TECHNOLOGY AND ITS RELATIONSHIPS WITH DISTANCE AND ONLINE LEARNING CONSTRUCTS IN UNDERGRADUATE MATHEMATICS IN NIGERIA

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ABSTRACT – There is some research to suggest that recent improvements in technology may have improved the teaching and learning of mathematics through distance and online modes in many universities. However, little research focuses specifically on how available technology (AT) affects the three core processes of distance and online course provision: viz. instructional delivery (ID), assessment procedures (AP) and learning facilitation (LF) in undergraduate mathematics education, especially in Nigeria. This paper presents results from survey study designed to investigate the relationships between technology and these essential constructs in students' experiences of distance and online undergraduate mathematics. The hypotheses explored in the study include: there is no statistical relationships between AT and the constructs (ID, AP and LF) in distance and online undergraduate mathematics in Nigeria. A closed-ended questionnaire was conveniently administered to a purposive sample of (60) students from a dual and single mode (of delivery) universities in Nigeria to test the stated hypotheses. The instrument was validated by experts in curriculum, distance and online learning and a university committee. Pilot study was also carried out to determine the validity of the instrument. Composite scores were obtained for each construct corresponding to each hypothesis. Partial Least Square (PLS) regression was used to determine the degree of relationship of the constructs (ID, AP and LF) with technology. Constructivism as a theory of learning that places students at the centre of learning experience was used as a lens to investigate the students' technological experiences with distance and online mathematics learning. The results revealed that despite the problems the students encounter learning through this mode, there existed a positive relationship between AT and ID. It was also found that a significant relationship exists between AT and AP while AT was positively related to LF. Hence, leading to rejection of null hypotheses stated in this paper. These results clearly and firmly confirmed the request from the students for incorporation of technology in the ID, AP and LP of distance and online mathematics education in Nigeria. The paper recommends continuous investigation of technologies as they evolve in relation to ID, AP and LP in order to maintain their adequacy.

KEYWORDS: Technology; Distance and online Learning; Constructs; Undergraduate Mathematics

INTRODUCTION

Educational technologies have contributed immensely to the progress and development witnessed in Open and Distance Learning (ODL) worldwide (Perraton, 2000). ODL institutions moving towards integrating technology aim at flexible need of the students and try to keep the students at the centre in the design and development of learning opportunities (Leow & Neo 2014). The remarkable employment of technology in distance and online education is having, for example, a major and important effect on the way students learn undergraduate mathematics. The advancement in technology has enabled the ODL institutions to broaden the learning process of mathematics through distance and online mode, and this led to increment in educational needs of the students. Oates (2016) also pointed out that research on the pedagogical value of technology in assisting students to understand and solve specific mathematics problems has been on the increase.

The study of Luhan, Novotna and Kriz (2013) which considered Information and Communication Technology (ICT) support for creative teaching of mathematics discipline expressed concern that students tend to concentrate more on the technology than on the real mathematical problem to be solved. Thus, the students have to be guided on the proper use of the technology tools in finding solutions to mathematics problems. Aluko (2015) argued that despite the progress made in using modern technology in delivery of distance and online education programmes, greater number of African

countries have not advanced beyond first-generation method of delivery. A logical question in this paper remains whether relationships exist between available technology and distance and online learning constructs (ID, AP and LF) of undergraduate mathematics education in Nigeria. Studies have shown that ODL teachers have used technology to enhance learning in disciplines like engineering, computer science and mathematics (Galligan, Loch, McDonald & Taylor, 2010). This paper examines in detail the impact of available technology (AT) in ID, AP and LP in two ODL institutions in Nigeria.

The conceptualisation of the terms (AT, ID, AP and LF) is important to define the focus of this paper. AT in this context imply accessible multimedia instruments that can be utilised by mathematics distance and online learners. ID on the other hand is an innovative teaching approach employed in distance and online environment to facilitate learning. AP are processes used to determine the learners' present knowledge of the subject; and LF is the process employed to encourage learners' online interaction using supportive multimedia tools.

Advances in educational technologies present newest ways of communication, collaboration and participation in distance and online learning processes (Juan *et al.* 2008). Kissane, McConney & Ho (2015) identified technology as a powerful way of making mathematics learning more student-centred; providing the students with the experience of being mathematicians; promoting reflection in learning, and redefining and realigning students' constant access to learning instruction. The authors further found that effective use of technology in learning mathematics helps the students to develop a deeper understanding of mathematical concepts which assist them to perform well in examinations. According to Dawson, Heathcote and Poole, (2010), there is a possibility of improving classroom learning of mathematics using technology but Information and Communication Technology (ICT) tools with formats similar to rote learning activities might establish low-level tasks that have little or no impact on student learning outcomes.

More so, studies have identified technological divides such as, lack of computers with high speed internet connectivity, lack of functional mathematics laboratory, malfunctioning of mathematics content software or internet security, incompetence of both mathematics tutors and students in ICT tools as challenges of distance and online learning of mathematics (Jarvis, 2012). ODL institutions in Nigeria have upgraded learning facilities, equipped with technologies to facilitate students' learning (Garrett, 2016), including mathematics. However, there is little understanding on how technology relates to the constructs (ID, AP and LF) in distance and online learning of mathematics in these institutions in Nigeria.

BACKGROUND

The distance and online education in Nigeria takes the forms of dual and single modes. Distance Learning Institute (DLI), University of Lagos, for example, was established in 1973 and in 2008 it became one of the dual mode institutions in Nigeria approved by National Universities Commission (NUC) to offer distance and online education to adult students and those who for one reason or the other failed to secure admission to conventional universities (Ajadi, Salawu & Adeoye, 2008). The institution at its inception offered courses in science education (Biology, Chemistry, Physics and Mathematics) at undergraduate level. Though currently, admission, registration and checking of results are done online, greater parts of teaching, assessment and examination take place face-to-face at the university. As a result, the students visit the institute on regular bases.

National Open University of Nigeria (NOUN) on the other hand was accredited as the only single-mode university in 2001 to provide open and distance learning education in various university programmes including mathematics (Osang, 2012). The processes of admission, registration and learning are done online apart from facilitation and examinations which are still conducted at the various study centres in Nigeria. These practices allow the students to visit the study centres only when there is a need. As ODL institutions, both (DLI and NOUN) are expected to meet the educational needs of the learners using

appropriate technologies (Ajadi *et al.* 2008; Obilade, 2012). Presently, there seems to be no systematic investigation of any relationships between AT and ID, AP and LF of distance and online mathematics learning in Nigeria.

According to Oginni, (2016), the advent of distance and online education in Nigeria appears to have strengthened the knowledge, understanding and usage of technology in its classrooms. Therefore, ODL institutions in Nigeria are required from time to time to update their teaching and learning to include technological tools to deliver learning opportunities to the students. Additionally, the guidelines establishing these institutions required all students to have access to technology such as functional internet to assist the learners in their specific programmes (Federal Republic of Nigeria, 2004). Despite the policy statement on ODL in Nigeria, there are limited empirical research results on the relationships between technology and ID, AP, LF of distance and online mathematics learning in Nigeria.

Literature indicates that integration of technology in mathematics education has been to greater extent slower than what is expected (Oates, 2016), hence there is a need for research at undergraduate level to examine its relationships with distance and online learning constructs. Some of the benefits of learning with technology according to Olibie, Offor and Onyebuchi (2016) include: flexible learning, enhanced communication among the learners, students' self-motivation to learn, peer participation in discussion and privacy of the learners. Sife, Lwoga and Sanga, (2007) assert that television and radio, CDs and DVDs, Internet, mobile technology (smart phones, tablets and laptops), electronic learning platforms, web-based technology and video conferencing are some of the technologies that can be utilised by the distance and online learners.

Some of the challenges identified in the use of technology in distance and online learning in Nigeria include lack of training among the teachers and students and lack of integration of technology in primary and secondary schools to prepare the students for higher education studies (Zakaria & Daud, 2013; Oginni, 2016). There are limited empirical research that emphasises on the relationships that exist between technology and the constructs (ID, AP and LF). The present paper attempts to fill the gap by seeking to understand the relationships between technology and distance and online learning constructs of undergraduate mathematics. The following hypotheses were explored to address the issue:

- There is no statistical relationship between AT and ID in distance and online learning of mathematics in both DLI and NOUN.
- There is no statistical relationship between AT and the construct AP in distance and online undergraduate mathematics in DLI and NOUN.
- There is no relationship between AT and LF in distance and online learning of mathematics in DLI and NOUN.

THEORETICAL FRAMEWORK

The framework is aimed at answering the question: What are the relationships between AT and distance and online learning constructs (ID, AP and LF) in undergraduate mathematics education in Nigeria? The answer is expected to provide important information to the institutions, mathematics facilitators and students. The National Council of Teacher of Mathematics (NCTM 2008) declared in

their position statement that technological tools are indispensable in learning mathematics, hence, it is necessary for schools to ensure student access to technology. Technology has the capability to speed up and expand the impact of learning when carefully designed and accurately utilised (U.S. Department of Education 2017).

There is a remarkable use of constructivism learning theory in distance and online education research with the slogan that the students should construct their own knowledge and create meaning from their experiences (Duffy & Cunningham 1996). Students acquire knowledge by observing, interacting with the environments (technologies), processing and interpreting information (Wilson, 1997). The theory is student-centred and places the students as active learners, responsible for their learning. Students working collaboratively with the lecturers are encouraged to learn beyond what they are taught in the classrooms. Crawford (2009) stressed the role constructivism theory plays in creating stimulating environment that captures the students learning interest. Some of the characteristics of constructivism learning theory pertinent in this paper include lecturers serving as guides, facilitators and tutors; provision of environments and opportunities to encourage students self-reflection and self-awareness; students constructing knowledge individually through collaboration and being at the centre of learning; independent knowledge being achieved through exploration; encouraged authentic delivery, assessment procedures and learning facilitation (Koohang, Riley, Smith, & Schreurs 2009).

Oh and Yager (2004) examined the associations between development of constructivism classrooms and changes in student attitudes. The results indicate that "students' attitudes toward science lessons develop more positively as their science classrooms become more constructivist" (p. 110). Also, DePrinter (2013) suggests that a constructivist-based approach within the distance and online mathematics learning classroom has a definite impact on students' learning experiences; hence, mathematics is best learnt in a constructivist-based environment" (p. 3). This paper differs from these studies by examining the relationships between technology and distance and online learning constructs (ID, AP and LF) of undergraduate mathematics in Nigeria.

METHODOLOGY

The aim of this paper is to examine the relationships between AT and distance and online learning constructs (ID, AP and LF) in undergraduate mathematics education in Nigeria.

Instrument

The instrument was structured in five parts to cover students' demographic information on instructional delivery, assessment procedures, learning facilitation and available technology. The Course Experience Questionnaire (CEQ) of Ramsden (1991) was developed to measure a variety of factors that combined to form students learning experiences (Henman & Phan, 2014). Some aspects of CEQ (clarity of objectives of learning, assessment, resources and supports) were adapted, adjusted and used for the development of the instrument. This was done to suit the Nigerian ODL environment. The students were expected to relate their experiences with AT and the constructs ID, AP and LF in learning mathematics through distance and online education on a 5-point Likert scale of (5-strongly agree, 4-agree, 3-neutral, 2-disagree and 1-strongly disagree).

The instrument was revised based on several comments of experts (professors in curriculum, distance and online learning) and a university committee. The inputs from these groups of experts were used for final improvement of the questionnaire and approval was also obtained from a university ethics committee. The reliability coefficient of (AT-0.93, ID-0.72, AP-0.54 and LF-0.74) was determined using Cronbach's alpha method. Additionally, reliability of the instrument was examined using pilot study involving n=8 students different from those used in the study. The results of the pilot showed that the participants understood the main constructs under study.

Participants

The participants were (n=60) mathematics education students from third year of undergraduate degree in ODL institutions in Nigeria. Thirty (n=30) students came from DLI, university of Lagos while the other

thirty (n=30) students were from NOUN. Purposive sampling as a non-probability sampling method was used to ensure only mathematics education students in the two ODL institutions were selected. The ages of the students showed that the majority were between 25-34 years old and 77% were males. The DLI students meet in their various study centres located within the University of Lagos fortnightly for face-to-face teaching and facilitation. Majority of the students are married and have jobs with diverse responsibilities and work schedules that keep some of them busy even on weekends. Hence, not all of them attend centre meetings as scheduled. NOUN on the other hand has three study centres located in different parts of Lagos. The students are allowed to conveniently visit any of the centres nearest to them for any help and support.

The survey instrument was administered to and collected from DLI students on their centre meeting days and Short Message System (SMS) was used to invite NOUN students to complete the questionnaire since they do not have a specific day of study centre meeting. Both groups completed 77-item survey instrument (AT=27-items; ID=29-items; AP=12-items and LF= 9-items). The students were assured that their participation was voluntary and without penalties for withdrawal or non-participation. And consent form was completed by all the participants at the beginning of data collection.

DATA ANALYSIS

The purpose of this paper is to examine relationships of available technology and instructional delivery, assessment procedures and learning facilitation of undergraduate mathematics in distance and online learning mode.

In the study, composite score was obtained for each construct corresponding to each hypothesis by totalling the individual mean scores of the survey items and calculating their means (Tables 1 and 2). This was used to examine the students' experiences with the constructs (AT, ID, AP and LF) in distance and online learning of mathematics. Spearman correlation coefficient was also obtained to explore whether a linear relationship exists between the variables. Then Partial Least Square (PLS) regression was used to determine the degree of relationships between AT and ID, AP and LF. The path coefficients in the PLS model are presented in Table 3 while bootstrap (Figure 1) shows the paths, strength and path coefficients in the PLS model.

PRESENTATION OF RESULTS

We now present in our study the composite scores regarding the 29 items of ID, 12 items of AP, 9 items of LF and 27 items of AT as raised in the questionnaire.

Table 1: The key statistics of composite variables

Variable (Table)	No. of items	Mean	SD	95% Confidence interval for mean		Min	Max
				Lower Bound	Upper Bound		
Instructional delivery	29	97.930	11.187	95.362	101.171	52	118
Assessment procedures	12	38.920	5.003	37.624	40.209	21	47
Learning facilitation	9	29.670	5.695	28.196	31.138	18	42
Available technologies	27	83.130	18.755	78.563	88.371	37	115

The composite scores of these constructs were obtained by totalling the individual mean scores of the questionnaire items and calculating their means. The results are as represented in Table 1.

Table 2: Summary of descriptive statistics of composite variables

Variable (Table)	N	Min	Max	Mean	SD	Average %	No. of items
Instructional delivery	60	1.793	4.069	3.377	0.386	82.99	29
Assessment procedures	60	1.750	3.917	3.243	0.417	82.81	12
Learning facilitation	60	2.000	4.667	3.297	0.633	70.64	9
Available technologies	60	1.370	4.259	3.079	0.695	72.29	27

Table 2 on the other hand provides a summary of the key statistics of the composite variables. As shown in Tables 1 and 2, for example, a total score was computed from 29 questionnaire items for ID. The theoretical range is 29 to 145, a score of 87 is the middle point, and consequently, higher scores indicate students' strong experiences with ID. There is no score less than 87 (Mean = 97.930, SD = 11.187, score range: 52-118, 95% CI = 95.362-101.171). A large proportion of mathematics education students in DLI and NOUN had higher scores toward distance and online delivery. Hence, the participants seem to show high positive student experiences with distance and online mathematics delivery.

Furthermore, a total score computed from 12 questionnaire items for AP indicated that the theoretical range is 12 to 60. A score of 36 is the middle point and so higher scores show students' satisfaction level with the AP. Overall, AP had scores higher than 36 (Mean= 38.920, SD= 5.003, Score range: 21-47, 95% CI=37.624-40.209). As seen in the results, students have higher scores toward AP, therefore, the participants seem to demonstrate positive satisfaction with distance and online AP. Similar analyses for LP and AT indicate that the students have positive experiences with learning undergraduate mathematics through distance and online mode. Moreover, as can be seen from Table 2, the average percentage of the students' response to questionnaire items on these constructs are reasonably high, indicating positive significant level with the constructs.

To check the possible relationships between the constructs (ID, AP and LF) and AT, we used Spearman correlation coefficients. This was mainly because the data was ordinal in nature. The summary of Spearman correlation coefficients (ρ) and p-values for the different variables are provided in Table 3.

Table 3: Summary of the Spearman correlation coefficients and p-values

Variable 1	Variable 2	Spearman correlation (ρ)	p-value
Available technologies	Instructional delivery	0.396	<0.01
Available technologies	Assessment procedures	0.564	<0.01
Available technologies	Learning facilitation	0.632	<0.01

The table shows that there are statistically significant correlations between AT and ID (ρ=0.396), AT and AP (ρ=0.564), and AT and LF (ρ=0.632). They are all significant (p<0.05). These results led to rejection of

the null hypotheses that there is no statistical relationship between AT and ID in distance and online learning of mathematics in both DLI and NOUN; there is no statistical relationship between AT and the construct AP in distance and online undergraduate mathematics in DLI and NOUN, and that there is no relationship between AT and LF in distance and online of mathematics in DLI and NOUN.

In presenting the degree of significance by relationships, we used the Partial Least Square (PLS) regression method of constructing predictive models. This model is used by researchers when the factors are many, highly collinear and in handling relationships between constructs (Wold 1985). PLS was preferred in this study because it is robust in handling small sample or normally distributed multivariate data.

Table 4: Bootstrap confidence intervals and paths coefficients (PLS, n=60)

Path	Bootstrap lower (2.5%)	Bootstrap mean	Bootstrap upper (97.5%)	Path coefficients
Available technologies -> Instructional delivery	0.191	0.389	0.554	0.392
Available technologies -> Assessment procedures	0.407	0.564	0.698	0.561
Available technologies -> Learning facilitation	0.454	0.624	0.760	0.622

Table 4 displays the statistical significance of the paths and path coefficients in the PLS model which is assessed using bootstrap confidence intervals. Therefore, the path, strength and significance of the path coefficients assessed by Partial Least Squares (PLS) are shown in Figure 1.

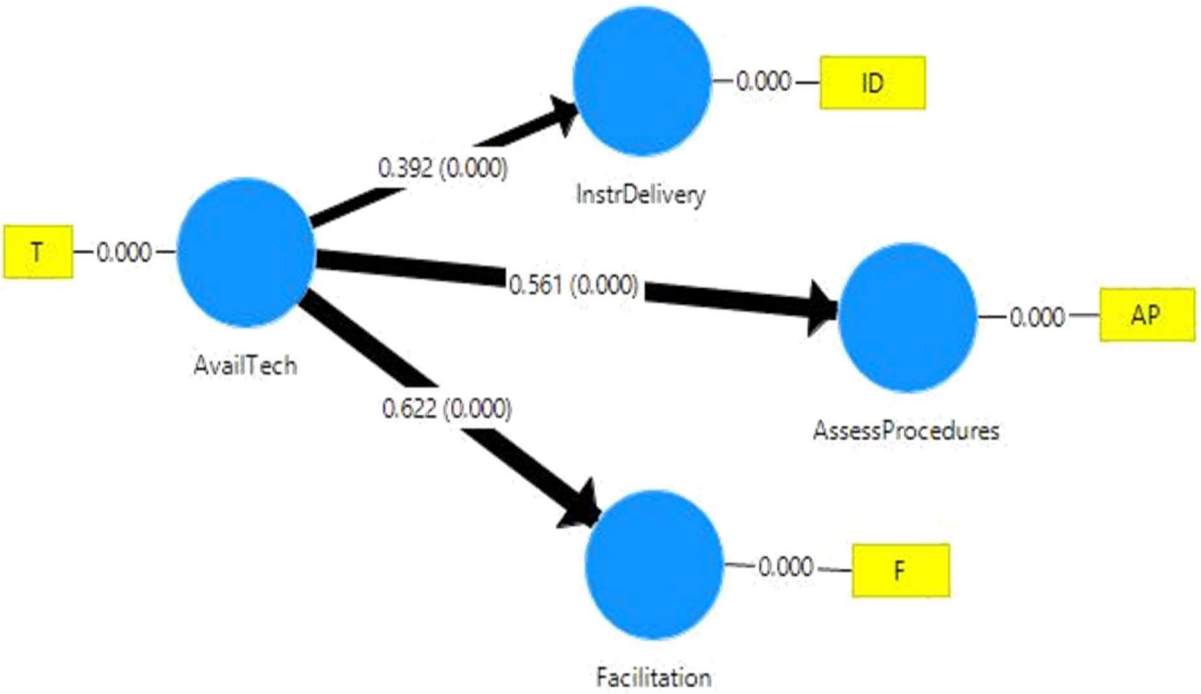

Figure 1: Path, strength and significance of the path coefficients assessed by PLS (n=60)

As confirmed by significant path coefficients (γ = 0.392) (Table 4 and Figure 1), there is a positive relationship between AT and ID. A positive relationship also exists between AT and AP (γ = 0.561). The path coefficients (γ = 0.622) again indicates a positive relationship between AT and LF.

DISCUSSION

The mean scores and average percentages indicated in Tables 1 and 2 showed that ID, AP, LF and AT all have statistical significant effects on the students' distance and online mathematics learning. These findings show that despite the problems ODL students encounter when learning mathematics through technologies as identified by (Jarvis, 2012), they are relatively satisfied with their learning. The results also support Oginni, (2016) evidence that the advent of distance and online education in Nigeria appears to have strengthened the usage of technology in its classrooms.

The lower p-values ($p<0.01$) in Table 3 show there are statistically positive correlations between AT and ID, AP and LF. This indicates that AT has a significant positive influence on ID, AP and LF. This finding is in line with the view of (U.S. Department of Education 2017) pointing out that technology has the capability to speed up and expand the impact of learning when carefully designed and accurately utilised. Another study conducted by Rhema and Miliszewska (2014) also found that students with better access to technology and the Internet display positive attitudes to distance and online learning. Nevertheless, institutional failures to satisfy this demand due to backwardness in modern technology advancement in many African ODL universities is still a concern Aluko (2015). Another vital outcome on the analysis was the finding displaying the path, strength and significance of the path coefficients assessed by PLS as shown in figure 1. There is a positive relationships between AT and the constructs (ID, AP and LF) as indicated by path coefficients. This led to rejection of null hypotheses raised in this study. This supports the view that students demand the inclusion of technology in the ID, AP and LF of distance and online mathematics learning (Liyanage, Strachan, Penlington, & Casseleden, 2013).

Furthermore, distance and online learning with modern technologies help in addressing the constructivist approach that places the students at the centre of learning. Hence, the results are consistent with the constructivism learning theory that emphasises the importance of students constructing their own knowledge for meaningful learning experiences. They also support the assertion that constructivism theory plays an important role in creating stimulating environment using technology to capture the students learning interest (Crawford 2009). The findings of this present study further support the results of the researchers who encouraged and support the use of technologies as a key element for students' mathematics learning ((Handal, Campbell, Cavanagh, Petocz, & Kelly, 2013; Oates 2016; Oginni, 2016).

CONCLUSION AND RECOMMENDATIONS

The significance of the findings in this paper is that there are statistical positive relationships between AT and ID, AP and LF in ODL undergraduate mathematics learning. Hence, these reveal what is desirable in an ideal distance and online mathematics learning situation. It is imperative that technology has a definite impact on students' distance and online mathematics learning experiences. As distance and online creative learning of mathematics increases, care should be taken to make sure that the students do not tend to concentrate on the technology than on the real mathematical problem to be solved. Also, rote learning activities that might establish low-level tasks with little or no impact on students learning outcomes should be avoided in designing utilisation of these technologies. We also recommend continuous investigation of technologies as they evolve in relation to ID, AP and LP in order to maintain their adequacy.

This study made use of data collected from distance and online undergraduate mathematics education of a dual mode and a single mode in Nigeria. Therefore, the findings could only be generalised to other ODL universities with distance and online mathematics programmes similar to these universities.

REFERENCES

Ajadi, T.O., Salawu, I.O. & Adeoye, F.A. (2008). E-Learning and Distance Education in Nigeria. *The Turkish Online Journal of Educational Technology (TOJET),* 7(4), 61-70.

Aluko, F. R. (2015). Throughput Rates in Open Distance Learning: Towards Understanding and Managing the 'Revolving Door' Syndrome. In M. Letseka (Ed.). *Open distance learning (ODL) in South Africa*. New York: Nova Science Publishers. pp. 77-89.

Dawson, S., Heathcote, L., & Poole, G. (2010). Harnessing ICT Potential: The Adoption and Analysis of ICT Systems for Enhancing the Student Learning Experience. *International Journal of Educational Management*, *24*(2), 116-128.

DePrinter, T. (2013). An investigation of teaching strategy in the distance learning mathematics classroom. *Journal of Educators Online*, 10(2), 1-20.

Duffy, T.M., & Cunningham, D.J. (1996). Constructivism: Implications for the design and delivery of instruction. In D. Jonassen (Ed.). *Handbook of research on educational telecommunications and technology*. New York, NY: Macmillan. pp. 170-198.

Galligan, L., Loch, B., McDonald, C. & Taylor, J. (2010). The use of Tablet and Related Technologies in Mathematics Teaching. *Australian Senior Mathematics Journal* 24(1), 38-51.

Garrett, R. (2016). The state of open universities in the commonwealth: A perspective on performance, competition and innovation. Commonwealth of Learning, Canada, Burnaby, British Columbia

Federal Republic of Nigeria (2004). *National policy on education*, Lagos, NERDC

Jarvis, D. H. (2012). Teaching Mathematics Teachers Online: Strategies for Navigating the Intersection of Andragogy, Technology, and Reform-Based Mathematics Education. In A. Juan, M. Huertas, S. Trenholm, & C. Steegmann (Eds.), *Teaching Mathematics Online: Emergent Technologies and Methodologies* (pp. 187-199). Hershey, PA: IGI Global. doi:10.4018/978-1-60960-875-0.ch009

Handal, B., Campbell, C., Cavanagh, M., Petocz, P., & Kelly, N. (2013). Technological pedagogical content knowledge of secondary mathematics teachers. *Contemporary Issues in Technology and Teacher Education*, *13*(1), 22-40.

Henman, P. & Phan, N. H. L. (2014). CEQ and the performance regime in Australian Higher Education A review of the policy context. Australia. The University of Queensland.

Juan, A., Huertas, A., Steegmann, C., Corcoles, C., & Serrat, C. (2008). Mathematical e-learning: State of the art and experiences at the open university of Catalonia. *International Journal of Mathematical Education in Science and Technology*, 39(4), 455-471.

Kissane, B., McConney, A., & Ho, K.F. (2015). Review of the use of Technology in Mathematics Education and the related use of CAS Calculators in External Examinations and in Post School Tertiary Education Settings. Perth, WA: School Curriculum and Standards Authority

Koohang, A., Riley, L., Smith, T., & Schreurs, J. (2009). E-Learning and Constructivism: From Theory to Application. Interdisciplinary Journal of E-Learning and Learning Objects, 5, Pp. 91-109.

Leow, F. T., & Neo, M. (2014). Interactive Multimedia Learning: Innovating Classroom Education in a Malaysian University. *Turkish Online Journal of Educational Technology – TOJET*, 13(2), 99-110.

Liyanage, L., Strachan, R., Penlington, R. & Casseleden, B. (2013). Design of educational systems for work based learning (WBL): The learner experience. *Higher Education, Skills and Work-Based Learning,* 3(1), 51-61.

Luhan, J., Novotna, V. & Kriz, J. (2013). ICT Support for Creative Teaching of Mathematics Discipline. Interdisciplinary Studies Journal, 2(3), 89-100.

NCTM (2008). The role of technology in the teaching and learning of mathematics. Retrieved 22 March 2016 from http://www.nctm.org/uploadedFiles/publications/write_review_referee/journals/TCM%20Technology.pdf

Oates, G. (2016). Technology in Mathematics Education: a Stocktake & Crystal-ball Gazing, *Proceedings of the 21st Asian Technology Conference in Mathematics,* 14-18 December 2016, Pattaya, Thailand, pp. 1-17. ISBN 978-0-9972807-0-8 (2016) [Refereed Conference Paper]
Obilade, T. (2012). Instructional Technology and Distance Education in Nigeria: Historical Background and a Critical Appraisal. *Journal of Distance Learning*, 10(1), 25-29.
Oginni, O. I. (2016). Effects of Mathematics Innovation and Technology on Students' Performance in Open and Distance Learning. *Istraživanja u pedagogiji*, *6*(1), 66-75.
Oh, P. S. & Yager, R. E. (2004). Development of Constructivist Science Classrooms and Changes in Studens Attitudes toward Science Learning. Science Education International, 15(2), pp. 105-113.
Olibie, E. I., Offor, U. I. and Onyebuchi, C. G. (2016). A Tale of Two Cities: Hindrances to Distance Learning Programmes in Awka and Nnewi Cities in Anambra State Of Nigeria. *European Journal of Open Education and E-learning Studies,* 1(1), 58-74.
Osang, F. (2012). Internet Access in Nigeria: Perception of National Open University of Nigeria (NOUN) Students. *International Journal of Emerging Technology and Advanced Engineering,* 2(10), 492-497.
Perraton, H. (2000). Open and Distance Learning in the Developing World. New York: Routledge.
Rhema, A., & Miliszewska, I. (2014). Analysis of student attitudes towards e-learning: The case of engineering students in Libya. *Issues in Informing Science and Information Technology, 11,* 169-190.
Sife, A.S., Lwoga, E.T., & Sanga, C. (2007). New Technologies for Teaching and Learning: Challenges for Higher Learning Institutions in Developing Countries. *International Journal of Education and Development using Information and Communication Technology,* 3(2), 57-67.
U.S. Department of Education, Office of Educational Technology (2017). Reimagining the Role of Technology in Education: National Education Technology Plan Update, Washington, D.C.
Wilson, B.G. (1997). Reflections on constructivism and instructional design. In C.R. Dills & A.J. Romiszowski (Eds.). *Instructional development paradigms*. Englewood Cliffs, NJ: Educational Technology Publications. pp. 63-80.
Zakaria, E., & Daud, M.Y. (2013). The Role of Technology: MOODLE as a Teaching Tool in a Graduate Mathematics Education Course. *Asian Journal of Management Sciences and Education*, 2(4), 146–152.

Appendix – Questionnaire for distance and online learning mathematics students

Select and rank your response by placing an 'x' on the answer of your choice using: 1 – strongly disagree (SD); 2 – disagree (D); 3 – Neutral (N); 4 – agree (A) and 5 – strongly agree (SA)

	Students' mathematics experiences with instructional delivery	SD	D	N	A	SA
1	The objectives of learning mathematics at distance and online are clearly made known by my tutor.					
2	Distance and online learning of mathematics is difficult because I do not understand it.					
3	Learning of mathematics through distance and online mode in my institution is frustrating.					
4	Many mathematical problems cannot be solved through distance and online learning.					
5	I enjoy learning mathematics through distance and online.					
6	Learning mathematics through distance and online mode saves time and effort for learners.					
7	I have reliable access to internet for my school needs.					

8	The course materials are well developed for learning of mathematics in my university.					
9	The course materials are sufficient for learning of mathematics in my university.					
10	The course materials challenge and arouse my curiosity to learn new mathematical concepts.					
11	The course materials challenge and arouse my curiosity to learn difficult mathematical concepts.					
12	The abstract nature of mathematics is not simplified in the design of the course materials.					
13	I have access to course materials online over the internet.					
14	The contents covered in the mathematics course materials are quite adequate for the period the student is required to complete the course work.					
15	ODL course materials in my institution meet students' mathematical and experiential needs for:					
	(a) Personal mathematics interest.					
	(b) Skill development.					
	(c) Requirements for degree award and certification.					
16	I usually feel so bored when I study mathematics concepts that I quit before I finish what I planned to cover in the course material.					
17	When the mathematics course material is difficult to understand, I give up or study only the easier parts.					
18	The course materials are fairly interactive for me to understand.					
19	Even when the mathematics course materials are not interactive enough, I manage to continue working to understand and finish them.					
20	The following can help to further improve the students' experiences in distance and online learning of mathematics in my institution:					
	(a) Access to efficient internet facilities.					
	(b) Access to my mathematics tutors/ lecturers.					
	(c) Flexible teaching and learning.					
	(d) Using different forms of media – print, audio, video, etc.					
21	Distance and online learning gives access to ENOUGH resources to learn undergraduate mathematics at my university.					
22	Distance and online learning gives access to QUALITY resources to learn undergraduate mathematics at my university.					
23	Face-to-face remains the dominant method of teaching and learning of mathematics in my institution.					

24	Learning of mathematics through the distance and online mode is not efficient.					
	Students' Experiences with assessment procedures in distance and online mathematics learning environment					
25	Assessment procedures are well specified and included in the design of mathematics course materials in my institution.					
26	There are no adequate resources to support student assessment procedures.					
27	The guiding principle on mathematics assessment is not well understood by the students.					
28	The students' assessment guidelines involve too much paper work (i.e. traditional method of assessment) than distance and online activities.					
29	Online assessment of mathematics students is the only form of assessment procedure used in my institution.					
30	My institution makes use of both online and traditional assessment procedures in assessing the mathematics distance learners.					
31	I prefer traditional method of assessment than online assessment.					
32	It is better to use both online and traditional procedures to assess distance and online mathematics students.					
33	Access to assessment procedures in my institution's distance and online platform is very easy.					
34	I enjoy doing mathematics assessment online.					
35	Assessment feedback is promptly obtained online.					
36	Distance and online assessment procedures in my institution are very effective.					
	Students' experiences with distance and online mathematics facilitation					
37	I work with other students from my university to complete course assignments.					
38	I prefer setting aside time to discuss course materials with a group of mathematics students in my school.					
39	I work together with my instructor to clarify the abstract concepts of mathematics.					
40	When I have difficulty learning mathematics concepts in my school, I try to remain a self-learner without obtaining help from anyone.					
41	Collaborative activities with other mathematics students help to improve my performance in mathematics.					
42	Online collaboration is very effective in my school and it fosters mathematics learning.					
43	I have opportunity to experience academic collaborative activities					

	with other ODL mathematics students in other institutions such as:					
	(a) Online collaborative learning of mathematics concepts.					
	(b) Face-to-face collaborative learning of mathematics concepts.					
	(c) Sharing of mathematics course materials.					
	The technologies that influence support services in distance and online mathematics learning					
44	Support services are available for mathematics students all through the week (24 hours/7days).					
45	Support services are provided only during the working hours of the week.					
46	The following technologies are provided to meet the mathematical needs of students in my university:					
	(a) Computer.					
	(b) Internet.					
	(c) Audio and video conferencing.					
	(d) Intranet.					
	(e) Print materials.					
	(f) CD/DVD.					
	(g) Radio lessons.					
	(h) Television lessons.					
47	The following media are used to support mathematics students in my institution:					
	(a) E-mail.					
	(b) Telephone.					
	(c) Chat.					
	(d) On-site Tutorial.					
	(e) Mobile text messages.					
	(f) Learning Management System e.g. Blackboard or Moodle					
	(g) Facebook or other social media platforms					
48	My institution has a designated office or Centre that provides one-stop services (i.e. offering a wide variety of services) for mathematics distance and online learners on:					
	(a) Admission.					
	(b) Registration.					
	(c) Results checking.					
	(d) Course materials and resources					
	(e) Technology related challenges e.g. login problems or software compatibility, etc.					
	(f) Solving major problems encountered by distance and online mathematics learners.					
49	There are sufficient library resources for mathematics distance and online learners to use.					

50	There are accessible library resources for mathematics distance and online learners to use					
51	I am able to access the library resources online from anywhere in the world					
52.	My institution provides access to career counselling for distance mathematics students.					