment prospects for school leavers.

Supply side barriers: These are ascribed to inadequacies such as lack of school facilities and infrastructure, proportion of teachers to student (PTR), lack of competent teachers, and the safety of children.

Policies, governance, capacity, and financing barriers: This includes factors such as low political will to enforce appropriate policies, weak school level management, poor financing and poor teacher development programs, inadequate supply of relevant books in basic education schools etc.

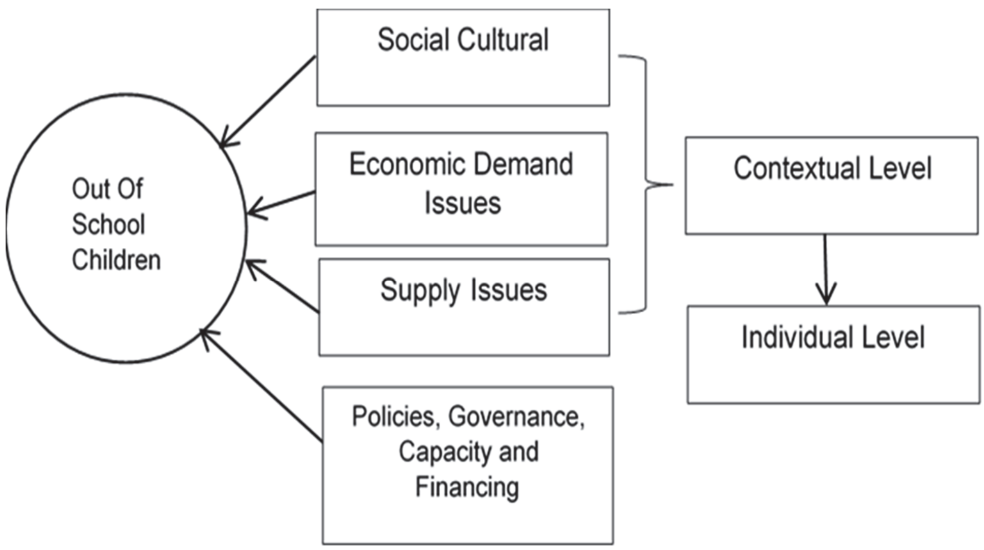

FIGURE 3 Comparing factors instigating OOSC across contexts (Adapted from Kozma & Wagner, and UIS, 2012)

In comparing the factors leading to the issue of student dropout from the aforementioned perspectives (see Figure 3), it is observed that on one hand, the contextual level described in Kozma and Wagner's study can be linked to the three of the categories enumerated by UIS. In addition, the perspective of UIS explains the individual level factors within the economic demand issues. On the other hand, it can be deduced that in the case of Kozma and Wagner, the policies, governance, capacity, and financing issues are not highlighted. The perspective from previous researchers (e.g., Akpan-Obong, 2010; Avgerou 2008; Howie, 2010; Traxler, 2018) may explain the reason policies, governance, capacity and financing issues are not included in the study of Kozma and Wagner as a root problem.

That is, the fact that the latter's study was conducted within the context of OECD countries and not developing countries may demonstrate the disparity.

Another study by Crompton (2017), on mobile learning initiatives between 2002 and 2015, revealed constraints that were typical of individual contexts along the divide of developing and developed countries. (See Table 1).

TABLE 1 Problems associated with mobile learning initiatives across contexts by Crompton (2017)

Developing Countries	Developed Countries
Lack of government policies for developing mobile learning	Student exposure to inappropriate content
Lack of modern mobile phones	Student exposure to inappropriate behaviours e.g. cyberbullying
Lack of understanding of the potentials of mobile devices for educational purposes	Lack of understanding of the potential of mobile devices for educational purposes
No network coverage	Perceived as a learning distraction by parents and those in education, or a method for students to cheat
Lack of appropriate educational resources suitable for specific regional languages	Lack of teacher training on how to use mobile devices for learning purposes
Lack of local trainers familiar with technology to sustain technical needs	Lack of bandwidth in schools
Limited battery life and lack of access to constant power supply	High cost of mobile learning initiatives

From the table, the developing countries appear to contend with more infrastructure related problems than the developed countries. A point of similarity is that in both contexts, they require elaborate enlightenment and hands-on examples on how to harness the potentials of mobile devices (and possibly other ICT in general) for achieving educational goals.

Context is therefore an important phenomenon to be emphasised when considering the implementation of an innovation like ICT. In fact, context should first be understood and explained ahead of the implementation process. Okon (2015) argues that most ICT development initiatives in Africa do not flourish because the peculiarity of her socio-cultural context is most times overlooked. Likewise, Lubin (2018) asserts that the immense educational technological contributions have not been proportionate to the outcomes in terms of boosting quality of education in developing contexts and this is attributed to the negligence of context. This sentiment is shared by other studies (e.g., Bhuasiri, Xaymoungkhoun, Zo, Rho & Ciganek, 2012) and evidenced in the comprehensive evaluation of the contextual factors that explained the differences between 26 countries using specific ICT indicators of the SITES (Pelgrum, 2001). Observable is the fact that Pelgrum's study did not provide a level playing ground for the developing countries considered because for instance, compared to developing countries, the application and physical presence of information technology in classrooms is more common in developed countries (Olofson, Swallow & Neumann, 2016).

Blignaut, Hinostroza, Els, and Brun, (2010) provide a fairer basis for comparing Chile and South Africa, both being developing countries. Their findings reveal that Chile did better in eight[8] indices, while South Africa had a higher number of schools lacking ICT skills. Three key success factors that distinguished Chile are: investments in the ICT training of teachers, school administrators who align with the vision for ICT significance and the corresponding reforms at education system level. However, the authors point out that overcrowded classrooms, lack of educational facilities, and the multiplicity of languages may be responsible for South Africa's slow adoption and implementation of ICT. Therefore, successful implementation of technology integration should be addressed analogously with the understanding of the specific context.

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8 Availability of ICT infrastructure, technical support and maintenance; pedagogical support; availability of ICT-related courses; teachers' confidence in applying ICT; principals' belief in ICT for building of 21st century skills; pedagogical practices using ICT; teachers' perceptions about the positive impact of ICT

3 THEORETICAL FRAMEWORK

In this chapter, an overview on frameworks in relation to technology integration within the education context (3.1) will be provided. This will be followed by discussions on the selected frameworks used for the study (3.2), alongside the rationale behind these choices.

3.1 On theories in educational technology

Prior to 2005, research on technology integration in education lacked the use of framework (Bond, Zawacki-Richter & Nichols, 2018; Mishra & Koehler, 2006). For example, frameworks that could be used to direct teachers on how to apply ICT in the classrooms were scarce (McCusker, 2017). In fact, Bernard, Borokhovski, Schmid and Tamim, 2018 observed that early research concerning technology integration dwelt on testing and comparing improvement in learning experiences. Similarly, Mishra and Koehler (2006) adjudge the slow pace of technology integration in education to the misdirection of emphasis, which was on technology rather than the process of integration.

Although not all prior studies have employed the use of a framework in their investigations (Kaliisa & Picard, 2017), a variety of frameworks have been used in a number of educational technology studies that exist. As explained earlier, the wide spread availability and use of mobile devices resulted in the application of such technologies in learning environments. This trend gave rise to numerous studies discussing for example, adoption of WhatsApp in learning using the Decomposed Theory of Planned Behaviour developed by Taylor and Todd (1995), (Nyasulu & Chawinga, 2019). In mobile learning studies, Al-Emran, Mezhuyev and Kamaludin (2018) reviewed 87 studies that used the Technology Acceptance Model framework by Davis (1989).

From mobile learning studies in developing countries' context, Kaliisa and Picard (2017) found that the use of Technology Acceptance Model was the most common. Other theories consisted of those founded on Bourdieu, Authentic learning, Unified Theory of Acceptance and Use of Technology (UTAUT), Access to ICT, Framework for the Rational Analysis of Mobile Education (FRAME) by

Koole (2006), Diffusion of Innovations by Rogers (1962), Theory of planned behaviour by Ajzen (1991). As noted by Kaliisa and Picard (2017), these theories generally focus on the rate of technology adoption and perception of the users. Howard and Maton (2011) noted that early conceptualizations of knowledge was influenced by a dichotomy of lenses – psychological (knowing) versus sociological (knower) and thereafter, the variants of social constructivism became predominant in the 1970s. Similarly, Graham (2011) enumerates that some reasons for the lack of theory within the educational technology research field over the years were: the evolving technology, misguided research questions, poor methodological designs, and less emphasis on theoretical structures. Moreover, a framework that would guide the practical use of technology in the classrooms was lacking in literature until the development of Technological Pedagogical and Content Knowledge (TPACK) (Archambault & Barnett, 2010).

3.2 Theoretical frameworks used in the study

Having explained in the first and second chapters the objective of this research and the particular interest in contextual influences on technology integration, it was necessary to select suitable framework(s) along these lines of thought. Accordingly, TPACK (3.2.1) and SITES (3.2.2) were practical fits because of their consideration for contextual influences. However, previously reviewed literature on studies using the TPACK framework was lacking the perspectives of developing countries (Chai, Koh, & Tsai, 2013; Voogt, Fisser, Roblin, Tondeur, & van Braak, 2013; Willermark, 2018; Wu, 2013).

3.2.1 Technological Pedagogical Content Knowledge (TPACK)

TPACK is an advancement of the teachers' knowledge requirement conceptualized as Pedagogical Content Knowledge (or PCK) by Shulman (1986, 1987). The motivation for PCK was derived from the imbalanced priority given to the individual concepts and the resultant effect on the teacher education programs. Shulman (1986) on PCK contends that although an offshoot of the two distinct knowledge domains, the pure blend of both knowledge results in effective teaching. As he explains it, PCK is "*the ways of representing and formulating the subject that make it comprehensible to others*" which includes recognising the *conceptions* and *preconceptions* of the students on the subject thus, requiring that teachers have a robust repository of knowledge (p.9).

For today's digital era, Koehler and Mishra (2005, p.132) describe the relationship between teachers' knowledge and the technology as being mutual. While, Ertmer and Ottenbreit-Leftwich (2013) stress the mutual relationship between teachers' pedagogical knowledge and knowledge for integrating technology. Implying that teachers' knowledge requires more than just about the technology rather, it is a systemic knowledge and intricate in nature because it requires an understanding of the network of elements within the teaching context (i.e., the users, technology, practices, and tools). The TPACK framework was therefore designed to capture the intricate nature of this knowledge that an efficient teacher should possess in these times.

As shown in Figure 3, the framework describes three main knowledge aspects (i.e., Technology, Pedagogy, Content or TK, PK, CK). Further, accentuated in the framework is the synergy and network among these main knowledge aspects, which result in three other distinct knowledge aspects (i.e., TCK, PCK, TPK). Finally, the relationship among the latter three form the seventh distinct knowledge aspect – TPACK.

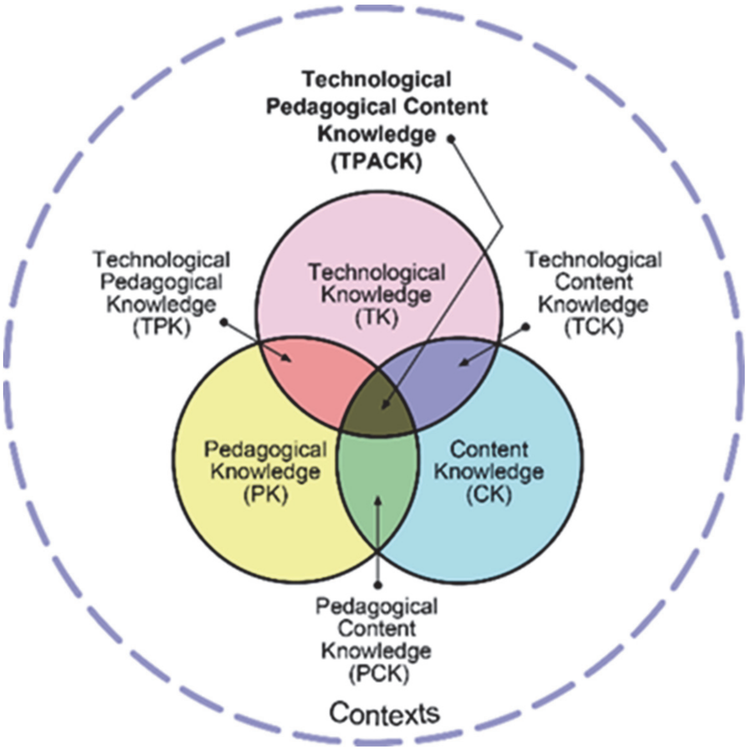

FIGURE 4 TPACK framework reproduced by permission of the publisher, 2012, http://tpack.org

The seven knowledge constructs represented in this framework (Figure 4) are described accordingly.

3.2.1.1 Content Knowledge (CK)

CK refers to knowledge of a specific subject that is to be learnt of taught. Bearing in mind that the content of the English language for a first-grade student is different from that of a high school student.

3.2.1.2 Pedagogical Knowledge (PK)

PK describes an understanding of the strategies and systems involved in teaching and learning towards accomplishing the long-term educational goal. In this instance, the teacher knows the appropriate method for assessing what the learners have understood, what teaching strategy would be more rewarding for the specific group of learners.

3.2.1.3 Technological Knowledge (TK)

TK involves the knowledge of different types of technologies (regular or contemporary) and the ability to manipulate them. Example of regular technologies are blackboards and projectors while contemporary technologies are laptops and Internet. Given the constantly evolving nature of technology, TK requires that teachers are equally updating their learning and adapting their knowledge accordingly.

3.2.1.4 Pedagogical Content Knowledge (PCK)

PCK is parallel to the Shulman perspective provided earlier. This distinct knowledge requires the ability to identify specific pedagogic strategies that suit specific contents and vice versa. Thus, it is a fine blend of the constituting knowledge domains.

3.2.1.5 Technological Content Knowledge (TCK)

TCK describes the distinct knowledge arising from the blend of TK and CK. In practice, the teacher understands the effect of one on the other. For example, a teacher with this knowledge understands the potentials and effect of technology on the teaching of the specific subject.

3.2.1.6 Technological Pedagogical Knowledge (TPK)

TPK is the understanding of how to apply technology in alignment with the pedagogical objective. It involves strategically choosing the technology based on the knowledge of its capabilities in evaluating for example students understanding, being the pedagogic objective here.

3.2.1.7 Technological Pedagogical Content Knowledge (TPCK or TPACK)

TPACK is thus, a distinct knowledge resulting from the blend of the three knowledge aspects. It is a specialized type of knowledge that characterizes an effective teacher in today's technologically influenced world.

There have been various attempts at modifying the TPACK framework (e.g., Angeli & Valanides, 2009; Chai, Koh, Lim & Tsai, 2014; Koh, Chai & Tay, 2014). One of such was in the direction of knowledge of scope and actors (see Figure 4). Based on their review of TPACK research literature, Porras-Hernandez, and Salinas- Amescua, 2013 offered a broader perspective of the framework by highlighting components of actors (Teachers and students) and scope (micro, meso and macro).

3.2.1.8 Context

Although context plays a significant role in technology integration, it has been rarely and vaguely defined or even applied differently in previous studies (Porras-Hernandez & Salinas-Amescua, 2013). Recently, Mishra (2019) argues that context should be recognized as a distinct knowledge construct in itself and in addition to the other seven knowledge constructs, a teacher's knowledge for integrating technology is fortified. Notwithstanding, in relation to previous studies, context can refer to the subject that is learned in the classroom (e.g., Bauer, 2013; Guerrero, 2010). It has been applied with respect to the background of the students (Angeli & Valanides, 2009; Shulman, 1986). The prior experience, training or beliefs of a teacher can explain a teacher's context (Angeli & Valanides, 2009; Shulman, 1986). Another representation (which applies to the current study) is its use in describing the prevailing conditions and culture of the institution or environment where learning and teaching is conducted.

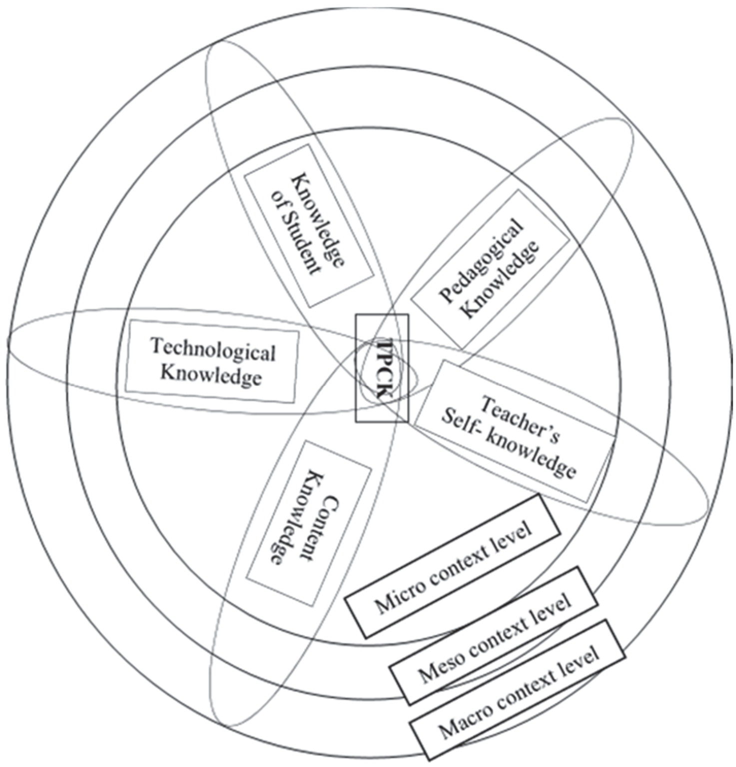

FIGURE 5 The expanded TPACK framework by Porras-Hernandez and Salinas-Amescua (2013, p.232)

3.2.1.8.1 Macro context

This level is characterized by influences as a result of "*social, political, technological, and economic*" actions (Porras-Hernandez & Salinas- Amescua, 2013, p.228). Policies at global level such as the Millennium Development Goals (MDG) and Education for All (EFA) have influenced the policies in Nigeria at the National level. For example, actions taken to address aspects concerning increasing access to education and improving literacy rates. Another example is, as a result of technological developments and global policies, the FME (2019b) was motivated to strategize on how to integrate technology to meet Nigeria's education demand and objectives. For instance, the mission statement for the national implementation of ICT in education (p.2) is as follows:

> To meet human capital requirement of the nation for attaining and enhancing sustainable socio-economic development, global competitiveness as well as the individual's ability to survive in a contemporary environment

This mission statement is accompanied with practical objectives such as facilitating teaching and learning processes, access to education, improving future skills, advance the commercialization of ICT in education and ensuring that teachers are trained to teach using ICT. Thus, indicating a level of commitment to the application of ICT in the Nigerian schools.

3.2.1.8.2 Meso context

At this level, decisions and influences of the school administrators, guardians and the entire school community are represented. The technology integration related choices and dispositions of this group of persons at this level of context evidently influence the teachers' own decisions on applying technology in their classroom.

3.2.1.8.3 Micro context

This aspect of context is defined by the learning circumstance within the classroom. This includes for example, the physical presence of ICT and the teacher's strategy on accomplishing the educational goals. It is at this level, that the educational interaction as a result of the network among the content, teacher and students is emphasized (Ifinedo & Rikala, forthcoming).

3.2.2 The Second Information Technology in Education Study (SITES)

The Second Information Technology in Education Study (here after SITES) programme is a project that began in late 1990s (see Carstens & Pelgrum, 2009) by International Association for the Evaluation of Educational Achievement (IEA). It consists of several modules that investigate the effect of ICT on students and the way they learn in schools. The first module of SITES was aimed at studying the preparedness to incorporate the use of ICT for teaching and learning in schools. This module was based on a school survey carried out in 1997. In 2001, the second module was designed to compare and examine the relationship between innovative pedagogical practices and the use of ICT in the classrooms. This second phase used 174 case studies of innovative pedagogical practices from different countries. The objective of the third module by 2006 was to highlight the pedagogical practices in use by teachers and schools of different educational systems and their application of ICT in these practices. Consequently, a conceptual framework for the analysis of ICT-using pedagogical practices was formed (see Figure 6).

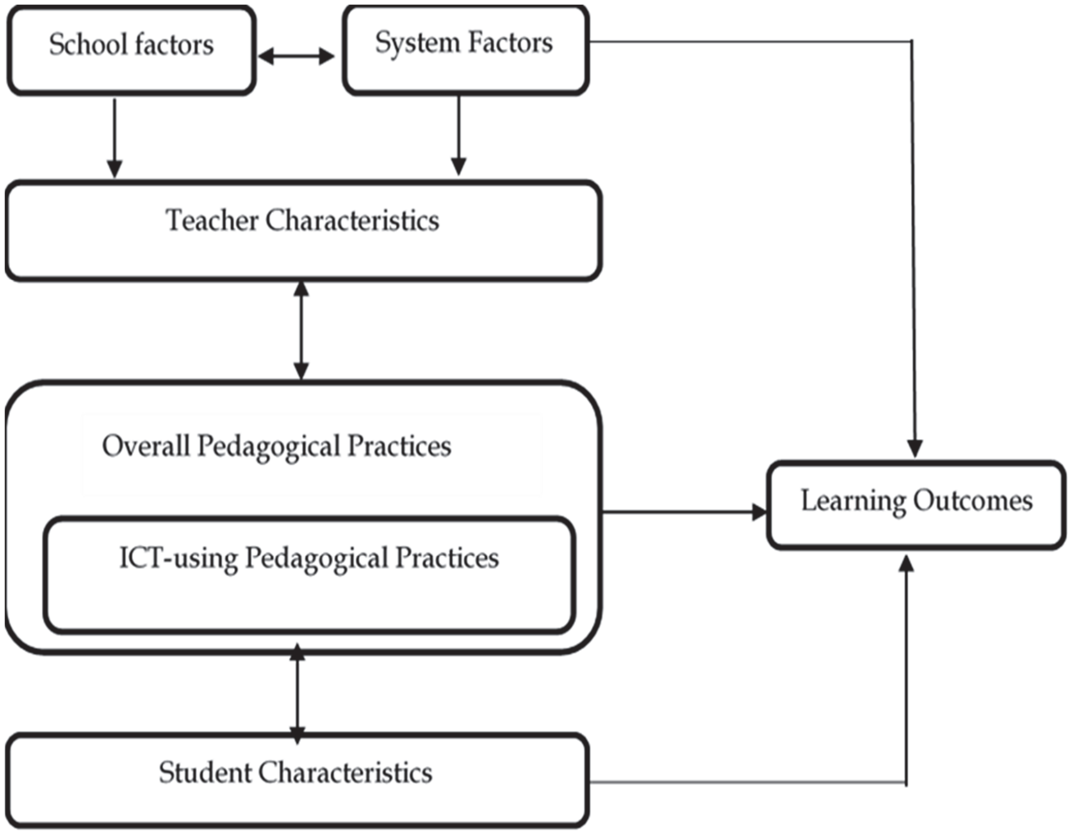

FIGURE 6 The 2006 conceptual framework of SITES by Carstens and Pelgrum (2009, p.13)

The framework is based on the premise that the experience from the students' pedagogical practices affects their learning outcome and these outcomes in turn affect the teachers' decisions eventually. Other factors such as the teacher, the school and the system go through changes in order to adapt to the impact of pedagogical practices. This structure highlights the role that teachers play as a major aspect to be considered in the use of ICT devices for learning. Some of the survey concepts used in SITES, which are relevant to this study will be applied. This is to ascertain the representativeness of the framework and the ensuing result in the Nigerian context and by extension, other African countries or institutions. This research in line with the objectives of SITES, will improve the understanding of the influence of ICT use on students' learning experience and teachers' pedagogical practices.

The thesis author views the system and the school factors of the SITES framework as similar to the macro and meso context levels explained in the TPACK framework (3.2.1.8.1 and 3.2.1.8.2) respectively.

4 METHODOLOGY

The purpose of this chapter is to provide information regarding the philosophical assumptions underpinning the study (4.1). Next, explanations on the research design are offered. The information on the data and analysis techniques used in the study are discussed in 4.3 and 4.4.

4.1 Research Methodology

When undertaking research, the researcher's actions are influenced by philosophical assumptions. These assumptions are labelled differently by authors for example, as 'worldview', 'paradigms', 'research methodologies', 'epistemologies and ontologies' (Bettis & Gregson, 2001; Creswell, 2009) but their connotations are the same. In this thesis, the 'worldview' label is used. The feature of any worldview is shaped by the process of inquiry and at the centre of the research inquiry process are three questions: what is reality and is it a function of human perspective? (Ontology), what is the nature of reality? (Epistemology) and the method.

To achieve the objective of this study, the philosophical assumptions of the pragmatic worldview was adopted (Creswell, 2009). Pragmatism uses sound practical reasoning that is not limited to a specific form of reality (Creswell 2009; Shields, 1998). Thus, the researcher attempts to appreciate the research problem and purposefully decides the best way to answer the research question by applying a variety of assumptions, methods and techniques (Figure 7).

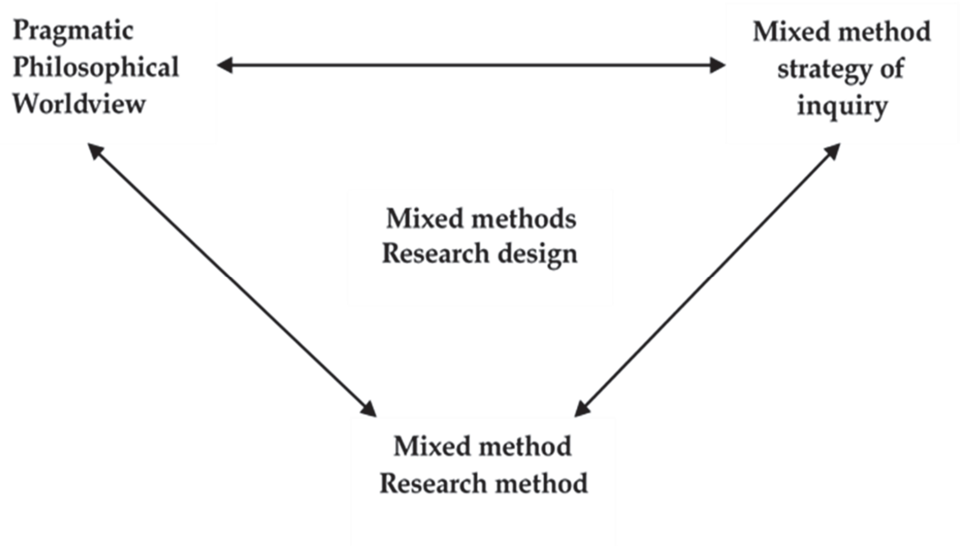

FIGURE 7 Framework of the research design (adapted from Creswell 2009, p.5)

In contrast to other philosophical ideologies (Postpositive, Social construction and Advocacy), the pragmatic view is not restricted to one system or reality and it offers the liberty in selection of methods that enhance the research goal. As such, the strategy of inquiry used in this study is the transformative mixed method. A transformative mixed method is one that involves the use of a theoretical framework as a guide (Creswell, 2009).

4.2 The Mixed Method Research Design

Although, there is a lack of uniform design on the use of mixed method in literature, Creswell, Plano Clark, Gutmann and Hanson (2003) identified four common factors that characterize a mixed method design namely: Implementation of data collection, Priority, Integration and Theoretical perspective. In all the cases, the researcher's decision on each factor should be instigated by the goal of the research.

The data collection implementation procedure: This refers to the order in which the qualitative and quantitative data was collected or incorporated. There are two sequential procedures where either the qualitative or quantitative data is collected or incorporated one ahead of the other and a third procedure where both qualitative and quantitative data are collected or incorporated *concurrently.*

Priority refers to the level of influence either of the qualitative or quantitative data collection has during the period of collection. Usually, the researcher determines whether or not to prioritize either, or if to prioritize then, which method should dominate the other. Priority can be reflected all through the research (that is, from introduction to the discussion of result).

Integration stage is defined as '*the combination of quantitative and qualitative research within a given stage of inquiry*' (Creswell et al, 2003, p.173). For example, formulating research questions inductively or deductively. In this case, the period during which the research question is formulated is the inquiry stage. Other stages of inquiry are the data collection, Data analysis and Data interpretation.

Theoretical perspectives: There are two variants for this perspective. Firstly, the view of the researcher (informed for example, by experiences) which is indicative of their position in the research. Secondly, when the researcher uses a theory as a lens to view the research. A mixed method design that uses a theoretical lens is referred to as a transformative design (Greene & Caracelli, 1997).

The aforementioned factors will next be explained in the way they were applied in the context of the present study.

4.2.1 Applying the mixed method design in the study

The study employed the *Concurrent transformative design* of mixed method (see Figure 8) to which end, the theoretical frameworks of TPACK and SITES (described in chapter 3) essentially motivated the decisions on the methodology used. The main data (both qualitative and quantitative in nature) in the study were collected simultaneously. One reason for using this method is because the thesis author views the study from both deductive and inductive perspectives. From the inductive perspective, the emphasis lies in understanding the meanings attributed to the significance of technology integration by the teachers in the classroom environment while the deductive perspective aims at testing the TPACK and SITES frameworks. Another reason for this choice was to elicit the advantages of both quantitative and qualitative methods (Johnson & Onwuegbuzie, 2004). As they affirmed, the choice on when and how the researcher should merge both approaches should be driven by how best the research questions can be answered.

In summary, the main data (qualitative and quantitative) was collected by the thesis author from the teacher educators (TEs) of three colleges of education from the southern part of Nigeria between December 2017 and January 2018. The thesis author discussed with the research participants, the intention to collect both types of data using equal emphasis on the significance to the study. Thus, equal priority was given to both data collection methods at the data implementation stage. Amidst the research process, the quantitative data received some level of priority over the qualitative at the data analysis phase. This is reflected in the number of articles that used quantitative analysis to answer some of the overall research questions. The mixing of both methods occurred during the qualitative analysis of PIII, where some of the data being descriptive was represented quantitatively while in PIV, the result from both methods were integrated to show the influence of school level support on technology integration.

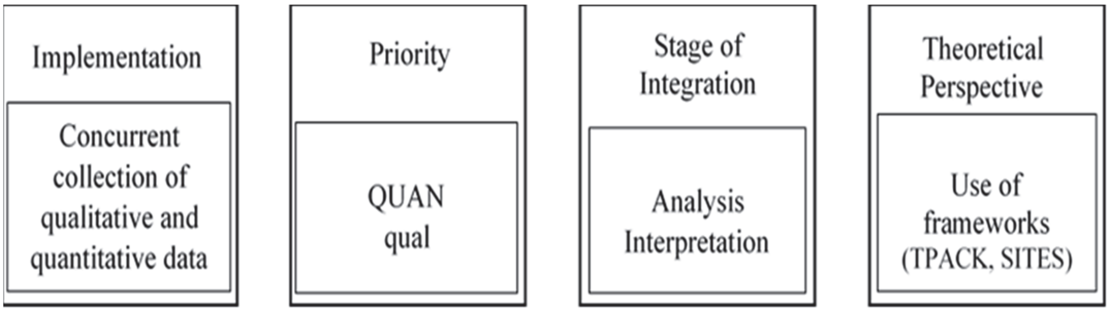

FIGURE 8 Concurrent transformative mixed method design (adapted from Creswell et al., 2003)

4.3 The Qualitative Data

On arriving at the proposed research sites, the thesis author contacted the office of the Provost (administrative heads for the institution) of two Nigerian colleges of education using a hand delivered letter (see appendix 1) explaining the intent to schedule an appointment for interviews in order to obtain their perspectives on the subject of the research. These attempts failed as one of the schools' Provost responded with a letter instructing that no negative insight about the school should be published while the other out rightly declined. Thereafter, the thesis author decided to approach the teacher educators (or TEs) of the schools on individual basis. After introducing the purpose of the research to some of the TEs and with an assurance of anonymity, the author was able to find voluntary participants (who in turn, invited other colleagues) for a focused interview (Catterall & Maclaran, 1997) at the three schools. In addition, one TE in every school acted as a 'gatekeeper' (Bryman et al., 2011, p.350). For example, the use of a gatekeeper made it possible to communicate and easily reschedule an interview at one of the schools. Rescheduling the interview was due to the nationwide fuel scarcity that affected the availability most of the TEs on a previously agreed date. In this way, the thesis author was able to save travelling cost and time since these schools are in different cities.

4.3.1 Analysis of the qualitative data

In total, the three focused interviews (Catterall & Maclaran, 1997) consisted of nineteen TEs (12 males and 7 females) and lasted 99 minutes and eight seconds. A Samsung tablet device was used to make video recordings in all three focused interviews which held in the office of one of the TEs as agreed by the others (in each of the three instances). The specific question asked during the interview was, *what factors act as facilitators or inhibitors to the use of ICT from teacher educator's perspective*? The following supplementary questions were further used to obtain more information:

- Currently do you use or have you had a reason to use ICT in your classrooms?
- Does your school promote the use of ICT in your school? If yes,
- Does your school provide technical support personnel?
- Do the students of your school have access to ICT in the school?

Afterwards, the qualitative data collected was analysed using the open, focused, and theoretical coding as described by Thornberg and Charmaz (2013).

4.3.1.1 Notes on the research sites and visit

In majority of the classrooms in the three schools, the types of technology present were chalk and board. The teachers however, mentioned that they had buildings dedicated to the use of computers where the students could get access if needed. The thesis author was able to see the computers in these buildings in the case of school I and II. The computer building was locked and could not be accessed in school III. (See photos of computer buildings and classrooms in appendix 2 as well as the links to short video clips[9]).

In school I, the teachers seemed very satisfied with the provisions the school made in terms of ICT. They mentioned that their school supported technology integration by providing them laptops. They alleged that both teachers and students have access to their e-library and technical support. In addition, students usually go to the e-library to complete course assignments by using resources from the Internet. During the data collection period, the thesis author observed that the teachers in this school had their laptops on their desks at most of the offices visited.

In school II, the teachers complained that a good number of the computers in the dedicated building were not functional. In addition, they claimed that the school administration was not supportive of ICT use through their own assessment of the school's policies, infrastructure, lacking professional training opportunities and technical support staff. For example, one of the teachers complained that her laptop (provided by the school) was having battery related problems and because it was an outdated model, it was difficult to fix. These problems increased the burden of teaching with technology in their classrooms.

School III could be placed somewhere in between the other schools. The teachers in this school mentioned that even though they had magic boards and computers in the computer buildings[10] , they still needed some connections[11], before they could have access to the building. They further acknowledged that previously (some years ago), the school organized external ICT trainings for teachers as a pre-condition for job promotion. Such trainings were no longer provided. At the time of the data collection, the thesis author observed that the teachers' offices had white boards and in addition, some teachers were working with laptops that were allegedly not provided by the school.

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9 https://figshare.com/s/13ed9d39c5e008a82947
https://figshare.com/s/5c25b606659b12949256

10 There were three such buildings spread across this school

11 Having a certain level of rapport with the authority

Additional information on the qualitative aspects of the research can be found in article PIII.

4.3.2 Trustworthiness of the research

The trustworthiness of the qualitative data and analysis is explained along four constructs; credibility, transferability, dependability, and confirmability (Bryman et al., 2011; Lincoln & Guba, 1985). To ensure the credibility of the research, the data collection was obtained by observing research ethics. The objective of the research was explained in clear terms to the respondents and the videos recordings were replayed to the gatekeepers (i.e., respondent validation).

For transferability, the research context was discussed in details in the corresponding articles and in this summary. In addition, access to short video clips and pictures of the process were made available to provide in-depth descriptions on context.

To provide for dependability, records of procedures such as fieldwork notes, videos, interview transcript and data analysis are properly kept. In addition, the thesis author obtained auditing support by discussing the analysis and coding of data with co-author and research colleagues.

The thesis author admits that confirmability to an extent may have been challenging in the research therefore, the total delineation of her predispositions and bias in relation to the study should be ruled out. However, she has been transparent in providing all the necessary information at all phases of the research.

4.4 The Quantitative Data

To ensure content validity, the first version of the survey instrument was reviewed by an expert in research on the use of technology in teacher education thereafter, the feedback was used to improve the design.

While at the research site, the difficulty in accessing the school administrators in some schools (explained in 4.3) and the limited resources made the thesis author consider the option of concentrating on the teachers' perspective as optimal. In addition, the author of the thesis was sceptical about disseminating an online version of the survey because several *gatekeepers* mentioned the risk of low response given the structure of the questions. Therefore, data was quantitatively collected using paper based self-reporting survey. In most cases, for the TEs who agreed to fill the survey, the responses were collected immediately while a few others asked the thesis author to return at a later date for pickup (half of these surveys were not returned).

Of the 200 questionnaires that were distributed to the TEs, 148 were returned, denoting a 74% response rate. The questionnaire was made up of three sections that addressed different aspect of the research. The first section collected the demographic information of the research participants. Table 2 shows the variables and descriptive statistics on the demographic section of the main survey.

TABLE 2 Demographic information of the research participants

Variable	Content	Frequency	Percentage
Gender	Male	81	59.6
	Female	48	35.3
	missing	7	5.1
Age group	25 – 29	3	2.2
	30 – 39	25	18.4
	40 – 49	60	44.1
	50 – 59	42	30.9
	Above 59	5	3.7
	Missing	1	0.7
Categorized department	Art	11	8.1
	Science	48	35.3
	Social science	68	50
	Missing	9	6.6
Work title	Lecturer	117	86
	Senior lecturers	5	3.7
	Principal/ Chief lecturer	6	4.4
	Non-academics (instructors)	2	1.5
	Missing	6	4.6
Teaching experience	below 2 years	2	1.5
	2 - 4 years	8	5.9
	5 – 9 years	36	26.5
	10 – 19 years	52	38.2
	Above 19 years	38	27.9
Average class size	0 – 50	60	44.1
	51 – 100	23	16.9
	101 – 150	13	9.6
	151 – 200	1	0.7
	201 – 500	19	14
	Above 500	5	3.7
	Missing	15	11
Device ownership: (Phone, laptop, tablet, desktop computer)	Only one	10	7.4
	Combination of 2	70	51.5
	Combination of 3	43	31.6
	Combination of 4	12	8.8
	Others	1	0.7

The first section of the survey instrument collected information on seven variables with majority of the respondents being male, own at least two ICT devices and 44% are between the age group of 40 and 49. More information is available on the table and from the analysis of the corresponding articles.

The second section of the survey was used to examine the teachers' ICT practices, their beliefs on impact on students and frequency of use. The questions used were adapted from a SITES related study by Kenttälä, Kankaanranta, and Neittaanmäki, (2017).

The teachers' TPACK was measured in the third section of the survey. These TPACK questions were adapted from the original survey designed for preservice teachers by Schmidt et al. (2009) but with some changes made for this study. The changes ensured that the survey could be applied to in-service teachers as was the case in the current research. For example, the questionnaire for this study was not subject specific so as to allow for a broad range of subjects to be observed. However, this resulted in a one indicator construct for the technological content knowledge (TCK), which affected the final choice of software used in the analysis (see 4.4.1). Another item changed was, 'I can adapt the use of the technologies that I know in different teaching activities' became a replacement for 'I can adapt the use of the technologies that I am learning about to different teaching activities', because the current study did not include technological training courses as part of the research design.

Overall, the survey instrument consisted of questions that have been employed in previous studies and of varied Likert scales (from 3 to 5). Further details on these aspects of the questionnaire are available in appendix 3 and the corresponding articles (i.e., PV-PVII). With respect to the specific questions, the respondents were to mark the appropriate choice on the Likert scale. The reliability of each construct used in the individual articles (PV -PVII) were assessed and found within the acceptable benchmarks.

A link for accessing the statistical data used in the analysis of the teacher educators' perception of their TPACK is provided below[12].

4.4.1 Analysis of the quantitative data

After the responses to the survey were collected, the thesis author returned to Finland for the next course of action. The Statistical Package for Social Sciences (SPSS) version 24 was used to pre-process the data. Consequently, variable labels and value labels were generated for each variable to enable easy interpretations of the output. For instance, from table 2, age is labelled 'age' but value label for those between 25 and 29 is 1. Of the 148 responses that were initially collected, the List wise deletion was used to remove twelve badly filled questionnaires leaving 136 useable responses.

Given previous criticisms concerning the ambiguity of the boundaries between and among the knowledge construct of the TPACK framework (Archambault & Barnett, 2010; Graham, 2011), the structural equation model (SEM) was selected for further analysis of the data. AMOS 24 software was initially selected but later found unsuitable because the minimum indicators per construct permissible in the analysis is two. Recall (in 4.4) that the TPACK questions were modified to suit the current research participants and therefore, the TCK construct ended up with one indicator. Notwithstanding, the partial least squares (PLS) procedure became the favoured. The SEM technique is used to measure complex correlations between observed variables and latent variables (Hair, Ringle & Sarstedt, 2011). It can be applied through either the covariance-based method (e.g., AMOS, LISREAL, and MPLUS) or the component-based method (e.g., PLS). Prior to 2010, the covariance based was the predominant method of SEM used (Hair, Risher, Sarstedt & Ringle, 2019). Recently, the PLS method has become attractive because in contrast to the other method, it is able to measure non-normal data and complex models having several constructs, indicators and structural paths (Sarstedt, Ringle & Hair, 2017). PLS is capable of analysing one indicator constructs and accommodates small sample sizes (Hair, Hult, Ringle, & Sarstedt,

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12 https://figshare.com/s/d294d3139901a436ea14

2016). To conduct the PLS procedure, the free three month- trial version of Warp-PLS 6.0 software developed by Kock (2017) was downloaded. Data analysis using PLS required that the information previously recorded on SPSS be converted to an Excel file. Eventually, the PLS procedure (Hair, Ringle & Sarstedt, 2011; Lowry & Gaskin, 2014) of the structural equation modelling was used to test the individually hypothesized models of the study as well as the relationship among the constructs of the models in article five to seven. In addition, the full collinearity assessment approach was used to examine for common method bias (Kock, 2015a; Podsakoff, MacKenzie, Lee, & Podsakoff, 2003). The Goodness of Fit (Tenenhaus, Vinzi, Chatelin, & Lauro, 2005), which describes the performance of both the structural and measurement model was examined according to prescribed benchmarks (Akter, D'Ambra, & Ray, 2011) in each model used in the study.

4.4.2 Reliability and validity of the research

The PLS provides for evaluating two aspects of a model, these are, the measurement model and the structural model. For every model used in the quantitative analysis of the study, the reliability and validity of the constructs used were proven in the measurement models. Reliability was evaluated through the internal consistency and indicators of the constructs by obtaining the values of their Cronbach Alpha Coefficient (α) and Composite Reliability Coefficient (Hair et al., 2011; Lowry & Gaskin, 2014). In the case of the models' validity, the value of Average Variance Extracted (AVE) was used to assess their convergent validity while and their indicator loadings and the heterotrait-monotrait (HTMT) were used to assess their discriminant validity (Hair, Risher, Sarstedt & Ringle, 2019). Across the research, the convergent and discriminant validities of the data used in the study were established in accordance to predetermined benchmarks (Hair et al., 2011; Henseler et al., 2016; Lowry & Gaskin, 2014).

Similarly, in the structural model, the data is evaluated to determine how accurately a model predicts the paths hypothesized. In PLS, this information is provided by the correlation coefficient (R^2) of the endogenous variables and path coefficient (β). Where R^2 is reflective of the percentage of the variance of a given construct in the model, β reflects the strength of relationships among constructs. The Q^2 coefficient is also used to determine the predictive validity of a model (Kock, 2015b). For each model used in the study, the R^2, β and Q^2 coefficients were explained.

5 SUMMARY OF ARTICLE CONTRIBUTIONS

This chapter provides the summary of the seven articles in this thesis. At the beginning (5.1) the relationship between the articles is explained and then followed by a discussion on their research objective individually (5.2 – 5.8).

5.1 Cohesion and Coherence of the included papers

In addressing the research objective of this study, which is to highlight technology integration as a means to improving education particularly in developing country contexts, the first paper (PI) was exploratory. Education has been influenced by the development of ICT and among the stakeholders, the students have a primary position. Learners are now perceived to be more in control of their learning process, in fact, syllabi and curricula are now designed to be 'learner centred'. Therefore, the paper set out to obtain preliminary information on students' attitude and readiness to use mobile devices for educational purposes. The findings suggest that the problems associated with technology integration within the Nigerian education context is outside the domain of the students.

Based on the assumption that technology integration could be used to improve the quality of education, it was important to highlight this potential by searching for practical gaps. Thus, PII provided in general, practical dimensions for which the technology integration innovation can be achieved in Nigeria as a solution to the education related problems (previously discussed and referred to in 1.3).

PIII elicited teachers' perspective on how they perceived the use of technology integration in their classrooms and how frequently it was used. In the process, the analysis of their responses aligned to a large extent with the TPACK framework

In the cause of the research, a gap was identified within the TPACK framework and this reinforced earlier criticism of the framework. As a result, PIV proposes the integration of the aspect that clearly captures the educational interaction between the learners and teachers within the micro level of the TPACK framework. In this way, one framework can be used to evaluate both teachers and students as against previous research that have used the framework for the one group of *actors* separately.

PV investigates in detail the technology integration readiness of the Nigerian teacher educators by examining the structure of the seven knowledge constructs defined in the TPACK model. PVI juxtaposes the findings of paper PIII and PV in order to examine difference between the teacher educators' skill and ICT practices vis a vis their respective school's support. Finally, PVII strengthens the TPACK framework by combining the teachers' knowledge constructs from the TPACK framework with their belief, ICT practices and characteristics (from SITES).

In summary, the papers PI, PII and PIV focused on student's perspective while PIII, PIV, PV, PVI and PVII addressed teacher's perspective. PII and PV highlighted contextual issues while PIV and PVII proposed the modification of the TPACK framework.

5.2 Article PI: Exploring Nigerian University Students' Perception towards Mobile Learning

This article was published in the full paper proceedings of World Conference on Educational Media and Technology (EdMedia 2017), pages 833-842.

Objectives

Generally, learners are considered important agents in the framework of educational technology. Therefore, as an explorative study, the objective was to ascertain the preparedness of the Nigerian undergraduate students towards technology integration (in this case, mobile learning).

Method

The study used a survey to sample 135 voluntary undergraduate students from two southern federal owned Nigerian universities. The survey instrument consisted of a total of 25 questions distributed among six main themes (mobile phone ownership, technological skill, internet access, perception towards social networking sites, travel history and awareness). With a response rate of 79.4%, the collected information was coded and pre-processed using SPSS version 21. Thereafter, univariate and descriptive analysis such as bar charts were used to provide answers to the study questions.

Contributions and results

The objective of the study required examining the participants' mobile phone ownership, technological skills, internet activities, daily travel history (between the school and home). In this way, availability, and accessibility of digital devices to the students provides the background information on which to build research on technology integration in the Nigerian context. The result showed that at the time, majority of the students (99%) had mobile phones and that 89 percent of them could access the internet with their phones. In addition, through the internet (as against other media outlets e.g. television, magazines, newspapers) 46 percent of them had knowledge of mobile learning. With regards to their technological skill, the data revealed that they perceived the internet as easy to use and they had above average skill in use of email, word processing and internet surfing. In terms of educational activities, the use of the internet by 51% was beneficial in completing course assignments in at least four courses. Students from faculties classified under Art and Social sciences used the internet for course assignments less than their science counterparts. Mobile phones were the predominant means of accessing the internet; followed by the use of personal laptops and public computers at cyber cafes; while the least was through the use of computers provided at school. A high percentage of students (94%) were found to use social networking sites majorly for interacting with other people and keep abreast of events. Investigation into the students' travelling habits between school and home showed that the highest percentage made the trip by bus (47%) although the duration of the trip was less than one hour.

As an explorative study, three major concepts as contributions of PI that offer credence towards technology integration in Nigerian schools are 'availability', 'interaction' and 'skill'. Availability is considered in terms of the ubiquity of mobile device ownership by Nigerian university students; interaction, in relation to the students' favourable disposition to learning through these devices and the motivation for engaging in social networking sites; while skill refers to their ability to navigate the internet to source for relevant information towards course assignment completion. Although the aim of the study at this point was not the testing of a theoretical framework, the findings thematically align (that is, device- availability; social- interaction; learner– skill) with the Framework for the Rational Analysis of Mobile Education (FRAME) model (Koole, 2006) which was designed for analysing the use of mobile devices for learning.

Author's contribution

The data used in the publication of this paper was collected, analysed and the result was interpreted by the thesis author. In addition, the thesis author wrote the article and presented it at the EdMedia 2017 conference in Washington DC, USA.

5.3 Article PII: The Nigerian Education and the Opportunities ahead for Mobile Learning

This article was published in the 2018 proceedings of E-Learn World Conference on E-Learning in Corporate, Government, Healthcare, and Higher Education, pages 246-251.

Objectives
Integrating ICT in education has the potential to improve the quality however, it is known that the integration does not occur in a vacuum. Rather, research is needed to evaluate specific challenges that require the intervention of ICT. This paper assessed the Nigerian education and practices in other to highlight practical opportunities for ICT integration.

Method
The study uses secondary data collected between May and August 2015 by both the National Population Commission of Nigeria and RTI International. Descriptive analysis was then used to obtain the results to the study questions.

Contributions and results
The root causes of three major challenges (out of school children, N= 13,996; dropout rate, N= 1,339; and low literacy rate) were highlighted in this study. At the national level, the result showed that the top five factors influencing the Nigerian school children's presence at school are: school distance, child labour, financial cost, poor school quality and the lack of interest. Other factors at this national level are: security issues, disability, illnesses, and parents' beliefs that the child is too young be in school or that education is insignificant or that there are not enough jobs for graduates. Similarly, five top factors influencing children to drop out of school are financial cost, child labour, poor school quality, school distance and early marriage. Result of survey response to questions assessing literacy (N= 78,558) and numeracy (N=78,293) shows the child literacy rate as 49%. Across the country, regional disparities were observed. For example, considering the literacy and numeracy, the north was lagging compared to the south.

Another observation was that overall, the children were better at summing than reading. In the end, the use of ICT in the form of mobile learning was proposed as a solution to the identified problems. For example, children who lack interest in schooling can be motivated by learning materials designed to attract their interests. Providing multiple channels of access to learning materials can address children with school distance problems.

Author's contribution
The author of this thesis sourced for the data, analysed, and produced the figures that were used to interpret the result. The paper was written and presented by

the thesis author at the E-Learn world conference on E- Learning in corporate, Government, Healthcare and Higher Education in Las Vegas, USA.

5.4 Article PIII: Understanding the influence of Context on Nigerian Teachers' Technology Integration

The article is under the second review at the Technology, Pedagogy and Education.

Objective
Given the role that information technology plays in the transforming the learning environment in this digital era and the role of teachers as instructors, this article presents the perspective of the Nigerian teacher educators. The aim of the research at this juncture, is to highlight the effect of context on teachers' technology integration. Their perspective which is based on practice and experience is important for designing suitable pedagogical practices that leverage on ICT usage.

Method
The data used in this paper was collected qualitatively through focused interview of nineteen teacher educators (7 females and 12 males) from three different colleges of Nigeria located in the southern region of the country. A Samsung tablet was used to make the video recordings of the interview, which lasted a total of 99 minutes and 8 seconds. Subsequently, the responses were manually transcribed on Microsoft word and analysed using the open, focused and theoretical coding technique.

TABLE 3 Factors influencing Nigerian teachers' technology integration

Scope of level context	**Attributes**
Macro	Infrastructure (4), National budget (3), Policy issues (3), Value for education (3), No funding (3), high cost of living/ data (2), Ignored research (2), Poor attitude to ICT implementation, Poor feedback, Pollution.
Meso	Facilities are inaccessible/unutilized/ outdated/ limited/ non-functional (16), Manpower/ training/competency (7), Institutional policies/ issues (7), Lack of finance (4), Poor curriculum (2), Teacher's view is not considered.
Micro	Teacher's attitude (3), Student related issues (5)

Contributions and results

The study indicated the influence of context on teachers' technology integration by aligning with the context levels (see Table 3) of the TPACK framework as delineated by Porras-Hernandez and Salinas- Amescua, (2013). Accordingly, the expanded version of the framework along two categories: the context and the actors.

Further, the context consists of three levels namely: micro, meso and macro while the actors take into cognisance the knowledge of the teacher and the knowledge of the student (as discussed earlier in chapter 3 of the thesis). The themes that emerged from the analysis of the data followed these categories.

Specifically, in the three schools, the teachers' responses mirrored the challenges from these context levels as influential factors to their decisions on technology integration in their classrooms. Generally, they attributed their success and failures more to the influence of the meso context level. For example, school I appeared satisfied with their school's effort at providing the required facilities (e.g. laptops, internet access, e- library) while the teachers from the other schools blamed their school for their inability to explore opportunities for technology integration in their classes. Along the 'actors' construct, they identified the advantages of technology integration to their teaching profession as well as to their students' learning. Nevertheless, identified in the study are teachers who despite the challenges they perceive from their context, create avenues to apply available technology in their teaching.

This study suggests that there is significant effect of context in the integration of technology by Nigerian teacher educators in their classrooms. The recognition of such contextual peculiarities outlined in this study provides support and better understanding to the TPACK model. Accordingly, the major contribution of this research is in identifying the various components of the contextual elements at play in the studied institutions, namely – micro, meso, macro, teacher, and student. In addition, successful technology integration could be influenced at the level of the institution by factors such as appropriate policies, teachers' involvement in planning process and provision of the needed facilities

Author's contributions

The focused interview was conducted and qualitative data collected by the thesis author. Subsequently, the data was transcribed, analysed, and interpreted by her. All sections of the ensuing paper were written by the thesis author who is also the corresponding author.

5.5 Article PIV: TPACK and Educational Interactions – Pillars of Successful Technology Integration

This article will be published in the 2019 proceedings of E-Learn World Conference on E-Learning in Corporate, Government, Healthcare, and Higher Education.

Objective
Educational technology is beneficial for developing learners fit for the 21st century working place and this is one of the main purposes it is advocated. On one hand, the Technological Pedagogical Content Knowledge (TPACK) framework provides a theoretical framework for understanding teachers' technology integration as they accomplish their teaching objectives. On the other hand, educational interactions have been emphasized as a critical component of the educational practices (including the processes and contexts). Relatively however, these two concepts have been studied and developed individually. The proposed framework combines the two approaches and provides a better understanding of technology-based education, with the focus on the micro context level of the classroom.

Method
Based on a collection of 88 articles, a literature review was conducted. Specifically, the focus during the assessment of these articles was on educational interactions, the TPACK framework, context, content, learners, and teachers. As a result, the inclusion of educational interaction to the TPACK framework was proposed.

Contributions and results
The article highlighted barriers to technology integration from the perspective of past literature and distinguished the TPACK framework as one that provides a firm basis for studies relating to teachers' competence and learner-centeredness in today's technology-driven era. Besides, cognizance of the context aspects and how they influence classroom interactions improves the functionality of the TPACK framework towards a digitally creative educational environment. In view of this, the paper contributes to previous discussions by proposing a conceptual framework (see Figure 10). This proposed framework advances the TPACK by including the educational interactions that occur at the micro level context. In the proposed framework, educational interactions are viewed as multifaceted, context-bound, and process-oriented concepts that depend on the learning environment, contextual factors, and the actors involved in the process.

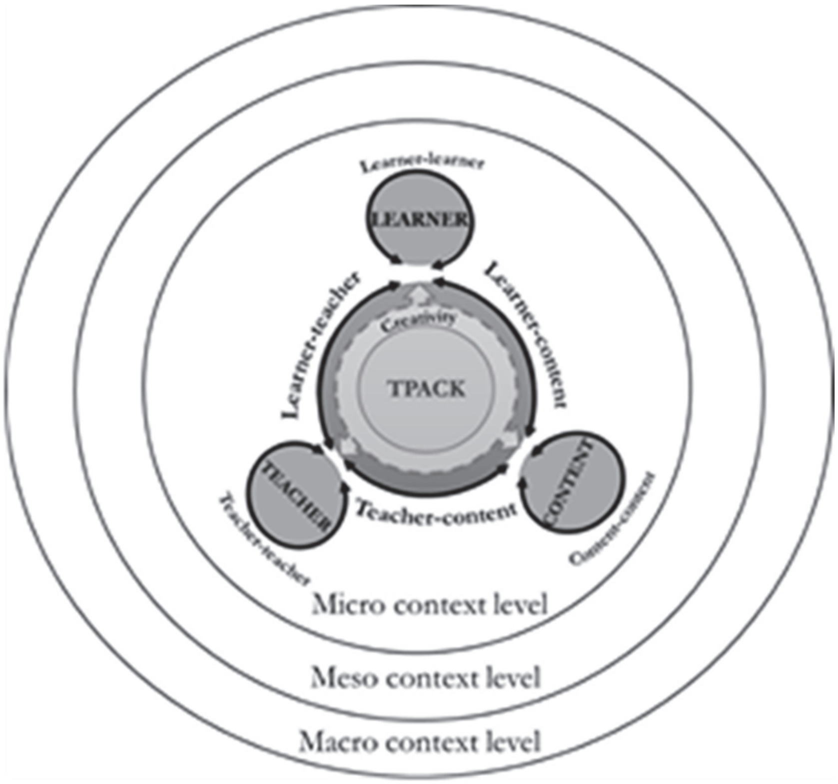

FIGURE 9 Framework for educational technology (Ifinedo & Rikala, 2019)

Author's contributions
All sections of the paper were jointly written. In addition, the thesis author was responsible for the paper presentation at E-Learn world conference on E- Learning in corporate, Government, Healthcare and Higher Education in New Orleans, USA.

5.6 Article PV: Analysing the Nigerian Teacher's Readiness for Technology Integration

This article was published in the International Journal of Education and Development using Information and Communication Technology. (IJEDICT) 15(3), pages 34-52.

Objective
The Technological Pedagogical Content Knowledge (TPACK) framework offers a foundation for understanding how teachers integrate technology in their classrooms. The belief in the framework is rooted in the interaction between and among the seven knowledge constructs that a teacher is required to possess in order to successfully teach in today's technologically ubiquitous world. As such, this article aspired to apply the framework using the paths hypothesised by Koh, Chai and Tsai (2013) in the Nigerian context (see Figure 11). The paper examined

the Nigerian teacher educators' TPACK perceptions and the existent relationship among the variables of their TPACK construct.

Method

The study uses the pre-processed data from the section one and three of the main survey. Subsequently, the partial least square of the structural equation modelling technique is applied to provide insights to the teachers' TPACK.

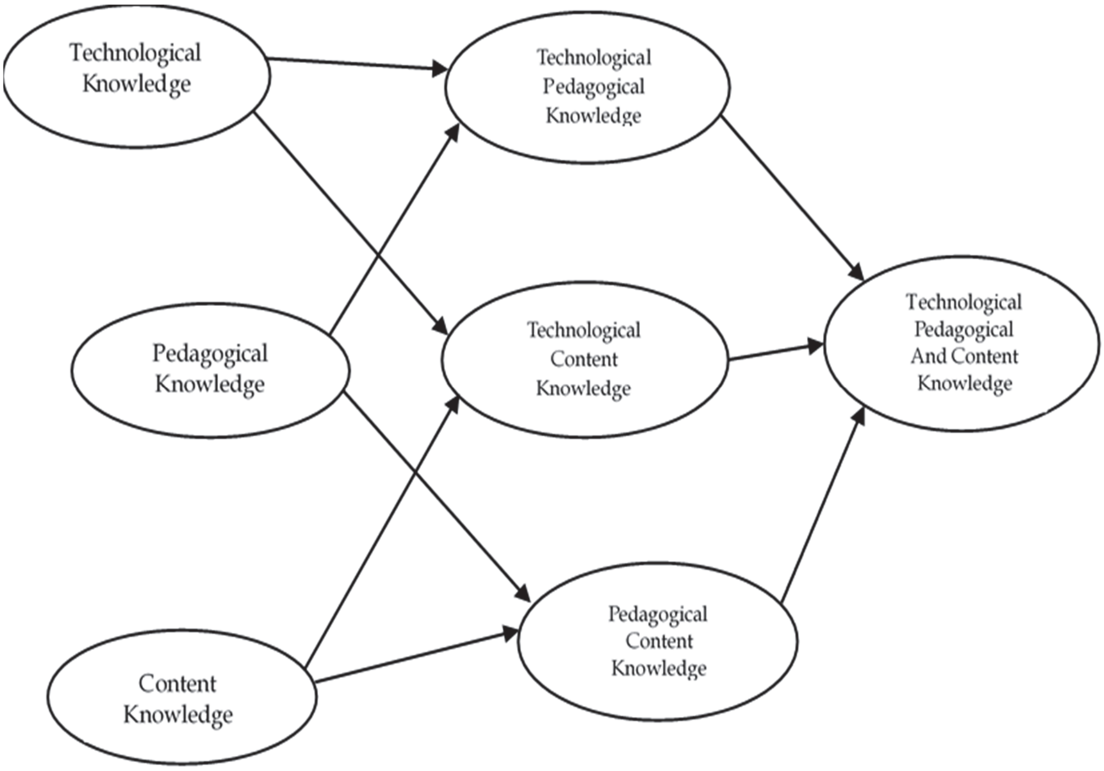

FIGURE 10 TPACK path model (as predicted by Koh et al., 2013)

Contributions and results

The result showed that the average mean of the teacher educators' perception of their TPACK (considering TPACK 1, 2 and 3 constructs) is 3.81 and with reference to the Likert scale used, this result is above the average.

Assessing the relationship among the seven variables of the TPACK framework, it was observed that the three main components of knowledge (TK, PK, and CK) predicted directly their individual secondary knowledge bases formed by their interrelationships (that is, TPK, TCK and PCK). Among the predictors of their individual secondary knowledge constructs, CK possessed the least direct effect size among the primary knowledge bases while the PK has the highest. Assessing from the direct and indirect effect, both PK and TK are significant predictors of the Nigerian teacher educators' TPACK.

However, at the secondary level, the TPK and TCK of the Nigerian teacher educators proved to be significant predictors of their TPACK while their PCK did not. In addition, of these three secondary knowledge constructs, the TPK was best explained by the combined strength of TK and PK in their variation of 50%. This suggests that the teacher educators' knowledge of their technological and pedagogical skills improves significantly the perception of their TPK. Generally, the TPK has the highest direct effect size on their TPCK. This could signify that the Nigerian teacher educators being experienced teachers with average teaching experience above ten years (from the demographics) believe in the benefits of ICT use in their teaching. Similarly, this could imply that pedagogical knowledge when appropriately integrated with knowledge of technology produces significant effect on technology integration. Comparing with research conducted among teachers from other contexts, a similar result was found in Singapore (more details are available in PV). Theoretically, the model (Figure 9) consisting of seven constructs with the two main paths to achieve TPACK as previously hypothesized by Koh et al. (2013) was proven useful in the Nigerian context. In addition, this is the first TPACK research that has been applied to the Nigerian context to the knowledge of the thesis author.

Author's contributions
The thesis author conducted the survey distribution of the questionnaire to the participants. She collected the data, pre-processed, analysed and interpreted the result. In addition, she wrote the paper and was the corresponding author of this journal publication.

5.7 Article PVI: Comparing the Effect Size of School Level Support on Teachers' Technology Integration

This paper will be published in the 2019 full paper proceedings of the conference on Smart ICT in Saidia, Morocco.

Objective
Within the classrooms, teachers should guide the innovative use of technological tools for achieving their educative objectives. Nevertheless, research literature reveals that a number of factors influence teachers' ICT pedagogical decisions. Consequently, the objective of this study was to investigate the influence of school level support on teacher educators' technology integration.

Method
The overall data analysis involved a mixed method, where the data was collected (both qualitatively and quantitatively) and individually analysed (qualitatively and quantitatively). Thereafter, both were integrated to achieve the aim of the paper. The qualitative result from PIII were summarized according to the overall perception of the teacher educators' school support on their technology integration. For the quantitative aspect, the study model was developed using the partial least square of the structural equation model technique. Finally, the effect sizes

of the main constructs of the hypothetical model was then compared for each school.

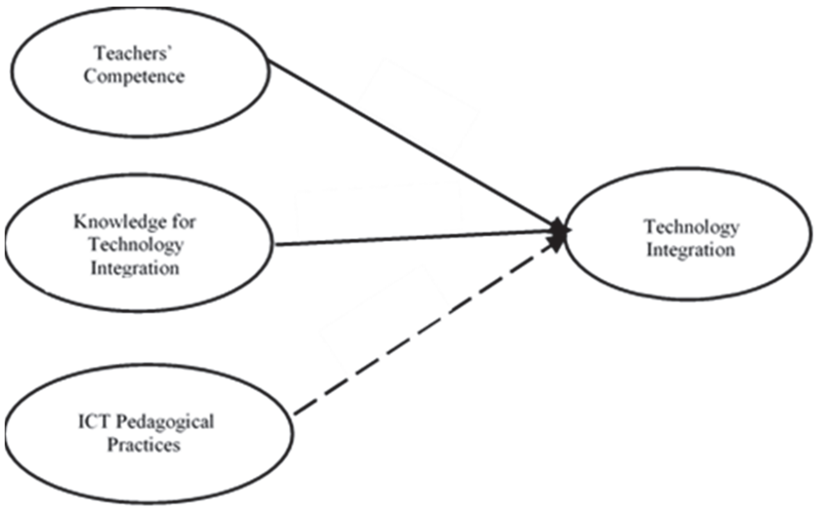

FIGURE 11 The hypothetical model used in PVI

Contributions and results

Hypothetically, the study's model was supported by the data. The study revealed that both constructs of teachers' ICT competence and their knowledge for integrating technology were significantly associated with their technology integration. Noteworthy is that their ICT pedagogical practices did not statistically associate with their technology integration which contradicts previous research expectation.

In addition, appreciable variance between the teachers' skill was indicated by the result when their technology integration was mediated by school support. Comparing among the schools, the analysis revealed that the teachers' competence in I school did not predict their technology integration in contrast to the other schools. Prior studies have indicated that school support is an important factor in teachers' technology integration and the evidence in the current article confirms that the lack of school support generated statistically non-significant relationship with teachers' ICT competence.

Author's contributions

The model and tables developed in this paper were by the thesis author. Besides, the data analysis, interpretation and writing of the entire paper was done by her. She was the corresponding author as well as the paper presenter at the conference on smart ICT in Saidia, Morocco.

5.8 Article PVII: Factors affecting Nigerian teacher educators' technology integration: Considering characteristics, knowledge constructs, ICT practices and beliefs.

This article has been accepted by Computers and Education.

Objective

The paper attempts to provide a view into the multidimensional aspects of teachers' TPACK (technological, pedagogical, and content knowledge) in relation to practice. The main objective of the study was to investigate the factors influencing the Nigerian teacher educators' (or TEs') technology integration and the correlation between the teacher educator's use of ICT and their TPACK. This was achieved by examining first, the teachers' characteristics and the influence on their knowledge for technology use versus knowledge not involving teaching with technology. Secondly, the relationship that exists among the factors considered in the study and how they influence the technology integration.

Method

The two frameworks - TPACK and SITES (3.2.1 and 3.2.2) guided the scale development. While the hypothetical model (see Figure 13) of the study was developed using the partial least square -structural equation modelling approach. Following the aim of the study, the eighteen hypotheses listed below the model were formulated and tested.

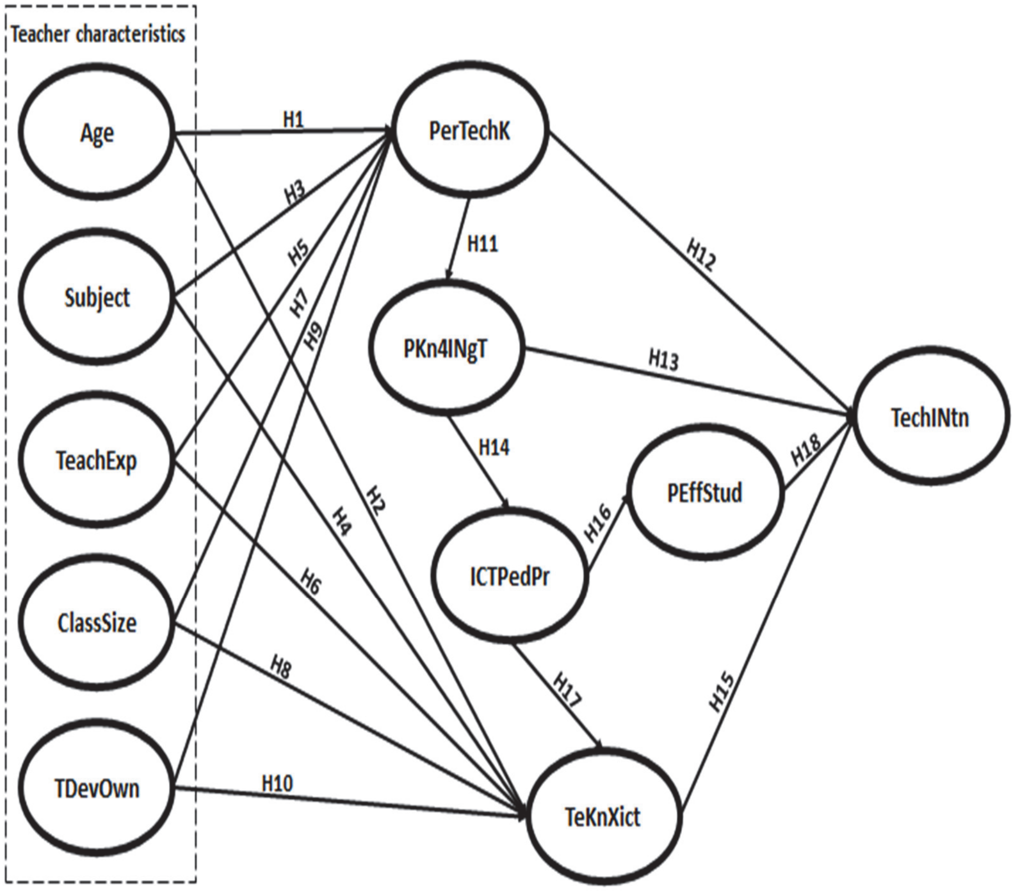

FIGURE 12 The hypothetical model used in PVII

From the model, hypotheses one to ten were used to answer the question, *what characteristics influence TEs' knowledge for technology use and knowledge not involving teaching with technology*. While hypotheses eleven to eighteen provided the answers for the *relationships that exist among TEs' perceived teaching knowledge, knowledge for technology use, perceptions, and ICT pedagogical practices.*

- H1: Teacher educators' ages negatively influence their perceived knowledge of technology (PerTechK)
- H2: Teacher educators' ages positively influence their perceived teaching knowledge (excluding technology) (TeKnXict)
- H3: The subject taught influences the teacher educators' perceived knowledge of technology (PerTechK)
- H4: The subject taught influences the teacher educators' perceived teaching knowledge (excluding technology) (TeKnXict)
- H5: Years of teaching experience (TeachExp) positively influences the teacher educators' perceived knowledge of technology (PerTechK)

- H6: Years of teaching experience (TeachExp) positively influences the teacher educators' perceived teaching knowledge (excluding technology) (TeKnXict)
- H7: Class size (ClasSize) influences the teacher educators' perceived knowledge of technology (PerTechK)
- H8: Class size influences the teacher educator's perceived teaching knowledge (excluding technology) (TeKnXict)
- H9: Technological device ownership (TDevOwn) positively influences teacher educators' perceived knowledge of technology (PerTechK)
- H10: Technological device ownership (TDevOwn) positively influences teacher educators' perceived teaching knowledge (excluding technology) (TeKnXict)
- H11: TEs' perceived technological knowledge (PerTechK) positively influences their perceived knowledge for integrating technology (PKn4INgT)
- H12: TEs' perceived technological knowledge (PerTechK) positively influences their technology integration (TechINtn)
- H13: TEs' perceived knowledge for integrating technology (PKn4INgT) positively influences their technology integration (TechINtn)
- H14: TEs' perceived knowledge for integrating technology (PKn4INgT) positively influences their ICT pedagogical practices (ICTPedPr)
- H15: TEs' perceived teaching knowledge, excluding technology (TeKnXict), positively influences their technology integration (TechINtn)
- H16: TEs' ICT pedagogical practices (ICTPedPr) positively influence perceived effect of teaching with technology on students (PEffStud)
- H17: TEs' ICT pedagogical practices (ICTPedPr) positively influence their perceived teaching knowledge that excludes technology (TeKnXict)
- H18: TEs' perceived effect of teaching with technology on students (PEffStud) positively influence their technology integration (TechINtn)

Contributions and results

In the study the five teachers' characteristics were utilized as exogenous variables namely, age, subject, class size, teaching experience and device ownership. In the result, it was noted that subject, class size, teaching experience and device ownership influence both teachers' technological knowledge and their knowledge not including technology. The teachers' age negatively influenced both their technological knowledge and knowledge not including technology. However, the relationships were not statistically significant. In almost equal strength, both constructs (technological knowledge and knowledge not including technology) were influenced by teaching experience and device ownership. On closer inspection of the paths between the teachers' characteristics and their technology integration, it was found that only teaching experience and class size were statistically significant albeit their effect sizes were not practically relevant.

Among the endogenous variables, three constructs (teachers' knowledge excluding technology, perceived knowledge for technology and knowledge for integrating technology) directly influenced the teachers' integration while the other two (ICT pedagogical practices and perceived technology gains for their students) did not. By assessing the indirect effect of the constructs on their technology integration, the perceived knowledge for technology construct was found to be statistically significant with considerable effect size.

Overall, this study contributes to the literature in terms of theory development. The usefulness of the TPACK framework for evaluating teachers' technology integration has been questioned in the past, therefore in this study, three constructs (teachers' characteristics, ICT pedagogical practices and the perceived impact of these practices on the students) which are inspired by the SITES framework were added. In addition, the study is based on the perspectives of teachers' technology integration from the Nigerian context.

Taken together, explaining cause and effect in educational technology research is challenging because of the multiplicity of factors and contexts involved.

Author's contribution

The thesis author wrote sections three to five and is the main and corresponding author of the paper. The model applied in this paper was designed by her. In addition, the analysis and interpretation of data were done by her. The second author wrote the first two sections of the paper.

5.9 Notes on co- authors

Except where it was specified, the co-authors for the respective articles critically reviewed and provided constructive comments, and supervised the intellectual contents, which helped the improvement of the articles. In some cases, they recommended appropriate conferences and journals where the articles would be better appreciated.

5.10 Summary of included articles and contributions

Altogether, the seven articles presented above make up the thesis and provide the contributions to the study. Table 4 provides in summary, the contributions of all the articles included in the dissertation. As earlier indicated, the study aimed to highlight the contextual influences affecting the implementation of educational technology in Nigeria. The study found a variety of contextual factors that are peculiar to developing countries like Nigeria and thus are different from developed countries' context. The TPACK framework as expanded by Porras-Hernandez and Salinas-Amescua was therefore found valuable for explaining these contextual influences.

TABLE 4 Contributions of the study

Paper	Title	Article research questions	Data analysis and source	Research findings and contribution
PI	Exploring Nigerian University Students' Perception towards Mobile Learning	What type of mobile devices do the students possess? Attitude to mobile learning activities? What technological skill do they have?	Descriptive analysis The study uses survey data of students (N = 135).	Widespread mobile device ownership Positive disposition to mobile learning education activities. Above average technical skill (word processing, email use, software downloading and internet surfing)
PII	Nigerian Education System and the Possibilities Ahead for Mobile Learning	Identify the challenges in the Nigerian education sector by examining the policies and practices. Identify the possibilities technology integration can offer as a solution to the challenges.	Descriptive analysis. The study uses secondary data from NEDS 2016.	3 major challenges identified are high number out of school children and dropout rate and low literacy rate although at varying degree across the country. 3 top causes of these problems are Cost, school distance, children used for labour, no interest in education. Possibilities for mobile learning: Educative and motivational materials in digital forms, e.g. mobile devices.
PIII	Understanding the Influence of Context in Technology Integration from Teacher Educators' Perspective.	What factors act as facilitators or inhibitors to the use of ICT from teacher educator's perspective?	Open, focused, and theoretical coding. The study uses data from 3 focused interviews of teacher educators	In relation to the context aspects of the TPACK framework, the meso level posed greater challenges to the teacher educator's technology integration in their teaching experience.

			from 3 colleges of education in Nigeria.	Factors such as accessibility, outdated/ non-functional equipment, Policy issues at institution level, Finance, Lack of ICT training and support were the examples of inhibitors and facilitators of technology integration.
PIV	TPACK and Educational Interactions – Pillars of Successful Technology Integration	Identification of research gap	Literature review	Based on extensive study literature, we propose the inclusion of the educational interaction aspect to the TPACK framework.
PV	Analysing the Nigerian teacher's readiness for technology integration	How proficient are the teacher educators?	The study uses survey data of teacher educators from three Nigerian colleges of education (N = 136) Testing nine paths as hypothesized in other contexts. PLS-SEM	Eight of the nine hypotheses were confirmed. The teachers' PCK did not statistically associate with their TPACK. Among the exogenous variables PK and TK were the strongest predictors of their TPACK
PVI	Comparing the Effect Size of School Level Support on Teachers' Technology Integration	How do the study constructs predict the teachers' technology integration? What is the influence of the school level context on these constructs?	The study develops and tests a hypothetical model. Uses both quantitative (PLS – SEM) and qualitative (result of focus interview analysis of PIII)	Teachers' ICT pedagogical practices did not predict their technology integration. Evidence that school level context influences teachers' ICT competence
PVII	Factors affecting Nigerian teacher educators' technology integration: Considering characteristics, knowledge constructs, ICT practices and beliefs.	What characteristics influence TEs' knowledge for technology use and knowledge not involving teaching with technology? What relationship that exists among the constructs of the study and what constructs of the study influence the TEs' technology integration?	It uses the main survey data of teacher educators from three Nigerian colleges of education (N = 136) The study develops and tests a hypothetical model. 18 hypotheses tested. PLS-SEM	No statistical correlation between their technology integration and both of ICT practices and perceived benefits of teaching students with ICT. 15 of the hypotheses were supported.

6 CONCLUSION, IMPLICATION AND FUTURE STUDY

As the concluding chapter of the thesis, the conclusion (6.1), implications for both research and practice (6.2), limitations and directions for future research (6.3) are presented.

6.1 Conclusion

The analysis presented in this study describes technology integration in Nigeria through the pragmatic worldview that was strongly dependent on the TPACK framework (see PIII – PVII). Through this, contextual influences, missing educational interaction and, dissociation between ICT practices and technology integration were revealed. Although the findings of this study have been presented elaborately elsewhere (chapter 4 and individual articles), this section aims to provide a summary of the answers to the research questions in relation to the articles included in the thesis.

When the peculiarity of context is understood and defined (for instance, level of students, subject, type of technology available, teacher's beliefs, teaching experience) integrating technology in the classroom becomes a less complex process as previous studies imply (Mishra & Koehler, 2006; Webb, 2013; Willis, Lynch, Fradale, & Yeigh, 2019). In response to RQ1, the study provides insights on the educational activities of the Nigerian students and teachers (see PI & PV). This included ownership of multiple mobile devices, willingness to engage in learning and teaching activities using ICT and adequate technological skill. While PI and PIII provided in-depth information on how significant the use of ICT was both in carrying out their teaching and learning functions. In addition, the positive disposition of both actors to the use of ICT for educational activities were noted (PI & PIII). Taken together, the result shows that both the students and teachers are prepared to integrate technology into Nigerian schools (RQ1). Notwithstanding, being a *good user* of technology involves taking purposeful actions in the midst of contextual influences (Hammond et al., 2009, p.70). Therefore, considering RQ2, the hindering factors enumerated in the study (PIII, PVI, PII) were found existent within the compartments of the context levels (i.e., macro, meso, micro) as described in the favoured TPACK framework. Within the macro context level, the teachers made mention of factors such as lack of infrastructure, the national budget allocation for education, policy related issues, lack of funding as discouraging. From the meso context level, there exists factors like the lack of facilities, where some facilities were available, they were not accessible or not functional, poor policy at school administrative levels and lack of finance. While the micro level indicated factors such as teachers' attitude (e.g. low technological skill), low PCK and student related issues. Similar constraints were found in Kenyan universities (Tarus, Gichoya, & Muumbo, 2015)

However, two factors were observed to encourage the teachers: the school support, which corresponds to the meso context level and the personal decision to innovatively teach with available ICT (i.e. teachers' belief belonging to the micro context level) regardless of discouraging factors from other context levels (i.e. meso or macro). Nevertheless, as research has shown, contextual elements from meso level such as those from schools require less effort to resolve compared to the other context levels.

A review of research literature showed that innovations in educational technology were usually approached and concluded from perspectives of comparing learning outcomes or investigating the attitude, skills of the users thus, positioning technology integration as a question. For example, does the test on learning outcome prove that technology should be integrated in classrooms? Such positions do not consider the continuously developing technology and how it has become part of everyday living. Thus, in this study, further actions were taken to identify factors that have not been accounted for when discussing technology integration (RQ3). In this way, the current study offers technology integration as answers to educational problems such as were found in the Nigerian context (PII: high drop out and out of school children, low levels of school children literacy rate). Likewise, educational interactions (PIV) were found scarce in most educational technology frameworks and this study proposed its inclusion to advance educational technology research beyond implementation and for creating processes for sustainability and practical applications.

6.2 Implication

In earlier research, preparedness to use, availability and ownership of mobile devices have been stressed as factors that promote the use of educational technology among students (Corlett, Sharples, Bull, & Chan, 2005; Crompton & Burke, 2018; Litchfield, Dyson, Lawrence, & Zmijewska, 2007; Sharples, Taylor & Vavoula, 2005; Utulu & Alonge, 2012). Therefore, the information contained in this study benefits development of research in learner centeredness, usability, human behaviour, and technology. In practice, the evidence provided by the result of PI is beneficial to policy makers within various levels of the education in

Nigeria. The result shows that the students require the use of the internet in completion of course assignment, which in turn points to the need for school administrators to consider designing pedagogies and curricula that leverage on these learning activities. The education sectors of other sub-Saharan African countries may find the outcomes published in this thesis useful due to the contextual relatedness.

Children faced with various challenges become irregular at school, which in turn leads to failure then dropping out of school and ultimately, they stop attending school (i.e., out of school children) (UIS, 2012). Thus, in describing the relationship between both, dropping out of school is a sub group of out of school problem. Some of the identified root causes (e.g. school distance, lack of interest and poor school quality) have been tackled in other contexts through technology integration (e.g., Kozma & Wagner, 2006). In practice, PII implies that the innovative use of educational technology provides some answers to the out of school children and low literacy problems at the national level in Nigeria. Particularly, PII shows that the potential of technology integration has not been maximized in the Nigerian context which may apply to other developing countries (UNESCO, 2015). There is the need to advocate policies and platforms that leverage on the technology integration designed for the inclusion of the disadvantaged learners within Nigeria's basic education level to improve the quality of education. Generally, the study offers support for subsequent research in developing countries and initiatives advocating for quality education such as Education for All and Millennium Development Goal.

For research, the input of PIII helps the understanding of the TPACK framework and design studies. The result illustrates that arising from the context aspect of the framework are factors that can motivate or demotivate teachers from the use of technology in fulfilling their pedagogical duties. Thus, supporting previous views for representing context when discussing TPACK (Rosenberg & Koehler, 2015; Voogt & Tondeur, 2015). In practice, the evidence shown in the result could serve Nigerian schools in realising how significant their role is in encouraging teachers and students towards achieving their educational goals as other previous research has shown (Drent & Meelissen, 2008; Tondeur, Van Keer, Van Braak & Valcke, 2008; Voogt & Tondeur, 2015). Institutions can support technology integration by providing the facilities, using contemporary policies that involve the teachers in the design of the processes and practices.

In research, PIV advances the TPACK framework by adding the educational interaction aspect. It suggests that both actors will benefit from the use of TPACK in the classroom. Where the meanings of TK and CK remain the same for both actors, PK for the student can be explained as learning strategies that students apply before and during their learning process to achieve their educational goals. In addition, while learners apply their knowledge through learning strategies, teachers can provide appropriate supervision to help learners achieve more.

In the case of PIV, the implication for practice at the context levels is that, at both the meso and macro context levels, the study indicates the need for strong cooperation among all stakeholders at all levels of education towards the development of common goals, values and strategies on improving technology integration practices. The development of such practices creates supportive and healthy environments for teachers to collaborate, reflect on experiences and plan next steps for improving their technology integration. Thus, given that the impact from the other context levels is visible at micro level, it is essential to strengthen the teachers' competency through all three knowledge constructs: technological, pedagogical, and content. However, at the micro context level, the decisions necessary to actualize the educational goals are made by the teacher and thus, this study recognizes the significant position and considerable independence that in reality, teachers both occupy and function in. Accordingly, teachers need to strategize on when, how and for what topics and pedagogic purpose the use of technology will support the educational goals. Through this process, the role of educational interaction is evident as it shapes the content, practices, context, and the learner's characteristics. Requiring therefore, that teachers become open-minded, critical, creative thinkers, designers, and lifelong learners themselves.

The implication of PV in research is the broader insight it adds in relation to the application of the TPACK framework in the Nigerian context. The framework was proven useful for analysing teachers' perception of their technology integration. The result of the study was relevant for identifying appropriate professional developments programmes. Specifically, the need to reinforce the Nigerian teachers' content knowledge and pedagogical content knowledge (i.e., CK and PCK) was evident. In practice, this research (PV) highlights the need for updating the teaching curricula towards improving the teachers' content knowledge and their pedagogical content knowledge. As these two knowledge constructs were the weakest from the evaluation. In addition, administrators of the Nigerian schools can coordinate design-based workshops and trainings aimed at creating collaborative and motivating opportunities for the teachers to contribute to the process of developing the required rich content that recognises the influence of pedagogy and technology.

In research, the study (PVI) advanced the TPACK framework in two respects. Firstly, the result provides credence to the fact that school support influences teacher's technology integration. Secondly, the Nigerian teacher's ICT practices did not influence their technology integration as previous research have shown. Agreeably, proficiency in ICT does not equate to educational technology because it requires more, such that the innovation should influence the content and pedagogical practice (Mishra & Koehler, 2006). It follows that in practice, there is need for ICT trainings that connect the teachers' ICT practices and content with their technology integration. For the teachers to fully exploit the opportunities of technology integration, the support of the school in terms of policies, strategies and investments are essential.

The research implication for PVII is in the advancement of the TPACK framework. In addition to the seven knowledge constructs of TPACK, three others (motivated by SITES framework) were added. These three are - teachers' characteristics, ICT pedagogical practices and the perceived impact of these practices on the students. Thus, providing a wider range of factors that influence teachers' technology integration. In practice, when teachers partake in designs (e.g., learning by design, Koehler & Mishra, 2005) they build artefacts in connection with all three-core knowledge thus growing their TPACK. Consequently, the disassociation between the Nigerian teachers' PCK, ICT practice, belief, and their technology integration as it was observed in this study, require that the Nigerian teachers are actively participating in designing ways to build their TPACK.

6.3 Limitations and future study

Technology integration occupies a significant role in education and this dissertation has pointed to improving quality in education as one of such significance. Admittedly, the studies contained in this thesis have been able to provide the perspectives of the Nigerian students and teachers on the subject and thereby, a basis for designing capability building strategies that fit the needs of the context. Given that teachers were in consensus on the relevance of using technology in executing their teaching duties, an aspect for considering future work is in the use of case studies wherein teachers and students are supported on the applications of ICT as an integral and natural part of learning and teaching.

Similarly, it was found some teachers, who despite the challenges they experience are willing to innovatively use available technology in their teaching practices. What is the effect on students learning and future work place when not all teachers are teaching effectively with technology? Can such opportunities be exploited further to help these teachers attain their teaching potentials? Continuing research using design studies is needed to provide these answers.

Evident in the result was a widespread ownership and combination of mobile devices by the Nigerian teachers and students. This is a rich opportunity to leverage on using design studies that provide and support mobile learning applications in the Nigerian context. In the analysis, the teachers' ICT practices and belief (i.e., perceived benefits of ICT practices on the students) did not influence their technology integration contrary to previous studies. Perhaps, the dissociation in this instance points to the weakness of the TPACK framework. Further investigation is therefore needed to broaden the discussions on and to ascertain the ICT practices that influence technology integration of teachers using the TPACK framework.

The studies considered the perspectives of Nigerian undergraduate students, school aged children and teacher educators majorly from the southern region and within the Nigerian public sector schools. Further research can add insights from the perspectives of *actors* from the private school sector and northern region of Nigeria.

From the context dimensions, the analysis of this research did not investigate stakeholders beyond the *micro* context level. As such, research at these meso and macro level can develop and enrich the discussions on technology integration in Nigeria.

Finally, the expanded version of the TPACK framework proposed in (PIV) remains to be empirically tested and thus, future research can provide further information on its applicability.

YHTEENVETO (SUMMARY IN FINNISH)

Tämä tutkimus tarkastelee teknologiaintegraatiota nigerialaisessa kontekstissa käytännöllisen eli pragmaattisen lähestymistavan kautta, jonka keskiössä on TPACK-malli (katso PIII – PVII). Tutkimuksessa esiin nousseita seikkoja olivat kontekstuaalinen vaikutus, puuttuvat vuorovaikutuselementit sekä TVT-käytänteiden ja teknologiaintegraation välinen kuilu. Tutkimuksen tulokset on esitetty erikseen (luku 4 ja yksittäiset artikkelit), mutta tämä yhteenveto kokoaa yhteen kokonaisuuden eri osat.

Kontekstin ymmärtäminen edistää teknologian integroimista. Ensimmäiseen tutkimuskysymykseen (RQ1) etsittiin vastausta nigerialaisten opiskelijoiden ja opettajien opetusteknologian käyttöön liittyvistä näkökulmista (katso PI & PV). Näihin näkökulmiin sisältyivät useiden mobiililaitteiden omistaminen, halukkuus osallistua oppimis- ja opetustoimintaan TVT:n avulla sekä riittävät teknologiset taidot. PI ja PIII puolestaan tarjosivat syvällistä tietoa siitä, kuinka merkittävässä roolissa TVT:n käyttö on opetus- ja oppimistehtävien suorittamisessa. Selvisi, että opiskelijat ja opettajat ovat halukkaita hyödyntämään tieto- ja viestintätekniikkaa oppimis- ja opetustoimintaan (PI & PIII). Yhdessä nämä näkökulmat osoittavatkin, että opiskelijat ja opettajat ovat valmiita integroimaan teknologiaa nigerialaisiin kouluihin. Teknologian käyttäjän tulee kyetä toimimaan tarkoituksenmukaisesti myös kontekstuaalisten vaikutusten keskellä (Hammond ym. 2009, s. 70). Toisen tutkimuskysymyksen (RQ2) huomion kohteena olivatkin käyttöä estävät tekijät (PIII, PVI, PII), joita tunnistettiin kolmella kontekstuaalisella tasolla (makro, meso ja mikro). Nämä tasot on kuvattu myös TPACK-mallissa. Makrotasolla opettajat kuvasivat estäviä tekijöitä, kuten infrastruktuurin puute, kansallisen tason budjetointi koulutukseen, politiikkaan liittyvät kysymykset sekä huono taloudellinen tilanne. Mesotasolla puolestaan esiin nousi tekijöitä, kuten puutteelliset tai toimimattomat tilat ja laitteet, koulujen menettelytavat hallinnollisella tasolla sekä rahoituksen puute. Kun taas mikrotasolla havaittiin tekijöitä, kuten opettajan suhtautuminen (esim. heikot teknologiset taidot) sekä pedagogiseen sisältötietoon ja opiskelijoihin liittyvät kysymykset. Samanlaisia rajoitteita löytyy myös Kenian yliopistoista.

Kaksi TVT:n käyttöä edistävää tekijää olivat koulun tarjoama tuki mesotasolla sekä opettajien päättäväisyys hyödyntää innovatiivisia opetuskäytänteitä TVT:n avulla (toisin sanoen opettajien mikrotason yhteenkuuluvuudentunne). Nämä kaksi tekijää edistivät TVT:n käyttöä, siitäkin huolimatta, että muilla tasoilla (esim. meso tai makro) oli estäviä tekijöitä. Tutkimukset viittaavatkin siihen, että mesotason (esimerkiksi kouluun liittyvät) esteet vaativat yleensä vähemmän ratkaisuponnisteluja verrattuna muiden tasojen esteisiin.

Kirjallisuuskatsaus osoitti, että opetusteknologista innovaatiota lähestytään usein tarkastelemalla oppimistuloksia, käyttäjien asenteita tai taitoja asettaen teknologiaintegraatio kysymykseksi, kuten riittävätkö testeistä saadut tulokset osoittamaan sen, että teknologiaa tulee integroida luokkahuoneisiin. Tällaiset näkemykset eivät ota huomioon jatkuvasti kehittyvää teknologiaa tai sitä, miten teknologiasta tulee osa luokkahuoneen arkea. Siksi tässä tutkimuksessa pyriittiinkin tunnistamaan sellaisia tekijöitä, joita ei ole huomioitu teknologiaintegraatiokeskustelussa (RQ3). Tämä tutkimus näkee teknologian integroimisen vastaukseksi nigerialaisiin koulutusongelmiin (PII: koulupudokkaat, koululaisten alhainen lukutaito). Useimmissa opetusteknologiaan liittyvissä malleissa ei myöskään ole otettu huomioon vuorovaikutuksen merkitystä. Tästä syystä tutkimus ehdottaa puuttuvien vuorovaikutuselementtien sisällyttämistä opetusteknologisen tutkimuksen edistämiseksi sekä kestävien prosessien ja käytänteiden luomiseksi.

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APPENDIX 1: SAMPLE OF LETTER TO SCHOOL PROVOST

17.11. 2017.

The Provost,
…………………College of Education,
……………… State.
Nigeria.

Dear Sir/ Madam,

REQUEST FOR YOUR PARTICIPATION IN OUR RESEARCH

Eloho Ifinedo is a PhD student/researcher at the University of Jyvaskyla, Finland. Her research focuses on technology integration from the perspective of a developing country, Nigeria. Technology integration is perceived to play a significant role in transforming education globally because of the advantages it offers in terms of anytime, anywhere access and the possibilities for interaction and collaboration. The research attempts to highlight the perspectives of teacher educator students and teacher educators to encourage Information and Communication Technology (that is, ICT) as a useful tool for education. Particularly, it investigates the role of ICT in solving educational challenges in Nigeria. On one hand, the research opens a channel through which we can evaluate the speed of ICT adoption from selected colleges of education. On the other hand, the research provides a basis to evaluate how other factors influence the rate of adoption in these institutions.

To achieve the objective, this research requires that primary and secondary data relating to teacher educators, teacher educator students, education institution leaders and policy makers within the Nigerian context, are collected. In this regard, the cooperation of your institution is needed to enrich the research attributes by adding your perspective as experts on educational matters as it concerns the colleges of education in Nigeria.

Eloho Ifinedo has displayed strength and high level of commitment in her previous research works and I am confident that she will perform this work with diligence and required competence. Your support and assistance will be appreciated so that she can accomplish her data collection task.

Please find below my contact for any further information you may require.

Yours Sincerely,

Professor Marja Kankaanranta
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APPENDIX 2: PHOTOS FROM RESEARCH SITE

SCHOOL I

#1: The e-library building
#2, 3, 4: Different computer classrooms in the e-library

APPENDIX 2: CONTINUED

SCHOOL II

#1, 2: lecture rooms
#3, 4, 6: computer classrooms
#5: teachers’ office

APPENDIX 3: THE MAIN QUESTIONNAIRE FOR THE STUDY

Investigating the use of Technology by Nigerian Teachers (Educators) to address Educational Challenges

For the purpose of this questionnaire, technology implies digital technology/technologies that is, the digital tools we use such as computers, laptops, tablets, mobile phones, interactive whiteboards, software programs, etc. Please answer all of the questions, and if you are uncertain of or neutral about your response, you may always select "Neither agree nor disagree. "

General information:

1. School name
2. Age group:
   a. below 25 b. 25- 29 c. 30-39 d. 40 – 49 e. 50 – 59 f. above 59
3. Sex: a. male b. female
4. Current subject you teach:
5. Job title:
6. How many years of teaching experience do you have?
   a. below 2years b. 2- 4years c. 5- 9years d. 10- 19years e. more than 19years
7. How many students do you have in your class on average?
8. Which of the following devices do you own? (multiple options are allowed)
   a. phone b. laptop c. Tablet d. desktop computer e. Others __

ICT Use and significance

9. Which of the following describes you?
   a. I use technology with my students once a week or more
   b. I use technology with my students a lot within a given period of time in a school year (e.g. during some task/ project)
   c. neither of the above

10. How often do you use the following equipment for teaching in a school year?

	Never	Rarely	Usually	Almost always
equipment and practice materials (e.g. laboratory equipment, musical instruments, art materials, calculators)				
Practice / lesson notes				

General office programs (e.g. MS word, databases, spreadsheet, PowerPoint tools)				
multimedia production tools (e.g. media storage and editing tools, drawing programs, web site / multi-media tools)				
communication applications (e.g. email, chat, discussion forum)				
Digital sources (e.g. Encyclopedias, dictionaries)				
Mobile devices (e.g. tablets, phones)				
Others (name them)				

11. In teaching your students this academic year, how often have you used technology in the following activities

	Never	Rarely	Usually	Almost always
Presentation of information/ demonstration and or giving instruction to students				
Providing support or extra lesson to individual students or small groups				
Helping or advising students on information retrieval / search				
organization or observation of student-led class discussions, demonstrations and presentations				
Evaluating students learning through experiments, tests, and interviews				
Giving feedback to individuals or small groups				
Organizing, monitoring and supporting the formation of students' groups and co-operation				
co-operation with parents / guardians to support / monitor and / or guide learners' learning				
Others (name them)				

12. In your opinion, how does teaching with technology affect your students in the following way?

	Disadvantage	No effect	Advantage
Knowledge of the subject			
ICT skills			
Learning Motivation			
Students are able to navigate subject at their own pace			
Messaging skills			
information processing skills			
cooperation skills			
Student able to direct self			

Problem solving skills			
Level of differences among students			
Confidence			

13. Technical knowledge:

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
I know about a lot of different technologies					
I have the technical skills I need to use technology					
I know how to solve my own technical problems					
I can learn technology easily					
I frequently play around the technology					
I have had sufficient opportunities to work with different technologies					

14. Content Knowledge:

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
I have various ways and strategies of developing my understanding of the subject I teach					
I have examples on how to apply the subject I teach in the real world					

15. Pedagogical Knowledge:

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
I can use different teaching methods in the classroom (collaborative, instruction, inquiry, problem based etc)					
I can adapt my teaching style to different learners					
I know how to assess student performance and learning in different ways.					

I am familiar with common student understandings and misconceptions of the subject.					
I can adapt my teaching based on what students currently understand or do not understand					

16. Pedagogical Content Knowledge:

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
I know that different concepts in the subject I teach do not require different teaching approaches					
I know how to select effective teaching approaches to guide student thinking and learning in the subject I teach					

17. Technological Content Knowledge:

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
I know about technologies that I can use for understanding and teaching my subject.					

18. Technological Pedagogical Knowledge:

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
I have the technical skills I need to use technology appropriately in teaching					
I can adapt the use of technologies that I know in different teaching activities					
I think critically about how to use technology in my class					
I can choose technologies that enhance my teaching					

approaches for a lesson					
I can choose technologies that enhance students' learning during a lesson					

19. Technological Pedagogical Content Knowledge:

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
I can teach lessons that appropriately combine my subject, technologies, and teaching approaches.					
I can select technologies to use in my classroom that enhance what I teach, how I teach, and what students learn.					
I can provide leadership in helping others to coordinate the use of content, technologies, and teaching approaches at my school.					

INCLUDED ARTICLES

I

EXPLORING THE NIGERIAN UNIVERSITY STUDENTS' PERCEPTION TOWARDS MOBILE LEARNING

by

Eloho Ifinedo, Marja Kankaanranta, Timo Hämäläinen & Pekka Neittaanmäki, 2017

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Exploring Nigerian University Students' Perception towards Mobile Learning

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Abstract: The specific objective of this study was to better understand Nigerian university students' perceptions and readiness towards mobile learning. Recently, the influence of mobile technology is seen to have infiltrated everyday life and the learning institutions. It is thus crucial for learning institutions to assess and understand the factors advancing the mobile learning adoption. This study offers some important insights into mobile learning adoption especially in developing countries like Nigeria. Data for this study were collected using a survey. Undergraduate students at two Nigerian universities (N = 135) were non-randomly allocated to respond to a survey. Overall, the results reveal the existence of the widespread use and ownership of a mobile phone by the Nigerian students. Also deduced, is that a good number of the courses require the use of internet for completion of course assignments. Therefore, we recommend that course resources should be designed for delivery through a mobile device.

Introduction

Learning in institutions has been shaped as well as influenced by the various types of technology that have been witnessed in the past and present. During recent years, especially the potential of portable wireless device (i.e. laptops, tablets, smartphones and other portable electronic devices) for enhancing and diversifying learning has received increased attention. Literally, this concept is called mobile learning or m-learning (Leung & Chan, 2003; Litchfield, Dyson, Lawrence, & Zmijewska, 2007; Costabile et al., 2008)). It is predicted that the predominance of mobile phone and its importance will outnumber the use of personal computers (Motiwalla, 2007; Sharples, Taylor, & Vavoula, 2005) and other previous technologies (Kalba, 2008). It is therefore crucial for learning institutions to assess and understand the factors advancing the mobile learning adoption.

Despite the rapid development in technology, extant literatures reveal limited information on technology integration in schools of learning in Nigeria. An increasing number of studies were found on m-learning with most of them being conducted in the USA, Asia, Britain, Scandinavia, and Australia (Litchfield et al., 2007; Sergis, Sholla, Zervas, & Sampson, 2014; Serrano & Yang, 2013; Jiranantanagorn, Goodwin, & Mooney, 2012). As the mobile learning trend is observed in other continents of the world, it is important to investigate the digital inclusiveness of the African continent. According to Avgerou and Madon (2005), digital inclusion can be achieved when the gap between each person's competences at integrating technology into learning is bridged. From the point of view of this study, a successful adoption of mobile learning should be built on students' perception towards m-learnig, in other words, information concerning students' ownership of the mobile devices, students' technical skill and practices.

Hence, this study seeks to investigate the state of preparedness of the Nigerian universities for mobile learning. The study attempts to bring to light the relative association or similarities existent across various courses of study (departments), sexes, age and other variables. The willingness of the students to use their mobile phones for instructional learning is also explored. In this regard, the questions to be answered are:

- What type of mobile devices do the university students possess?
- Are the students aware of mobile learning?
- Do the students have technical skills for mobile learning?

Thus, this study offers important insights into mobile learning adoption especially in developing countries like Nigeria.This paper is organized as follows. First, the m-learning literature is reviewed followed by a discussion of the context of the Nigerian education and technology. After this, the the research methodology is described, including a discussion of the sample the variables and their measurement. Finally, the results are presented, followed by a discussion of the findings and the paper is concluded with reflective remarks.

On Mobile Learning

In the technology era, the acquisition of knowledge is depicted as a process that is mediated by the device. The emerging technologies pave the way to the progress of numerous prospects that enhance the learning process in such a manner that was not possible before now. According to UNESCO (2012), the affordances of the technology offers not only possibilities for new experiences and learning but also places demands for acquisition of new skills such as computational thinking, problem solving, innovative product creation, collaborators, effective communicators. In addition, technology has provided opportunities for communication and by extension made the learning experience better (Sharples, 2000; Fuller & Joynes, 2015). The traditional ways of classroom lectures, acquiring information through the use of books at the library has been made easier in higher institutions of learning by the advent of electronic learning or e-learning.

In recent times, the evolution of the mobile technologies which comes in various shapes, sizes and functionalities has further potentials for learning in various ways. For example, while a mobile phone which possesses several capabilities and functionalities is basically for communicating, mobile learning aims at optimizing these properties in a learning environment. Literarily, mobile learning is the use of portable wireless device for learning however, a number of definitions are provided for mobile learning in various scholarly articles. Leung and Chan (2003) define mobile learning as the point at which mobile computing and electronic learning intersect to produce anytime, anywhere learning experience. Litchfield et al., (2007) define it as the facilitation of learning and access to educational materials for students using mobile devices through a wireless medium. Costabile et al., (2008) also affirm that the combination of e - learning and mobile computing is called m - learning. In these definitions, it can be observed that the availability of the appropriate mobile device, the access to the wireless network, the need to acquire knowledge within varied context and appropriate pedagogy that culminates in the m-learning experience.

M-learning shares the same benefits with E-learning as they both afford the learner the flexibility of studying anywhere, any how and any time with the use of portable wireless technologies. Motiwalla (2007) maintains that, ‘it is facilitated by a convergence of Internet, wireless networks, mobile devices and e- learning’. The portability of the device and the technology enables the learner take advantage of breaks or spare time such as lunch periods to seek out information. The desire for information can therefore be fulfilled as it arises instead of for instance, delaying till there is access to computer or arrival at the nearest library. Koole (2006) regards the portability feature of the device as an enabler to the process of accessing information such that with m-learning, the information moves to the learner instead of the learner moving to the information.Thus, mobile learning is depicted as a situation in which the mobile device (commonly used are laptops, tablets, smartphones and portable electronic devices to name but a few) acts as a facilitator in the learning process. In this paper, the device is seen as the tool which acts as the focal point that reconciles all forms of learning activities, experiences and explorations. Thus, this study is based on the social constructive theories which project learning as a social activity that is focused on the learner and the mobile phone as a tool for communication which provides a platform for feedback.

Koole (2006) provides a comprehensive framework for mobile learning. The Framework for the Rational Analysis of Mobile Education (FRAME) model was built as the thematic bedrock for evaluating the efficiency of the integration of mobile devices for learning. It provides an explanation of the procedure involved in the mobile learning process and it is based on the perspective of information as the learning environment within which the learner is situated. The model (figure 1) is made up of three parts represented as circles (device A, learner B, and social C) in a Venn diagram. The combination of all individual aspects (A, B, C), their primary intersections (AB, BC, AC, ABC) and the information context offers a depiction of what mobile learning is. Their intersections, Device Usability (AB) refers to the point at which the student begins to manipulate the device to execute learning tasks. In this sense, a blend of attributes such as portability, funtionality and satisfaction are at play. Social Technology (AC) mirrors the students and the technology and in this case attributes like collaborative tools, interactions are at fore. Lastly the Interaction Learning intersection (AC) considers external influences on the learners as well as their influences on one another illustrated by learning theories.

In this study, this framework is considered to be extensive since it explains elements that are learner centered and provides a basis for theories of learning and instruction found in the social constructivist philosophy. Nevertheless, due to constraints in time, resources and the fact that this study is in an exploratory phase, all aspects of Koole's model are not captured. Besides, it emphasizes that the learners should be the core focus for a successful implementation of m-learning. As such, the assumption is that the students require the skills to access relevant information at the time of need through mobile devices. This implies that the availability of the mobile device and wireless connectivity are necessities for the students in order to consider the integration of technology into education.

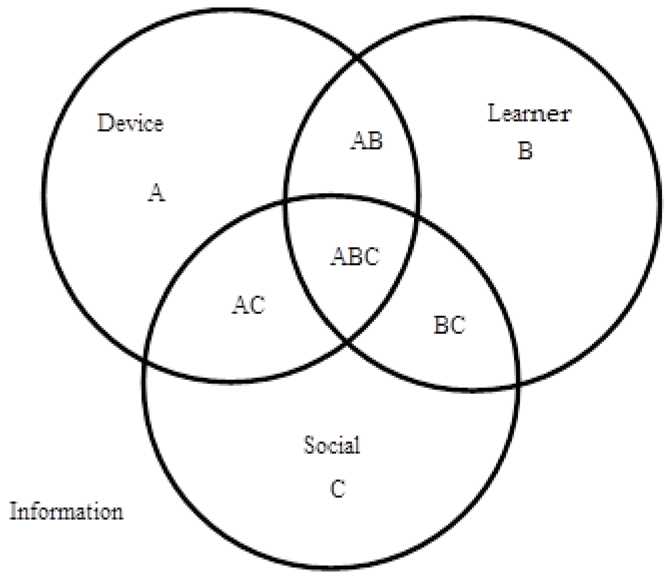

Figure 1: Adapted from Koole's FRAME Model (2006, pg 33)

Nigeria: Development in Education and Technology

As at 2015, Nigeria's population was estimated at about 182.2 million (World Bank, 2016). According to Worldometer (2016), this is 2.48% of the world's population. The country occupies a landmass of about 923, 768sqkm and with a total of about 274 ethnic groups. World Bank (2016) asserts that Nigeria accounts for 47% of the West African population and about 20% of the Sub-Saharan Africa population.

Education is seen as an economic driver towards development of any nation but the challenge of affordable education for the Nigerian populace in the midst of decreasing national resources and the increasing growth of the population is quite high. National University Commission (NUC, 2016) maintains that Nigeria presently has 152 universities: 40 Federal universities, 44 state universities while 68 are privately owned. This figure does not include tertiary institutions such as Colleges of Education, Polytechnics and Monotechnics. Beside, there has been higher demand for university education than can be catered for by the number of universities available in Nigeria. Oyewole (2010) suggests that the swift increase in the private and distance tertiary institutions of learning in Africa in the last ten years is partly due to the increasing population and quest for education which has surmounted the resources available in current public institutions.

In terms of technology development in Nigeria, the history of telecommunication services in the country begins in 1886 (Ajadi, Salawu, & Adeoye, 2008) and became well known in era of the then colonial government. As at December 2014, the subscriber data reflects that there are approximately 139.1million connected lines comprising of mobile GSM, mobile CDMA and fixed wire/ wireless (Nigerian Communications Commission (NCC), 2016).

In 2014, the number of mobile phone holders in Africa was estimated at 700million and this is more than in the United States and Europe (ITU, 2014; AFD & UNESCO, 2015). With a population of about 936 million and growth rate of 2.4% per year, the Sub-Saharan Africa is notably the region with the highest population growth in the world. However, the number of internet users in the region lags behind the world average when compared to Asia, the Pacific and Arab world. (Agence Francaise de Developpement, (AFD) & UNESCO, 2015). The influence of the mobile industry, has led to significant coalitions in Africa. Coalitions such as mobile banking (for example mPESA in Kenya), mobile health (for instance MoteCh in Ghana, MPedigree in Sub-Saharan Africa), mobile education (Tangerine system in Kenya), mobile farming (Used in Niger). A few other programmes worthy of mention are American One Laptop per Child (OLPC), Classmate PC by Intel group and Computer for School in Kenya (CFSK), (AFD & UNESCO, 2012). As a result of the opportunities that access to mobile technology offers, traditional methods of teaching and learning now begin to evolve while building on the ownership of the mobile devices. UNESCO (2012) reports on mobile learning projects used to support classroom teaching and curriculum delivery in South Africa, Tanzania and Mali. However, based on eight countries within the sub-Saharan Africa (the Democratic Republic of Congo (DRC), Ghana, Kenya, Malawi, Mauritius, Mozambique, Tanzania and Uganda), Bon (2010) recounts the current state of access to ICT in tertiary education and identifies that constraints which are political, financial and structural are acting as impediments.

The advent of wireless network in Nigeria presents a welcoming platform towards the integration of technology in the institutions of learning. M-learning also provides an attractive solution to the high demand for education in the country. Some studies within the Nigerian context have concentrated on the benefits and challenges of mobile learning. For example, it is advocated for nomadic education programmes by Aderinoye, Ojokheta and Olojede (2007). Similarly, Osang, Ngole and Tsuma (2013) look at the issues in relation to m-learning for Open University and distance learners. This paper aims at examining the perception and practices of university students towards mobile learning and the associated concerns which maybe characteristic to Nigeria and the sub- Saharan region at large. Therefore, from the point of view of this study, a successful adoption of mobile learning should be built on information concerning students' ownership of the mobile devices, students' technical skill and practices.

Method

The purpose of this study was to explore the readiness of the Nigerian university students in anticipation for mobile learning adoption. The study served as a pre-study for providing understanding of the prevailing status of mobile learning among the university students.

Participants

The participants were 135 non-randomly selected undergraduate students from two southern federal Nigerian universities. The study cuts across students from different years of study, gender, age group and departments. The bias in this study is for undergraduate university students in Nigeria and as a result, it excludes students of polytechnics, colleges of education, private universities, already graduated or in postgraduate studies.

Instrument

In order to achieve the objective of this study, data was collected using a survey consisting of twenty- five questions based on the works of Motiwalla (2007) albeit with some modification. The survey comprised of 6 main themes namely, mobile phone ownership (3 questions), skill (2 questions consisting of 7 sub-questions), internet access (6 questions), attitude towards social networking sites (1 question consisting of 4 sub-questions, travel history (3 questions), lastly, the students' awareness of mobile learning and willingness to use their mobile device for learning (2 questions). In terms of the students' skill, the questions were designed to understand their disposition towards the use of email, word processing, internet surfing, software downloads and navigating the internet to obtain information. Information on their access to the internet was obtained by examining what type of device was used, the frequency and the need for such access in relation to course assignments. Data on the students travel history was gathered using questions related to their mode of transportation, the duration and frequency of travel. Some questionnaires were distributed to the respondents and response was collected almost immediately while a few others were collected a few days after.

Overall, the administration of the questionnaire was done within a period of 3 weeks in each school at different departments and lecture halls and the participants in the survey were informed on the aim of the study. It was originally intended that both the self- administration and on-line method of survey be employed in this study. However, as a result of envisaged low response rate and the limited time available for the study, self – administration of the questionnaire through gatekeepers appeared more advantageous in terms of response rate. Initially, 170 questionnaires were sent out and 140 received after completion. Five of the 140 collected questionnaires were eventually rejected as the respondents were graduates and therefore did not qualify for inclusion in the target population. The difference of 30 questionnaires fell into the category of badly filled (10 questionnaires) and unreturned (15 questionnaires). A high response rate was found in this study to be 79.4%, this ensures a representativeness of the wider population from where the sample has been drawn. (Buckingham & Saunders, 2004)

Data Context

Some of the variables used in this study needed to be further categorized to enable data analysis. An example is the area of course of study where a number of departments and courses had to be grouped together into a single faculty. The faculties were grouped into six categories which are Engineering, Medicine, Agriculture, Art and humanities, Sciences and Social sciences.

Variables	Participants	Percentage (%)
Total sample size	135	100
University A	57	42
University B	78	58
Faculty		
Engineering	16	12
Medicine	12	9
Agriculture	16	12
Social Sciences	9	5
Sciences	62	46
Art and Humanities	21	16
Gender		
Male	73	54
Female	57	42
Age group		
≤18	19	14
19 - 22	68	50
23 – 26	43	32
27 - 30	1	0.7
Study Year		
Year 1	13	9.6
Year 2	51	38
Year 3	25	18.5
Year 4	29	21.5
Year 5	15	11
Others	1	0.7

Table 1: Data Variables of the Study

Result

Next we offer the outcome of the main questions and themes that this study aimed to answer. The results are presented using charts and measures of central tendency to enable comparison and upfront comprehension (Bryman, Bell, Mills, & Yue, 2011).

Type of Mobile Devices Owned by Students

The result revealed that of the 128 students who answered the question, 99% own a mobile phone (Figure 2). In addition, 89% of the students owned mobile phones with which they could access the internet while 82% of the students could access data services.

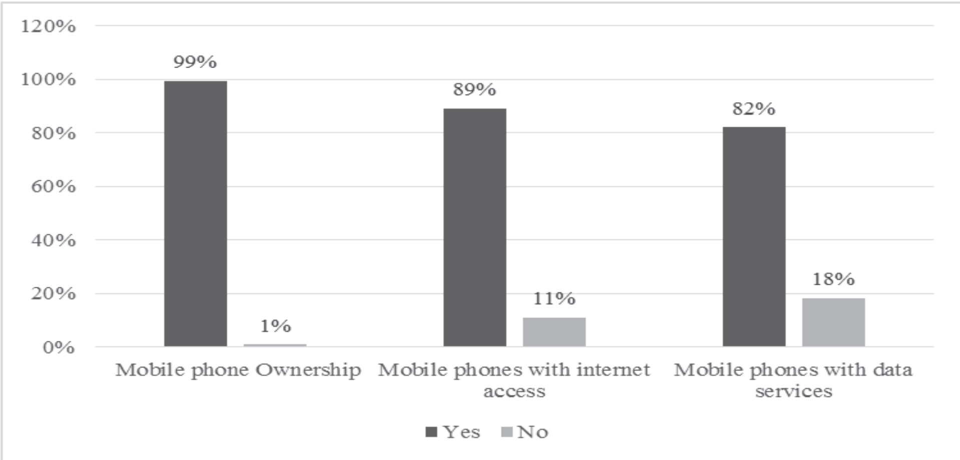

Figure 2: Students' Ownership of Mobile Phones

Students Knowledge of Mobile Learning

In response to the students awareness regarding mobile learning (see figure 3), a descriptive analysis reveals that 58% of the participants (N= 74) heard previously about mobile learning whereas, 42% had not. The internet ranked the most predominant medium of obtaining this knowledge with 46%. Subsequently, the television was 22% and magazine was 12%. Further, 93% (N= 126) were favourably disposed towards using their mobile phones for learning.

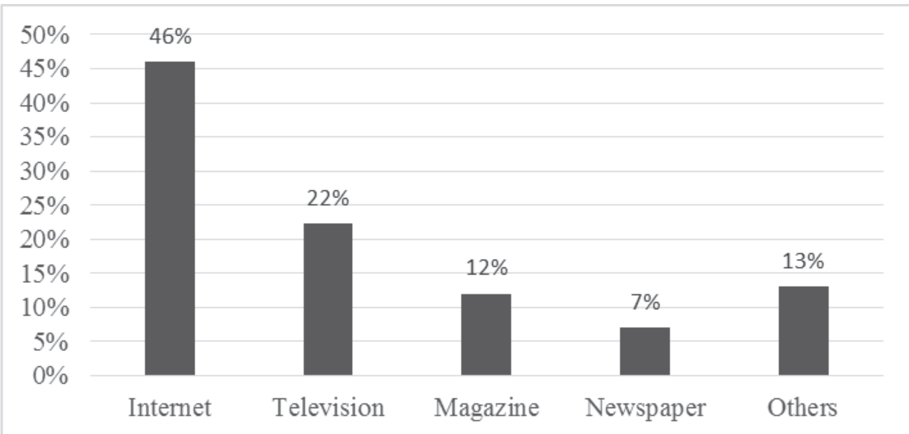

Figure 3: How They Learnt about Mobile Learning

Students' Skill

From the descriptive analysis of the result (table 2), it was observed that the mean ranged between 3.63 and 4.24 for all cases. A greater number of participants had skills in internet surfing. Those with very good skill were 36.2% (N = 130) while those with good skill were 29.2% and 28.5% had average skill. The majority of the students also were confident of their ability to navigate and obtain information from the intenet with 88.5% (N = 122).

Skill \	N	Range	Minimum	Maximum	Mean	Std. Deviation
Word processing	134	4	1	5	3.67	1.095
Use of email	133	5	0	5	3.93	1.031
Internet surfing	131	4	1	5	3.94	0.983
Software downloading	132	4	1	5	3.63	1.327
Use of Internet is clear and understandable	126	4	1	5	4.24	0.862
Navigate and Obtain Information from Internet	123	4	1	5	4.18	0.897
Internet is easy to use	126	4	1	5	4.14	0.953
Valid N (list wise)	119					

Table 2: Descriptive Statistics of Skill

Internet Access and Use

From the response to the survey, 51.2% (N= 127) claimed they require the use of the internet in 4 and more courses for completion of assignments. When the results were compared with respect to their individual faculties, it was observed that the students from the social science, the art and humanities faculties' belived they require the use of the internet for completion of course asignments for less than 4 courses. In addition, the most common mode of access to the internet (see figure 4) was through the use of their phones (31.6%; N= 133), followed by their laptops (26.3%), then through cyber cafes (20.3%). Only 1.5% was found to access the internet through the use of their school computer.

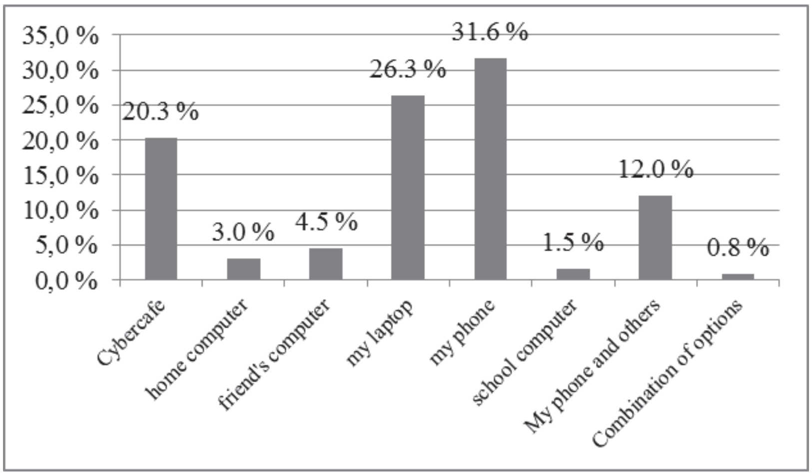

Figure 4: Mode of Internet Access

Attitude to Social Networking Sites

The result showed that 94% of the participants (N = 133) use such sites. While 91% (N = 133) admit that they use such sites in order to connect with people and 76% (N=131) acknowledge the fact that they use such sites to keep in touch with events. However, about 36% (N = 132) of the respondents accept that among other reasons, they also use such sites because others use it. These details are presented in figure 5.

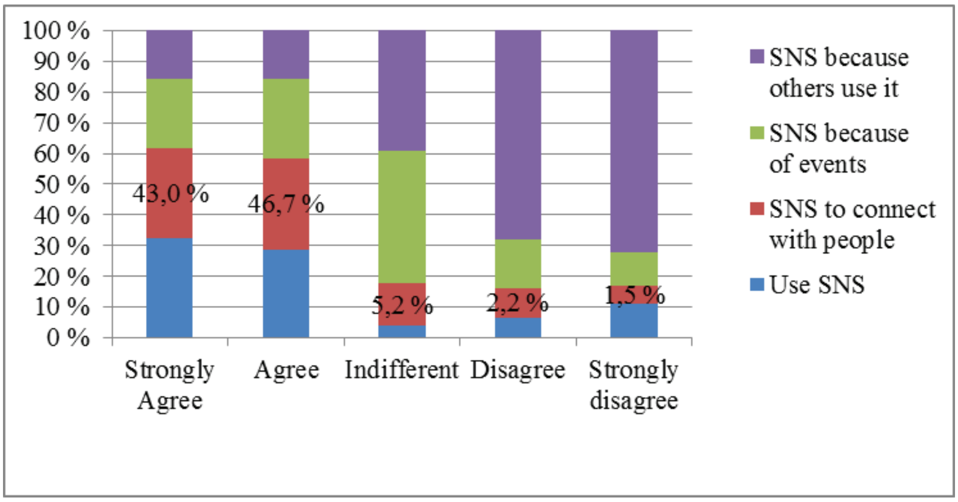

Figure 5: Attitude towards Social Networking Sites

Travel History

Most students represented as 47% travelled to school by bus (N = 134) and 48 % (N= 125) made these trips twice a day. However, 60.8% (N =125) spent less than one hour on such trips.

Conclusion

The result of this explorative study provides support for mobile learning in terms of the observed widespread ownership of the mobile device by the students and their general positive disposition. The device focused on was a mobile phone that is able to access the internet. The findings appear to be consistent with Koole's (2006) framework from the view point of the device availability which highlights the students' potentials in manipulating these devices towards course objectives. Also, the prospect of their co-construction of knowledge based on future collaborations among themselves as seen in their favorable disposition towards interactive activities (for example, social networking sites) and willingness to engage in mobile learning. Besides, a number of the courses required the use of internet for completion of course assignments and a high percentage of the students in this study obtained information about m- learning from the internet which confirms the desire for information. The key benefit of m-learning is observed in the ability to obtain information that is suitable and meets the timely need. Education stakeholders should consider pedagogies that promote learning activities which involve for example, sharing and collaboration using suitable technologies. The result further attests to the current trend in the ubiquitous use of the mobile device in developing countries especially in the sub -Saharan Africa (Sharples et al., 2005). Thereby supporting the argument put forward by Litchfield et al., (2007) that the students ownership of and readiness to use their own mobile device is a critical success factor in the implementation of m- learning. This may be valid because, it phases out the issue of cost of providing the device for the students and resolves the issues concerned with usability which was identified as a challenge to m – learning in a study by Corlett, Sharples, Bull and Chan (2005). In the same study, Corlett et al., (2005) confirm the significance in owning the mobile device as they observed that the students having been loaned PDAs, were found to be unenthusiastic in devoting time and money in personalizing and extending the device. Zhang et al., (2010) maintains that the ubiquitous technology has resulted in a growing enthusiasm among educators with regards to exploiting the benefits of m- learning.

With regards to travelling history, a good number of students in this study spend less than an hour at least twice in a day. Nonetheless, there are different learning activities that can be designed to fit various time frames while bearing in mind that it is difficult to delineate learning from other everyday activity but rather it should be incorporated in various non-learning activities (Sharples et al., 2005).Travelling time was referred to as *dead time* by Fuller and Joynes (2015) and in their research, they affirm that students' optimization of such opportunities for learning led to significant changes in their work placement. Nevertheless, the findings appear to be consistent with the report by UNESCO (2015) which claims that the use of ICT in education remains at the developing stage in most sub- Saharan countries.

As increasing development of technology continues to define the future, it is imperative that educational practices align with this trend. This study surveyed the students' ownership of mobile devices, their awareness and intent to use their devices for m- learning. Based on the findings revealing widespread ownership of the mobile device, the necessary skill and willingness to embrace mobile learning, we recommend that course resources should be designed for delivery through the mobile device. In addition, it is pertinent to choose or adopt suitable pedagogical approaches to learning activities that are appropriate for use considering the types of mobile devices owned by the students. The limitation of the study is such that the sample comprised undergraduates of two federal universities in the southern part of Nigeria.

Future research can examine the preparedness for m- learning in state universities, secondary schools or other institutions of learning in other regions of the country. In addition, since the focus of this study was solely students' perspective, the authors intend to further investigate the view of the teachers, their skills and attitude towards m – learning in the Nigerian universities.

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II

THE NIGERIAN EDUCATION AND THE OPPORTUNITIES AHEAD FOR MOBILE LEARNING

by

Eloho Ifinedo & Marja Kankaanranta, 2018

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The Nigerian Education and the Opportunities ahead for Mobile Learning.

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Abstract: Information technology is providing opportunities to improve education and therefore, research is needed to identify what gaps exist and how these gaps can become opportunities for technology integration such as mobile learning. This paper suggests that successful integration of technology towards improving quality education should be driven by the existing challenges which are contextually peculiar for every country. The case of the Nigerian education was examined alongside practices and policies. The study used secondary data from Nigeria Education Data Survey (NEDS). This paper highlights three major problems that Nigeria faces in basic education, namely: large number of out of school children, high dropout rate, and low literacy rates. It also forms a basis for further research in advancing mobile learning.

Introduction

In striving to improve quality in education, countries in developing world are tapping into innovative possibilities that are offered by Information Communication and Technology (or ICT) integration. These innovations in education are in effect investments in human capital which are perceived to result in eventual benefits such as economic and social developments for the populace (Howie, 2010; Oluwatobi, Olurinola & Taiwo, 2016; Watanabe, Naveed & Neittaanmaki, 2017). Mobile learning (or M learning), electronic learning, distance learning are some examples of innovations in education that have leveraged on the existence of technology. Technology therefore acts as a means to bridging the digital gap with benefits in quality of education.

According to UNESCO Institute for Statistics (or UIS, 2015), the quality of education can be improved by subsequently enhancing literacy rates and access to education. They also point out that efficiency in education can be measured in terms of the dropout rates and factors which are responsible for inequality. Other indicators identified by UIS (2015) are: Public Education Expenditure per Pupil (PPE) and Pupil Teacher Ratio (PTR). PPE reveals a country's commitment to education at each school level while PTR is a proxy for learning quality and a resource availability indicator.

Educational outcomes resulting from quality education have been observed to be facilitated by advancement in ICT integration. Watanabe, Naveed and Neittaanmäki (2017) categorized 20 countries according to their ICT integration level. Interestingly, their findings reveal that those 10 countries (e.g. Finland, Singapore, Netherlands, and UK) which they classified as ICT advanced (IAC) were distinguished from the other groups by the state of their internet access, quality of education and management system. They argue that the effects are seen in the transformation of their learning environments. Likewise, Oluwatobi, Olurinola and Taiwo (2016) found a positive relationship between internet usage and enrolment in primary, secondary and tertiary education.

However, some studies have identified factors that influence the ICT integration process in some countries. For instance, in Rwanda, Egypt and Nigeria, policy related problems at practice and implementation phases were observed (Byungura, Hansson, Masengesho, & Kaunaratne, 2016; Kozma, 2005, Oye, Salleh & Iahad, 2011) respectively. Howie (2010) also shows that the strategy for ICT integration was the issue in the case of South Africa.

The question is how can ICT be positioned for use in education in order to achieve quality education? Although ICT is claimed as vital to development, its presence and continuous evolution has not led to the desired impact particularly in developing countries (Heeks, Gao & Ospina, 2010). The studies enumerated so far, emphasis the need for attention to the entire process of ICT integration, that is, from policy formation to implementation stage. In addition, Howie (2010) points out that previous research on ICT policies have been shaped by perspectives of developed world and add that in the case of developing countries, cognizance of context related challenges should be noted. In line with Howie's perspective, this paper aims to:

- Identify the challenges in the Nigerian education sector by examining the policies and practices.
- Identify the possibilities technology integration can offer as a solution to the challenges.

Nigeria is selected as a case example for the study, as it has wide industry in the field telecommunication but at the same time, the country is struggling with its educational challenges and ICT use still plays a minor role in education. The rest of this paper is divided as follows. In order to provide an understanding of the country's current structure, the next segment will describe the Nigerian context in terms of profile and the education system and issues. Next, the data extracted and the main challenges are presented. Thereafter, we offer some discussion and conclude.

Nigeria: Profile and Education system

The population of Nigeria as at 2017 was estimated at 184million (World Bank), which accounts for 47% of the West African population, as well as, about 20% of the Sub-Saharan Africa population.

In 2012, the National Council on Education modified the Nigerian education system from four levels (6-3-3-4) to five levels (1-6-3-3-4) in order to provide better access to education (Federal Ministry of Education, 2014). This implies that formal education is made up five levels namely: One year of kindergarten, six years of primary school, three years of junior secondary school, three years of senior secondary school, and four years of university or undergraduate education leading to a degree award. According to the federal ministry of education, the overall objective of this system is to produce individuals that are resourceful and therefore suitable for employment. Basic education refers to the education provided for children up till the age of fifteen. In Nigeria, the government provides compulsory basic education beginning usually from age five and over a span of nine years. The technical and vocational education is also available and advocated towards meeting the societal demands. Also, the junior secondary school is both pre-vocational and academic while the senior secondary school incorporates subjects that are technical, commercial and vocational in nature in order that school leavers at this point can find themselves relevant in the labor market. In addition, there are the colleges of education which are responsible for training in order to produce professional teachers. This training is completed in three years and a Nigerian Certificate in Education is obtained. The academic year in the country begins in September and ends in July. The federal, state and local government, together with the communities and private organizations in Nigeria, all share the mandate for delivering the objectives in the education sector.

Underlying Issues in the Education Sector

According to Education Policy and Data Centre (or EPDC, 2014), the number of pupils enrolled in primary and secondary education in 2010 was 30.6 million with expected increment in subsequent years (UIS, 2015). However, 70% of these pupils are enrolled in primary education which indicates the assertion by World Education Services (in WENR, 2017), that the youth population growth is a factor that challenges the Nigerian basic education system especially its inability to accommodate a significant portion of this population category.

Literacy is viewed as a basic skill required for advanced levels of learning as well as provides a system for appraising a nation's learning achievements. EPDC (2014) claims the literacy rate among the Nigerian youth population at 66% is lower than the average among other lower middle-income countries.

Over-age and under-age students are usually as a result of either late entry into or grade repetition at the primary or secondary school. An over-aged pupil is one that is two or more years older than the official grade age. Conversely, a pupil is under-aged if he or she is one or more years younger than the official grade age. An on-time pupil is therefore one who is within the official age range for their specific grade (National Population Commission, Nigeria or NPC Nigeria & RTI International, 2016). Late entry to school and repetition rates contributes to inefficiency in education system. In addition, the over/ under-age problem affects the teachers as they have to consider their teaching approach with respect to the differences in the maturity of the students. These problems can also affect the classroom experience for the students in general. In 2015, the percentage of Nigerian primary school students found to be on-time, over-age and under-age was 59, 22 and 19 respectively (NPC Nigeria & RTI International, 2016).

The pupil to teacher ratio (PTR) is observed to decline. For example, the PTR for primary and junior secondary school in 2014 was 40 and 26 respectively (National Bureau of Statistics or NBS, 2015). In comparison, the PTR was given as 37.6 for primary education while it was 31 for the junior secondary school and 36 in upper secondary school (EPDC, 2014). Evidently, the PTR in primary school is higher than in secondary school levels in Nigeria. Similarly, a decline is observed, when comparing the primary school net attendance, which was 68.7% in 2014 against 71% in 2012 and the completion rate for primary school which was 74% in 2014 from 87.7% in 2012

(NBS, 2015). Net attendance is the number of pupils in the official age group for a given level of education who attend school in that level, expressed as a percentage of the total population in that age group. This declining trend in the education sector appears to confirm the assertion by NBS (2015) that Nigeria still struggles to attain targets such as the Universal Primary Education (UPE), Education for All (EFA), and Millennium Development Goal (MDG).

According to UIS (2012), the Out of School Children problem is the biggest contributor to the country's inability to meet these aforementioned targets. For example, NBS (2015) asserts that almost 3million Nigerian children (8.1%) between the age brackets six to 14 were out of school while 3.2 percent of this population dropped out of school in 2010. Further, Nigeria is ranked as one of the countries with the largest out of school population (UNESCO, 2015). Kozma and Wagner (2006) propose that in combating education problems, efforts should be directed at the root cause, which in their study was associated mainly with social factors. As a result, they proposed solutions which are ICT based as well as *support social engagement with learning*.

Information and Communication Technology (ICT) in Nigerian Schools

UIS (2015) recommends early integration of ICT into levels of education such as primary and secondary curricula towards building digital literacy, which is essential for youth empowerment and lifelong learning. In addition, UIS (2015) enumerates lack of formal policy, financial resources, basic infrastructure and competent teachers as factors that militate against ICT integration in education. The importance of ICT in promoting the delivery of basic education in Nigeria is acknowledged and reflected in the National Policy on Education (2013, p.15 & 42) specifically in the area of developing teachers, capacity and infrastructure. However, initiatives that address the needs of the Nigerian primary and secondary school students through ICT integration are lacking. For example, the lack of instructional materials in primary schools as suggested by Federal Ministry of Education (n.d.) can be addressed by technology integration according to Oluwatobi, Olurinola and Taiwo (2016).

Moreover, the development in the telecommunication industry in Nigeria has been monumental and its relative opportunity in terms of mobile learning will yield gains in schools. Some studies have shown high penetration level of mobile devices among the Nigerian university students (Ifinedo, Kankaanranta, Neittaanmäki, & Hämäläinen, 2017; Utulu & Alonge, 2012). However, this development has not led to its widespread use in education. Nevertheless, Adedoja, Botha and Ogunleye (2012) have enumerated two mobile learning initiatives currently in use in Nigeria (JAMBMOBILE and UI Initiative). JAMBMOBILE's target audiences are students who are interested in getting admission into universities while the UI initiative is designed for students of one university.

Data Extract

This paper is based on the premise that the successful integration of technology towards quality education should be driven from the view point of the existing challenges which can be peculiar for different countries. To achieve this, the study uses secondary data obtained from Nigeria Education Data Survey (NEDS), which was conducted between May and August 2015. This is reportedly, a nationally representative sample survey, which in partnership with the Federal Ministry of Education, the Universal Basic Education Commission and the National Bureau of Statistics was executed by the National Population Commission. In addition, technical assistance was obtained from RTI International and funding from United States Agency for International Development. The aim of the survey was to provide data on household level and the necessary information on the demand for schooling. The sample participants were children, parents and guardians.

Challenges in Nigeria's Education

UIS (2012) describes monetary cost in terms of direct fees, private expenses or opportunity costs. Examples of direct fees are school fees, Parent and Teacher association levies or for activities. Examples of private expenses are uniforms, transport fare or books. To the parents or guardians, the opportunity costs of having their children or wards in school results in forgoing the alternative, usually in form of child labor. The data extracted from the NEDS of 2015, highlights three major challenges, which are presented thus.

Reasons for Never Attending School

Figure 1 highlights five main reasons the Nigerian children are not attending school at the national level. Other reasons revealed in the survey are: too young, critically ill, disabled, travel unsafe, poor school quality, no jobs for graduates and school is not important. From the responses (n = 13,996), it is observed that the regions differ as to reasons the children are not attending school. Financial cost is the main reason for the North Central, South East and the South-South. The South West region has the highest number of children (46.5%) with no interest in education and 44.5% are away from school because they are needed for labor. The school distance is indicated in the North East while for the North West it is the labor needed factor.

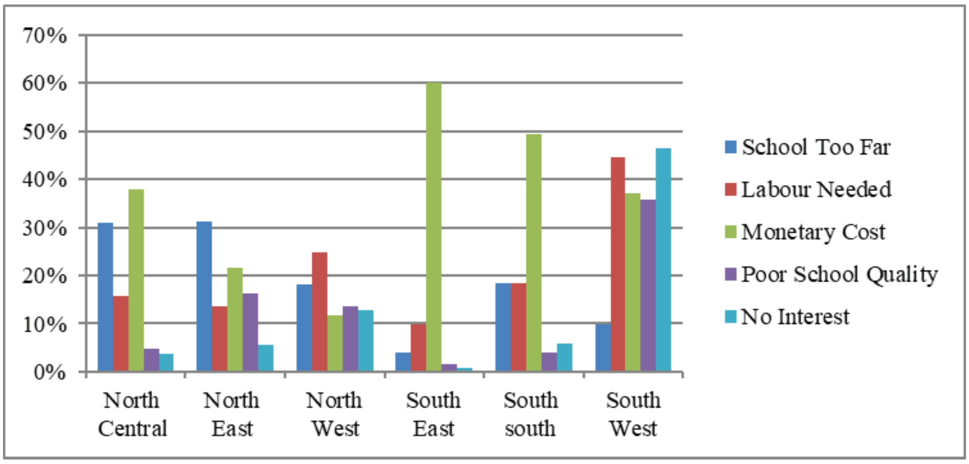

Figure 1: Reasons for Never Attending School (extracted from NEDS 2015)

Reasons for Primary School Dropout

At the national level, five leading issues were identified as responsible for school age children's dropout. Figure 2 presents the response (n = 1,339) across the regions. In the case of the dropout problem, the monetary cost is observed to be the prominent reason across the regions except in the North East. The same factor accounts for the highest share of dropouts along the rural and urban divide. Next is the labor needed factor which appears to be highest in the North West.

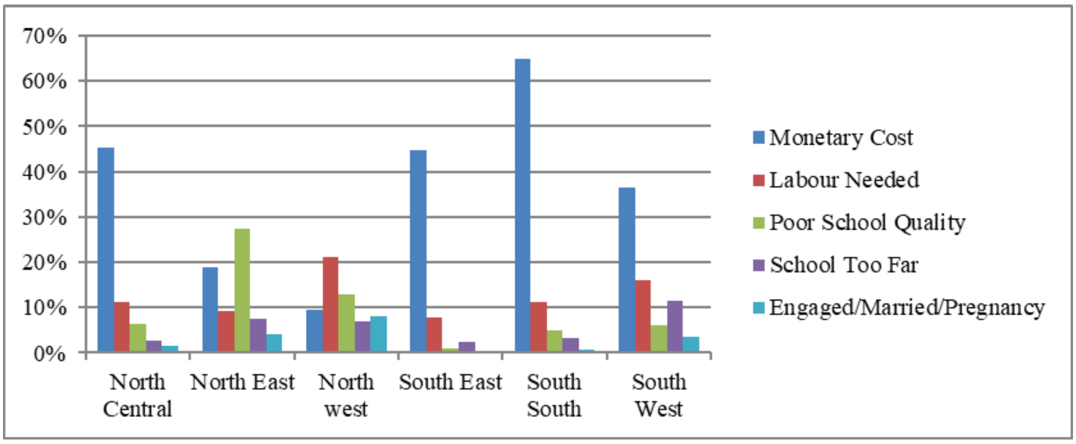

Figure 2: Reasons for Primary School Dropout (extracted from NEDS 2015).

Children's Literacy Rate

Figure 3 presents the literacy rates among children between the ages five to 16. Literacy (can read) in this context refers to the children's ability to read all or part of a sentence while numeracy (can sum) refers to those who can correctly sum numbers. The result of the survey shows that the overall literacy (n = 78, 558) and numeracy (n = 78, 293) for the school children between the aforementioned age group was 48.5%. Along the rural and urban divide, the children's reading skill was 20.4% and 48.9% respectively while their summing skill was 39.6% and 75.4% respectively.

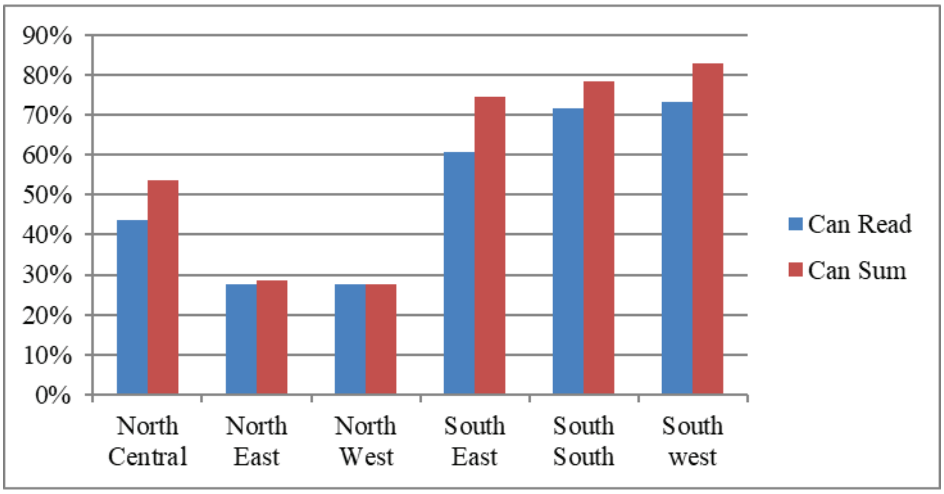

Figure 3: Children's Literacy and Numeracy Rate (extracted from NEDS 2015).

Discussion and Conclusion

UIS (2012) opined that when children enrolled into school are challenged by situations, it results in irregular school attendance that may lead to failure and then dropping out of school and eventually, they become Out of School Children. This suggests that the drop out issue is a subset of out of school children issue. Thus, on the factors challenging the Nigerian education according to the regions, the following discussion is offered.

From this study, it was observed that the regions were influenced differently. The reasons for children never attending school was mainly due to monetary cost. Others were, no interest, labor, poor school quality and school too far. Along the rural – urban divide, the school distance is the highest factor that instigates the out of school problem for those in the rural areas while the monetary cost is the highest for those in the urban area. In the case of literacy rate, it is perceived that across the board, the children seem to be more proficient at summing numbers than in reading. Also, a wide spread need for improving the children's reading skill is evident.

Overall, the use of ICT can address some problems of the school children such as no interests and school distance, labor needed by providing them with multiple channels of learning, motivational and educative materials on for example, mobile devices. Materials for promoting reading and summing skills can be designed for delivery through mobile devices for all the regions albeit a bit of variation according to the regional needs highlighted. The challenges as revealed in this study indeed offers an opportunity for the use of technology since access to mobile devices for example, enables access to information and interaction which in turn could lead to development of motivation, curiosity and reading competencies of the children as shown by Pruet, Ang and Farzin (2016).

Aside from less infrastructural requirement in mobile learning when compared with other technologies, it avails enormous potentials for achieving numeracy and literacy skills but most promising, is its ability to take educational experiences outside classrooms (UNESCO 2015). In considering the use of ICT for bridging the gap in education, Kozma and Wagner (2006), propose that the objective (meeting the academic and social needs of the school or society at large) should drive the process (design, policies, practices, strategy). In the Nigerian context appraised, this means that, in order to improve the quality of education, the government needs to reinforce the objective of the appropriate policies designed for inclusion of the out of school children, dropouts and improve the literacy rate. These policies require the participation of all stakeholders and should be coherent as well as connect with the overall goal to be achieved as pointed out by Heeks, Gao and Ospina (2010).

In conclusion, this paper identified the problems within education in Nigeria with a view to suggesting innovative ICT-based solutions to improve the quality. Nigeria is selected as the context for the study since the country has a wide industry in the telecommunication field and a youth population growth that poses a threat to her basic education system. The three major problems inherent in the Nigerian basic education were; large number of out of school children, high dropout rate, and low literacy rates. The study offers support for subsequent research in developing countries and initiatives advocating for quality education such as Education for All and Millennium Development Goal. Further, this research sets the stage for the next phase which entails the investigation of how the challenges identified in this paper can be reduced using affordable technologies within Nigeria. The need for further research to aid the effective policy implementation with regards to ICT integration in education was also highlighted. Specifically, policies that leverage on the availability of mobile devices for the inclusion of the disadvantaged learners within Nigeria's basic education level as a means to improving the quality of education is advocated. A strong need for evaluating the current status of ICT use in Nigerian schools as well as design of case studies in which teachers and students are supported towards applying ICT as an essential and natural part of learning and teaching practices is highlighted.

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III

UNDERSTANDING THE INFLUENCE OF CONTEXT ON NIGERIAN TEACHERS' TECHNOLOGY INTEGRATION

by

Eloho Ifinedo & Marja Kankaanranta, 2019

Under second review at Technology, Pedagogy and Education

Request a copy from author.

IV

TPACK AND EDUCATIONAL INTERACTIONS – PILLARS OF SUCCESSFUL TECHNOLOGY INTEGRATION

by

Eloho Ifinedo & Jenni Rikala, 2019

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TPACK and Educational Interactions – Pillars of Successful Technology Integration

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Abstract: It is important to understand what drives the success of technology integration in educational settings, because learning in schools with technology develops the students' capacities to participate fully in the digital age. Educated students, in turn, can transform our societies through innovative scientific discoveries. Recently, the Technological Pedagogical Content Knowledge (TPACK) framework has emerged as a theoretical framework needed for understanding the teacher's integration of digital technologies into teaching. Educational interactions, in turn, have been emphasized as a critical component of the educational practices, processes and contexts. However, these two concepts have been studied and developed rather independently. This paper reviews both educational interactions and the TPACK framework. Against this background, we outline and propose an integrated framework that combines two approaches and allows providing a better understanding of technology-based education, especially at the micro level of the classroom.

Introduction

Digital technologies are spreading rapidly across the globe, and different technologies have become integral parts of everyday life. Also, educational institutions have recognized the potential to improve learning in classrooms with technologies along with the importance of developing the capacities of their students to use technologies to participate fully in the digital age (Fraillon, Ainley, Schulz, Duckworth & Friedman, 2019). Adding technologies into the classroom remains a challenging process and researchers have been trying to understand and explain how best to achieve this in education for over 30 years (Petko, Prasse & Cantieni, 2018). In discussing the process, most literatures usually point to interrelated factors surrounding the technology, users and contexts (e.g., Bingimlas, 2009; Ertmer, 1999; Drent & Meelissen, 2008; Tay, Lim & Lim, 2013).

Notably, teachers occupy a significant position in the technology integration process and several educational technology frameworks have been developed (Bower & Vlachopoulos, 2018) with the intent to help education stakeholders as well as improve the complex process. Recently, the Technological Pedagogical Content Knowledge (TPACK) framework has emerged as a noteworthy tool for understanding effective teaching with technology and thus, an important theoretical foundation for technology integration research. Hundreds of studies have utilized the TPACK framework to explore teachers' technology use in classroom settings (Phillips, 2017). However, the TPACK framework has also been criticized for not explicitly addressing context and actors (Porras-Hernández & Salinas-Amescua, 2013; Rosenberg & Koehler, 2015). More so, Bower and Vlachopoulos (2018), argued that technology integration frameworks rarely provide explicit and substantial consideration of the interactions between students and teachers. Therefore, this paper reviews both educational interactions and the TPACK framework. Against this background, we outline and propose an integrated framework that combines two approaches and allows providing a better understanding of digital educational environment and success in classroom.

Technology Integration into Teaching and Learning

Vygotsky (1979) stressed that it is impossible to separate learning from its social context. Hence, learning is an integral and inseparable aspect of social practice (Lave & Wenger, 1991). Learners learn from various sources, settings, and interactions—from humans or objects (e.g., books)—and through technologies (Okita, 2012). Therefore, learning is always constituted through a situated interaction of learners, teachers, and technologies (Mercer & Littleton, 2007). Based on these assumptions, we collected and investigated a range of existing artifacts and factors and their relationships that influence successful technology integration, especially at the micro level of the classroom where behaviors of students, teachers, and technologies interact to provide learning opportunities (Webb, 2013). In this section, we summarize the research on educational technology integration. Educational technology integration models generally focus on the individuals, the specific characteristics of the context, and the innovation to predict future use (Straub, 2009). We have structured our literature review based on these factors.

Role of the Teacher

Teachers are central to the success and sustainability of technology integration for instruction (Ng & Nicholas, 2013) and thus, they are the most important agents in shaping education for students and bringing innovation to educational practices (Solheim, Ertesvåg & Dalhaug Berg, 2018). Consequently, it is expected that teachers gain skills and knowledge of effective instructional practices that incorporate meaningful uses of technology (Ertmer 1999). Furthermore, much of the effect of teachers and classrooms on student learning is seen in the interactions that take place between teachers and students (Hamre et al., 2013). Therefore, we begin by reviewing teacher competence and teacher-student interactions.

Teacher Competence

Several researchers emphasized teachers' competencies as an essential part of successful technology integration (Crompton, Olszewski & Bielefeldt, 2016; Tay et al., 2013; Redecker & Punie, 2017). Teacher competence, in turn, comprises cognitive, skill-based, and affective components that depend on the learning environment and contextual factors (Binkley et al. 2012; Caena 2014; European Commission 2018; Redecker & Punie, 2017). The TPACK framework similarly highlights areas of competence that teachers in this ever-changing digital era need to have to take full advantage of digital learning environments. TPACK is developed from the knowledge constructs (pedagogical and content knowledge, or PCK) modeled by Shulman (1986). In the PCK model, an integration of content knowledge (CK) and pedagogical knowledge (PK) culminates in how subject knowledge is taught to the learner. Koehler and Mishra (2006) advance the PCK model by introducing the knowledge of integrating technology, which answers the question of how to apply technology in the teaching of a subject. The TPACK framework consists of three key components of teachers' knowledge: content (CK), pedagogy (PK), and technology (TK) and the interaction between and among them. According to Koehler and Mishra (2009), PCK is similar to Shulman's (1986) idea of the knowledge of pedagogy that is applicable to teaching specific content. TCK, in turn, is an understanding of how technology and content influence and constrain one another. TPK is an understanding of how teaching and learning can change when technologies are used in particular ways. TPACK thus represents an understanding of how to teach with technology.

Evidence has shown that many teachers lack the TK needed to use technology effectively, which in turn limits their potential impact (Hinostroza, 2018). Although teachers need to be confident and competent technology users, they also need to understand how to incorporate technologies purposefully into learning plans and curricula to personalize, engage, and create an interactive atmosphere for the student (Tsai & Chai 2012; Willis, Lynch, Fradale, & Yeigh, 2019). This is suggestive of the fact that effective practices using technology blends with the teacher's other knowledge: that is, all types of knowledge constructed by the teacher, such as those developed from years of teaching experience, the subject taught, the students' characteristics and needs, along with devices. Earlier studies have emphasized teacher attitudes, perceptions, and personal factors as critical drivers of technology integration within the classroom (Aldunate & Nussbaum, 2013; Almerich, Orellana, Suárez-Rodríguez & Díaz-García, 2016; Salinas, Nussbaum, Herrera, Solarte & Aldunate, 2017; Tondeur, Aesaert, Prestridge & Consuegra, 2018). Accordingly, teacher competence is an experience-based and emotionally-affected mix of competence that also involves values, attitudes, and a certain mindset. Likewise, Joo, Park and Lim (2018) allude that the teachers' TPACK affects teacher self-efficacy and influences the teacher's perceived ease of use, along with the perceived usefulness of technology in the classroom. Self-efficacy and perceived usefulness of technology, in turn, affect teachers' intention to use technology. In other words, teachers who have high levels of TPACK might find it easier to use technology and would also perceive using technology as a helpful teaching tool. Hence, in the high satisfaction classroom, the teacher is pedagogically and emotionally engaged, which appears in the form of organized learning activities, flexibility, and creativity in instruction as well as enthusiasm and positive feelings regarding the classroom (Kangas, Siklander, Randolph & Ruokamo, 2017). Signifying that during the technology integration process, teachers might need to overcome second-order barriers, including their beliefs about technology and teacher-student roles, curricular emphases, and assessment practices (Ertmer, 1999).

Teacher- Student Interactions

According to Houssaye (1988), all teaching and learning situations can be defined as an interaction between two of the three points of a triangle: the teacher, the learner, and knowledge. This kind of triangle highlights the specific interrelationships and interactions between a teacher, student, and content in a given pedagogical situation (Friesen & Osguthorpe, 2018; Page 2015). The interactions between a learner and teacher are essential, for instance, to assess current understanding and design appropriate approaches, along with stimulating critical reflection and diagnosing misconceptions (Anderson & Garrison, 1998; Kostiainen et al., 2018; Larson, 2000). The teacher-learner interactions also comprise emotional, organizational, and instructional domains (Hamre et al., 2013). Thus, the teacher is responsible for facilitating and orchestrating interactions to enhance student learning (Anderson, 2004). Research has indicated that learners are most motivated to learn when teachers support their need to feel competent, positively related to others, and autonomous (Hamre et al., 2013). Therefore, the primary role of the teacher is to facilitate the student's active, partly self-regulated sharing of thoughts: for example, by asking open-ended questions and providing more opportunities for reflection (Dukuzumuremyi & Siklander, 2018; Muhonen, Rasku-Puttonen, Pakarinen, Poikkeus & Lerkkanen, 2016). Hence, students become empowered learners primarily through their teachers' interaction and instruction (Hamre et al. 2013; Houser & Fymier, 2009), and the resultant learning opportunities created (Karvonen, Tainio & Routarinne, 2018). Thus, the learner-teacher relationship is dual in nature; it takes both the form of interaction between the teacher and learner and of the bond between the learner and the teacher via developed teaching materials (Anderson 2004; Page 2015). Teaching materials can be static and nonresponsive or interactive multimedia, such as audio or video recordings, computer software, or other multimedia technologies and content that are constantly refreshing and updating (Lonn, Teasley & Krumm, 2011). Technologies, for instance, provide avenues that enable learners to interact and capture experiences in both physical and social realms and make learning more experiential and multifaceted (Ting 2013). Therefore, it is also important to note that student-teacher interactions are tied to a specific context (van Es & Sherin, 2002). As a result, a teacher never just gives a lesson; rather, in most cases, the classroom interaction is designed and planned with the specificity of students and context in mind (Friesen & Osguthorpe, 2018).

Role of the Learner

Amid the ongoing discussion of technology integration in education, the learner is recognized as not only a stakeholder but also as the focus of the learning or teaching process (Koole, 2009). In other words, the reason the teacher intentionally chooses the pedagogy or technology suitable for specific content is to enable the learner to obtain a clear understanding of the subject. Consequently, in the student domain, we observe distinct features of context (classroom and school) and actors (teachers and students), and their actions influence the learning goals.

Woods and Baker (2004) argued that learners have opportunities for four potential realms of engagement: a teacher, learners, content, and environment. In each of these realms, the learner can ignore an engagement or engage in interactive communication. Anderson and Garrison (1998), in turn, suggested six types of interaction: learner-teacher, learner-content, teacher-content, learner-learner, teacher-teacher, and content-content. These interaction classifications allude to the fact that interactions between one learner and others are important in investigating and developing multiple perspectives and understanding course content (Anderson, 2004; Kurucay & Inan, 2017; Okita, 2012). Thus, learners learn together with their peers and their teachers; they learn while collaborating and doing (Illeris, 2009; Lonn et al., 2011; Moore, 1989). Learners may move within different physical and virtual locations, participate and interact with other people, information, and systems (Koole, 2009). Thus, requiring an environment that is learner-centered and technology-rich where students are actively engaged and take ownership of their learning (An & Reigeluth, 2011).

Characteristics of the Context

Teaching and learning do not happen in a vacuum. These processes are affected by the world in and beyond the classroom. Bronfenbrenner (1994), suggested that the interactions between the individuals and their environment can be categorized into various systems, also known as an ecological system, that shape their development over time. This ecological system consists of five rings of interconnected systems: microsystems, mesosystems, exosystems, macrosystems, chronosystems. The microsystem is the immediate environment (e.g. family, school, peer group, and workplace). The mesosystem is a system of microsystems. The exosystem, in turn, is the linkages and processes taking place between two or more settings. The macrosystem consist of micro-, meso, and exosystem (i.e., characteristics of a given culture, belief systems, material resources and opportunity structures). The chronosystem encompasses change or consistency over time in the characteristics of the person and environment.

Equivalently, several studies have indicated that effective technology integration in education using the TPACK framework should consider context. Angeli and Valanides (2009) extend the TPACK with the inclusion of two features: knowledge of context and knowledge of students. Porras-Hernández and Salinas-Amescua (2013) likewise identified from previous TPACK literatures four main characterizations of context: namely, student characteristics, classroom and institutional conditions for learning, and teachers' epistemological beliefs. Thereafter, the latter extended the TPACK framework by outlining context (scope) in three dimensions (micro, meso, and macro) and the knowledge construct of the actors (teachers and students). Another discussion on context and its impact on teachers' technology integration is seen in the study by Koh et al. (2014), who explained the context in terms of teachers' beliefs (intrapersonal), school (cultural or institutional), technology (physical), and peers (interpersonal). In addition, the model by Chai, Koh, Lim and Tsai (2014) describes context as consisting of five levels (micro, meso, macro, chrono and exo) and at each of the levels, different education stakeholders (actors) exert some amount of influence on the process of technology integration, which affects the teacher's TPACK. These efforts to modify the TPACK framework reveal that careful consideration of context in research is necessary in order to fully understand the technology integration process. Indicating further, that context can either support or hinder teaching and learning with technology. Typically, these hindering and supporting factors of meso and macro levels are described in terms of the types of resources (e.g., equipment, time, training, support) that are either missing or available in teachers' implementation environments (Drent & Meelissen, 2008; Ertmer, 1999; Tay et al., 2013). Thus, comparing these dimensions of context, it infers that the meso and macro context levels directly influence teachers' decisions on how they integrate technology (Cheah, Chai & Toh, 2018), and the impact of such influence is reflected on what happens in the classroom or the micro level (Kim, Hannafin & Bryan, 2007).

Innovation in Education

Researchers have noted that innovative teaching flourishes when the school culture is collaborative and supportive in terms of peer support and sharing (Shear al., 2011). Therefore, teacher-teacher interactions may encourage teachers to take advantage of knowledge growth and discovery, both in their subject areas and within the scholarly community of teachers (Anderson 2004). Teachers' improvement in classroom interaction is dependent on both the teacher's own strong knowledge of classroom interaction and that of their colleagues (Solheim et al., 2018). Therefore, professional development programs need to be sensitive to teachers' individual and collaborative learning experiences to support teachers in the natural context (Rytivaara & Kershner, 2012).

Although teachers are key drivers of innovation, organizational capacity to exploit innovations is also needed (Wilcox & Lawson, 2018). Amponsah, Kwesi and Ernest (2019) enumerated multiple factors, such as workload, lack of teaching and learning resources, remissness of creative learning, social-cultural influences, and objectives stated in the curriculum might inhibit creative teaching and learning in schools. Therefore, the main elements of innovative digital schools are visions of school, leadership, the practice of the teaching community, innovative and creative pedagogical practices, school-level knowledge practices, and digital resources (Ilomäki & Lakkala, 2018). Chai et al. (2014) emphasized that teachers, students, curriculum designers, heads of departments, school principals, ministry officers, software designers, parents, and industry partners all contribute to the technology integration. An effective technology integration with teaching and learning is therefore dependent on successful interactions between the leadership team, community, technical support personnel, and key users—teachers and students (Ng & Nicholas, 2012). Hence, communication and dialogue are important parts of the systemic change process (Joseph & Reigeluth, 2010).

As technology advances, commensurate change is required at institutional levels: for example, changes in procedures, pedagogy, and school culture. One of the most important aspects of the systemic change process is helping stakeholders to evolve their mindset and mental models about education (Joseph & Reigeluth, 2010). Burke et al. (2018) have stated that teachers with constructivist-oriented pedagogical beliefs are more likely to adopt technology than transmission-oriented teachers. Successfully facilitating technology adoption must consequently address cognitive, emotional, and contextual concerns (Straub 2009; Wilcox & Lawson, 2018). In order to foster creativity in schools, teachers must take risks by trying new, learner-centered, and alternative methods in their work (Amponsah et al., 2019).

The Proposed Framework

In the previous section, we presented the main variables, dimensions, and core actors of our conceptual framework. In this section, we will assemble them.

Micro Context Level

First, our proposal for the framework (see Figure 1) suggests that the key actors (teachers and students) are bound within the micro context level (i.e., classrooms and other learning environments). Competent integration of technology is evident at this micro level context, and the actors become objects of knowledge with their unique inner and external contexts (Porras-Hernández & Salinas-Amescua, 2013, p. 231). At this level, the teachers are most relaxed and possess a greater sense of autonomy, which is displayed in the classroom interaction (i.e., interactions among teachers, contents, and learners).

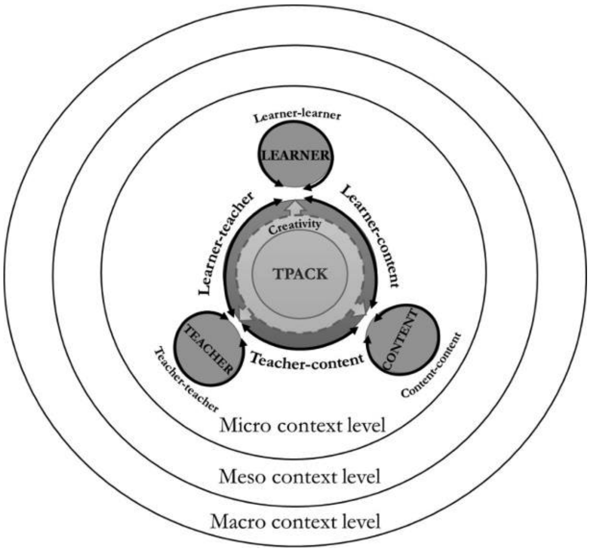

Figure 1: Proposal for the educational technology integration framework

Richards (2007) argued that interaction design in context is the missing link needed to harness new learning technologies more effectively in educational practices. We see that the viewpoint of interaction provides clarity on the actors' domain by highlighting their in-depth relationship to their educational objective. How the teacher frames educational objectives and students' interactions with educational technologies at the micro level affects students' learning. Thus, knowledge building takes place in a learning environment where the behaviors of students, teachers, and technologies interact to provide learning opportunities (Webb 2013).

Meso and Macro Context Level

Our proposal considers the contextual parameters of meso and macro levels, which can influence teachers' professional development and decisions on how they integrate technology (Cheah et al. 2018). For instance, macro level cultural, societal, and technological changes affect the meso level content and context of teaching and learning (Wei & So, 2012). Change is reflected in national policies and curriculum reforms. Education providers, in turn, create local level curricula based on national level policies and curriculum. Also, the current economic situation is reflected in the meso level parameters. Meso level parameters include technology tools and resources, technology training alongside administrative support (Francom, 2016; Ruggiero & Mong, 2015).

Niemi et al. (2012) identified six meso level characteristics of successful technology integration: strategic planning as part of school culture, leadership and management, communication, flexible curricula, methods that facilitate participation and empowerment, and the teaching staff's capacity and commitment. Thus, if the school culture and vision are anti-technology and no technologies are available, teachers' opportunities to integrate technologies into teaching and learning are insufficient (Burke et al., 2018). Continuous professional development may give teachers the support they need to promote the mastery of skills, along with changing teachers' beliefs regarding technology and pedagogy (Ryan & Bagley, 2015). Professional development efforts should focus particularly on strategies to facilitate changes in teachers' attitudes and beliefs, since those key areas are required when introducing technology at the meso level (i.e., school culture) and developing a sustainable practice (Ertmer et al., 2012). When teachers' comfort and professional competence are relatively high and teachers are working together, they might begin to reimagine and refresh their pedagogy and design new, creative, learner-centered ways to utilize technology (Erbes et al., 2016; Shear et al., 2011). Therefore, it is recommended that professional development programs for teachers should be related to their pedagogical context, include collaboration, be customized for teachers' needs and interests, and stimulate reflective learning (Uerz et al., 2018). Proper technology infrastructure also enhances meaningful integration. Therefore, the technology infrastructure should be robust and capable of supporting new learner-centered educational methods.

Given that the proposed framework is an educational technology integration framework that views technology integration in an educational context, the framework does not consider the exo and chrono context levels. Inasmuch as we recognize that these levels are important and they contribute to shaping learner development over time (especially in informal learning environments), our focus is on shaping the meaningful interactions that occur between the main actors within their immediate learning context of the micro level.

TPACK and Creativity

TPACK is the core of our approach. TPACK can be understood as a teacher's specialized brand of knowledge (i.e., a blend of TK, PK, and CK). Teaching future skills by utilizing new and evolving technologies requires a variety of skills and knowledge that are different from what most teachers understand (Makoe 2012; Redecker & Punie, 2017). Avidov-Ungar et al. (2018), for instance, noted that teachers with both high PK and high TK were able to apply innovative pedagogy in the classroom in a manner that implements innovation, indicating that effective practices using technology requires various types of knowledge. Shulman (1987) argued that the knowledge base for teaching is neither fixed or final, and that the knowledge base remains to be discovered, invented, and refined. Accordingly, we have simplified this knowledge base. We see that TPACK includes knowledge of how to integrate technology in meaningful ways to promote learning and interactions at the micro context level. Teachers choose the appropriate pedagogical and technological tools and adapt them for their student population (Avidov-Ungar et al., 2018). Hence, TPACK culminates in classroom interactions (learner-content, learner-teacher, and teacher-content). We also see that in some forms, TPACK could be applied to the student. Students also need TK and CK. If PK is understood as learning strategies that students apply before and during their learning process, then TPACK is applicable for students as well. Moreover, TPACK does not exclude the fact that the learner is at the center of the learning. At the same time, TPACK also accentuates that technology use in the classroom requires a balance between the curriculum, the students' needs, and human-technology interactions: in other words, knowledge of practical teaching with technology (i.e., a blend of TK, PK, and CK). Therefore, TPACK forms the core of our approach.

Tsai and Chai (2012) emphasized that design thinking can resolve some technology integration issues and create what is desired. In line with Mishra and Henriksen (2018), we see the importance of creativity in repurposing technology tools to make the tools fit pedagogical and discipline-specific learning goals and classroom interactions. Differing resources, the needs of learners, the rapid changes in technologies, and the shifting expectations of society make it impossible to prescribe educational experiences that will be suitable for all circumstances (Albion & Tondeur, 2018). Consequently, teachers need creativity to be able to adapt methods and experiment with new tools. Consider, for example, the interactive whiteboard as an educational tool. The whiteboard is usually placed in the front of the classroom and is therefore usually under the control of the teacher: in other words, framing the nature of student-teacher interaction (Harris et al., 2009). However, if framed differently, an interactive whiteboard can provide opportunities for innovative and active participation from students, either one at a time or in a group activity with several students. Thus, educational technologies such as whiteboards or mobile devices in general can be employed in a wide variety of ways to enhance learning in both formal and informal education. It is essential to select technologies that support meaningful learning experiences. The educational technology itself usually does not determine the way in which it is used and applied to support teaching or learning (Passey 2014). Therefore, purposeful pedagogical design is important. Our proposed framework is pedagogically flexible leaving room for teacher's creativity.

Classroom Interactions

In this framework, we see educational interactions as a multifaceted, context-bound, and process-oriented concept that depends on the learning environment, contextual factors, and the actors involved in the process. The combination and impact of these multifaceted interactions on teaching and learning objectives are tangible, especially within the spectrum of the micro level of the classroom or learning environment. In these interactions, learners participate and interact with other people, information, and systems across diverse learning environments (Koole 2009). Through their interaction with learners, teachers stimulate learners' interest and help students utilize and understand course content (Illeris, 2009; Lonn et al., 2011; Moore, 1989). Hence, we see that the learner's cognitive abilities, memory, prior knowledge, emotions, and motivations play a key role in the learning process (Koole 2009) and that the teacher can, for example, facilitate the student's active, partly self-regulated, sharing of thoughts by asking open-ended questions that allow more students to share thoughts and provide opportunities for reflection (Muhonen et al. 2016). The teachers also have a key role in providing triggers for interaction in collaborative settings (Dukuzumuremyi & Siklander, 2018). The technological tool can enhance this process by providing access to content and information in multiple formats and enabling communication and collaboration among individuals and systems (Koole, 2009). Hence, we see that the orchestration of tools, contents, and methods, along with the constant adaptation to the reality of students and the class dynamic, is an ongoing and collaborative process (Pedro et al., 2018).

Conclusion

In this paper, we have shown various barriers to technology integration that previous researchers have noted, and that the TPACK framework continues to offer a stable foundation for studies of teachers' competence and learner-centeredness in a technology-driven era. Furthermore, we have shown that adding the perspectives of context and interaction can contribute to the enhancement of the TPACK framework's usefulness for bringing change and innovation to educational practices.

Implications and Recommendations for Meso and Macro Context Level

Educational technology integration is much more than simply throwing technology at the classroom and waiting for magic to happen. We suggest the following:

All stakeholders (e.g., ministries and government agencies, curriculum designers, school leaders, technical support personnel, teachers, and students) should work together to improve the practice of technology integration. Thus, educational technology integration should never be a top-down decision, for the reason that such an approach can result in feelings of anxiety and resistance among teachers. Rather, developing common visions and strategies about the role of technology in education with all stakeholders within micro, meso, and macro level contexts is practical. Thus, technology integration should consider the needs of all those who will be involved. At best, this kind of strategy and vision can ensure that resources, such as finances and time, are spent more efficiently.

Without holistic improvements in support (e.g., technical and pedagogical support, availability of infrastructure, policies, time allocated to incorporate new technologies) and training, teachers might struggle to use technologies in the classroom. Therefore, teachers need resources and opportunities to collaborate, experience, and critically reflect on the educational value of technologies at the micro context level. They need examples and hands-on experiences of the usefulness of technology in teaching. Therefore, it is important to develop teacher education curricula. Thus, rather than focusing only on general technology skills development, all three areas—technological, pedagogical, and content knowledge—become strengthened when considering principles of interaction and micro context level factors.

Implications and Recommendations for Micro Context Level

Since the teachers have a certain degree of autonomy to choose the technology that matches their pedagogical needs, the teachers have a key role in bringing change to educational practices. Therefore, we suggest the following:

Teachers at the micro level of the classroom should consider how and for which lessons technology will be used, how it will enhance teaching and learning, and how it will help to achieve learning goals. It is important to pay attention to the processes of social interaction and cooperation, using these processes to structure learning activities around content and contexts as well as learners' needs and preferences to empower students and promote new ways of working and interacting. Hence, teachers need to be open-minded, critical, and creative thinkers and designers, as well as lifelong learners.

Both the teachers and students need TPACK to be able to work effectively with technology in the classroom. CK and TK are essential to the understanding of, and participation in, education. For students, PK can be understood as learning strategies that students apply before and during their learning process. Teachers know their students' learning styles and needs, and therefore can select and adapt their strategies and methods to accommodate different learning styles and help each student achieve their full potential.

Limitations and Future Research

Our conceptual framework values the micro level context in which teachers exploit different domains of knowledge to frame educational interactions. We argue that continuous interplay between teachers' knowledge and their environment can explain technology adoption and its influence on teaching practices and interactions. Since our framework is a conceptual framework, much remains to be accomplished from an empirical point of view. We recognize that unless a conceptual framework is tested empirically, it may be inadequate for application in practice, representing only a limited, subjective perspective. However, keeping this limitation in mind, our conceptual framework contributes to the body of knowledge in the discipline as it provides an understanding of the role of TPACK and multifaceted interactions in technology integration, especially at the micro context level that is characterized in teaching and learning practices.

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V

ANALYSING THE NIGERIAN TEACHERS' READINESS FOR TECHNOLOGY INTEGRATION

by

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Analysing the Nigerian Teacher's Readiness for Technology Integration

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ABSTRACT

Technology integration promises better quality in education. This integration is challenging to accomplish, especially for teachers in a developing country like Nigeria where the demand for education remains a struggle in the face of dwindling resources. The technological pedagogical content knowledge (TPACK) framework promotes designing strategies suitable for the teachers' needs. Therefore, in order to determine the readiness of the Nigerian teachers for technology integration, this study examines the Nigerian teacher educators' (N=136) TPACK and the relationship among the constructs using self-completion survey and partial least square techniques. The results reveal that among the seven knowledge constructs, the teachers' technological, pedagogical, and technological pedagogical knowledge are the most significant predictors of their TPACK. The theoretical and practical implications of the result are discussed thereafter.

Keywords: *Technology integration; Teacher educators; Nigeria; TPACK; Partial Least Squares; Structural Equation Modelling*

INTRODUCTION

Information and communication technology (ICT) has become widespread and ICT tools have become accessible and useful in fulfilling mundane needs. This usefulness has moved from supporting traditional roles to substantially supporting different sectors, such as education, health, government and businesses. Owing to the perceived role of ICT in education, a growing number of studies continue to discuss and debate its impact on learning outcomes. Thus, developments in ICT has led to changes in the dynamics of how teaching and learning are fostered (Okanlawon et al., 2017; Sinha & Bagarukayo, 2019). E-learning offers access and flexibility to people who want to work and learn at the same time, which is an improvement on the traditional distance learning programme of study (Owolabi & Owolabi, 2015). The developments in the usability of mobile devices have also led to the paradigm known as mobile learning. This paradigm emphasizes the possibility for learning to occur regardless of time and location and thus leverages on the diffusion of mobile devices (Adedoja et al., 2013). Another development is blended learning, which uses both traditional face-to-face teaching and learning involving the use of ICT (Olelewe & Agomuo, 2016). Finally, developments in ICT have given rise to possibilities and challenges even for teachers and their professional development needs (Dintoe, 2019; Dlamini & Mbatha, 2018). Therefore, education and ICT remain effective channels to develop any country as some studies have indicated the economic benefits of such investments (Howie, 2010; Oluwatobi, Olurinola & Taiwo, 2016; Watanabe, Naveed & Neittaanmaki, 2017).

It is recognized that Nigeria lags behind in terms of quality of education and resources for teacher education (Okolie et al., 2019; Olulobe, 2006; UNESCO, 2014). However, at the same time, Nigeria ranks as Africa's largest Internet user (Edo, Okodua & Odebiyi, 2019) and the diffusion of mobile devices is evident among Nigerian students (Ifinedo et al., 2017; Utulu & Alonge, 2012). Consequently, the attraction and benefits of ICT in education could offer some solution to combating these issues (Ifinedo & Kankaanranta, 2018). In terms of policy, the Federal Ministry of Education (2014) shows the significance of ICT for promoting the delivery of education in Nigeria with emphasis on developing teachers, capacity and infrastructure. Nevertheless, Yusuf (2005) attributes the lack of appropriate strategies for integration of technology in education as well as lack of vibrant ICT policies as contributors to the problem of employability of graduates in Nigeria. This indicates the need for initiatives that fill such employability gaps. Previous studies have implied that preparing an information society acquiescent workforce led to the success of some economies (Howie, 2010; Oluwatobi, Olurinola & Taiwo, 2016; Watanabe, Naveed & Neittaanmaki, 2017). Thus, the preparation of this workforce is a direct result of learners that easily adapt to the continuous evolving technological, socio-cultural and economic environs.

Following from the benefits that ICT integration offers in education, our research investigates the teacher educators' knowledge that is required for technology integration in their classrooms, that is, their technological pedagogical content knowledge (TPACK). Thus, this study aims to provide answers to the following research questions:

1. What are the Nigerian teacher educators TPACK perceptions?
2. What relationship exists among the variables of the TPACK construct?

Having highlighted the development and significant role of ICT particularly in education in the introductory section, we seek hereafter to answer our research questions, by first discussing the context of the study from where the sample was drawn and reviewing the technology integration related studies that have been conducted within this context. Next, we provide the theoretical underpinning, and the research method, participants, survey instrument and the data analysis technique are described. Subsequently, the results followed by a discussion on the findings are presented. The conclusions, implications, and limitations, alongside future work are explained.

Research Context: Nigerian Teacher Education

As part of on-going efforts to improve the quality of education, the government of Nigeria made provision especially for colleges of education as the institutions where professional teachers are produced within a three-year span. The National Commission for Colleges of Education (NCCE) was established through the 1989 Education Act and the Amendment Act 12 of 1993, specifically to oversee the higher education institutions in the country with focus on improving the quality of teacher educators (Federal Ministry of Education, 2014). At present, however, along with the other tertiary institutions in the country (that is, the universities and polytechnics), the colleges of education are being governed by the NCCE, the National Board for Technical Education and the National Universities Commission.

There are 89 colleges of education in Nigeria (NCCE, 2017), which signifies the emphasis placed on teacher education in the country. These colleges of education are equally shared (that is, 44:45) between the northern and southern part of the country. They are categorised according to their administrators (that is, governed by federal: 22, state: 20 or, private: 47) and in accordance with the programmes offered (in this case, technical: nine, conventional: 79 or special: one).

It is expected that colleges of education would be institutions where future teacher educators acquire pedagogical skills relating to their fields of study or interest (Federal Ministry of Education, 2014) but it is only realistic that these future teachers will eventually teach based on what skills they have received or practiced from training (Shonola & Joy, 2014a). Igwe & Rufai (2012) showed in their evaluation of professional qualifications of Nigerian teachers that the majority of the teachers are indeed qualified with degrees ranging from NCE (Nigeria Certificate in Education) to master's level certificates and are therefore capable of providing quality teaching service. However, the study by Olelewe & Okwor (2017) revealed differences in skill levels between the teachers in the university, polytechnics and colleges of education even though the teacher education provided is expected to produce teachers who are professionally skilled for service in all levels of the education system. The way that teachers are trained at their respective colleges of education is therefore important. For example, stand-alone computer courses did not translate into ICT competence among the preservice teachers investigated by Garba (2014) because the teaching method was characterized by the traditional face-to-face method, devoid of the practical approach and active participation of the students. It is therefore necessary, that in order to prepare the future teachers and learners with 21st-century skills, the teacher educators themselves should be the front-runners in matters of technology integration. Understanding the critical role that adequately equipped teachers play, inspires the need to consider their perspectives, experiences and beliefs and the advantages that seemingly new innovations add to their teaching practices.

Related studies on technology integration in Nigerian Education

Developments in technology have brought about opportunities for improving teaching and learning especially in terms of access to resources. The Internet, for example offers learning platforms and capabilities in bridging the distance between learners and teachers. As such, developments in technology have led to its various forms of integration in education with examples like mobile learning, online learning and blended learning. As a result of these technological developments, educational activities can occur through electronic mail, chats, web-based conferencing, messaging platforms and web pages for sharing information resources (Utulu & Alonge, 2012). These educational activities in turn facilitate interactive and collaborative learning and enhances assessment during the teaching-learning process (Olelewe & Agomuo, 2016).

A number of authors within the Nigerian context have produced scholarly works that assessed the extent to which the higher education institutions in Nigeria have attempted to infuse ICT based teaching and learning techniques. At the secondary school level, a factor analysis study by Ogundile et al., (2019) found five categories of factors that influence the use of ICT in Nigerian schools namely, support, availability, infrastructure, learning tools and cognitive. Chaka & Govender (2017) found that students of three colleges of education from the north-central part of Nigeria expressed enthusiasm in implementing mobile learning. Utulu & Alonge (2012) revealed the engagement of mobile devices by lecturers and students in their institution mostly for communication, recording results, accessing resources online and sharing knowledge. Likewise, Adedoja et al. (2013), studied students' attitude towards the use of mobile phones for lesson delivery and the result showed a positive, increased interest and motivation of students to learn. Their study further suggested that attitude is influenced by the perceived benefit, which implied students' perceived benefit (such as, flexibility in terms of studying time and location offered by the mobile phone delivery platform) triggered the students' motivation to learn. Olelewe & Agomuo (2016), using a quasi-experimental design investigated the effects of blended learning and face-to-face learning on computer education student achievement. The result, which was attributed to interaction and active participation among the students, showed that with the blended learning approach, the students' achievement improved significantly. Owing to the ubiquitous, collaborative and social features, Oyelere et al., (2018) designed a mobile learning application to aid learning among computer science students and it was observed that their learning outcome improved significantly.

Common to the above described related studies is the use of ICT in various forms, which is observed to enable access to educational content, result in increased motivation to learn and eventually improve the outcome for learners. Although these studies describe the positive impact of technology integration in education, they, however, focus on student perspectives. What is therefore lacking is the perspectives of teacher educators. Igwe & Rufai (2012) recommended the continuous review of the teacher education programme in order to improve the efficiency of the teaching service. The perception of teacher educators in the adoption, implementation and use of any technological innovation in an education system, cannot be overemphasized since it is their responsibility to decide the appropriate mode of communication, technique and teaching aid that would be effective for service delivery.

Oluwafeyikemi, Ajayi, & Gata, (2018) investigated the use of an interactive board in teaching Christian Religion Knowledge in Colleges of Education in the Northcentral region of Nigeria. Although the teachers complained that the devices were too few, the level of use was also observed to be low. Inije et al., (2013) considered the use of e-learning technologies in business education instructional delivery in colleges of education in the Delta state of Nigeria. The findings indicated low usage levels at the institutions despite the availability of e-learning technologies such as e-lectures, e-examination, e-drill, e-books and an e-library. Another constraint identified in the study was the low proficiency of teacher educators in the integration of the available technologies in their schools.

Although Samuel, Onasanya & Olumorin (2018) suggest in their study that lecturers had a positive disposition towards the use of mobile technologies for research purposes, the authors also maintain that the lecturers' perceived usefulness and ease of use of these technologies were average. Likewise, Shonola & Joy (2014a) describe the barriers to mobile learning in higher education institutions within the southwest of Nigeria. In doing so, they highlighted constraints such as obsolete curriculum, lack of infrastructure, funding and policy issues. In addition, a major challenge was the lack of skills among teachers and their attitude towards using technology, specifically, because the training they received was not in accordance with the present day digital era. Also mentioned, was the fear of losing control over the students and that the students are more likely to become technology dependent with improvements in their technological skills that would not necessarily translate to improving their learning outcomes. Further investigation by Shonola & Joy (2014b) through interviews on perspectives of 30 lecturers of computer science departments at three higher education institutions, on security issues pertaining to the use of technology (mobile devices) as teaching aids, found that the majority of these lecturers feared the exploitation of security, and privacy breaches. Specifically, in the area of the interception of personal and confidential information by students and outsiders as well as unauthorised access to learning content or unpermitted sharing of copyrighted e-materials by the students. In addition, they feared virus and malware attacks leading to loss of confidential information, loss of control leading to examination malpractices for example, during e-assessment and e-examination.

In most of these studies, a common feature of the barrier to use ICT in the classroom is the question surrounding the teacher educators' competence. In addition, noticeable in these studies, is the lack of evaluation of teachers' knowledge domain using the TPACK framework despite the fact that the framework is acclaimed to provide a basis for understanding how teacher educators integrate technology in their classrooms (Stoilescu, 2015).

TPACK FRAMEWORK

The TPACK framework has emerged as a theoretical framework needed for understanding the teacher's integration of ICT into teaching. Shulman (1986) in an analysis of the distinct knowledge construct known as pedagogical content knowledge (PCK), which is required by a teacher, provides the basis for the TPACK framework. The TPACK framework (see Figure 1.) further describes a distinct knowledge construct required by teachers especially in today's technology-driven era (Mishra & Koehler, 2006). This distinct knowledge construct, that is, TPACK, is an aggregate of three main components of knowledge (TK, PK, CK) and their interrelationship which produces three other types of knowledge (TCK, PCK, TPK). The technology knowledge (TK) as the name implies, denotes the knowledge of different technologies. Pedagogical knowledge (PK) represents the teachers' deep knowledge about the systems, approaches, procedures and practices of teaching and learning. Content knowledge (CK) describes the teachers' knowledge on the subject taught as well as emphasizes the importance of teachers having a well-rounded knowledge of the field in which they teach. TCK is such that the teacher is able to combine both knowledge of technology and of subject matter while understanding the resultant effect they individually have on each other. This knowledge can influence the teachers' decision on the appropriate technology for specific subjects and vice versa. Akin to the original concept by Shulman (1986), the PCK refers to the pedagogical knowledge required by a teacher for teaching a specific subject. TPK enables the teachers' understanding of the effect of learning and teaching with different technologies such that the tool is regarded as a facilitator of the learning or teaching process. The framework therefore, enables the design and evaluation of what knowledge is required and how such knowledge can be cultivated (Schmidt et al., 2009). In this way, understanding the knowledge base of the teachers is critical in revealing the prevalent gaps in regard to technology integration and thus provides strategic opportunities to address such gaps.

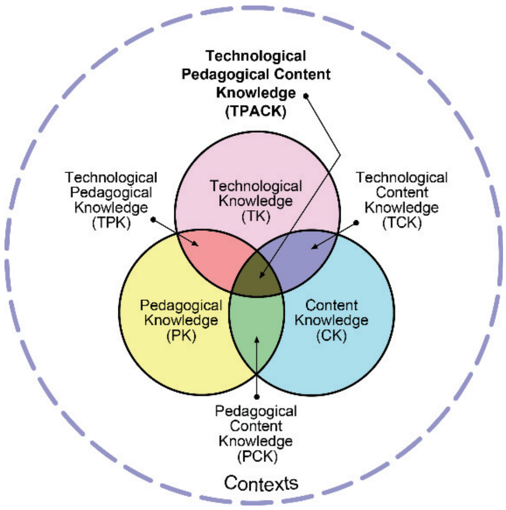

Figure 1: TPACK framework (reproduced by permission of the publisher, © 2012 by tpack.org

The TPACK framework has been utilized in many different contexts but it seems that so far, the use has been limited in the context of developing countries. We however, acknowledge the study by Kihoza et al., (2016) conducted in Tanzania where a combination of TPACK and the Substitution-Augmentation-Modification-Redefinition frameworks were used to assess teachers' technology integration. Previous studies using solely the TPACK framework have examined contexts such as, preservice teachers (Schmidt et al., 2009), in-service teachers (Liu, Zhang, & Wang, 2015) and in regard to the professional development of new higher education teachers (Wu et al., 2016). The framework has also been used in subject specific contexts like mathematics (Guerrero, 2010) or music (Bauer, 2013). Heitink et al., (2016), evaluated the perspective of teacher reasoning in relation to their technology usage within the Dutch context while Chuang & Ho (2011) reflect the Taiwanese context. In addition, previous studies have used the framework in comparing teachers' technology integration across country contexts (Alqurashi, Gokbel, & Carbonara, 2017; Redmond & Peled, 2018). In addition, the result of an international collaboration (Dalal, Archambault & Shelton, 2017) that assessed the perceived technology integration abilities of sixteen secondary school teachers from seven developing countries using the TPACK framework indicates development of all seven constructs of their TPACK. The authors of the latter study linked part of the gains of the study to the contextualised exposure of the teachers to educational technology tools, resources and applications with which they were equipped. Accordingly, the technological tools, resources and applications accessible to the Nigerian teacher educators have been noted earlier in this paper. Also, an overview of the TPACK studies contained in previous literature reviews (Voogt at al., 2013; Willermark, 2018) attest to the scarcity of studies from the developing country context. More specifically, references to studies that actually capture the knowledge of teachers in relation to ICT integration within the context of the Nigerian teacher education are sparse. Therefore, the current study is an exploratory one, where the TPACK framework and instrument is used to investigate the Nigerian teachers' knowledge for technology integration and thus provide answers to the specific research questions indicated earlier.

METHOD

This research is part of a larger study, which employed the use of both quantitative and qualitative methods to investigate the use of ICT in Nigerian schools. This paper, however, will offer insights relating to the analysis of data collected quantitatively using the TPACK framework as a guide. The convenience sampling technique was used to select the schools and participants of this study.

Sample

In this study, a paper-based self-completion survey was used to collect data from 148 teacher educators from various departments of three colleges of education from the southern part of Nigeria. Listwise deletion was used to eliminate cases that answered the TPACK questions incompletely, leaving 136 usable responses. The various departments were eventually categorised into three: Art (language, religious studies), science (physics, chemistry, database management), and social science (accounting, geography, agriculture). Of the participants, 60% were male (n = 81) and 35% female (n = 48). The participants consisted of various age groups; however, 75% were found to be 40 years and above. Most of them (50%) teach within the social science category and about 44% teach a class size of range between 0-50 students. From the 95% who responded, it can be observed that the majority of the participants engage in actual teaching activities. Over 90% own more than one mobile device. More details on the sample's demographics are shown in Table 1.

Common method bias (CMB) occurs as a result of the measurement method used in structural equation modelling (SEM) (Kock, 2015a). In accordance with reducing the effects of CMB (Podsakoff et al., 2003), some recommended measures were followed. First, the respondents' anonymity was ensured. Secondly, the questionnaire included clear instructions at the top and clear wording was used to design the items overall. Further, in assessing for CMB, the full variance inflation factors (VIF) for data analysis using WarpPLS software was employed (Kock, 2015a; Kock & Lynn, 2012). For the constructs, TPACK, TPK, TCK, PCK, PK, CK and TK, their VIFs were 3.55, 3.31, 2.23, 1.40, 1.97, 1.87 and 1.69 accordingly. Notably, VIFs above the benchmark of 3.3 are regarded as suggestive of models having the presence of CMB. However, this threshold remains under scrutiny and in particular, Kock (2015a) argues for higher benchmarks than 3.3 when factor-based PLS-SEM algorithms are utilized as is the case in this study. Therefore, the VIFs of the constructs of this study could be considered non-problematic for the data collected.

Table 1: *Demographic Profile of Participants*

Variable	Content	Frequency	Percentage
Gender	Male	81	59.6
	Female	48	35.3
	missing	7	5.1
Age group	25 – 29	3	2.2
	30 – 39	25	18.4
	40 – 49	60	44.1
	50 – 59	42	30.9
	Above 59	5	3.7
	Missing	1	0.7
Categorized department	Art	11	8.1
	Science	48	35.3
	Social science	68	50.0
	Missing	9	6.6
Work title	Lecturer	117	86.0
	Senior lecturers	5	3.7
	Principal/ Chief lecturer	6	4.4
	Non-academics (instructors)	2	1.5
	Missing	6	4.6
Teaching experience	below 2 years	2	1.5
	2 - 4 years	8	5.9
	5 – 9 years	36	26.5
	10 – 19 years	52	38.2
	Above 19 years	38	27.9
Average class size	0 – 50	60	44.1
	51 – 100	23	16.9
	101 – 150	13	9.6
	151 – 200	1	0.7
	201 – 500	19	14.0
	Above 500	5	3.7
	Missing	15	11.0
Device ownership: (Phone, laptop, tablet, desktop computer)	Only one	10	7.4
	Combination of 2	70	51.5
	Combination of 3	43	31.6
	Combination of 4	12	8.8
	Others	1	0.7

These main TPACK survey questions contained five Likert Scale type questions (from strongly disagree to strongly agree) as designed by Schmidt et al. (2009) but with some revisions specifically to suit in-service teachers as against the initial design, which was for pre-service teachers. An example of such revision was in generalising the questions in terms of subjects taught to accommodate the various departments in the Nigerian colleges of education sampled. This implied that the TCK construct consisted of only one item ‘I know about technologies that I can use for understanding and teaching my subject'. Another example was in the TPK construct where the item referring to the teacher education program was not included. In addition, the item, "I can adapt the use of the technologies that I am learning about to different teaching activities" was changed to "I can adapt the use of the technologies that I know in different teaching activities". Table 2 contains the complete record of items used to measure the constructs for this study together with descriptive statistics. The mean of their responses to the items ranged between 2.66 and 4.77.

Table 2: *Items in the Questionnaire along with their Descriptive Statistics and Item Loadings*

Construct	Item	Item description	Mean	Standard deviation	Item loading
Technical Knowledge	TK1	I know about a lot of different technologies	3.80	1.010	0.658
	TK2	I have the technical skills I need to use technology	3.82	0.913	0.828
	TK3	I know how to solve my own technical problems I can learn technology easily	3.34	1.027	0.709
	TK4	I frequently play around the technology I have had sufficient opportunities to work with	4.04	0.888	0.659
	TK5	different technologies	3.58	1.054	0.737
	TK6		3.27	1.119	0.742
Content Knowledge	CK1	I have various ways and strategies of developing my understanding of the subject I teach	3.97	1.025	0.934
	CK2	I have examples of how to apply the subject I teach in the real world	4.07	0.809	0.934
Pedagogical Knowledge	PK1	I can use different teaching methods in the classroom (collaborative, instruction, inquiry, problem based etc.)	4.26	0.779	0.824
	PK2	I can adapt my teaching style to different learners	4.23	0.730	0.863
	PK3	I know how to assess student performance and learning in different ways	4.27	0.683	0.832
	PK4	I am familiar with common student understandings and misconceptions of the subject.	4.10	0.822	0.814
	PK5	I can adapt my teaching based on what students currently understand or do not understand	4.18	0.732	0.815
Pedagogical Content Knowledge	PCK1	I know that different concepts in the subject I teach do not require different teaching approaches	2.66	1.268	0.736
	PCK2	I know how to select effective teaching approaches to guide student thinking and learning in the subject I teach	4.13	0.814	0.736
Technological Content Knowledge	TCK	I know about technologies that I can use for understanding and teaching my subject.	4.00	0.834	1.000
Technological Pedagogical Knowledge	TPK1	I have the technical skills I need to use technology appropriately in teaching	3.74	1.018	0.831
	TPK2	I can adapt the use of technologies that I know in different teaching activities	3.80	0.921	0.868
	TPK3	I think critically about how to use technology in my class	3.76	0.996	0.800
	TPK4	I can choose technologies that enhance my teaching approaches for a lesson	3.94	0.865	0.911
	TPK5	I can choose technologies that enhance students' learning during a lesson	3.93	0.869	0.891
Technological Pedagogical Content Knowledge	TPCK1	I can teach lessons that appropriately combine my subject, technologies, and teaching approaches.	3.79	0.890	0.906
	TPCK2	I can select technologies to use in my classroom that enhance what I teach, how I teach, and what students learn.	3.82	0.950	0.897
	TPCK3	I can provide leadership in helping others to coordinate the use of content, technologies, and teaching approaches at my school.	3.83	1.008	0.890

Data Analysis

Models entrenched in theory can be tested using structural equation modelling (SEM) (Henseler, Hubona, & Ray, 2016; Schreiber et al., 2006). Therefore, SEM using the partial least squares (PLS) procedure as described by (Hair, Ringle & Sarstedt, 2011; Lowry & Gaskin, 2014) was utilized in this study. Secondly, given that the aim of the study was testing the TPACK framework within the Nigerian teacher educators' context as well as to explore the relationships among the seven constructs, the PLS was found most suitable compared to other SEM procedures. In addition, PLS is convenient for small sample sizes and there is less restriction on the constructs' measurement properties (for example, constructs measured by a single item can be utilized) (Hair et al., 2016). The WarpPLS 6.0 software (Kock, 2017) was used to conduct the data analysis, which subsequently provided information on the structural and measurement model.

RESULTS

Measurement model

For reflective models as is the case with the model in this study, reliability and validity are assessed in accordance with the stipulated benchmarks (Hair, Ringle & Sarstedt, 2011). The internal consistency reliability of the constructs, which is indicated by their Cronbach Alpha Coefficient (CAC) and Composite Reliability Coefficient (CRC), should be above 0.70. For PLS-SEM however, the CRC is more reliable (Lowry & Gaskin, 2014). In addition, the indicator reliability which is reflected in the item loading should be higher than 0.70.

The data in Table 3 indicates that the conditions for the reliability of the model are satisfied. Convergent validity is derived from the Average Variance Extracted (AVE) and the value should be higher than 0.50 while in the case of discriminant validity, the indicator loading should be higher than all its cross-loading (Hair et al., 2011). The data in Table 4, indicate that these conditions for convergent and discriminant validity were met.

Table 3: *Composite Reliability, Cronbach Alphas, Average Variance Extracted and Inter-Construct Correlations*

	CRC	CAC	AVE	TPCK	TPK	TCK	PCK	PK	CK	TK
TPCK	0.926	0.880	0.806	**0.898**	0.794	0.661	0.442	0.626	0.640	0.588
TPK	0.935	0.912	0.741	0.794	**0.861**	0.681	0.418	0.571	0.619	0.590
TCK	1.000	1.000	1.000	0.661	0.681	**1.000**	0.430	0.592	0.522	0.492
PCK	0.702	0.152	0.541	0.442	0.418	0.430	**0.736**	0.496	0.326	0.284
PK	0.917	0.887	0.689	0.626	0.571	0.592	0.496	**0.830**	0.413	0.392
CK	0.931	0.853	0.872	0.640	0.619	0.522	0.326	0.413	**0.934**	0.512
TK	0.868	0.817	0.525	0.588	0.590	0.492	0.284	0.392	0.512	**0.724**

CRC = Composite Reliability Coefficient, CAC = Cronbach Alphas Coefficient, AVE = Average Variance Extracted. Correlations among constructs are shown in the off-diagonal elements; The bold fonts in the leading diagonals are the square roots of AVEs.

Table 4: *Item Loadings and Cross-Loadings*

	TPCK	TPK	TCK	PCK	PK	CK	TK
TPCKI	**0.906**	0.718	0.599	0.369	0.559	0.612	0.495
TPCKII	**0.897**	0.739	0.626	0.420	0.600	0.538	0.543
TPCKIII	**0.890**	0.682	0.555	0.401	0.527	0.574	0.545
TPKI	0.683	**0.831**	0.663	0.293	0.458	0.506	0.620
TPKII	0.724	**0.868**	0.552	0.331	0.462	0.534	0.596
TPKIII	0.592	**0.800**	0.403	0.289	0.433	0.450	0.350
TPKIV	0.713	**0.911**	0.672	0.447	0.580	0.598	0.465
TPKV	0.702	**0.891**	0.628	0.426	0.517	0.559	0.508
TCK	0.661	0.681	**1.000**	0.430	0.592	0.522	0.492
PCKI	0.107	0.110	0.096	**0.736**	0.054	0.120	0.076
PCKII	0.543	0.505	0.536	**0.736**	0.676	0.360	0.343
PKI	0.520	0.523	0.535	0.420	**0.824**	0.443	0.271
PKII	0.538	0.512	0.547	0.483	**0.863**	0.356	0.343
PKIII	0.450	0.435	0.455	0.353	**0.832**	0.274	0.332
PKIV	0.602	0.470	0.455	0.443	**0.814**	0.333	0.349
PKV	0.490	0.429	0.461	0.356	**0.815**	0.307	0.329
CKI	0.596	0.577	0.502	0.266	0.347	**0.934**	0.507
CKII	0.600	0.579	0.472	0.343	0.424	**0.934**	0.449
TKI	0.447	0.452	0.475	0.306	0.370	0.326	**0.658**
TKII	0.477	0.480	0.449	0.227	0.366	0.380	**0.828**
TKIII	0.339	0.365	0.311	0.192	0.164	0.319	**0.709**
TKIV	0.472	0.428	0.353	0.200	0.305	0.540	**0.659**
TKV	0.401	0.429	0.242	0.147	0.205	0.351	**0.737**
TKVI	0.425	0.416	0.317	0.176	0.294	0.326	**0.742**

Note. The bold fonts highlight the item loadings. They are all higher than their cross-loadings (that is, the discriminant validity condition is satisfied).

Structural model

The result of the analysis shows the relationship between the constructs of the study - TK, PK, CK, TPK, TCK, PCK and TPACK. The Goodness of Fit (GoF) is globally used as a measure of fit for explaining the performance of both the structural and measurement model (Tenenhaus et al., 2005). In this study, the GoF value for this model is 0.59, indicative of the data's capability in estimating the model when compared with the 0.36 threshold (Akter, D'Ambra, & Ray, 2011). According to Hair, Ringle & Sarstedt (2011) and their recommended benchmarks, the objective of evaluating the structural model is to explain the variance among the endogenous constructs. The R-squared measures (R^2), the path significance (ρ - value) and the path coefficient (β) which are criteria used to evaluate the structural model are shown in Figure 2. The figure shows that eight of the nine paths depicted in the model were supported significantly by the data and that the R^2 values are above the 0.20 benchmark (Hair, Ringle & Sarstedt, 2011). The model did not require a revision since the R^2 coefficients in the model were above 0.02 (Kock, 2017). The Q-squared (Q^2) coefficient through the endogenous constructs is used to evaluate the predictive validity of the model (Hair et al., 2011; Kock, 2015b). Thus, the Q^2 coefficient of TPCK, TPK, TCK and PCK are 0.67, 0.51, 0.36 and 0.35 respectively.

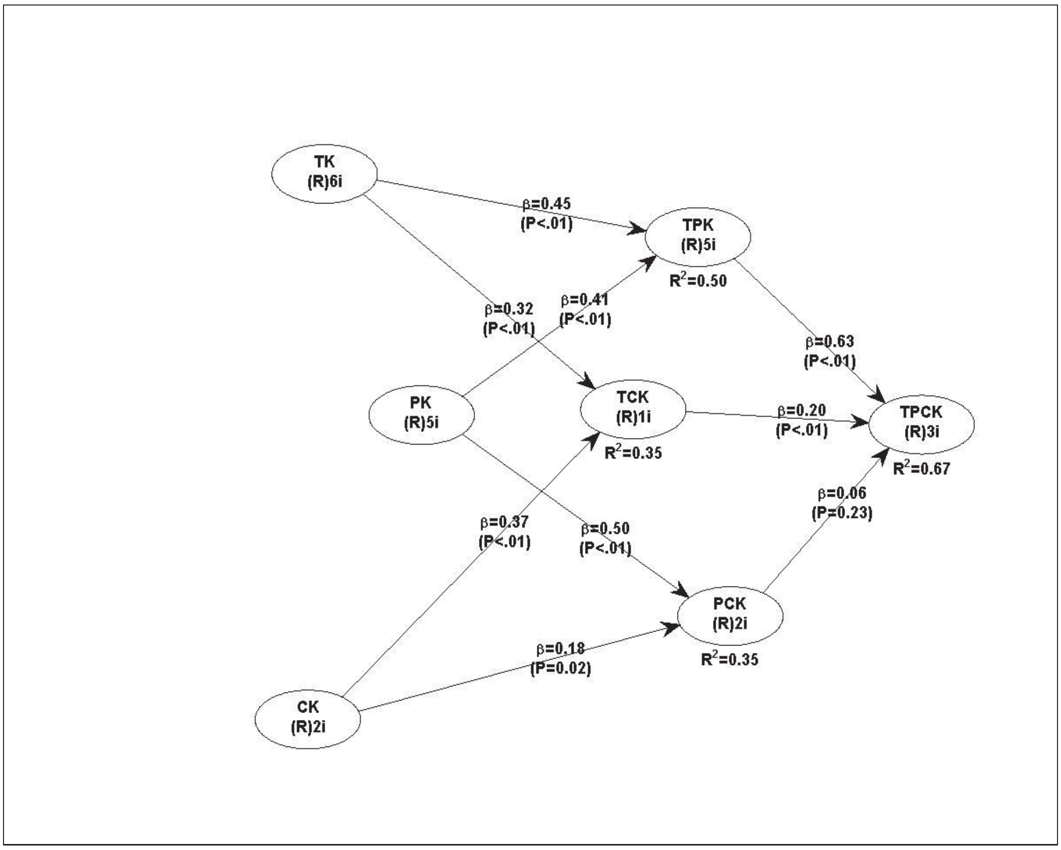

Figure 2: Partial least squares (PLS) analysis result for the proposed model.

Research Question 1: What are the Nigerian teacher educators' TPACK perceptions?

Table 2 shows the mean of each of the three items (TPCK 1, 2 and 3) used to measure the teachers' perception of their TPACK. The lowest mean of 3.79 is indicated by TPCK 1 (that assesses their ability to adequately combine knowledge of technology, subject and teaching approaches) while the highest mean of 3.83 is indicated by TPCK 3 (that assesses their ability to provide leadership in helping others to coordinate the use of content, technologies, and teaching approaches in their school). In summary, the average mean of the teacher educators' perception of their TPACK is 3.81 and in reference to the Likert scale used, this result is above average.

Research Question 2: What relationship exists among the variables of the TPACK construct?

The result shows that all three main components of knowledge (TK, PK, and CK) are direct predictors of their individual interrelationships resulting in TPK, TCK and PCK. Among the three dyadic constructs comprising of their primary knowledge constituents, TPK was best explained by the strength of TK and PK in their variation of 50%. Thus, implying that the teacher educators' knowledge of their technological and pedagogical skills improves significantly the perception of their TPK. In sum, the result shows that the range from 35 to 67% explains the amount of variance resulting from the interactions of the endogenous constructs. This implies the amount of variance in the teacher educators' belief of their TPACK that is explained by the relationship of their TPK, TCK and PCK at 67%.

The model shows that TK was significantly associated with both TPK ($\beta = 0.48$, $\rho < 0.001$) and TCK ($\beta = 0.32$, $\rho < 0.001$). Similarly, PK was significantly associated with both TPK ($\beta = 0.41$, $\rho < 0.001$) and PCK ($\beta = 0.50$, $\rho < 0.001$). In addition, CK was significantly associated with both TCK ($\beta = 0.37$, $\rho < 0.001$) and PCK ($\beta = 0.18$, $\rho = 0.02$ or $\rho < 0.05$).

Similarly, for the endogenous constructs, the model reflects significant and positive associations. The TPK was significantly associated with TPCK ($\beta = 0.63$, $\rho < 0.001$), TCK was significantly associated with TPCK ($\beta = 0.20$, $\rho < 0.01$) while PCK was not significantly associated with TPCK ($\beta = 0.06$, $\rho = 0.23$). In the TPK domain, it suggests that the teacher educators' perception of their Technological Knowledge ($\beta = 0.45$, $\rho < 0.001$) and Pedagogical Knowledge ($\beta = 0.41$, $\rho < 0.001$) were positively associated with their TPK. This relationship is explained by the 50% variance in the Technological Pedagogical Knowledge in the model. The instance of TCK indicates that the teacher educators' opinion of their TK ($\beta = 0.32$, $\rho < 0.001$) and CK ($\beta = 0.37$, $\rho < 0.001$) were positively associated with their TCK. The model explained 35% of the variance in their TCK. For the PCK, the teacher educators' view of their PK ($\beta = 0.50$, $\rho < 0.001$) and CK ($\beta = 0.18$, $\rho = 0.02$ or $\rho < 0.05$) were positively associated with their PCK. In the model, the variance of the teacher educators' PCK explained by their PK and CK is 35%. Finally, in the TPCK domain, while the teacher educators' perception of their TPK ($\beta = 0.63$, $\rho < 0.001$) and TCK ($\beta = 0.20$, $\rho < 0.001$) were associated positively with their TPCK belief, their PCK ($\beta = 0.06$, $\rho = 0.23$) was not.

DISCUSSION

The interactive relations between the primary knowledge constructs of the Technological Pedagogical Content Knowledge (TPACK) framework has provided a basis for a number of studies specifically in understanding how teachers can integrate technology in their classrooms. The objective of this study was to evaluate the TPACK of the Nigerian teacher educators and the relationships among their knowledge domains. On examining the Nigerian teacher educators' TPACK, the result shown in the model of the study suggests that at the primary knowledge level, TK, PK, and CK are significant predictors of their respective second level knowledge bases - TPK, TCK and PCK. However, at the second level knowledge bases, while the TPK and TCK of the Nigerian teacher educators are apparently significant predictors of their TPACK, their PCK's are not. This result is in keeping with that identified by Khine, Ali & Afari (2017); Koh, Chai, & Tsai (2013 in their studies of teachers within the UAE and Singaporean contexts respectively. Although, the hypothetical model proposed by Khine et al. (2017) does not include the TCK construct and examines the case of preservice teachers. Conversely, Celik, Sahin & Akturk (2014) in their investigation of Turkish pre-service teachers found that their TPACK was predicted significantly by their PCK and TCK but not TPK.

In addition, as a predictor of its secondary knowledge base, CK has the least direct effect size among the primary knowledge bases while the PK has the highest. Koh, Chai & Tsai (2013) study findings could be used to explain a possible reason for low CK effect size, which they describe as circumstantial in the sense that the teachers do not perceive ICT tools as integral aspects of the subjects they teach. Nevertheless, results from the study by Chai et al., (2011) show that during the training period, consisting of a combination of ICT designed courses and content courses occurring simultaneously, the Singaporean pre-service teachers' CK was clearly increased. Within the Nigerian context, the teacher educators' low CK can be adjudged to the fact that teachers use outdated teaching practices and are not motivated to enforce the curricula because they lack the necessary training opportunities (Ofoegbu, Okaro & Okafor, 2018). As such, ‘learning by design approach' training (Koehler & Mishra, 2005) can provide conducive environments for teachers to understand practical ways in line with current methods, on how to apply ICT tools in their specific subjects.

Directly and indirectly, both PK and TK are significant predictors of the Nigerian teacher educators' TPACK. However, overall, the TPK has the highest direct effect size on TPCK. This could signify that being experienced teachers with average teaching experience above ten years (from the demographics), Nigerian teacher educators believe in the benefits of ICT use in their teaching. Similarly, this could imply that pedagogical knowledge when appropriately integrated with knowledge of technology produces a significant effect on technology integration. Contrary to our result is the finding by Koh, Chai and Tsai, (2013), where the Singaporean teachers perceived their TCK to have the largest effect on their TCPK. In the Shanghai context, the study by Wu et al., (2016) infers that the relatively new teachers perceived both TPK and PCK as significant predictors of their TPCK (with higher TPK) albeit it should be noted that in this case, the evaluation was conducted after an ICT professional training course. Thus, in reiterating the recommendations for the professional development of teachers, the Nigerian teacher educators' CKs and PCKs can be improved when adequate hands-on and subject specific training is designed to be integrative.

CONCLUSION

Theoretically, this study offers a broader insight on discussions surrounding teachers' technology integration by evaluating the teacher educators' perception of their technology integration within the Nigerian context. The result of the study showed that the TPACK framework is relevant for understanding how teachers integrate technology in their classrooms, and what professional development programmes can be designed to strengthen areas of their TPACK where they are found to be weak. Noteworthy is the identification of the seven constructs with the two paths to achieve TPACK as previously hypothesized by Koh et al., (2013). Within the Nigerian context, the result showed that the teachers' TPK predominantly explained their TPACK and that their PCK did not have any influence. In explaining the relationship between the seven constructs, all three primary knowledge bases were significant predictors of the secondary knowledge bases but only two of the latter predicted their TPACK significantly.

In practice, teachers are expected to champion the cause of technology integration in their classrooms in order to produce learners, future teachers and other professionals that fit the 21st century skills requirement of the workplace. In this light, one of the major practical implications of this research is the need for updating the content of the curricula in order to strengthen the teachers' content knowledge, which in turn strengthens their pedagogical content and technological content knowledge and eventually their technological pedagogical and content knowledge. School administrators can organise training that provide collaborative and motivating opportunities for the teachers to contribute to the process of developing the required content (Koehler & Mishra, 2005; Stoilescu, 2015). Subsequent training involving the use of available ICT tools in different subject areas as it applies to the teacher can be designed. From the data, over 90% of the teachers own more than one mobile device, which shows opportunities for technology integration in teaching abound. Nevertheless, the process of achieving success in teacher's technology integration demands the reinforcement of policies, appropriate strategies and investments by all relevant levels of the schools' governance. However, as pointed out by Dlamini and Mbatha (2018), these policies are more effective when teachers are involved in the decision-making process and when the implementation strategy uses a bottom-up approach (Dintoe, 2019).

Limitations and Future Work

In considering the limitations of this research, first, we point out that the data analysis was based on responses to self-completion questionnaires and thus social desirability bias may apply. Second, the participants are from three schools within the southern part of Nigeria; therefore, caution should be applied in generalizing to the entire country since differences in culture and values for formal education exist. Third, a convenience sample, which was affected by exogenous factors, was used. Fourth, the sample size is relatively small although any bias is reduced when PLS is applied. Fifth, it should be noted that the research participants are teacher educators and as such, the findings may not apply to teachers outside the colleges of education context. Future research can extend this study by addressing the above limitations. Further, studies comparing the teachers' TPACK pathways (with pre-service teachers) or with other regions within the Nigerian context as well as other African countries can be conducted. The use of longitudinal data, observation and interviews can be employed to enrich the data. In addition, increasing the items measuring the subscales of CK, PCK and TCK may improve the survey instrument as recommended by Schmidt et al. (2009).

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VI

COMPARING THE EFFECT SIZE OF SCHOOL LEVEL SUPPORT ON TEACHERS' TECHNOLOGY INTEGRATION

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VII

FACTORS AFFECTING NIGERIAN TEACHER EDUCATORS' TECHNOLOGY INTEGRATION: CONSIDERING CHARACTERISTICS, KNOWLEDGE CONSTRUCTS, ICT PRACTICES AND BELIEFS

by

Eloho Ifinedo, Jenni Rikala & Timo Hämäläinen, 2019

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Abstract

To provide a diverse comprehension of teachers' *TPACK* (Technological, Pedagogical, and Content Knowledge) and how TPACK is reflected in practice, this study examined teacher educators' (TEs') conceptions of technology integration. Specifically, the main objective of the study was to investigate the factors influencing Nigerian teacher educators' technology integration using a self-completion survey administered to Nigerian teacher educators from three schools in the southern region of Nigeria. We utilized the partial least squares structural equation modeling (PLS-SEM) approach for the data analysis. Two frameworks—TPACK and Second Information Technology in Education Study (*SITES*)—guided the scale development. The results indicated that three constructs (perceived technological knowledge, teachers' knowledge [excluding technology] and perceived knowledge for integrating technology) directly influenced the TEs' technology integration, while two others (information and communication technology [ICT] pedagogical practices and perceived effect on students) did not. Among the teachers' characteristics, teaching experience, and class size were found statistically associated with their technology integration. The results of this study are beneficial for developing professional training to help teachers integrate technology specifically by developing their ICT pedagogical practices. Through such training, teachers could be enlightened on how to align their perceived effect of teaching with technology.

Keywords: ICT in education; technology integration; teacher educators; partial least square – sequential equation modelling (PLS-SEM)

Factors affecting Nigerian teacher educators' technology integration: Considering characteristics, knowledge constructs, ICT practices, and beliefs

Introduction

Both educators and policymakers have high expectations that ICT will support educational reforms and better teaching and learning practices (Elstad, 2016). In addition, ICT literacy and twenty-first century skills have been recognized as essential for productivity in an information society (Groff, 2013). Accordingly, what happens inside the classroom is crucial (OECD, 2016) and questions concerning how teacher trainees learn to integrate technology into their teaching practices should be considered. Nevertheless, it behooves TEs to help teacher trainees to become digitally literate individuals who can teach the necessary skills to their future students (Binkley et al., 2012; Howells, 2018); hence, TEs are recognized as “gatekeepers” (Tondeur et al., 2019), because of the role they play in the preparation of the future generation of teachers.

Research over decades has shown that technology integration in the classroom depends on several connected factors relating to teachers' characteristics, schools, and educational systems (Bingimlas, 2009; Buabeng-Andoh, 2012a; Inan & Lowther, 2010; Joo, Lim, & Kim, 2016; Petko, Prasse, & Cantieni, 2018; Plomp, Pelgrum, & Carstens, 2009; Tay, Lim, & Lim, 2013; Taimalu & Luik, 2019). A recent systematic review of the literature by Lai and Bower (2019) examined the intricacy of this technology integration process, and discussions on educational technology integration have continued with regard to the different factors influencing the integration process (Howard, Chan, Mozejko, & Caputi, 2015). Bower (2019), for instance, argued that it is crucial to understand the ways in which beliefs, knowledge, practices, and the environment mutually influence each other in relation to educational technology usage; therefore, in the current study, we developed our scales based on two well-known frameworks—TPACK and SITES—to probe more deeply into the factors influencing teachers' technology integration.

Koehler and Mishra (2006) proposed the TPACK framework for clarifying the knowledge necessary for the successful integration of ICT into teaching and learning; however, many researchers have argued that the TPACK framework oversimplifies the factors surrounding technology integration by excluding teachers' beliefs and various contextual barriers, such as access to resources, training, and support (Angeli & Valanides, 2009; Brantley-Dias & Ertmer, 2013; Yurdakul et al., 2012). As a result, to provide broad insight into teachers' technology integration, we adopted constructs from the SITES framework, which was introduced by the International Association for the Evaluation of Educational Achievement (IEA). The IEA has long been interested in the use of ICT in education. In the 1990s, the IEA initiated the SITES. The third module of the SITES project, asserted that system and school factors have a significant effect on teachers' pedagogical use of ICT (Law & Chow, 2008). The SITES 2006 conceptual framework emphasized that school-level and system-level factors, and teachers' characteristics, determine the teachers' pedagogical practices, which in turn influence students' learning outcomes (see Plomp et al., 2009, pp. 12-13). It therefore inferred that the SITES 2006 framework mainly concerns the application of ICT in classroom activities. The phenomena examined in the current study included the teachers' ICT practices that contribute to their technology integration. In particular, we paid attention to understanding the technical competencies and behaviors of TEs as they prepare future generations of teachers. This is particularly important for understanding TEs' influence on future teachers' technology integration.

The main objective of this study was to investigate the factors influencing Nigerian TEs' technology integration. Among the African countries, Nigeria is listed as the highest internet consumer (Edo, Okodua, & Odebiyi, 2019), and the ownership and use of information technologies, such as mobile phones, laptops, tablets, and personal computers, have become popular among Nigerian students, teachers, and schools (Ifinedo, Saarela, & Hämäläinen, 2019; Ifinedo, Kankaanranta, Neittaanmäki, & Hämäläinen, 2017; Oluwafeyikemi, Ajayi, & Gata, 2018; Utulu & Alonge, 2012). Despite these developments, the Nigerian education system is threatened by problems such as the large number of out-of-school children, high dropout rates, and low literacy rates (Ifinedo & Kankaanranta, 2018). Technology integration may be one solution for addressing these educational challenges; therefore, the Federal Ministry of Education (2014) has emphasized ICT's integration in the delivery of education in Nigeria. Onyia and Onyia (2011) indicated that many Nigerian faculties fail to integrate technology into classrooms, and Ameen, Adeniji, and Abdullahi (2019) observed this low level of ICT integration among Nigerian teachers and students. Olokooba, Okunloye, Abdulsalam, and Balogun (2018), in turn, identified challenges such as the unavailability of computers, the lack of instructional software, the inadequacy of teachers' technical knowledge, the irregular power supply, and the deficient maintenance of computer systems as the main barriers to the use of ICT in Nigerian schools. Findings from a literature review relating to ICT integration in education revealed that TEs in Nigerian colleges of education and other institutions did not use digital technology in their pedagogical practices (Garba, Singh, Yusuf, & Ziden, 2013); hence, our study specifically focused on Nigerian TEs' perceived technological knowledge, perceived knowledge for integrating technology, ICT pedagogical practices, the perceived effect of teaching with technology on students, teaching knowledge that excludes technology, and technology integration. The research questions were as follows:

- **Research question 1:** What characteristics influence TEs' technological knowledge and their teaching knowledge (excluding technology)?

- **Research question 2:** What relationships exist among TEs' teaching knowledge (excluding technology), perceived technological knowledge, perceived knowledge for integrating technology, ICT pedagogical practices and perceived effect on students?

Theoretical Foundations

Researchers have been trying to explain the foundations of successful educational technology integration for over 30 years (Petko, Prasse, & Cantieni, 2018). These studies have had a common interest in recognizing the interrelationship of factors arising from the technology and the users within the school context and beyond (e.g., Ertmer, 1999; Drent & Meelissen, 2008; Tay, Lim, & Lim, 2013). To deal with a world consisting of both social and technical factors, teachers should be equipped with the relevant competencies to enable them to recognize and perform tasks with the appropriate technological tools in the classroom (Meyers, Erickson, & Small, 2013); for example, the teachers' characteristics that are associated with ICT use in the classroom include the teacher's age, years of teaching experience, the subject taught, and the class size (Gil-Flores, Rodríguez-Santero, & Torres-Gordillo, 2017; Law & Chow, 2009). A teacher's teaching knowledge, perceptions, access, and characteristics, as well as the subject culture, all have an appreciable effect on the teacher's decisions regarding technology integration (Burke, Schuck, Aubusson, Kearney, & Frischknecht, 2018; Ertmer & Ottenbreit-Leftwich, 2010). Prestridge's (2012) study showed an existing association between teachers' ICT skills, confidence, and practice; thus, in this study, we aimed to understand how these factors (i.e., teachers' characteristics, perceived technological knowledge, teaching knowledge, belief and ICT pedagogical practices) together affect technology integration among Nigerian TEs.

In this study, we adopted the knowledge constructs of the TPACK framework. Previous research suggested that technologically and pedagogically competent teachers are more willing to use ICT in the classroom (Chai, Koh, Tsai, & Tan, 2011; Darling-Aduana &

Heinrich, 2018; Maican, Cazan, Lixandroiu, & Dovleac, 2019; Sang, Valcke, van Braak, & Tondeur, 2010; Suárez-Rodríguez, Almerich, Orellana, & Díaz-García, 2018; Vongskulluksn, Xie, & Bowman, 2018); hence, a teacher should be a specialist in both the subject and pedagogy, as well as a competent user of technology (Adams & Ivanov, 2015; Groff, 2013; Luik, Taimalu, & Suviste, 2018). The core of effective teaching with technology consists of three components—content, pedagogy, and technology—and their interconnection (Koehler & Mishra, 2009). This framework, known as TPACK, was based on pedagogical content knowledge (PCK) constructs modeled by Shulman (1986). Koehler and Mishra (2006) modified the PCK framework by adding knowledge of technology integration (i.e., understanding how technology is applied in the teaching of a particular subject). As a result, the TPACK framework includes seven types of knowledge: technological knowledge (TK), pedagogical knowledge (PK), content knowledge (CK), pedagogical content knowledge (PCK), technological pedagogical knowledge (TPK), technological content knowledge (TCK), and technological pedagogical content knowledge (TPACK).

In addition, we utilized the SITES 2006 framework, which views ICT-using pedagogical practices as part of the overall pedagogical practices of the teacher, so that the reasons why and how teachers use ICT in the classroom are underpinned by their overall pedagogical vision and competence (see Carstens & Pelgrum, 2009, pp.13). The SITES 2006 framework also emphasizes that pedagogical practices are not determined solely by the characteristics of the teachers, but also by school- and system-level factors; thus, SITES 2006 recognized that teacher-, school-, and system-level factors often have to change to accommodate the expected or actual impact of pedagogical practices on students (Plomp et al., 2009). SITES 2006 included a teacher survey to assess the perceived impact of pedagogical ICT use on teachers and their students. Indicators derived from the questions relating to personal and contextual factors provided explanatory indicators for the SITES study (Law & Chow, 2009). Personal factors included: demographic background (e.g., age, gender, and professional experience), technical competence, competence in using ICT for pedagogical purposes, pedagogical beliefs, and the rationale for using ICT. Contextual factors included: teacher's participation in ICT-related professional development activities, their perceptions of obstacles, and the presence of a community of practice in their schools. The teacher questionnaire also included questions concerning the target class (e.g., the number of students in the class and the gender mix). In particular, this study adopted constructs such as teachers' demographics, ICT pedagogical practices, and the perceived impact of these practices on students from the SITES framework.

Material and Methods

Research Purpose, Model, and Hypotheses

A previous study focused on Nigerian teachers' preparedness to integrate technology and investigated their seven knowledge constructs according to the TPACK framework (see Ifinedo, Saarela, & Hämäläinen, 2019). Unlike that study, the main objective of this study was to investigate the factors influencing Nigerian TEs' technology integration. Specifically, the study examined their characteristics, perceived knowledge of technology, perceived knowledge for integrating technology, ICT pedagogical practices, and their perceived impact on the students, teaching knowledge (excluding technology), and technology integration.

This study applied a PLS-SEM technique to develop a model representing the relationships between the factors underpinning teacher educators' technology integration. We considered the fact that schools and school districts are complex, but dynamic, systems affected by numerous factors (Mital, Moore, & Llewellyn, 2014) and that, consequently, several attributes affect technology integration success. Based on the complex interrelationships of factors that support technology integration, in this study we opted for a complex yet realistic model (Hirsch, Michaels, & Friedman, 1987). According to our hypothesized model, presented in Figure 1, two research questions and eighteen hypotheses were formed.

The first research question aimed to understand "*what characteristics influence TEs' technological knowledge and their knowledge that does not involve teaching with technology?*"

Age is a potential source of variation in ICT integration (Siddiq, Scherer, Tondeur, 2016); for example, previous research suggested that older teachers' low computer skills and self-confidence influenced their tendency and ability to use and integrate technology (Buabeng-Andoh, 2012b; Fraillon, Ainley, Schulz, Friedman, & Gebhardt, 2014; Inan & Lowther, 2010; Peeraer & van Petegem, 2011). Some weak relationships between technological, pedagogical, and content knowledge perceptions and age have also been found in other studies (e.g., Lee & Tsai, 2010; Koh, Chai, & Tsai, 2010). In addition, Luik et al. (2018) found that the connection between the age of teachers and their primary knowledge constructs (TK, PK, and CK) varied. It correlated negatively with TK, but positively with CK; however, there was no significant association between age and PK. In a study by Liu, Zhang, and Wang (2015), younger teachers had higher perceptions of their TK, but lower perceptions of their PK and PCK, while older teachers had lower perceptions of their TK, but higher perceptions of their PK and PCK. Younger teachers tend to be more open to the use of ICT in education (Inan & Lowther, 2010; Yilmaz & Bayraktar, 2014); accordingly, we postulated the following hypotheses:

- H1: Teacher educators' ages negatively influence their perceived knowledge of technology (PerTechK)
- H2: Teacher educators' ages positively influence their perceived teaching knowledge (excluding technology) (TeKnXict)

The subject taught also influences the use of ICT in the classroom (Howard et al., 2015). Siddiq et al. (2016), for instance, argued that teachers of humanities, languages, and arts tend to place greater emphasis on students' digital and ICT skills than do teachers of mathematics, science, or other subjects. Many mathematics teachers are under pressure to use ICT, but find it difficult to see how ICT can support learning without being restrictive (Tay, Lim, & Lim, 2015; Wikan & Molster, 2011; Xie, Kim, Cheng & Luthy, 2017). Subject practices and cultures may be barriers that hinder the use of technology in the classroom and may also have different effects on usage patterns (Hennessy, Ruthven, & Brindley, 2005; Hew & Brush, 2007; Nelson et al., 2019; Padmavathi, 2013). To this end, we postulated the following hypotheses:

- H3: The subject taught influences the teacher educators' perceived knowledge of technology (PerTechK)
- H4: The subject taught influences the teacher educators' perceived teaching knowledge (excluding technology) (TeKnXict)

Years of teaching experience has an influence on the teachers' knowledge and skill. Jang and Tsai (2012) stated that TPACK is influenced by the years of teaching experience; while experienced teachers may not be as technology-minded as their less-experienced younger peers, they feel more comfortable with their teaching responsibilities and know where to find support (Nelson, Voithofer, & Cheng, 2019). Experienced teachers, therefore, demonstrate higher CK and PK (Jang & Chang, 2016). Qualified teachers use teaching methods and strategies more effectively, because of their extensive knowledge of different content and teaching strategies (Jang & Tsai, 2012; Meskill, Mossop, DiAngelo, & Pasquale, 2002; Saltan & Arslan, 2017), and they are more adept at using new tools to help facilitate teaching and learning (Smarkola, 2007). However, Saltan and Arslan (2017) pointed out that teachers with more than 20 years of experience may not have the proper training to use modern technology or pedagogical approaches, so experience has an indirect influence through knowledge and skill (Farjon, Smiths, & Voogth, 2019). To this end, we postulated the following hypotheses:

- H5: Years of teaching experience (TeachExp) positively influences the teacher educators' perceived knowledge of technology (PerTechK)
- H6: Years of teaching experience (TeachExp) positively influences the teacher educators' perceived teaching knowledge (excluding technology) (TeKnXict)

Class size has an influence on classroom practices. Teachers' experiences of class size are connected to their emotional involvement in teaching (Blatchford, Moriarty, Edmonds, & Martin, 2002), and teachers' decisions regarding ICT integration depend, not only on the subject taught, but also on students' characteristics, such as the number of students in the class, the gender mix, and students' languages (Law, 2009). Although Gibbone, Rukavina, and Silverman (2010) emphasized that class size is not a limiting factor for technology use, class size may be a barrier to using technology, since teachers may be concerned about the amount of technical equipment needed in the classroom (McCulloch et al., 2018). Leendertz, Blignaut, Nieuwoudt, Els, and Ellis (2013) asserted that overpopulated classrooms lead to an increase in work pressure for teachers, which in turn results in less likelihood of integrating technology. Similarly, Hennessy, Harrison, and Wamakote (2010) listed large class size as a critical factor underpinning the lack of ICT competence among teachers within an African education context. Overall, classroom quality is associated with small class size (Marti, Melvin, Noble, & Duch, 2018). Small classes are better environments for learner-centered activities (Wright, Bergom, & Bartholomew, 2019), because students are more engaged and can interact with each other and their teachers in positive and enriching ways (Deutsch, 2003). Consequently, this research proposed the following hypotheses:

- H7: Class size (ClasSize) influences the teacher educators' perceived knowledge of technology (PerTechK)
- H8: Class size influences the teacher educator's perceived teaching knowledge (excluding technology) (TeKnXict)

Technological device ownership is linked to computer experience. Owning ICT is just as important as a person's confidence in using technology and the degree to which technology is utilized pedagogically (Yerdelen-Damar, Boz, & Aydın-Günbatar, 2017). Yurdakul (2017) emphasized that digital nativity is a significant predictor of TPACK competence, since teachers' daily ICT use is also reflected in their professional lives. The availability of technology at home, for instance, affects attitudes towards, and perceptions of, ICT use in the classroom (Islahi & Nasrin, 2019; Padmavathi, 2013). Kahveci, Şahin, and Genç (2011) asserted that ownership of personal computers is a significant predictor of teachers' high-level computer experience and, consequently, more positive attitudes and greater confidence and comfort. Kearney, Burden, and Rai (2015), in turn, noted that students' ownership of mobile devices positively influenced teachers' consideration of practical ways to apply such tools in their subject areas. Building personal ownership, and training teachers to be comfortable and creative users of technology, can help teachers to make innovative transformations in their classrooms (Barak, 2006; Riel, Schwarz, Peterson, & Henricks, 2000); therefore, we hypothesized the following:

- H9: Technological device ownership (TDevOwn) positively influences teacher educators' perceived knowledge of technology (PerTechK)
- H10: Technological device ownership (TDevOwn) positively influences teacher educators' perceived teaching knowledge (excluding technology) (TeKnXict)

The second research question was wider in scope and focused on how TEs' perceived technological knowledge, perceived knowledge for integrating technology, perceived teaching knowledge excluding technology, ICT pedagogical practices, and the perceived effect on students are related to TEs' use of educational technology. The second research question investigated "*what relationships exist among TEs' perceived teaching knowledge, knowledge for technology use, perceptions, and ICT pedagogical practices.*"

Teacher's perceived teaching knowledge influences technology integration, and several researchers have highlighted the relationships between the TPACK constructs. TK, for instance, has been found to have a direct positive influence on teachers' TPACK (Koh, Chai, & Tsai, 2013). Researchers have also found high correlations between PK and PCK, and between TPK and TCK (Çetin & Erdoğan, 2018). CK, in turn, directly and positively influences TCK and PCK (Kiray, Çelik, & Çolakoğlu, 2018). Kiray et al. (2018) further pointed out that PCK critically affects teachers' technology integration, since it has the greatest effect on the teachers' TPACK self-efficacy. Pedagogical competence is as significant as technological competence for successfully integrating technology in teaching (Li, Garza, Keicher, & Popov, 2018). Similarly, ICT integration practices (i.e., the selection of the ICT tools and how often the tools are used) influence teachers' technology integration knowledge (Chuang, Weng, & Huang, 2015), so perceived knowledge can lead to feelings of self-efficacy. Perceived TPACK positively affects teachers' self-efficacy, which means that teachers with TPACK find the technology accessible and useful (Joo, Park, & Lim, 2018). There is a positive relationship between TPACK confidence, TPACK level, and teachers' intention to teach with ICT (Güneş & Bahçivan, 2016; Joo et al., 2016; Joo et al., 2018; Koh & Chai, 2014). Teachers, however, do not usually think of their knowledge as a separate domain (Heitink et al., 2016); for instance, Luik et al. (2018) merged all items relating to technological knowledge (TCK, TPK) into one factor representing technology. Similarly, Boschman, McKenney, and Voogt (2015) highlighted that, in the teachers' narratives, pedagogy was usually addressed in conjunction with other knowledge domains. An interesting observation, however, was that, in general, teachers seemed to be orientated towards PCK, rather than technological knowledge constructs (Tseng, Cheng, & Yeh, 2019; Heitink, Voogt, Verplanken, van Braak, & Fisser, 2016). The current study attempted to investigate the following hypotheses:

- H11: TEs' perceived technological knowledge (PerTechK) positively influences their perceived knowledge for integrating technology (PKn4INgT)
- H12: TEs' perceived technological knowledge (PerTechK) positively influences their technology integration (TechINtn)
- H13: TEs' perceived knowledge for integrating technology (PKn4INgT) positively influences their technology integration (TechINtn)
- H14: TEs' perceived knowledge for integrating technology (PKn4INgT) positively influences their ICT pedagogical practices (ICTPedPr)
- H15: TEs' perceived teaching knowledge, excluding technology (TeKnXict), positively influences their technology integration (TechINtn)

Teachers' ICT pedagogical practices are linked to student outcomes and teachers' knowledge. Teachers' pedagogical practices, such as teaching techniques and strategies, enable learning to take place and provide opportunities for interaction between teachers, learners, and the learning environment (Bottino, 2004). ICT offers several ways to alter and enhance pedagogy and to customize and expand teaching repertoires, strategies, and methods for adapting different learning paths (Bitner & Bitner, 2002; Sutherland et al., 2004). However, the effectiveness of ICT depends on the teachers' actual practices and their ability to integrate ICT into teaching and learning (Comi, Argentin, Gui, Origo, & Pagani, 2017; Drent & Meelissen, 2008). It is therefore vital to consider the whole learning situation; not only the technological tools, but also the teachers who use them, the curriculum objectives, the assessment methods, the social context, and the pedagogical practices (i.e., the ways in which learning is organized and tools are used) (Adams & Ivanov, 2015; Bottino, 2004; Law & Chow, 2008; Okojie, Olinzock, & Okojie-Boulder, 2006). Technology can provide students with deeper understanding of subjects, and learning should, therefore, be the driving factor behind the use of technology in the classroom. Teachers' pedagogical viewpoints extend to what the teachers may consider to be valuable in terms of achieving student outcomes, so knowledge practices may be linked to student outcomes (Hudson, English, Dawes, King, & Baker, 2015). Similarly, teachers' attitudes towards ICT and their motivation for using it in their teaching are influenced by their pedagogies (Cox, 2003). Researchers have highlighted that the use of ICT can transform teachers' knowledge of the subject area, teaching repertoires, and pedagogical skills (Sutherland et al., 2004; Heitink et al., 2016). Hence, we propose the following hypotheses:

- H16: TEs' ICT pedagogical practices (ICTPedPr) positively influence perceived effect of teaching with technology on students (PEffStud)
- H17: TEs' ICT pedagogical practices (ICTPedPr) positively influence their perceived teaching knowledge that excludes technology (TeKnXict)

Teachers' perceptions of technology gains for their students affect classroom practices. Perception is closely related to attitudes, and attitudes, in turn, arise from beliefs and values; therefore, teachers' attitudes and beliefs significantly influence their actions and practices in the classroom (Burke, Schuck, Aubusson, Kearney, & Frischknecht, 2018; Gil-Flores, Rodríguez-Santero, & Torres-Gordillo, 2017; Willis, Lynch, Fradale, & Yeigh, 2019). Previous research has suggested that teachers' negative attitudes and beliefs about technology may prevent them from utilizing technology and, therefore, teachers' positive perceptions (i.e., beliefs and attitudes) are critical for increasing levels of ICT integration (Blackwell, Lauricella, Wartella, Robb, & Schomburg, 2013; Ertmer, Ottenbreit-Leftwich, Sadik, Sendurur, & Sendurur, 2012; Hutchison & Reinking, 2011; Islahi & Nasrin, 2019; Joo et al., 2016; Liu, 2011; Miranda & Russell, 2012; Peng & Wong, 2018 Vongkulluksn et al., 2018; Willis et al., 2019). Positive perceptions of ICT also explain high self-efficacy in TPACK and vice versa (Scherer, Tondeur, Siddiq, & Baran, 2018); therefore, a teacher's mindset plays an essential role in the choice of that teacher's teaching approach (Li et al., 2018).

Different factors impact teachers' perceptions, including their prior experience (Khlaif, 2018). When teachers use ICT frequently, they begin to appreciate ICT and understand the benefits and importance of ICT in teaching, eventually guiding their students to use ICT (Chew, Cheng, Kinshuk, & Chen, 2018; Miranda & Russell, 2012). Teachers who have sound experience of technology tend to be more confident users of technology (Miranda & Russel, 2012; Claro et al., 2018). Furthermore, teachers who see ICT as consistent with their educational goals, teaching philosophy, pedagogical beliefs, and practices are more likely to perceive ICT as valuable and adopt ICT (Hamari & Nousiainen, 2015; Las & Chow, 2009; McCulloch, Hollebrands, Lee, Harrison, & Mutlu, 2018; Taimalu & Kuin, 2019). In other words, teachers' characteristics, such as subject matter and teaching experience, also strongly influence teachers' perceptions (Jimoyiannis & Komis, 2007). To this end, we postulated the following hypothesis:

- H18: TEs' perceived effect of teaching with technology on students (PEffStud) positively influence their technology integration (TechINtn)

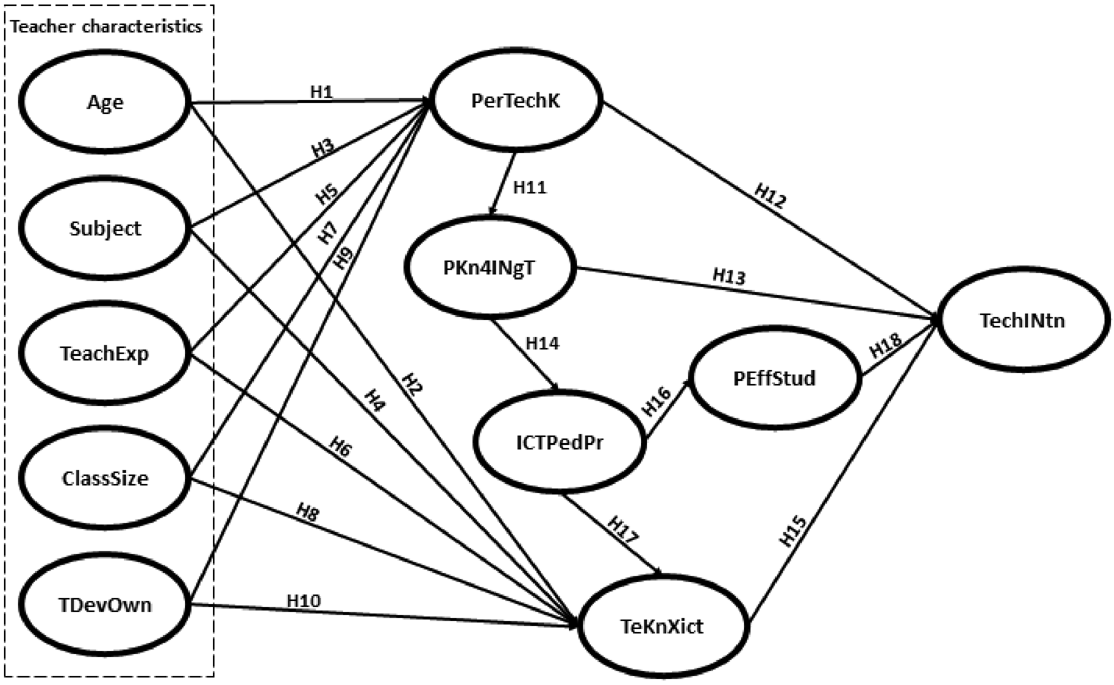

Fig. 1. The hypothesized model

Sample

Data was collected from 148 teacher educators in various departments. Some of the responses were poorly completed; therefore, listwise deletion was applied and, ultimately, 136 responses were found to be useful. Thereafter, the departments were condensed into three categories for ease of analysis—arts, sciences, and social sciences. Departments such as languages or religious studies were assigned to arts (8%), chemistry or database management were assigned to the sciences (35.5%), and geography or agriculture were assigned to the social sciences (50%). Sixty percent of the participants were male and 35% were female. The predominant age group was over 40 years of age (75%). Table 1 shows the remaining demographic information of the respondents.

Table 1: Demographic profile of participants

Variable	Content	Frequency	Percentage
Gender	Male	81	59.6
	Female	48	35.3
	Missing	7	5.1
Age group	25–29	3	2.2
	30–39	25	18.4
	40–49	60	44.1
	50–59	42	30.9
	Over 59	5	3.7
	Missing	1	0.7
Categorized department	Arts	11	8.1
	Sciences	48	35.3
	Social sciences	68	50
	Missing	9	6.6
Teaching experience	Under 2 years	2	1.5
	2–4 years	8	5.9
	5–9 years	36	26.5
	10–19 years	52	38.2
	Over 19 years	38	27.9
Average class size	0–50	60	44.1
	51–100	23	16.9
	101–150	13	9.6
	151–200	1	0.7
	201–500	19	14
	Over 500	5	3.7
	Missing	15	11
Device ownership: (phone, laptop, tablet, desktop computer)	Only one	10	7.4
	Combination of two	70	51.5
	Combination of three	43	31.6
	Combination of four	12	8.8
	Others	1	0.7

Data Collection Instrument

Previously designed and validated questionnaires were used in this study, as recommended for quantitative research (Bryman, Bell, Mills, & Yue, 2011). To improve the content validity, the design of the initial survey was subjected to the scrutiny of a professional in the field of teacher education and ICT use. The demographic information of the respondents, consisting of school name, age group, gender, subject currently taught, job title, years of teaching experience, class size, and ownership of devices, was collected. The demographic characteristics showed that the sample employed for our study was heterogeneous, improving the external validity of the study. Measures for reducing the effects of common method bias (CMB) were followed according to recommendations (Podsakoff, MacKenzie, Lee, & Podsakoff, 2003). The occurrence of CMB is attributed to the measurement approach that is used for structural equation modeling (SEM) (Kock, 2015a). Examples of actions taken to control CMB were ensuring the anonymity of respondents, the use of clear instructions at the top of the questionnaire, and clear wording in the overall design of the items. Specifically, in the survey, digital technologies were described as computers, laptops, mobile phones, interactive whiteboards, or software. In addition, respondents were given the option to list other items that they considered to be digital technologies. Furthermore, the full variance inflation factors (VIF) for the data analysis were assessed using WarpPLS software (Kock, 2015a; Kock & Lynn, 2012). The VIFs of the constructs ranged from 1.17 to 2.04, except for TechINtn and PKn4INg, which had higher VIFs of 3.81 and 3.38, respectively. VIFs above 5 indicate that significant collinearity problems exist (Hair, Risher, Sarstedt, & Ringle, 2019), so CMB was not considered to be a concern in this instance.

Measures for perceived technology knowledge (PerTechK), teachers' knowledge (excluding ICT) (TeKnXict), perceived knowledge of technology integration (PKn4INgT), and technology integration (TechINtn) were adapted from the TPACK instrument designed by Schmidt et al. (2009), using a five point Likert scale (strongly disagree, disagree, neutral, agree, and strongly agree). The TPACK questions were adapted for the in-service teaching context, in contrast to the original design, which was designed for a preservice teaching context; for instance, participants were selected from several departments of the college of education. The taught subjects were generalized during the analysis. In addition, items intended for use in teacher education programs in the original design were excluded. In addition, "I can adapt the use of the technologies that I am learning about to different teaching activities" was revised to "I can adapt the use of the technologies that I know to different teaching activities." Eventually, some of the items from the original instrument relating to TeKnXict were found to be poorly loaded and were removed (e.g., CK1, CK2, and PCKI).

Measures for ICT pedagogical practices (ICTPedPr) and perceived effect of teaching with technology on students (PEffStud) were adapted from a SITES-based study conducted in Finland (see Kenttala, Kankaanranta, & Neittaanmaki, 2016). The ICTPedPr construct used a four-point scale Likert (never, rarely, usually, and almost always) to assess how often the participants used ICT and for which activities. While the PEffStud construct used a three-point scale—disadvantage, no effect, advantage. The descriptive statistics for the items used in the questionnaire are shown in Table 2.

Table 2: The descriptive statistics and item loadings for the items in the questionnaire

Construct	Item description	Mean	Standard deviation	Item loading
Teachers' characteristics	Age	4.16	0.845	1.000
	Subject	2.45	0.651	1.000
	Years of teaching	3.85	0.947	1.000
	Average class size	2.26	1.632	1.000
	Technological devices owned	2.44	0.787	1.000
Perceived technological knowledge (PerTechK)	I know about many different technologies	3.80	1.010	0.658
	I have the technical skills I need to use technology	3.82	0.913	0.828
	I know how to solve my own technical problems	3.34	1.027	0.709
	I learn technology easily	4.04	0.888	0.659
	I frequently play with technology	3.58	1.054	0.737
	I have had sufficient opportunities to work with different technologies	3.27	1.119	0.742
Perceived knowledge for integrating technology (PKn4INgT)	I know about technologies that I can use for understanding and teaching my subject.	4.00	0.834	0.774
	I have the technical skills I need to use technology appropriately in teaching	3.74	1.018	0.843
	I can adapt the use of the technologies that I know to different teaching activities	3.80	0.921	0.853
	I think critically about how to use technology in my classes	3.76	0.996	0.763
	I choose technologies that enhance my teaching approaches for a lesson	3.94	0.865	0.912
	I choose technologies that enhance students' learning during a lesson	3.93	0.869	0.887
ICT pedagogical practices (ICTPedPr)	Presenting of information, demonstration, and/or giving instructions to students	2.49	0.891	0.718
	Providing support or extra lessons for individual students or small groups	2.49	0.840	0.717
	Helping or advising students regarding information retrieval	2.75	0.888	0.781

	Organizing or observing of student-led class discussions, demonstrations, and presentations	2.67	0.821	0.750
	Evaluating students learning through experiments, tests, and interviews	2.83	0.843	0.754
	Giving feedback to individuals or small groups	2.72	0.884	0.746
	Organizing, monitoring, and supporting the formation of students' groups and cooperation	2.46	0.922	0.735
Perceived effect of teaching with technology on students (PEffStud)	Knowledge of the subject	2.93	0.431	0.899
	ICT skills	2.92	0.427	0.771
	Learning motivation	2.95	0.397	0.790
	Messaging skills	2.83	0.580	0.718
	Information processing skills	2.86	0.523	0.760
	Cooperation skills	2.89	0.467	0.705
	Student self-direction	2.82	0.590	0.747
	Problem solving skills	2.87	0.514	0.803
	Confidence	2.88	0.496	0.686
Teachers' knowledge (excluding technology) (TeKnXict)	I can use different teaching methods in the classroom	4.26	0.779	0.829
	I can adapt my teaching style to different learners	4.23	0.730	0.855
	I know how to assess students' performance and learning in different ways.	4.27	0.683	0.801
	I am familiar with common student understandings and misconceptions of the subject.	4.10	0.822	0.812
	I can adapt my teaching based on what students currently understand or do not understand	4.18	0.732	0.808
	I know how to select effective teaching approaches to guide students' thinking and learning in the subject I teach	4.13	0.814	0.776
Technology integration (TechINtn)	I can teach lessons that appropriately combine my subject, technologies, and teaching approaches.	3.79	0.890	0.906
	I can select technologies to use in my classroom that enhance what I teach, how I teach, and what students learn.	3.82	0.950	0.879
	I can provide leadership in helping others to coordinate the use of content, technologies, and teaching approaches at my school	3.83	1.008	0.890

Data Collection and Data Analysis

The hypotheses were tested using a paper-based self-completed survey, which was administered to Nigerian TEs from three government-owned schools in the southern part of Nigeria, and participation was voluntary. Convenience sampling was used to select these schools, in addition to the fact that they all had ICT laboratories in which ICT tools for teaching were stored.

In this study, the PLS-SEM procedure was used (Hair, Ringle, & Sarstedt, 2011; Lowry & Gaskin, 2014) to explore the relationships between the Nigerian TEs' characteristics, their knowledge constructs, their ICT practices, and their belief in, and perceptions of, technology integration. PLS allows the testing of complex models, relationships between constructs, which are represented by observed variables (Henseler, Hubona, & Ray, 2016), and places fewer constraints on sample size. Data analysis was conducted using WarpPLS 6.0 software (Kock, 2017) and, thereafter, information concerning the structural and measurement model was obtained.

Results

The Measurement Model

The reliability and validity of the constructs in the measurement model, along with their measures, were examined. For reliability, the internal consistency and indicators of the constructs were assessed (see appendix for Table 3 and 4). The values of their Cronbach's alpha coefficients (CACs, α) and composite reliability coefficients (CRC) depicted the model's internal consistency and reliability, while the indicator loadings depicted the reliability of the items to load on their theoretically assigned constructs (Hair et al., 2011; Lowry & Gaskin, 2014), stipulating that values higher than 0.70 attested to satisfactory reliability. For the validity of the model, convergent validity and discriminant validity were evaluated. The average variance extracted (AVE) determined the convergent validity of the constructs. AVE values of 0.50 or greater were recommended by Hair et al. (2011). The conditions for discriminant validity are attained if an indicator loads more strongly on its own construct than on its cross-loadings. The information on our measurement model results are provided in Tables 3 and 4 (see appendix) and they show that the model satisfied all of the reliability and validity requirements. In addition, the heterotrait-monotrait (HTMT) ratio, which is said to be more efficient than the Fornell-Larker criterion for instance, for determining the discriminant validity of a model (see Hair et al., 2019), was examined. For our model, the HTMT ratio of the constructs ranged from 0.13 to 0.69. According to Henseler et al. (2016), HTMT ratio values greater than 0.90 suggest constructs that have discriminant validity problems; therefore, the discriminant validity of our model was established.

The Structural Model

The performance of a structural and measurement model can be described using the goodness of fit measure (Tenenhaus, Vinzi, Chatelin, & Lauro, 2005). For the model in this study, the goodness of fit value was 0.47, which is considered to be large in terms of the effect size (Akter, D'Ambra, & Ray, 2011). Essentially, regression coefficients are used to assess the variance among the endogenous constructs of the structural model. These coefficients include the R-squared measures (R^2), the path significance (p-value), and the path coefficient (β). Figure 2 provides the results for the hypothesized model. Since the R^2 of the model was greater than the 0.02 benchmark, a revision was not considered necessary (Kock, 2017). In addition, the Q-squared coefficient (Q^2), which evaluates the model's capacity to predict the endogenous constructs (Hair et al., 2011; Kock, 2015b), was assessed. The Q^2 coefficients of PerTech, PKn4INg, ICTPedP, TeKnXict, PEffStud, and TechINtn were 0.16, 0.38, 0.07, 0.21, 0.10, and 0.72 respectively. The results of the research model showed that fifteen of the eighteen formulated hypotheses were significantly supported (see Table 5). In summary, the amount of variance in the teacher educators' technology integration, explained by the independent constructs of the hypothesized model, was 72%.

Table 5: Summary of results of the hypothesis testing

Hypotheses	Path coefficient	p-value
H1: Age → PerTechK	-0.06	p < 0.1 (Not supported)
H2: Age → TeKnXict	0.08	p < 0.1 (Not supported)
H3: Subject → PerTechK	-0.12^{+}	p < 0.1 (Supported)
H4: Subject → TeKnXict	0.14*	p < 0.05 (Supported)
H5: TeachExp → PerTechK	0.22**	p < 0.01 (Supported)
H6: TeachExp → TeKnXict	0.25**	p < 0.01 (Supported)
H7: ClasSize → PerTechK	0.20**	p < 0.01 (Supported)
H8: ClasSize → TeKnXict	0.17*	p < 0.05 (Supported)
H9: TDevOwn → PerTechK	0.16*	p < 0.05 (Supported)
H10: TDevOwn → TeKnXict	-0.15*	p < 0.05 (Supported)
H11: PerTechK → PKn4INgT	0.61***	p < 0.001 (Supported)
H12: PerTechK → TechINtn	0.17*	p < 0.05 (Supported)
H13: PKn4INgT → TechINtn	0.55***	p < 0.001 (Supported)
H14: PKn4INgT → ICTPedPr	0.27***	p < 0.001 (Supported)
H15: TeKnXict → TechINtn	0.21**	p < 0.01 (Supported)
H16: ICTPedPr → PEffStud	0.39***	p < 0.001 (Supported)
H17: ICTPedPr → TeKnXict	0.21**	p < 0.01 (Supported)
H18: PEffStud → TechINtn	0.10	p < 0.1 (Not supported)

Note: *** = significant at p < 0.001, ** = significant at p < 0.01, * = significant at p<0.05, + =significant at p= 0.1.

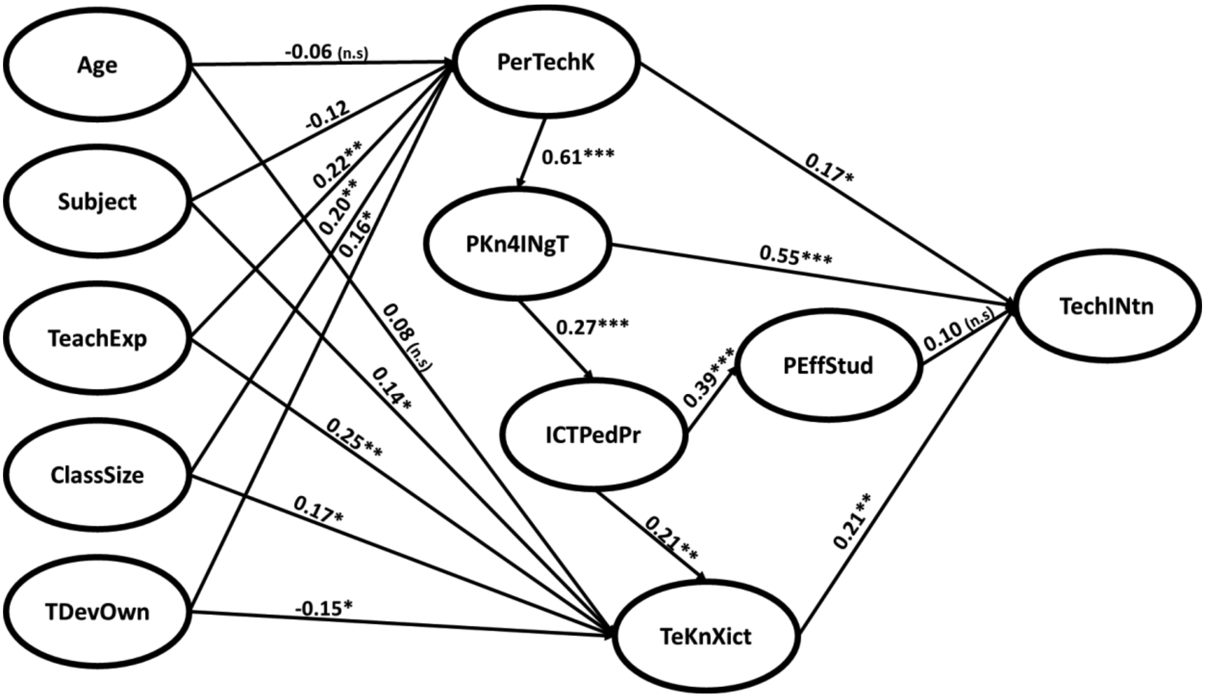

Figure 2: The results of the PLS analysis for the suggested model
Note: *** = significant at p < 0.001, ** = significant at p < 0.01, * = significant at p < 0.05, + = significant at p = 0.1, n. s = not significant.

Discussion

The main objective of this study was to investigate the factors influencing Nigerian teacher educators' technology integration. Specifically, by drawing from the TPACK and SITES frameworks, the study examined the TEs' knowledge (excluding technology), characteristics, perceived technological knowledge, perceived knowledge for integrating technology, ICT pedagogical practices, perceived effect of teaching with technology on the students, and technology integration. Hypothetically, the model held for the teachers in this study, since 72% of the variances of their technology integration were accounted for. Of the eighteen hypotheses formulated, thirteen were significantly supported by the data. Next, we discuss the hypotheses in relation to the research questions.

RQ1

The results for H1 (TEs' age negatively influences their perceived technological knowledge) was not supported. Although the predicted direction (b = -0.06) was consistent with the expectation, the p-value was not significant. Nevertheless, previous research outcomes have shown that age is negatively associated with teachers' computer proficiency (Buabeng-Andoh, 2012b; Claro et al., 2018; Inan & Lowther, 2010; Lee & Tsai, 2010; Luik et al., 2018; Koh et al., 2010). Our study's sample consisted mainly of TEs over 40 years of age, and it is possible that the training they received was not aligned with recent developments in technology, resulting in skepticism with regard to their technological skills; thus, their beliefs and attitudes regarding technology integration may not be as positive as those of younger TEs. H2, which predicted that TEs' age positively influences their perceived teaching knowledge, excluding technology, was also not supported. Surprisingly, this path coefficient also indicated a negative value, implying that as TEs grow older, their other knowledge, which does not involve knowledge of technology, decreases. Contrary to this result, Liu, Zhang, and Wang (2015) indicated that older teachers had higher perceptions of their PK and PCK. For a preservice teacher sample, age was not statistically associated with PK (Luik et al., 2018).

In the case of H3, the results supported the expectation that the taught subject would influence the teacher educators' perceived technological knowledge, albeit negatively. In comparison, TEs in the study showed that the subject they taught significantly and positively influenced their perceived teaching knowledge when the knowledge of technology was excluded (H4). In relation to our study sample, which consisted of 50% social science teachers, 11% art teachers, and the rest science, it is likely that the majority of the teachers (being social science teachers) did not perceive knowledge of technology as relevant for teaching their subjects. While Jang and Tsai (2012) maintained that the subject matter influences teachers' technology integration, other studies showed that, specifically, science teachers have greater digital competence, are more favorably disposed towards ICT use, and use computers more frequently than other subject teachers (Claro et al., 2018; Hennessy et al., 2005; Padmavathi, 2013).

The data supported both H5 and H6, which predicted that the years of teaching experience would influence the TEs' perceived technological knowledge and their teaching knowledge (excluding technology), respectively. As the teachers' experience increased yearly, they perceived an increase in their knowledge of technology as well as their teaching knowledge (excluding technology). Similar results were found in previous studies (Chew et al., 2018; Meskill et al., 2002; Miranda & Russel, 2012; Saltan & Arslan, 2017; Smarkola, 2007), while a negative relationship between teaching experience and teachers' ICT skill was found in prior studies (Buabeng-Andoh, 2012b; Inan & Lowther, 2010). Claro et al. (2018) demonstrated that, as teachers' tested digital competence moved from basic to more demanding tasks, their years of teaching experience became significantly associated with their digital competence. Similarly, other literature has demonstrated positive relationships between teacher's knowledge (excluding technology) (PCK, PK, CK) and teaching experience (Connor & Shultz, 2018; Hanuscin, Cisterna, & Lipsitz, 2018). In our results, however, there was little difference between the influence of teaching experience on either construct when considering their path coefficients and levels of significance; both were significant at the 0.01 level (see Table 5).

With respect to H7 and H8, the assumptions that class size would influence the TEs' perceived technological knowledge and their teaching knowledge (excluding technology) were individually confirmed. Class size more significantly influenced the TEs' perceived technological knowledge (H7 at level 0.01) than their teaching knowledge (excluding technology) (H8 at level 0.05). Consistent with our results were the observations of other studies (Hennessy et al., 2010; Leendertz et al., 2013) that suggested the influence of class size on teachers' technology competence.

The relationship between technology device ownership and both constructs (perceived technological knowledge and teachers' knowledge [excluding technology]) was corroborated by the data (H9 and H10**)**. Other studies offered similar insight (e.g., Kahveci et al., 2011; Padmavathi, 2013). Nevertheless, this result was inconsistent with Claro et al.'s study (2018), in which no statistical significance was found between access to digital devices at home and teachers' digital competence. There was a significant difference between the impact of personal device ownership on these constructs, respectively (i.e., both were significant at the 0.05 level with β= 16 and -15, respectively), implying that, while the ownership of technological devices negatively influenced their professional teaching knowledge, there was a positive relationship between the former and their perceived technological knowledge. Mama and Hennessy (2013) suggested that TEs' ownership of technological devices does not necessarily translate into an increase in their perceived technological knowledge. Yerdelen-Damar et al. (2017), on the other hand, illustrated the insignificant association between preservice teachers' ownership of technology and their TPACK perception, but when mediated by both technical competence and experience, the association became significant. However, Bitner and Bitner (2002) pointed out that teachers' personal development through ICT use promoted their engagement in ICT-based classroom practices.

Among the TEs' characteristics, subject, class size, teaching experience, and device ownership influenced both TEs' technological knowledge and knowledge that did not include technology. Although TEs' age negatively influenced both their technical knowledge and knowledge that did not include technology, the relationships were not statistically significant. Moreover, teaching experience and device ownership influenced both constructs almost equally.

In considering all the paths between these five TE characteristics and their technology integration, the total indirect effect was statistically significant for only teaching experience and class size ($p < 0.05$); however, their effect sizes were not practically relevant. Consistent with other studies (e.g., Farjon et al., 2019; Peeraer & van Petegem, 2011), similar characteristics among these five characteristics did not influence either pre-service or in-service teachers' technology integration when mediated by other factors.

RQ2

The results for H11 (TEs' perceived technological knowledge positively influences their perceived knowledge for integrating technology) was confirmed by the data. Previous studies supported this result (Koh, Chai, & Tsai, 2013; Taimalu & Luik, 2019).

Both TEs' perceived technological knowledge and perceived knowledge for integrating technology influenced their technology integration (H12 and H13). Previous studies agreed with this result (Nelson et al., 2019; Taimalu & Luik, 2019).

The data supported the expectation that TEs' perceived knowledge for integrating technology would influence their ICT pedagogical practices (H14). Prestridge (2012) illustrated the relationship between ICT competence and a similar effect on ICT usage in classrooms.

H15, which predicted that TEs' perceived teaching knowledge, excluding technology, would positively influence their technology integration was confirmed. This result, following the TPACK framework (Koehler & Mishra, 2006), in which path predictions in earlier studies (Kiray et al., 2018; Koh et al., 2013) were among the primary and secondary knowledge constructs, found that PK and PCK could be expected to influence the teachers' technology integration.

The relationship between TEs' ICT pedagogical practices and the perceived effect of teaching with technology on their students (H16) was confirmed. The extant literature posited a reverse relationship, in which the teacher is likely to increase the use of technology in the classroom if such usage is perceived to enhance students' learning (Blackwell et al., 2013; Ertmer et al., 2012; Liu, 2011; Miranda & Russell, 2012; Vongkulluksn et al., 2018; Willis et al., 2019). Scott and Mouza (2007) reported a relationship shift in teacher's pedagogical practices, which occurred when teachers began to see the benefits of technology for both their students and themselves, thus signifying an association between teachers' beliefs and practices.

For H17, the TEs' ICT pedagogical practices positively influenced their perceived teaching knowledge that excluded technology. Other studies gave credence to this result; for instance, Scott and Mouza (2007) asserted that the introduction of ICT tools in teaching influenced teachers' thinking and consideration of their pedagogical beliefs. Sutherland et al. (2004), in turn, emphasized that the use of ICT transformed teachers' knowledge of their subject areas and teaching repertoires, and Heitink et al. (2016) indicated that ICT use is relevant for improving teachers' pedagogical skills. Among the assessed teacher ICT practices, evaluation of students through experiments, tests, and interviews had the highest mean (2.83), and organizing students had the lowest (2.46).

No support was evident for the prediction that TEs' perceived effect of teaching with technology on their students would positively influence their technology integration (H18). This outcome paralleled that of Peeraer and van Petegem (2011). Conversely, however, the study by Leendertz et al. (2013) indicated that teachers with who taught mathematics using ICT had higher TPACK, and also involved their students in the use of ICT, leading to improved students' skills and knowledge of the subject. Similarly, Heitink et al. (2016) suggested that teachers can achieve their educational goals when they use technology. If teachers believe that integrating technology into teaching will benefit the learning goals of the students, then the technology integration skills of the teachers themselves should increase; therefore, the perceptions of teachers should align with those that enable technology integration to succeed (Chikasanda et al., 2013). Notably, in the study, the TEs' perceived effect of teaching with technology on their students was generally positive, with the highest means for learning motivation, ICT skills, and subject knowledge (Table 2). Such perceptions suggested that the TEs understood teaching with ICT to be learner-focused.

Overall, three constructs (teachers' knowledge [excluding technology], perceived technological knowledge, and perceived knowledge for integrating technology) directly influenced the TEs' technology integration, while the other two (ICT pedagogical practices and perceived technology gains for their students) did not. Further examination, using the indirect effect of the constructs on TEs' technology integration, showed only perceived technological knowledge to be statistically significant ($p < 0.001$), with an effect size of 0.20. Considering that over 90% of the TEs in our study personally owned at least two technological devices, this could be the reason for their perceived technological knowledge influencing their technology integration in this way. Notably, the TEs' ICT pedagogical practices did not indirectly influence their technology integration, which contrasted with a prior study demonstrating that teachers' pedagogical practices both directly and indirectly positively influenced their technology integration (Chuang et al., 2015; Drent & Meelissen, 2008). In addition, although their sample comprised preservice teachers, Farjon et al. (2019) indicated that such practices had little impact on their technology integration.

Limitations and Future Work

This study's results should be explained in relation to the following limitations. First, the research sample consisted of teacher educators; therefore, the findings may not apply to teachers within university, primary, or secondary school contexts. Second, we used convenience sampling, and the data was gathered using a cross-sectional survey; therefore, the results may not be applicable to a randomized experiment, and the use of data from longitudinal, observation, and interview studies would enrich the study. Third, the sample size was 136, and the respondents were drawn from only three colleges of education within the southern part of Nigeria; consequently, generalizing to the entire country should be done carefully. Fourth, social desirability bias may have applied in this instance, since a self-completed questionnaire was used to collect the responses from the participants. Although, as we mentioned earlier, PLS-SEM is beneficial for investigating complex models and relatively small sample sizes, a second study cycle with additional data would further strengthen and sharpen the study results.

Similar studies comparing younger TEs and TEs who teach specific subjects (rather than our three broad subject categories) could be conducted in order to explain the influence of subject or age. Further insight, as evident in the disassociation between TEs' technology integration and both ICT pedagogical practices and the perceived benefits for students, is necessary; for instance, Liu (2011) recognized that contextual factors are responsible for the discrepancies between teachers' beliefs and their teaching activities. Given that our study focused only on the teacher-level factors of technology integration, further research that considers the mediation of other contextual factors, such as the impact of the school-level and system-level on TEs, is needed, as reiterated by other studies (e.g., Buabeng-Andoh, 2012a; Nelson et al., 2019). Further studies could analyze the combined impact of school-level characteristics, teacher characteristics, and their experiences; for example, teachers who have TPACK in one setting might adjust their knowledge in a different way in another setting.

Conclusion

The usefulness of the TPACK framework for investigating teachers' technology integration continues to generate discussion of the factors that affect the complex process and the adequacy of the framework. As a result, in addition to the teachers' knowledge constructs in the TPACK framework, we included in this study other relevant constructs (such as teachers' demographics, ICT pedagogical practices, and the perceived effect of these practices on students), which were inspired by the SITES framework. In this way, we have contributed to the literature, in terms of theory development, by presenting the factors influencing the technology integration of teacher educators within a Nigerian college of education context. As Howard et al. (2015) explained, understanding technology integration requires the knowledge that the process consists of manifold relationships between and among the specific factors considered. In other words, no factor should be considered in isolation, since its influence can become significant when other factors mediate. Our study provides support for previous studies (e.g., Buabeng-Andoh, 2012b; Inan & Lowther, 2010; Nelson et al., 2019) that showed the impact of teacher characteristics on technology integration. It differs from these prior studies, however, because we went further and added factors other than age, subject area, and teaching experience to our model. Moreover, we included the antecedents of class size and device ownership, as well as other constructs—technological knowledge, knowledge for integrating technology, ICT pedagogical practices, perceived effects of these practices on students, and professional teaching knowledge—on teachers' technology integration. Claro et al. (2018) presented quite similar findings to ours, although they applied a different theoretical lens and focused mainly on the digital competencies of teachers within a Chilean context. Highlighted in our study context was the fact that teachers' access to ICT tools should no longer be a barrier to technology integration, due to the TEs' ownership of various technological devices. The information revealed in this study is relevant for developing teachers' technology integration strategies, the policies of the governing bodies of the learning institutions where the research was conducted, school environments in other regions of Nigeria, and other African countries.

Essentially, TEs should take the lead in matters concerning technology integration within the sphere of their classrooms, especially for shaping future professionals who will be competent in the future working environment. One major finding from our study, which raises concern, was that indicated by the lowest contributors of the study's constructs (e.g., ICT pedagogical practices and the perceived effect of teaching students using ICT tools) to the TEs' technology integration. Accordingly, the implication for administrators of educational institutions is the need for practical training, with examples that show how older TEs can align their ICT pedagogical practices and the perceived benefits that students gain through their technology integration. School administrators can encourage TEs to use their ICT devices for teaching. The study by Heitink et al. (2016) emphasized the benefits of supporting teachers' technology integration processes using such "authentic" scenarios. Moreover, such professional development training should provide interactive environments for teachers' reflection and their recounting of experiences and practices that foster or inhibit effective ICT integration processes. This study therefore concludes with a widely-accepted view that more professional development is needed. By adopting a bottom-up approach, more information concerning how our model's constructs can better influence teachers' technology integration can be uncovered.

Educational technology integration is difficult. Although it has been studied for over 30 years, there still is no explanation, theory, model, or framework that can explain the foundations for successful educational technology integration and how it can be achieved. This study has highlighted that technology integration can be understood as a combination of individual teacher-level factors (i.e., knowledge, perceptions, characteristics, and practices); thus, we have provided an understanding of some of a complex series of interconnected factors. Understanding the challenges of technology integration into classroom practice calls for perspectives that situate technology integration within everyday classroom routines. Consequently, we suggest that research on educational technology integration could benefit from taking a broad view, recognizing that technology integration must be considered critically and that many of the challenges have, indeed, already been identified in existing research.

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APPENDIX

Table 3: Composite Reliability, Cronbach Alphas, Average Variance Extracted and Inter-construct correlations

	CRC	CRA	AVE	Age	Subj	Teach Exp	Clas Size	TDev Own	Per TechK	PKn 4INg	ICT PedPr	TeKn Xict	PEff Stud	Tech INtn
Age	1.000	1.000	1.000	1.000	0.167	0.586	0.008	0.088	-0.041	-0.058	-0.054	-0.022	0.008	-0.158
Subject	1.000	1.000	1.000	0.167	1.000	-0.038	0.271	0.041	-0.043	-0.072	0.017	0.070	-0.002	-0.011
TeachExp	1.000	1.000	1.000	0.586	-0.038	1.000	-0.091	0.068	0.076	0.047	0.055	0.031	0.113	-0.000
ClasSize	1.000	1.000	1.000	0.008	0.271	-0.091	1.000	-0.077	0.018	0.041	-0.058	0.180	0.102	0.025
TDevOwn	1.000	1.000	1.000	0.088	0.041	0.068	-0.077	1.000	0.172	0.138	0.205	-0.045	0.302	0.201
PerTechK	0.868	0.817	0.525	-0.041	-0.043	0.076	0.018	0.172	0.724	0.603	0.162	0.403	0.207	0.588
PKn4INg	0.935	0.916	0.706	-0.058	-0.072	0.047	0.041	0.138	0.603	0.840	0.209	0.622	0.219	0.809
ICTPedPr	0.896	0.865	0.552	-0.054	0.017	0.055	-0.058	0.205	0.162	0.209	0.743	0.195	0.280	0.257
TeKnXict	0.922	0.898	0.662	-0.022	0.070	0.031	0.180	-0.045	0.403	0.622	0.195	0.814	0.117	0.644
PEffStud	0.927	0.911	0.588	0.008	-0.002	0.113	0.102	0.302	0.207	0.219	0.280	0.117	0.767	0.273
TechINtn	0.926	0.880	0.806	-0.158	-0.011	-0.000	0.025	0.201	0.588	0.809	0.257	0.644	0.273	0.898

Note: CRC = Composite Reliability Coefficient, CAC = Cronbach Alphas Coefficient, AVE = Average Variance Extracted. The off-diagonal elements depict the correlations among constructs while the bold fonts in the leading diagonals are the square roots of AVEs.

Table 4: Item loadings and cross-loadings

	Age	Subject	Teach Exp	Clas Size	TDev Own	Per Tech	PKn 4INg	ICT PedPr	TeKn Xict	PEff Stud	Tech INtn
Age	**1.000**	0.167	0.586	0.008	0.088	-0.041	-0.058	-0.054	-0.022	0.008	-0.158
Subject	0.167	**1.000**	-0.038	0.271	0.041	-0.043	-0.072	0.017	0.070	-0.002	-0.011
TeachExp	0.586	-0.038	**1.000**	-0.091	0.068	0.076	0.047	0.055	0.031	0.113	-0.000
ClasSize	0.008	0.271	-0.091	**1.000**	-0.077	0.018	0.041	-0.058	0.180	0.102	0.025
TDevOwn	0.088	0.041	0.068	-0.077	**1.000**	0.172	0.138	0.205	-0.045	0.302	0.201
TKI	-0.053	-0.111	0.023	-0.029	0.092	**0.658**	0.479	0.142	0.388	0.084	0.447
TKII	-0.037	-0.075	0.088	-0.012	0.152	**0.828**	0.499	0.180	0.372	0.163	0.477
TKIII	0.057	-0.043	0.097	-0.075	0.061	**0.709**	0.375	0.032	0.170	0.128	0.339
TKIV	-0.090	-0.014	0.025	0.064	0.158	**0.659**	0.436	0.096	0.314	0.281	0.472
TKV	0.025	0.089	0.120	0.034	0.227	**0.737**	0.415	0.152	0.214	0.147	0.401
TKVI	-0.084	-0.035	-0.032	0.096	0.056	**0.742**	0.419	0.095	0.294	0.105	0.425
TCK	-0.087	0.000	0.028	0.079	0.090	0.492	**0.774**	0.067	0.613	0.103	0.661
TPKI	-0.124	-0.157	-0.016	0.058	0.143	0.620	**0.843**	0.085	0.466	0.141	0.683
TPKII	-0.039	-0.114	-0.009	0.008	0.195	0.596	**0.853**	0.241	0.485	0.249	0.724
TPKIII	-0.046	-0.057	0.040	0.030	0.035	0.350	**0.763**	0.229	0.437	0.264	0.592
TPKIV	-0.009	-0.047	0.053	0.032	0.051	0.465	**0.912**	0.179	0.596	0.169	0.713
TPKV	0.001	0.015	0.134	0.006	0.176	0.508	**0.887**	0.246	0.541	0.182	0.702
IT4Inst	-0.034	-0.086	0.121	0.020	0.148	0.259	0.363	**0.718**	0.240	0.318	0.347
SuppLes	-0.009	0.149	-0.019	0.048	0.157	0.189	0.176	**0.717**	0.179	0.132	0.205
HelpAdv	-0.081	0.068	0.012	0.010	0.211	0.185	0.214	**0.781**	0.186	0.214	0.237
OrgObSt	-0.124	0.081	-0.015	-0.063	0.251	-0.025	0.062	**0.750**	0.095	0.148	0.151
EvaStud	-0.000	0.037	0.079	-0.121	0.139	-0.043	-0.072	**0.754**	0.019	0.262	0.087
Feedbac	0.010	-0.106	0.096	-0.144	0.041	0.157	0.130	**0.746**	0.124	0.169	0.125
ManStgr	-0.038	-0.059	0.015	-0.047	0.115	0.130	0.221	**0.735**	0.175	0.216	0.190
PKI	-0.004	0.021	-0.059	0.193	-0.005	0.271	0.551	0.174	**0.829**	0.041	0.520
PKII	-0.076	0.048	-0.069	0.177	-0.112	0.343	0.544	0.149	**0.855**	0.093	0.538
PKIII	-0.055	-0.020	0.062	0.137	-0.129	0.332	0.460	0.136	**0.801**	0.033	0.450
PKIV	-0.116	0.092	0.001	0.095	-0.014	0.349	0.490	0.229	**0.812**	0.153	0.602
PKV	0.065	0.090	0.135	0.117	-0.039	0.329	0.456	0.071	**0.808**	0.106	0.490
PCKII	0.087	0.113	0.091	0.156	0.086	0.343	0.535	0.192	**0.776**	0.147	0.543
KnofSub	-0.095	-0.070	0.029	0.069	0.292	0.143	0.180	0.302	0.065	**0.899**	0.227
ICTSkil	-0.090	-0.059	-0.014	0.003	0.265	0.204	0.181	0.297	0.021	**0.771**	0.158
LearnMo	0.016	0.045	0.040	0.141	0.248	0.216	0.191	0.225	0.063	**0.790**	0.193
MessSki	0.054	0.031	0.135	0.094	0.147	0.186	0.240	0.252	0.133	**0.718**	0.249
InfoPrS	0.066	0.100	0.141	0.098	0.091	0.178	0.161	0.190	0.191	**0.760**	0.214
CoopSki	0.061	-0.020	0.149	0.035	0.251	0.135	0.134	0.145	0.011	**0.705**	0.162
SelfDir	0.037	0.030	0.128	0.103	0.236	0.199	0.160	0.112	0.112	**0.747**	0.255
ProSolS	0.049	0.016	0.145	0.107	0.251	0.105	0.151	0.149	0.097	**0.803**	0.224
StuConf	-0.025	-0.083	0.045	0.051	0.302	0.060	0.112	0.256	0.122	**0.706**	0.205
TPCKI	-0.231	-0.082	-0.038	-0.018	0.167	0.495	0.731	0.169	0.567	0.220	**0.906**
TPCKII	-0.136	0.008	-0.021	0.075	0.204	0.543	0.755	0.195	0.622	0.257	**0.897**
TPCKIII	-0.057	0.047	0.059	0.010	0.170	0.545	0.692	0.329	0.544	0.259	**0.890**

Note: CRC = Composite Reliability Coefficient, CAC = Cronbach Alphas Coefficient, AVE = Average Variance Extracted. The off-diagonal elements depict the correlations among constructs while the bold fonts in the leading diagonals are the square roots of AVEs.