STUDENTS' EXPERIENCES WITH DISTANCE AND ONLINE LEARNING OF UNIVERSITY-LEVEL UNDERGRADUATE MATHEMATICS IN NIGERIA

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DECLARATION

I declare that the thesis which is hereby submitted for the PhD degree at the University of the Free state is my own independent work and that all sources I have used or quoted have been acknowledged by means of complete references. I further declare that the work has been submitted for the first time at this university towards a PhD in Education degree and has never been submitted to any other university for the purpose of obtaining a degree.

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COMFORT O. REJU   DATE

DEDICATION

To my darling husband Professor Sunday A. Reju. The only asset of my life and crown on my head. I appreciate your incomparable support and love throughout the programme.

To the children, for your prayers

To my brothers Christopher Ebeh (RIP), Ifeanyichukwu Ebeh (RIP) and my uncle, Charlse Onuorah (RIP). Their greatest wishes were to see me acquire a doctorate degree and to my uncle's wife Deborah Onuorah for instilling in me the importance of education from my childhood.

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Summary of the study

Enrolment and success rates in undergraduate mathematics are relatively low, even for the face-to-face mode of study. The situation is worse for distance and online modes. At the same time, distance and online learning is becoming progressively more popular with higher learning institutions across the globe. In order to increase enrolment in undergraduate mathematics and to boost success rates at open and distance learning (ODL) institutions, a clear understanding of the needs of distance and online mathematics students is required. In particular, it is important to understand their current experiences with four elements of provision: instructional delivery (ID), assessment procedures (AP), learning facilitation (LF) and support services (SS).

The key question being answered by this study is: What are the students' experiences with distance and online learning of university-level mathematics at two major distance-learning universities in Nigeria? The research uses a mixed-methods approach involving questionnaires, semi-structured interviews and document analysis to understand the way distance and online students perceive their mathematics experiences, with regard to these four elements, in two major ODL institutions in Nigeria.

The analysis of data included descriptive methods, inferential statistics and specifically *Partial Least Squares* (PLS) regression to test for relationships between variables and students' narratives. Experiential learning theory (ELT), transactional distance theory (TDT) and cognitive theory of multimedia learning (CTML), which are found to be influential in distance and online education, were used as lenses to explain student perceptions of ID, AP, LF and SS.

The findings reveal that teacher/tutor availability to facilitate and regulate learning and to mitigate the many challenges of learning mathematics in this mode is possibly the most critical success factor. Significant challenges also emerged in the Nigerian context, especially with internet availability and in obtaining adequate and self-explanatory course materials. Students frequently have to reach beyond the basic resources provided in their institutions by seeking textbooks and course materials from other ODL institutions.

Consequently, the students called for better inclusion of more up-to-date technologies (with special emphasis on accessible hardware, user-friendly software and stable internet access)

in the ID, AP and LF of distance and online mathematics learning. The institutional failure to satisfy this demand is another major finding of this study. The ELT, TDT and CTML models of learning, which call for distance and online students' maximum commitment to the learning experience, are relevant in terms of their emphasis on enabling understanding, content sharing and online interaction using technologies. It is evident from the findings that, despite the rapid development of information and communication technology (ICT) in our present time, there needs to be far more effective incorporation of modern technology in the teaching and learning of mathematics at ODL institutions, including training teachers/tutors to use it optimally.

The study also recommends that distance and online mathematics learners need to be supported in the construction of their own knowledge, by restructuring the learning processes to be more learner-centred. Moreover, regulatory agencies such as the National Universities Commission (NUC) in Nigeria, set up for quality assurance purposes, need to actively oversee the support of mathematics learning at university-level in order to strengthen the experiences of students and learning in online and distance modes.

Finally, the pedagogical issues of ensuring that mathematics students at ODL institutions are not disadvantaged require that priority and resourcing be given to mathematics and perhaps other similar scarce-skills subjects.

Key Words: student experiences; distance and online learning; instructional delivery; assessment procedures; learning facilitation; support services.

OPSOMMING VAN DIE STUDIE

Die inskrywings- en sukseskoers in voorgraadse wiskunde is redelik laag, selfs wanneer die vak van aangesig to aangesig aangebied word. Die situasie is erger vir afstand- en aanlynstudie. Terselfdertyd word afstand- en aanlynstudie al hoe meer gewild onder instansies vir hoër opvoeding regoor die wêreld. Om inskrywing in voorgraadse wiskunde te vermeerder en om die sukseskoers by oop- en afstandleer- (OAL) instansies te verbeter, word 'n duidelike begrip van die behoeftes van afstand- en aanlynstudente in wiskunde vereis. Dit is veral belangrik om hul huidige ervarings van vier elemente van verskaffing te verstaan: onderrigverskaffing (OV), assesseringsprosedures (AP), leerfasilitering (LF) en ondersteuningsdienste (OD).

Die sleutelvraag wat deur hierdie studie beantwoord word, is: Wat is die studente se ervarings met afstand- en aanlynstudie van universiteitsvlakwiskunde by twee belangrike afstandleerinstellings in Nigerië? Die navorsing gebruik 'n gemengde metodes-benadering wat vraelyste, semi-gestruktureerde onderhoude en dokumentanalise behels, om sodoende te verstaan hoe afstand- en aanlynstudente aan twee belangrike OAL-instellings hul ervarings met wiskunde beleef ten opsigte van hierdie vier elemente.

Die analise van data sluit beskrywende metodes, afgeleide statistieke en spesifiek *Partial Least Squares-* (PLS) regressie in, om vir verhoudings tussen veranderlikes en studente se narratiewe te toets. Ervaringsleerteorie (ELT), transaksionele afstandteorie (TAT) en kognitiewe teorie van multimedialeer (KTML), wat almal 'n sterk invloed op afstand- en aanlynonderwys het, is as lense gebruik om studente se persepsies van OV, AP, LF en OD te verklaar.

Die bevindings het onthul dat onderwyser-/tutorbeskikbaarheid om leer te fasiliteer en te reguleer en om die talle uitdagings van wiskundeonderwys in hierdie modus die hoof te bied, moontlik die mees kritieke suksesfaktor is. Beduidende uitdagings het ook in die Nigeriese konteks na vore getree, veral ten opsigte van toegang tot die Internet en verkryging van voldoende en duidelike kursusmateriaal. Studente moet dikwels verder soek as die basiese hulpbronne wat deur hul instellings verskaf word, deur handboeke en kursusmateriaal van ander OAL-instansies te verkry.

Gevolglik het die studente gepleit vir beter insluiting van meer hedendaagse tegnologieë (met spesiale klem op toeganglike hardeware, gebruikersvriendelike sagteware en stabiele internettoegang) in die OV, AP en LF van afstand- en aanlynstudie van wiskunde. Die institusionele mislukking om in hierdie behoefte te voldoen, is nog 'n hoofbevinding van hierdie studie. Die ELT-, TAT- en KTML-leermodel, wat afstand- en aanlynstudente se maksimale toegewydheid tot die leerervaring vereis, is relevant in terme van hul klem daarop om begrip, deel van inhoud en aanlyninteraksie deur tegnologie moontlik te maak. Uit die bevindings is dit duidelik dat, ten spyte van die vinnige hedendaagse ontwikkeling van inligting- en kommunikasietegnologie, daar veel doeltreffender inkorporasie van moderne tegnologie in die onderrig en leer van wiskunde by ODL-instellings moet wees, insluitend opleiding van onderwysers/tutors om dit doeltreffend te gebruik.

Die studie beveel ook aan dat afstand- en aanlynstudente in wiskunde ondersteun moet word in die konstruksie van hul eie kennis deur die herstrukturering van die leerproses as meer leerdergesentreerd. Verder moet regulerende agentskappe soos die Nasionale Universiteitskommissie (NUC) in Nigerië, wat tot stand gebring is om gehalteversekering te doen, die ondersteuning van wiskundeonderrig op universiteitsvlak aktief monitor, om sodoende die ervarings van studente in aanlyn- en afstandmodes te versterk.

Laastens vereis die pedagogiese kwessies van versekering dat wiskundestudente aan OAL-instellings nie benadeel word nie dat prioriteit en hulpbronne aan wiskunde en ander soortgelyke vakke wat skaars vaardighede verg, toegewys word.

Sleutelwoorde: studentervarings; afstand- en aanlynstudie; onderrigverskaffing; assesseringsprosedures; leerfasilitering; ondersteuningsdienste.

ACRONYMS

AP	ASSESSMENT PROCEDURES
AT	AVAILABLE TECHNOLOGY
CTML	COGNITIVE THEORY OF MULTIMEDIA LEARNING
DLI	DISTANCE LEARNING INSTITUTE
ELT	EXPERIENTIAL LEARNING THEORY
ID	INSTRUCTIONAL DELIVERY
LF	LEARNING FACILITATION
NOUN	NATIONAL OPEN UNIVERSITY OF NIGERIA
NUC	NATIONAL UNIVERSITIES COMMISSION
ODL	OPEN AND DISTANCE LEARNING
SS	SUPPORT SERVICES
TDT	TRANSACTIONAL DISTANCE THEORY

Table of Contents

List of figures

List of tables

CHAPTER 1

Orientation and background to the study

1.1 Introduction

Distance and online learning has recently become a trend in most institutions of higher learning particularly in developing countries such as Nigeria (Slagter van Tryon & Bishop, 2009). This occurs because many developing countries are beginning to realise that it could be an effective way of increasing access to university or higher education in general. More and more university subjects such as mathematics are being offered using distance and online approaches. However, one of the fundamental barriers to the spread of distance and online learning is to ensure that instructors are able and competent enough to deliver better quality instruction and set up meaningful educational experiences for the learners (DePrinter, 2013). This concern arises because of the unique nature of the distance and online mathematics classroom. Hence, this study sought to investigate students' experiences with distance and online learning of university-level undergraduate mathematics in Nigeria, in order to contribute to the ongoing discussions concerning the challenges and opportunities for distance and online learning of scarce skills subjects such as mathematics.

Understanding the needs of distance and online mathematics students will help shape the kinds of responses that are provided by open and distance learning (ODL) institutions to improve student success in the subject. ODL institutions require knowledge of students' demographics and their range of experiences with distance and online programmes in order to improve decision-making concerning distance and online learning programmes (Colorado & Eberle, 2010). To date, there has been an increase in the use of distance learning among institutions of higher education (Slagter van Tryon & Bishop, 2009) but the quality of the educational provision in many of the distance learning institutions is still a major concern (Jones & Long, 2013). In other words, how can institutions of higher learning best structure and organise the use of distance and online learning tools to offer profound educational experiences to students in their chosen careers and subject areas? The many advances in information and communication technology (ICT) have led to increases in the use of resources such as computers, cell phones, radios, television, e-mail, Internet and many

others. The use of ICTs at university has brought significant changes in the teaching and learning processes in most parts of the world. Oye, Salleh, and Iahad (2011) are of the opinion that as technology improved, new devices were developed and created, specifically the microprocessor and personal computer, which changed the scenario of learning, leading to distance and online learning, as we know it today.

Ohene and Essuman (2014) argue that there is little literature in Ghanaian universities on distance education compared with what is obtainable from other East and Southern African countries, where distance education started years earlier. They identified some of the challenges working against distance and online learning, namely institutional obstacles, prior knowledge of students before joining the distance and online education programmes, financial challenges and support services.

While ICTs have in many ways helped improve the offerings by many distance learning universities, some literature has also identified technology as a serious challenge in terms of accessing distance and online learning programmes. Fresen and Hendrikz's (2009) study at the University of Pretoria suggests that students' lack of access to Internet technology hinders distance and online facilitation, support services, interaction and communication. Similarly, Pitsoe and Baloyi (2015: 98) argue, "[the] majority of students at the University of South Africa (UNISA) do not have access to the Internet but rely on print-based material for their distance and online learning". Apart from the costs involved in acquiring the required technology for distance and online learning at the universities, there is also the possibility of under-utilisation by untrained university teachers. The availability of Internet connectivity to access distance education courses and information that would lead to entering an educational programme is vital. Ajadi, Salawu and Adeoye (2008) suggest that the cost of accessing the Internet is still high in most African countries compared to what is obtainable in developed countries. Furthermore, not every distance and online learner has access to personal computers (PCs) in their home (Fresen & Hendrikz, 2009) making them reliant on shared computers at local community or learning centres (Kawalilak *et al.*, 2012) in less than ideal conditions.

To complicate the challenges of distance and online learning further, research suggests that access and success in university mathematics are still real problems in most countries across the world, thus explaining the scarcity of mathematics experts across many

communities especially in developing countries. Tapfumaneyi (2013) observes that no nation in the world has accomplished giving access to education to all its citizens. A similar challenge, in terms of access and success in university mathematics, can be observed across many of Nigeria's higher education institutions. This gap gave rise to the development of distance and online education programmes, which sought to reach more students that traditional universities in Nigeria have been unable to reach.

Distance and online learning has often been considered as possible solutions to the challenge of access, in part, because of the flexibility in terms of scheduling and delivery. However, some researchers suggest that distance education and online learning present a different set of challenges to students that may sometimes complicate learning and access to some subjects, mathematics in particular (Bower & Hardy, 2004; Kawalilak *et al.*, 2012; Oye *et al.*, 2011). Very little research has been conducted, especially in developing countries, to explore distance students' experiences with specific university subjects in general. There is even less research that focuses on students' experiences in order to understand why so few students enter mathematics departments and eventually become successful mathematicians. Even scarcer, is the research on the conditions and experiences of learning mathematics through the distance and/or online mode. Therefore, the present study proposed to investigate students' experiences with mathematics teaching, learning and support at two of Nigeria's universities that offer distance and online programmes in mathematics, in order to understand issues of access and quality in the facilitation, learning and support for mathematics at university-level.

1.2 Background to the study

Distance and online learning plays a vital role in the educational experiences of students in different fields of life. Burton and Goldsmith (2002) hold the view that distance and online learning will continue to interest learners due to its flexibility, especially the adult learners who are faced with other responsibilities such as work and family. Distance and online learning is an essential tool for universities and institutions of higher learning, providing opportunities that allow learners not to be present in physical classrooms and offering flexible opportunities to learn and interact with other learners and instructors (Zakaria & Daud, 2013). These opportunities remove the temporal barrier that learners might face and make learning more accessible by using technologies.

Distance education is referred to as education that differs from the traditional face-to-face style of learning but with similar aims to fulltime conventional learning (Jegede, 2003). Keegan's (1995) definition of distance learning is adopted in the present study. Keegan (1995: 7) states that distance education and training, which in most cases are institution-based, results from the technological separation of teacher and learner and frees the students from the necessity of travelling to "a fixed place, at a fixed time, to meet a fixed person, in order to be trained". Hence, the teachers and learners may be separate from each other but interact through an appropriate technology. Chen (2001) argues that distance is not influenced by 'geography' alone but it is rather influenced by the level and type of interaction that exists between the instructor, learner and learning environment. Online learning on the other hand, according to Dabbagh and Bannan-Ritland (2005), is defined as "an open and distributed learning environment that uses pedagogical tools, enabled by Internet and web-based technologies, to facilitate learning and knowledge building through meaningful action and interaction". The definitions essentially indicate that there is a link between distance education, online learning and technology (Keegan, 1995).

Researchers have identified four key concepts from the definitions of distance learning to include institutional–based, which differentiates it from self-study. These concepts are separation of instructors and learners geographically and in time, interactive technology using synchronous and asynchronous means to connect instructors to learners and well-designed learning resources (Simonson, 2003; Schlosser & Simonson, 2006). Online learning as a new form of distance learning (Benson, 2002) involves access to learning experiences using technologies (Moore, Dickson-Deane & Galyen, 2011). Some other concepts that emerged from the online learning definition are its flexibility, connectivity and ability to support interactive learning environments that promote students' learning experiences (Hiltz & Turoff, 2005). The present study sought to explore these critical concepts through the mathematics experiences of students who are studying at the two major distance and online learning institutions in Nigeria.

Distance and online learning in Nigeria is considered a major and vital educational advancement. This is because of the provision of opportunities to people who cannot abandon their work for fulltime conventional learning (Jimoh, 2013). Hence, the rapid rise in demand for higher education could only be tackled by providing an alternative educational

system in the form of a distance and online learning system (Kanwar, 2008). Global experiences have shown that it is difficult for traditional institutions to satisfy the modern-day socio-educational needs of a nation, especially in developing countries such as Nigeria. Inadequate facilities in these institutions restrict access to education, including distance and online education. The limited availability of space hinders many qualified candidates from securing admission to Nigerian universities. This led the National Universities Commission (NUC) and the Committee of Vice Chancellors of Nigerian Universities (CVCNU) in 2008 to call attention to the need to create more vacancies for potential students. In one of the keynote addresses, Okebukola (2007) advocates for supporting and empowering the National Open University of Nigeria (NOUN) as a single mode institution to admit more potential undergraduate students who could not be accommodated at conventional institutions due to limited facilities. Six other (formerly) conventional institutions were also selected to deliver distance and online education in Nigeria with the aim of widening access to university education.

The commencement of distance and online learning in Nigeria can be traced back to the period of correspondence education (Jimoh, 2013). This type of education was often used to prepare students for the General Certificate in Education (GCE) as an entry qualification for the London Matriculation Examination (LME) for admission into the University of London. Later in 1983, correspondence became distance education through the establishment of NOUN by the Federal Government of Nigeria (FGN) but it was not functional until 2001. The aim was to remove barriers to teaching and learning and to encourage the students to learn what they wanted, whenever they wanted and wherever they may be. The Correspondence and Open Studies Unit (COSU) of the University of Lagos had originally started in 1973. This was later changed to the Correspondence and Open Studies Institute (COSIT) in 1983 and then to the Distance Learning Institute (DLI) in 1999, which is the name it bears to this day. Mathematics and other science subjects were the initial programmes that were put in place to award first-degree certificates to successful students (Ajadi *et al.,* 2008). To date, there has not been any systematic examination of the students' experiences with these innovations and experiments on distance and online learning of university students in Nigeria. The present study thus seeks to correct this anomaly by exploring mathematics students' experiences with teaching, learning and support in a distance and/or online learning programme.

1.3 Statement of problem

As is the case in most African countries, Nigeria's distance and online learning is associated with a number of challenges. Not all the students who opt to study through this mode have equal access to the necessary technologies, such as computers. This is what is often referred to as the 'digital divide' (Ajadi *et al.*, 2008) that hinders instructional delivery. In some cases, the instructors and learners have poor knowledge of computers. Furthermore, the cost of acquiring them is also exorbitant in many areas of Nigeria. Students' attitudes towards the use of computers in distance and online education may also be a problem that affects learning through this mode. Inadequate funding of distance and online programmes is also a major problem, adding challenges in terms of access to Internet connectivity, hardware and software which are not readily produced locally (Ajadi, *et al.*, 2008; Jimoh, 2013). The lack of technological skills among the facilitators equally affects the design of electronic course materials for delivery in a distance and online learning environment. There is also evidence to suggest that many students in distance and online education lack prior knowledge of information technology because it was not included in their elementary and secondary education curricula and in some cases when it was, it was not well taught and was not compulsory (Yusuf, 2006; Jimoh, 2013). Again, many of the distance and online learners believe that distance and online education is 'second best' and that it cannot be compared with conventional face-to-face modes of learning (Tapfumaneyi, 2013). This occurs because the evaluation of distance and online learning has been based on the standards set for the assessment of conventional face-to-face institutions in Nigeria.

Distance and online learning practices in Nigeria are still characterised by inadequate skills to handle problems associated with pedagogy in the distance mode (Ajadi *et al.*, 2008, Arikpo, Osofisan & Usoro, 2009). Distance education teachers and tutors cannot instantly attend to their problems because of the distance separating them. Mathematics imposes more unique and peculiar challenges for course developers on how to skilfully represent and exchange the concepts of the subject using abstract symbols for the learner to understand (Mayes, 2011), while studying on their own (self-study). Mensch (2010) argues that there is a 'high attrition rate' experienced by distance and online mathematics students compared to other online courses. The distance and online students may experience anxiety while learning in this mode, in part because of the unequal interactions they receive compared to those in conventional face-to-face modes of learning (Vilardi & Rice, 2014). It is more likely

that this anxiety level is heightened with distance and online mathematics learners because of the perceived difficulty of the subject itself.

Experience has shown that the problems of instructional delivery with appropriate technology, assessment procedures, facilitation and support services are not entirely solved in the distance and online systems of many local universities in Nigeria. Hence, this study sought to examine how these challenges are being handled to ensure effective student experiences with distance and online mathematics learning. It is also clear that no research has been done based on a combined investigation of dual and single mode programmes with large populations of students from diverse backgrounds, working environments and age groups such as those from the DLI of the University of Lagos and the NOUN mathematics. This study intends to fill this gap by investigating students' experiences with mathematics teaching, learning and support through distance and online modes.

1.4 Significance of the study

The motivating factor for this study is based on my experience as a distance and online mathematics instructor. I am interested in understanding how students experience the instructional material we prepare for them in the programme, what proportion of the mathematical concepts and skills they learn from the material and how these help in shaping their mathematical life experiences at undergraduate level. The development of effective distance and online instructional materials to satisfy the students' educational needs calls for the correct utilisation of course design standards (Siragusa, Dixon & Dixon, 2007). The argument put up by Ally (2004) is that course delivery approaches that link learners' new knowledge to their old knowledge is required to obtain better experiences of the subject in a distance and online learning environment. This can only be achieved when we have effective delivery, facilitation, assessment and support services in distance and online environments.

The author's own experiences with the manner in which course material development and delivery is handled at DLI and NOUN suggests a lack of collaboration between instructors, course material designers, distance and online media designers and graphic engineers for effective pedagogy leading to sound mathematical learning as seen in an ideal world (Caplan, 2004). This study contribute to the debates and provide a better understanding of how distance and online mathematics education is conducted in Nigeria, including the role

technology plays in shaping learning opportunities especially in the field of mathematics. The challenge of learning mathematics is a concern not only in Nigeria but in many other countries as well. The study thus has the potential to deepen conversations about opportunities to learn university mathematics, especially through online and/or a distance mode across many different countries and cultures.

The study has the potential to help the DLI, University of Lagos and NOUN in the delivery of better distance and online mathematics programmes. This, in other words, will translate to students' success and an increased demand for distance and online mathematics programmes. It will further assist distance and online mathematics teachers/tutors in effective customisation of their knowledge of existing technologies in order to create opportunities for students to learn mathematics better. The study also seeks to provide ODL institutions in Nigeria (and by extension across Africa) and provide effective strategies for resolving the challenges distance and online mathematics learners face in learning through this mode. The study also provide single and dual mode ODL institutions with empirical data to help them decide in measuring the success of the programme and how students' experiences with distance and online mathematics learning can be improved.

1.5 Research questions

The main research question that is addressed is: What are the students' experiences with distance and online learning of university-level mathematics at two major distance-learning universities in Nigeria?

The sub-questions that helped answer the main question of the study include:

i. What are the students' experiences with instructional delivery in the distance and online learning of university-level mathematics?

ii. How do assessment procedures shape the students' experiences with distance and online learning of university-level mathematics?

iii. How does learning facilitation influence the students' experiences in distance and online mathematics education at the university?

iv. How do support services, using newer and/or advanced technologies, affect the students' experiences with distance and online learning of mathematics at university?

v. How can university-level mathematics students' experiences with instructional delivery, assessment, facilitation and support in distance and online environments be understood and/or explained?

vi. What suggestions can be made to enhance the students' experiences with university-level mathematics in distance and online environments?

1.6 Aim and objectives of the study

The aim of this study is to investigate students' experiences with distance and online learning of university-level undergraduate mathematics in Nigeria.

The objectives of the study are to:

i. Examine the students' experiences with distance and online learning of university-level mathematics in two major Nigerian universities regarding instructional delivery.

ii. Explore how assessment procedures shape the students' experiences with distance and online learning of university-level mathematics in Nigeria.

iii. Assess how learning facilitation influences the students' experiences in distance and online mathematics education at university-level in Nigeria.

iv. Identify support services using accessible and advanced technologies that affect the students' experiences with distance and online learning of mathematics at university-level in Nigeria.

v. Explore how the university-level mathematics students' instructional delivery, assessment, facilitation and support in distance and online environments can be understood and or explained.

vi. Suggest how students' experiences with university-level mathematics in the distance and online environment can be improved.

1.7 Overview of the theoretical framework

The study used experiential learning theory (ELT), transactional distance theory (TDT) and cognitive theory of multimedia learning (CTML) as a theoretical framework. These theories are found to have a powerful effect on distance and online education.

ELT is based on four cyclic elements of concrete or tangible experience (CE), reflective or thoughtful observation (RO), abstract or intellectual conceptualisation (AC) and active or

practical experimentation (AE) and is adopted as a framework for this study. In my opinion, this framework is more appropriate than other cognitive theories of learning that stress acquisition, manipulation and recall of abstract symbols because ELT presents a more holistic model of the learning procedure. This learning procedure places students at the centre of learning and advances a multi-lateral model of adult development that is necessary in researching students' experiences (Kolb, 1984: 20-21; Kolb, Boyatzis & Mainemelis, 2000: 2). Tapfumaneyi (2013) noted that this development is holistic and should be able to affect the body and mind of the students.

The main application of the model the theory presents lies in its ability to manage and gain control of individual learning by creating unique learning experiences. Experience is a continuously vital component in learning because it involves the learner deliberately using the acquired experiences. Carver *et al.* (2007) argue that experiential learning provides an existing framework in which to develop a new model for online learning, featuring the individual alone or in creative interaction, as the mobile centre of gravity of the learning environment. This is to stress that the distance and online learner needs to address the four stages in this theory for effective learning experiences to take place. The method that the theory employs relies on cognitive initiative, perceived as the types of beliefs necessary to tackle the diverse challenges of distance and online learners. Although there are many other relevant and illuminating learning theories, this theory can lead directly to transformation in students. Hence, this study attends to Kolb's experiential theory.

TDT and CTML on the other hand are closely related to the motivation behind students' experiences with distance and online learning of mathematics. They are very significant in technology-assisted learning and present a lens through which to examine the procedures of teaching (Moore, 1991; Mayer, 1999). Moore (1991) based TDT on the principle that the "distance" in distance and online education is beyond a geographic separation of learners and instructors. Moore (1993: 23) stress that distance in education is pedagogical and not geographical and that the term 'transactional distance' is identified as the physical distance that influences a communication gap and/or "a psychological space of potential misunderstandings between the instructors and learners' behaviours". The theory is based on three variables, which include dialogue, learner autonomy and structure. Dialogue is the communication transaction that exists between the instructors and the learners during the

course. This dialogue is purposeful, constructive and valued by the learners and instructors. Structure determines how the course design and teaching programmes are organised so that they can be delivered through a variety of communication media as learner autonomy depends on the dialogue and structure. Learner autonomy also refers to students' control over the learning activities and processes (Moore, 1993). The concept of transaction also originated from John Dewey (Kang & Gyorke, 2008). In the context of distance and online learning TDT was introduced in the 1970s by Moore (1972) and since then the theory has witnessed multiple revisions. Learners in CTML use visual and verbal systems to process information. The theory is that teaching with multimedia tools allows the learner the potential to gain a better understanding compared to using only single media. Although there are other theories that can be used to examine students' learning experiences, this study gives attention to ELT, TDT and CTML.

These theories are vital for this study because of their call for distance and online students' maximum commitment to the learning experience. The learning process is structured around the learners' experiences, hence the focus of this study on students experiences with university-level mathematics at a distance. ELT, TDT and CTML are relevant in terms of understanding content sharing and online interaction using technologies. This study sought to explore the representations of mathematics that distance and online students in Nigeria construct from their coursework experiences at the two identified major ODL national universities.

Research in the area of mathematics at a distance tends to support constructivist theories (DePrinter, 2013), which is one of the bases for ELT and TDT. Many researchers in the area of mathematics education suggest that a constructivist-based approach within the mathematics classroom has a definite impact on students' learning experiences (Williamson, 2006; DePrinter, 2013). While Barker, Robinson and Kolb (2012) argue that even though ELT supports constructivist learning as a way of linking the learners' pre-existing experiences and knowledge to their individual knowledge, this procedure is different from many of the educational processes of today that involve the transmission of experiences and knowledge that previously existed. Constructivist-based learning is enhanced through online discussion, collaboration and participation to support students' mathematics learning. Garrison and Cleveland-Innes (2010) are of the opinion that interaction is seen as central to an educational

experience and is a primary focus in distance and online learning, which occurs using technologies. Studies have shown four dimensions by which interaction can effectively take place in distance and online education including learner-instructor; learner-learner; learner-content and learner-interface (linking device or technology) (Chen, 2001; Fresen & Hendrikz, 2009; Hill, Song & West, 2009) . As stated by DePrinter (2013), students can learn mathematics better and more effectively when they talk about mathematics by interacting with their peers.

Past research on students' experiences in learning mathematics at university-level indicates that students enrol in university education courses with significant distinctions in their previous experiences of learning (Crawford *et al.*, 1998; Wood *et al.*, 2011; DePrinter, 2013), which affects their view and method of approaching online mathematics learning. Crawford *et al.* (1998) stated that early studies of student learning in higher education distinguished main qualitative variations in students' previous orientations to study and their approaches to studying in a particular context. These studies have shown that students see mathematics as a disjointed form of knowledge and tend to adopt repetitive and surface approaches in learning the subject. Therefore, only a few students have a unified view of mathematics when entering university and tend to apply deep approaches to its learning. On this experience in learning mathematics, Crawford and his group argued that many students learn mathematics at university in a competitive atmosphere where mathematics is refined and polished as a finished product and where assessment supports reproduction of the statement of facts and known results. In this case, the students are simply presented with mathematics concepts, evidence (proofs), skills and methods but the procedures leading to these are kept secret. This makes it difficult for the students to have personal, meaningful mathematical experiences thereby misrepresenting the key features of the subject.

1.8 Overview of research methodology

This study adopts a mixed methods approach to data collection (questionnaire, interview and documents). The choice for a mixed methods approach was informed by the explanatory nature of the study. The method follows quantitative and qualitative oriented research approaches (Teddlie & Tashakkori, 2003). Quantitative and qualitative paradigms support pragmatism, some element of which is evident in this study. Qualitative approaches are inductive, constructivist, interpretative and explanatory in nature. The qualitative approach

was needed in this study to understand the way distance and online students process their mathematics experiences (Guba & Lincoln, 1994; Miles & Huberman, 1994; Creswell, 2007). Since interpretation of students' experiences was part of the goal of this study, understanding was developed by analysing the expression of those experiences. The interview, involving non-numeric data, was designed in themes based on the research questions as discussed below. This is to obtain knowledge on how students learn mathematics in these modes. A semi-structured interview was also used to allow the interviewees (students) the freedom to elaborate on their experiences with distance and online mathematics learning (Mathers, Fox & Hunn, 1998).

The quantitative approach used in this study was based on the principles stated by Creswell (2003). Unlike qualitative approaches, the quantitative approach is deductive, deterministic and experimental in nature. It is informed by the belief that at least to some extent human behaviour can be described by 'social facts' capable of using deductive reasoning (Horna, 1994). The survey questionnaire was used to gather data to answer research questions on the mode of delivery, facilitation, assessment and support services that influence students' experiences. This complemented the information gathered through the interviews; it also served in strengthening detail, expanding and developing the analysis and providing fresh insight in the study (Rossman & Wilson, 1991). Quantitative and qualitative approaches are not opposites, they address different dimensions of the same events and where they seem to coincide in application, the researcher makes a choice (Das, 1983).

Data were collected from mathematics students of the DLI, the University of Lagos and NOUN. The sampling strategy that was best suited for the study is purposive as it is a non-probabilistic sampling method (Cohen, Manion & Morrison, 2007). In this study, one dual mode institution and the only single mode institution (NOUN) in the country was used. Purposive sampling was used to ensure that only students studying mathematics in distance and online modes were selected. The questionnaire was administered to third year (3) students in the mathematics programmes in these two institutions because they would have had two years of experience in their programmes. Currently there are more than 30 third year mathematics students at DLI. The majority of them attend fortnightly weekend lectures organised by the institute. There are more than a hundred NOUN third year mathematics students in three study centres located in different parts of Lagos although only forty or less

attend voluntary weekly study centre meetings. This is because many work or are married with other responsibilities. The instrument was administered to thirty students in each of the two institutions. The instruments helped to understand and explain how instructional delivery, assessment procedures, facilitation and support using technologies were conducted in these two institutions. Five students in each of the two schools were then interviewed using the interview protocol. The interviews were recorded and documented to obtain suggestions on how the students' distance and online mathematics learning experiences could be improved.

A pilot study was conducted with mathematics students of the DLI of the University of Lagos to ascertain the suitability of the data collection method proposed in this study. The pilot was also aimed at ensuring that the instruments (questionnaire and interview protocol) were useful for data collection. A member-check was used to ascertain the credibility and trustworthiness of the interview responses. The pilot study was also used to test the data collection method in preparation for designing the main study (Polit, Beck & Hungler, 2001), providing warnings ahead of time, where problems might arise and where guidelines may need to be reviewed (van Teijlingen & Hundley, 2001). The results from the analysis of the pilot study are not counted towards the core study to avoid any bias that might arise due to the small sample used in piloting and any subsequent adjustment of the instrument. More discussion is included in chapter three (see section 3.6).

Descriptive and inferential statistics were used in this study. Descriptive statistics involve the frequency, percentage and mean while inferential statistics involve using non-parametric tests and partial least squares regression to analyse the quantitative data collected through the questionnaire. This was specifically used to answer research questions one to four, as stated in the research questions section (1.5) of this study. The qualitative data were coded (Miles & Huberman, 1994), organised and analysed using document, content and narrative data analysis. The analysis was based on the emerging themes such as students' mathematics experiences with instructional delivery, students' experiences with assessment procedures in a distance and online environment, students' experiences with distance and online mathematics facilitation, the technologies that influence support services in distance and online mathematics learning and suggestions to improve students' experiences with distance and online university-level mathematics learning. A full description of the methodology is contained in chapter three.

1.9 Ethical consideration

The purpose of this study was to investigate students' experiences with distance and online learning of university-level undergraduate mathematics in Nigeria. In order to meet the purpose, ethical considerations were taken into account by obtaining clearance letters from the two ODL institutions in Nigeria, DLI at the University of Lagos and NOUN, whose students were the subjects used for the study. The data for this study was gathered using questionnaires, one-on-one interviews and documents. Hence, the participation involved recording one-on-one interviews, completing a questionnaire, responding to member-check questions, face-to-face and/or through email. The recorded interview discussion was meant to assist the researcher in capturing the participants' own words, as the purpose of this study has not been disclosed to any other person.

The participants and their responses were protected by observing maximum confidentiality of the data. This was done by allowing the participants to ask questions and anonymously express their worries during the survey and interviews concerning the nature of the research. The names and identities of the participants are not used in the writing of the research in order to ensure confidentiality. The participants were requested to fill out a copy of the questionnaire to ascertain their experiences in instructional delivery, assessment, facilitation and support services in the distance and online learning environment. The individual responses were not shared with anyone else. There are no expected risks from participating in this study. The participants were allowed to withdraw at any time if they wanted to without any penalty, as participation was voluntary.

The quality of the study's results was ensured by constant maintenance of honesty and integrity throughout the study. The participants' involvement in this study was aimed at contributing to the knowledge of students' experiences with distance and online learning of university-level mathematics in Nigeria. The results of the study are expected to help ODL institutions in Nigeria structure the students' mathematics experiences in distance and online learning environments. The results will also be published in a professional journal in the field of distance and online learning or will be presented at a conference.

1.10 Delimitation of the study

The study is based on students' experiences with distance and online learning of undergraduate mathematics at university-level with a large population of students having widely diverse backgrounds, working environments and age groups such as the DLI of the University of Lagos and NOUN mathematics programmes in Nigeria. The distance and online mathematics learning programme at DLI is run over a minimum period of six (6) years, while at NOUN, it is run over a minimum period of four (4) years. The data were collected from third year distance and online learners over a period of two months to ensure proper administration of the instruments. Specifically, all the participants were third year undergraduate mathematics students with prior experience with distance and online modes of learning. Hence, it is not entirely representative of the whole mathematics learner population in DLI and NOUN.

1.11 Limitation of the study

This is a mixed method research study that employed quantitative and qualitative approaches; hence, the results of the study are exclusive to the contextual setting used for the study and the participants involved. The study explored how university-level mathematics students' instructional delivery, assessment, facilitation and support in distance and online environments can be understood and/or explained. Thus, the findings mostly apply to distance and online mathematics learners. Using a purposive sampling method in this study limits broad generalisations of the results. Hence, the findings are not generalised to all institutions offering distance and online learning in Nigeria. Furthermore, the implications of the study is based on the characteristics of the subjects used in the study. The scarcity of information on the educational benefit of students' experiences with distance and online mathematics learning at university-level in Nigeria is a clear and important gap. Although the findings of the study may not be generalised to all online and distance learning institutions, it is possible for similar institutions to draw lessons from the findings. ODL institutions in Nigeria need such information to be able to support the students who are learning in this mode effectively. This study tried to contribute to the knowledge base by examining students' experiences with distance and online learning of university-level undergraduate mathematics in Nigeria.

1.12 Definition of terms

In my study, the conceptualisation of terms is important to define the focus of the study and clarify how they are used. Upfront, I need to mention that the terms "learner" and "teacher/tutor" are used to refer to university students and university lecturers respectively, as is common in Nigeria.

1.12.1 Distance learning (DL)

Distance learning is defined as a learning procedure where someone who is removed in space and/or time from the learner (Perraton, 2010) conducts a substantial quantity of instruction. With the introduction of computers in course delivery, Moore *et al.* (2011) relate DL as the delivery of instruction to a learner located in a different place to the instructor and at a different time using printed and media materials. The definition of Keegan (1995: 7) is adopted for the purpose of this study: distance education and training, which in most cases is institution-based, results from the separation of the teacher and learner and frees the student from the necessity of travelling to "a fixed place, at a fixed time, to meet a fixed person, in order to be trained".

1.12.2 Online learning (OL)

OL is defined as learning that is partly or entirely done on the Internet. It can be referred to as access to learning experiences using various technologies. However, pedagogical tools that allow the use of Internet and web-based technologies are applied to facilitate meaningful learning.

1.12.3 E-learning

Sources such as Triacca *et al.* (2004) believe that e-learning is a form of online learning and is defined as learning that can be accessed using technological tools that are web-based, web-distributed or web-efficient (Nichols, 2003).

1.12.4 Face-to-face (f2f)

In this study, this refers to the type of teaching that is done in a specific place and in real-time. That is, the teacher and the student are in the same place at the same time, called a contact hour for learning. It involves instant and direct communication and feedback.

1.12 5 Blended learning (BL)

Ellis and Calvo (2007) define this as a methodological mixture of e-learning and face-to-face learning that ensure unity within the two contexts based on students' views of achieving the anticipated learning outcomes.

1.12.6 Learning

Learning is defined as the procedure of initiating knowledge based on the interaction experiences of the learner with the environment. Hence, there is improvement in learning when the learner builds his/her own learning environment (Lopez-Morteo & Lo´pez, 2005).

1.12.7 Learning style (LS)

Kolb's (1984) definition of learning styles was readily adopted in this study. A learning style is defined as an individual learner's favourite orientation towards learning. It involves the presentation of specific and visible evidence regarding the behaviour of individual learners that helps improve their learning capability.

1.12.8 Assessment

Dietel, Herman and Knuth (1991) define assessment as procedures used to determine the learner's present knowledge of the subject. For the purpose of this study, the interpretation is made known for the learner's use. The teacher gets to know where the learner is in the learning, where to help and the best option to apply for the learner to get there. Multiple-choice assessments, quizzes and a term paper, among others, are some forms of assessment procedures that can be developed to assess distance and online learners.

1.12.9 Students' facilitation (SF)

This refers to the support that is central to successful online delivery. It is essential in supporting students' reasoning in online interaction as shown in learning communities of practice (Wenger, 1998)

1.12.10 Student support (SS)

Simpson (2000) defined student support in a more comprehensive way. According to Simpson (2000), SS is all the activities that are different from the production and delivery of course materials that promote the improvement of students in their learning.

1.13 Outline of chapters

The thesis report is arranged in the following five chapters:

CHAPTER ONE – Introduction/background

This includes the introduction, background to the study, problem statement, rationale, research questions, aims and objectives, theoretical framework, overview of the research methodology, ethical considerations, delimitation of the study, limitations of the study, definition of the terms and the chapters' outline.

CHAPTER TWO – Literature review

The relevant materials on learning experiences of distance and online learners, opportunities to learn and distance and online mathematics learning were critically reviewed to form a theoretical foundation for the work. The basis of the study on cognitive theories, especially the experiential learning theories (ELT), transactional distance theory (TDT) and cognitive theory of multimedia learning (CTML) that forms the theoretical framework for the study were developed and explained in this chapter. A conceptual framework that guided the exploration of the specific issues being studied was also presented.

CHAPTER THREE – Methodology

The practical conduct of the study was discussed in this chapter. This section contained all the relevant issues of mixed methods research. It includes the research paradigms and approaches, a mixed methods research design, data collection approaches and instruments, data analysis methods, a pilot study and ethical issues of the study in addition to the limitations of the study and a summary of the chapter.

Chapter FOUR – Presentation and analyses of data

This chapter contains a detailed presentation and analyses of the collected data. Detailed descriptions of the research findings were discussed. The findings were presented in tables and figures according to the emerging themes.

CHAPTER FIVE – Conclusion and recommendations

As the last chapter, the summaries of the findings were presented and conclusions were drawn from the findings based on the existing literature. The study's contribution and the gap

it filled, which was identified earlier during the course of this study, were also discussed. Recommendations and areas for further study were also presented.

1.14 Summary of the chapter

The introduction and the background context of this work were discussed in this chapter in order to highlight and explain the type of research problems that form the focus of the study. The chapter explains the theoretical framework being used, the foundational argument and the methodology that was employed. The delimitation clarified the focus of the research while selected definitions were given for a precise understanding of the conceptual terms used in the study. An outline of the chapters was given to clarify the structure of the thesis. The next chapter provides a review of related literature on students' experiences with distance and online learning.

CHAPTER 2

Literature review on students' experiences with distance and online learning

2.1 Introduction

The theoretical and philosophical aspects of this study are extensively considered in this chapter in order to provide a basis for investigating students' experiences with distance and online learning of university-level undergraduate mathematics in Nigeria. I review research that will aid my understanding of how distance and online university-level mathematics education is conducted in Nigeria, the role of technology in shaping opportunities to learn and the kinds of challenges faced by students and institutions. The study is conducted within the context of distance learning. The literature review includes an overview of ODL, modes of instructional delivery, assessment, learning facilitation and support services using advanced technology, primarily in Nigeria. ELT, TDT and CTML were reflected upon and adopted as the theoretical framework to guide this study. These theories are influential in distance and online education. In particular, the following bodies of literature that proved important in shaping this study were reviewed under the following subheadings:

i.   Experiential learning theory (ELT), transactional distance theory (TDT) and cognitive theory of multimedia learning (CTML)

ii.   Instructional delivery, assessment, facilitation and support in distance and online environments.

iii.   Overview of ODL, its practices and institutional modes in Nigeria.

iv.   Challenges students face in distance and online learning environments.

2.2 Theoretical framework

The theoretical framework that provides the means to detail and measure the students' experiences with distance and online learning of university-level undergraduate mathematics and allows the researcher to make sense of instructional delivery, facilitation, assessment and support services using newer and/or advanced technology in this mode of learning is discussed in this section.

2.2.1 Employing experiential learning theory to expand the students' experiences with learning

ELT is based on four cyclic elements of concrete or tangible experience (CE), reflective or thoughtful observation (RO), abstract or intellectual conceptualisation (AC) and active or practical experimentation (AE). It was used extensively as a framework for this study as it gave a more learner-centred focus than cognitive theories of learning that stress acquisition, manipulation and recall of abstract symbols. ELT presents a holistic model of the learning experience with students at the centre and supports a multi-lateral model of adult development that seems necessary for this work (Kolb 1984: 20-21; Kolb *et al.*, 2000: 2). Tapfumaneyi (2013) noted that holistic development should be able to affect the body and mind of the students.

The main application of the ELT model is to empower students to manage and gain control of their individual learning by developing personal learning styles. This will help choose and improve the set of learning abilities each learner brings to any specific learning situation (Kolb 1976a, 1976b; Miettinen, 2000). Experience is a continuously vital component in learning because it involves the learner deliberately using experiences. Carver *et al.* (2007) stated that experiential learning provides an already existing framework in which to develop a new model for online learning, featuring the individual either alone or in creative interaction, as the mobile centre of gravity of the learning environment. This is to stress that the distance and online learner needs all four ELT abilities for the most effective learning experiences to take place. The method the theory employed has cognitive initiative, perceived as the type of beliefs necessary to tackle the diverse challenges of distance and online learners.

Kolb's ELT was developed using the learning concepts of John Dewey, the father of constructivism in education, Kurt Lewin, the father of social psychology and Jean Piaget, who specialised in cognitive developmental psychology. The theory is regarded as 'experiential' because its foundations come from the work of these three scholars (Richmond & Cummings, 2005). Kolb stated that his aim was not to develop an alternative theory of learning but to recommend a holistic integrative perspective on learning through ELT that unites experiences, perceptions, cognition and behaviour (Kolb, 1984: 21). ELT indicates that every student relates to all four cyclic stages of the model (Kolb, 1984: 30). The author noted:

Learners, if they are to be effective, need four different kinds of abilities – concrete experience abilities (CE), reflective observation abilities (RO), abstract conceptualizing abilities (AC) and active experimentation abilities (AE). That is, they must be able to involve themselves fully, openly and without bias in new experiences (CE). They must be able to reflect on and observe their experiences from many perspectives (RO). They must be able to create concepts that integrate their observations into logically sound theories (AC) and they must be able to use these theories to make decisions and solve problems (AE).

The procedures for learning are pictured in a cycle where the learners are involved in experiencing, reflecting, thinking and acting. The concrete experiences stimulate observation and reflection, which produce new actions. This in turn leads to practical experimentation that controls or leads to new concrete experiences (Kolb & Kolb, 2005). Kolb (1984) suggested perceiving and processing as two important elements of learning experiences. Perceiving signifies how learners sense and understand the information from concrete experiences to feed into reflective observation, while processing is how the learners understand and process the information from abstract conceptualisation to active experimentation. Kolb's experiential learning cycle is presented in figure 2.1 below.
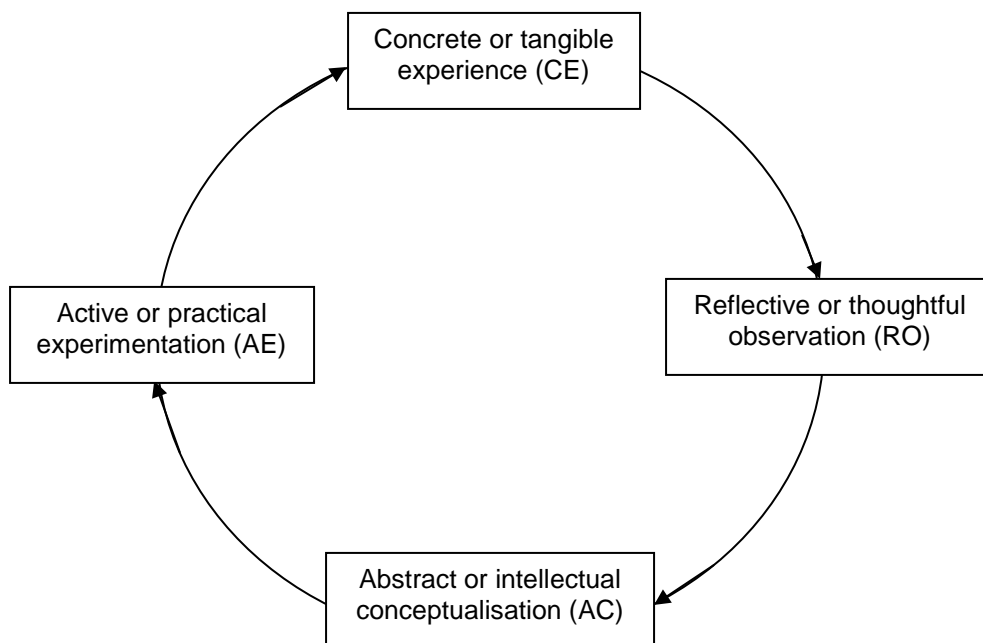
Figure 2.1: Kolb's adapted model of experiential learning

(Source Kolb, 1984: 141)

The model is used to explain the transformation of experience to ideas that sequentially influence the selection of new experiences. The process of using ELT to expand the students' experiences with learning can be understood from the point that it entails something personally meaningful to the students that they engage in. The entire person's senses, feelings, personality and not just the brain are involved in learning (Andresen, Boud & Cohen, 2000). There are opportunities for students to write and deliberate on their experiences and reflect on their thought all through the learning process. In Murphrey (2010: 213) it is stated that "one of the most important and powerful aspects of experiential learning is that the images in our brains come from the experience itself". Hence, students should be encouraged to create experiences that can be built on their previous experiences but which must be meaningful and applicable. The choice of this theory helps to investigate students' experiences in learning mathematics in a distance and online environment and reveals how students' experiences with university-level mathematics in distance and online environments can be improved.

One of the concepts used by Kolb in the development of ELT was John Dewey's constructivist theory of learning. The constructivist theory is a learning theory that allows the learner to construct meanings and make sense of their experiences (Merriam, Caffarella, & Baumgartner, 2007). The students in this learning environment acquire knowledge by observing, processing and interpreting information (Wilson, 1997). Every learner produces "rules and mental patterns" they can use to make meaning of their experiences (Cavanaugh *et al.*, 2004). Hence, learning is a process of regulating the mental mind to adapt to new experiences. The theory is student-centred rather than teacher-centred, where learners are active and responsible for their learning. They construct their own knowledge from previous experiences and interactions with their environment. Student-centeredness helps develop students' mental inquisitiveness, problem-solving capabilities, creative imagination, leadership expertise, reasoning and vitality (Henson, 2003). Merriam *et al.,* (2007) state that one important way students construct new meaning is by involving them in experience–based learning. The teacher facilitates and regulates learning instead of just giving out information. These types of learning activities give opportunities for effective distance and online learning in higher education institutions.

2.2.2 Using transactional distance theory and cognitive theory of multimedia learning as a lens to understand students' experiences with distance and online learning

These theories are closely related to the motivation behind students' experiences with distance and online learning of mathematics, which is at the heart of this study. They play a vital role in technology-assisted learning and present a lens through which to examine the procedures of teaching. Each of these theories will be discussed individually below.

2.2.2.1 The transactional distance theory (TDT)

TDT is based on the principle that the "distance" in distance and online education is beyond a geographic separation of learners and instructors (Moore, 1991; 1993). Moore stressed that distance in education is pedagogical and not geographical and the term 'transactional distance' is identified as the physical distance that influences a communication gap and/or "a psychological space of potential misunderstandings between the instructors and learners' behaviours" (Moore & Kearsley, 1996: 200). Moore and Kearsley (1996) maintain that education offers a variety of interactions ranging from less distant to greater interaction and more distant to where there may be less interaction. Hence, distance is not influenced by geography but by the level of interaction among the key constructs in the theory, comprising the learners, instructors and learning environment (Kang & Gyorke, 2008). This transactional distance construct favours the distance and online learning mode because interaction and collaboration among learners and between learners and instructors is a critical part of the development of the community of practice needed for learning to occur (Lave & Wenger, 1998). The theory is further based on three variables including dialogue, learner autonomy and structure.

Dialogue as a key variable in the theory is the communication transaction that exists between the instructors and the learners during the course and is purposeful, constructive and valued by the learners and instructors. Learners and instructors are respectful and active participants; every participant is a contributor and learns from the contributions of others (Moore, 1993; Mbatha & Naidoo, 2010; Shearer, 2010). In TDT, the nature of the communication medium influences the extent and quality of dialogue among learners and instructors. Hence, dialogue takes into account all forms of interaction within the context of well-defined learning targets, support and understanding on the part of the instructor and

finally leads to addressing the learners' educational problems (Giossos *et al.*, 2009). The frequency of dialogue is not important but its effectiveness in solving the learning problems the distance and online learners may be experiencing is important. Kang and Gyorke (2008) argued that the means of communication is the major factor that affects dialogue.

Structure is the second variable in this theory that determines how the course design and teaching programmes are organised so that they can be delivered with a variety of communication media (Moore, 1993). Stirling (1997) also stated that structure refers to how the instructional programme is designed and reflects the programme's capacity to respond to a learner's individual need in distance and online education. The motive according to Moore (1980: 21) is to determine,

> …the extent to which the objectives, implementation procedures, and evaluation procedures of a teaching programme necessary for students' experiences are prepared, or can be adapted to meet specific objectives, implementation plans and evaluation methods of individual learners. Structure is a measure of [an] educational programme's responsiveness to the learner's individual needs.

Structure illustrates the level of rigidity or flexibility of the course in distance and online learning. It involves the degree to which course objectives, the pedagogical method, assessment procedures and the capability of the course are specified to assist individual learners' needs.

Learner autonomy, which depends on dialogue and structure, refers to students' control over the learning activities and processes and uses the teaching materials and programmes to achieve their learning goals in their own way (Kang & Gyorke, 2008; Shearer, 2010; Falloon, 2011). This implies that the determination of goals, learning experiences and even assessment decisions lie with the learners and not so entirely with the instructors (Moore, 1984). Thus, it is more learner-centred than instructor-centred. Moore's (1984) TDT emphasises the existence of inverse relationships between the variables. In other words, an increase in one variable can produce a corresponding decrease in the others, as indicated in figure 2.2.
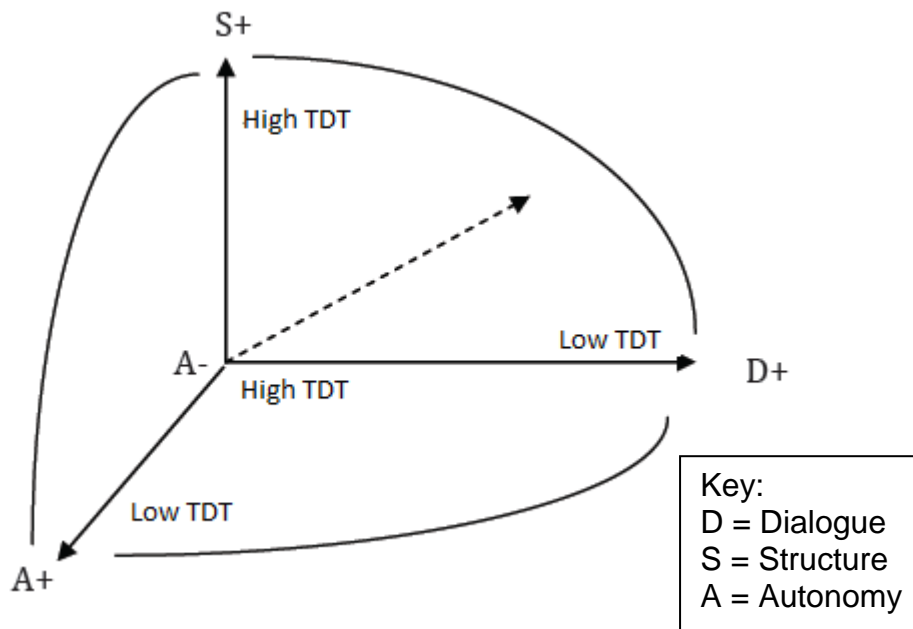
Figure 2.2: The three dimensions of transactional distance
(Source: Shearer, 2010: 2)

Figure 2.2 indicates that learners with high levels of autonomy do not need high levels of dialogue or structure to be successful in an educational environment. Hence, high levels of learner autonomy can be associated with low levels of structure, dialogue and transactional distance (Kang & Gyorke, 2008; Shearer, 2010).

According to Kang and Gyorke (2008), the concept of transaction also originated from John Dewey. In the context of distance and online learning, Moore (1972) introduced TDT in the 1970s and since then the theory has witnessed multiple revisions. According to Moore (1993: 22) and Chen (2001: 460), transaction means "the interplay among the environment, the individuals and the patterns of behaviour in a situation". The interaction in TDT takes place between the instructor and learners in an environment where the instructors are separated from the learners. This separation brings about special patterns of behaviours among the instructors and the learners that affect the teaching and learning in distance and online education. This development helps bridge the gap using distinctive methods in designing the instruction and interactions (Moore & Kearsley, 2005; Vilardi & Rice, 2014). Moore's TDT provides a theoretical framework from which to develop a successful distance and online learning environment by balancing the interaction of course structure and learner-instructor dialogue based on the autonomy of the individual learner (Stirling, 1997). Distance and online

learning was originally and has traditionally been an autonomous activity that learners complete on their own to gain the required learning experiences (Holmberg, 1986).

2.2.2.2 Cognitive theory of multimedia learning (CTML)

CTML occurs when the learner uses visual and verbal systems to process information. Moreno and Mayer (1999) argued that visual and verbal information is processed differently by the brain. The theory is that teaching using multimedia tools allows the learner the potential to gain a better understanding compared to using only single media tools. The rationale is that students learn more deeply when using words and pictures to teach compared to when words or pictures are used alone (Mayer, 2005; Vilardi & Rice, 2014). The use of multimedia tools is prevalent in distance and online learning, hence the relevance and need for this theory in this study.

These three theories are used on the assumption that distance and online education facilitates and opens avenues for effective learning, has the potential of placing the learner at the centre of learning, collapsing the transactional distance and providing opportunities for the use of multimedia tools. These theories have been used to improve the teaching and learning of mathematics (Moore, 1993, Knisley, 2002). Although there are other theories which can be used to examine students' learning experiences and which may lead to a related teaching transformation in students, the framework for this study attends to Kolb's experiential theory, Moore's transactional theory and Mayer's cognitive theory of multimedia learning as represented in the figure 2.3.
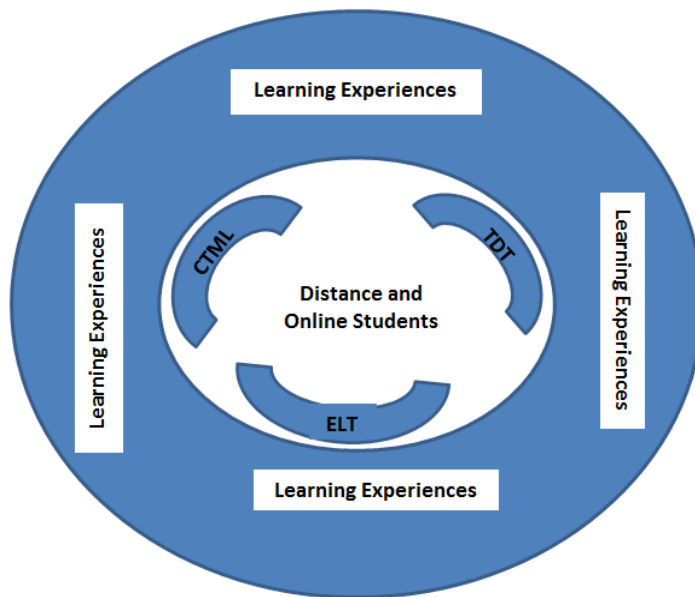
Figure 2.3: The conceptual framework guiding the study

Applying constructivism to distance and online mathematics learning emphasises the importance of structuring the educational environment to encourage students to learn. As stressed by DePrinter (2013), constructivist mathematical views value enquiry, prediction and discovery more than theorems and proofs, thereby transferring teachers' role as disseminator of mathematical ideas to the exploration of unknowns by the learners. Offenholley (2012) maintains that apart from the online environment being collaborative and learner-centred, for the learner to have meaningful learning engagements with learning materials and peers, there has to be specific types of instructor interaction. Schullo *et al.*, (2007: 332) argued that interaction "improves attitudes, encourages earlier completion of coursework, improves performance in tests, allows deep and meaningful learning opportunities, increases retention rates and builds learning communities" in distance and online education. The distance and online level of interaction is presented in figure 2.4.
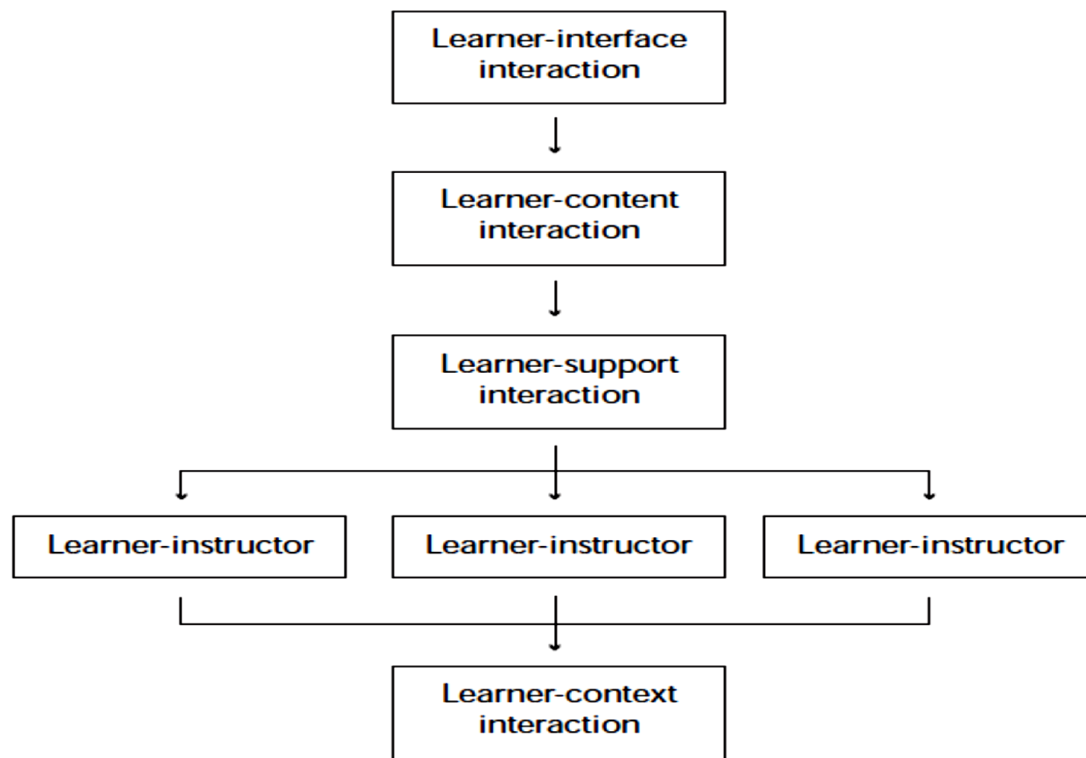
Figure 2.4: Online learning levels of interaction

(Source: Ally, 2004: 20)

The learner-interface is, identified in an extension of the work of Moore by Hillman *et al.* (1994). In figure 2.4, it is the lowest level of interaction that permits the learner to access and sense the information through the computer. The interface allows the learner to access the learning content and interact with other learners. The learner gains access to the components of the content to process the information through learner-content interaction. The online learners are expected to assess, analyse, synthesise, evaluate and reflect on what they learn (Berge, 2002). The higher the level of processing of information by the learner, the more familiar the learner will be with the content. This leads to a higher level of learning experiences (Ally, 2004). The support, which could take the form of learner-learner, learner-instructor and instructor-learner interactions, enables the learner to work through the content. Research has shown that learner-instructor interaction is ineffective compared to learner-learner and learner-content interaction but Offenholley (2012) argues that none of the interactions will occur without a certain type of instructor interaction. In distance and online learning, the strategy to promote learner-context interaction is necessary (Moore,

1989; Fresen & Hendrikz, 2009) to contextualise or situate the information, develop personal experiences and apply them to real-life situations (Bredo, 1994).

From the discussion above, it is clear that Kolb's experiential learning theory, Moore's transactional distance theory and Mayer's cognitive theory of multimedia learning that are employed in this study, have significant potential to add value to the learning experiences of distance and online learners of mathematics. These theories have been adopted as a broad framework within which to frame this study. The motivation is to help investigate the experiences of undergraduate mathematics distance and online learners and to describe and explain the instructional delivery, assessment, facilitation and support services as they relate to their mathematical learning experiences.

2.2.3 Application and relationships between Kolb's ELT, learning styles and learning environment in distance and online learning

The increasing demand for distance and online education has led to an urgent call to assess the impact and effectiveness on students' learning experiences of instructional delivery, assessment, learning facilitation and support services using modern technology (Richmond & Cummings, 2005). To ascertain the quality of experience and ultimately students' outcomes in distance and online modes of learning, Kolb's learning styles, learning modes and learning environments need to be considered. Richmond and Cummings (2005) have described assimilative, accommodative, divergent and convergent styles as Kolb's four main learning styles. These learning styles were integrated into combinations of any two of the learning modes: concrete experiences, reflective observation, abstract conceptualisation and active experimentation. The four learning environments that house the learning styles and learning modes as described by Kolb and Fry (1975) were affective, symbolic, perceptual and behavioural environments. They further stated that relationships exist between the learning modes, learning styles and learning environments and that a particular learning style can be integrated with more than one learning mode. That is, there are two matching learning styles for every learning mode and a corresponding learning mode for every learning environment.
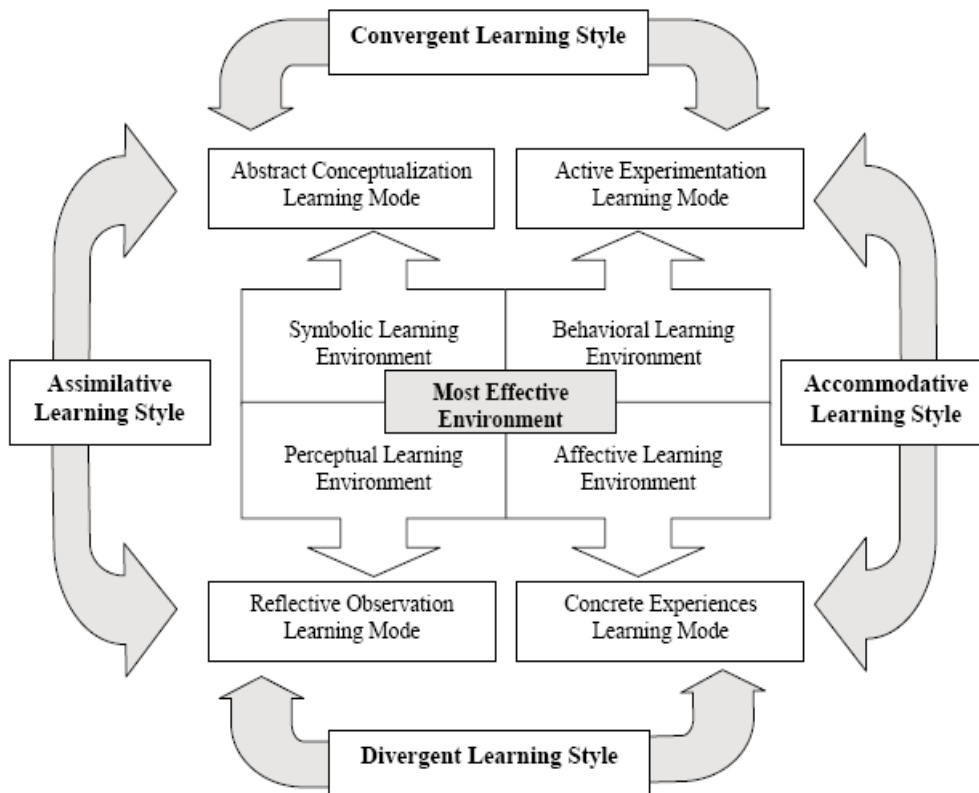
Figure 2.5: Conceptual layout of Kolb's learning styles, modes and the corresponding learning environments
(Adapted from Richmond & Cummings, 2005: 49)

Students with an assimilative learning style are good observers, being more interested in ideas and abstract thoughts. Accommodative learners are more meticulous in planning and completing tasks, easily adjusting to change and enjoy working in a group. Convergent learners, according to Kolb (1984) have the capability to successfully solve problems, take decisions and use them in further problem solving. They normally do well in established examinations because they can organise their thoughts to produce correct answers to standard problems. Kolb (1984) further identified students with a divergent style of learning as best in imagining and giving meaning to ideas, as they are creative and have the ability to recognise tangible and specific examples of concepts.

The four learning environments exist in tasks such as practical work, construction of mathematical models and field experiences. A symbolic learning environment involves presenting information through data, readings, lectures and picture forms. Learners in this mode are interested in solving problems with obvious correct answers. In a perceptual

learning environment, the process of solving problems is more important than just coming up with the answer, as students' opinion and professional opinion is required in solving problems. The behavioural learning environment stresses using practical skills or knowledge in problem solving. It involves students working in a small group and working on tasks that enable interaction and peer comments (Kolb, 1984). From this description, it clearly emerges that the learning styles and learning environments of Kolb offer insight into the distance and online learning of mathematics among university undergraduates.

Every learning mode is related to two learning styles and one learning environment (Kolb, 1984). The learning styles that relate to concrete experiences are divergent and accommodative learning styles while an affective learning environment promotes this type of learning mode. A perceptual learning environment supports the reflective observation learning mode and this is a component of divergent and assimilative learning styles. An abstract conceptualisation learning mode uses the symbolic learning environment with convergent and assimilative learning styles. Finally, a behavioural learning environment is related to an active experimentation learning mode with convergent and accommodative learning styles. These relationships can easily be adopted in distance and online delivery for effective learning.

While research works have examined the effects of learning styles in various fields of study, few have majored in distance and online education (Jones, Reichard & Mokhtar, 2003; Richmond & Cummings, 2005). The work of Simpson and Du (2004) on the effects of learning styles and students' enjoyment in an online environment indicates that students with convergent learning styles enjoy the distance and online class more than divergent, accommodative and assimilative learners. Some authors such as Terrell and Dringus (2000) argue that there is no indication that learning styles guarantee success in distance and online learning. They further noted that learners have the ability to function in all four learning styles but their favourite learning style may be influenced by the topic that is being taught. Hence, the ability of learners to choose their style and pace of learning also reduces transactional distance.

2.2.4 Implication of ELT, learning styles, TDT and CTML for distance and online learning

The inclusion of different learning styles in the learning materials for the distance and online learners enables them to select suitable activities based on their preferred learning style (Ally, 2004). Concrete experience learners prefer specific examples that will allow them to be involved and relate with their peers. They prefer learning support that will enable them to relate in-group with their peers. These learners recognise their instructor as a helper and prefer receiving feedback from their peers. Reflective observation learners enjoy thoroughly observing before acting and prefer that all the learning materials be made available for them. They see the instructors as experts and have the habit of avoiding interaction with other learners. Learners with abstract conceptualisation abilities prefer working more with things and symbols but work less with colleagues. They like working with theory and conduct methodical close examinations of situations. Active experimentation learners on the other hand, are good at solving practical problems through group discussions. Despite their preference for active learning methods, they generally like to devise their own methods of evaluating situations (Kolb, 1984; Diaz, 2000; Ally, 2004; Barker *et al.*, 2012).

Support levels and procedures are key agents in the distance and online learning of undergraduate mathematics and must essentially differ for learners with different learning styles. For instance, Ally and Fahy (2002) stated that learners with an assimilative style prefer the extreme presence of an instructor much more than accommodative learners would. Keeping learners active, doing meaningful activities in the distance and online environment promotes high level processing of information that assists in creating meanings that are very personal to each learner's experiences and cognition. The three theories used as lenses in this study support the construction of own knowledge by the learners, instead of just accepting the knowledge given by the teacher. In the distance and online mode of learning, knowledge construction is made easy by well-planned interactions through online instruction. Murphy and Cifuentes (2001) corroborated the view by stating that interaction is necessary in creating a sense of presence and community for distance and online learners. Interaction promotes transformational learning among the distance and online learners. This is because transformational learning in this environment encourages learners to interact with the content, other learners and instructors. According to Ally (2004: 20), "the design of educational experience includes the transformational nature of the relationship between

instructor, learners and content" and is important to the learning experiences. The learners control the learning agenda in a distance and online environment. Hence, they take initiative to learn and interact with other learners and instructors (Moore, 1993; Murphy & Cifuentes, 2001). Collaboration, which facilitates constructivist learning, allows the learner to work in groups for the development of real life experiences. Moore's TDT has indicated that instituting quality interaction and dialogue is an important element in overcoming barriers to success in distance and online learning.

Another implication involves allowing the learners in a distance and online learning environment to have control over the learning process. The instructor is to play the role of guide to the learners, while the learners make decisions on learning goals through the guided discovery. Time for reflection is needed for them to meaningfully process and internalise the information received from the content to enhance their learning experiences (Ally, 2004).

2.3 Previous research on the experiences of students learning mathematics at university-level

There have been considerable advancements recently in the area of student learning in higher education, specifically related to the increase in the use of distance and online learning among institutions of higher education (Slagter van Tryon & Bishop, 2009). The major concern is how best to use distance and online learning to present better quality and profound educational experiences to students. Researchers have conducted qualitative and quantitative studies that contribute to the body of knowledge and theory of how and what students learn at university-level. There is a sequence of networks between learning and teaching in higher education. Each component of good teaching helps to bring about the kind of learning that leads to changes in understanding (Ramsden, 1992). Studies have also confirmed that the students' previous orientations to learning and understanding of the subject relate to and depend on their experiences of the learning situation they engaged in (Crawford *et al.*, 1998; Ramsden, 1992). This directly influences any research into distance and online learning of mathematics, the focus of this study.

Past research on students' experiences in learning of mathematics at university-level indicates that students enrol in university education courses with significant distinctions in their previous experiences of learning (Crawford *et al.*, 1998; Wood *et al.*, 2011; DePrinter, 2013) and these affect their view and method of approaching online mathematics learning.

Crawford *et al.* (1998) are of the opinion that initial study in students' learning in higher education distinguished the main qualitative variations in students' previous orientations to study and influenced their approaches to study in a particular context. They explored the distinction between the orientations and approaches that are based on meaning and understanding, regarded as deep approaches and other approaches based on reproduction, which are regarded as surface approaches.

A deep approach to learning is something to encourage in university mathematics education. This category of learners should have the ability to gain in-depth knowledge of the learning materials, process the information holistically, give meaningful interpretations to the learning materials and integrate knowledge gained with previous knowledge. Surface approach learners on the other hand are interested in details and small and often isolated pieces of information, memorising the information as they were given it and itemising ideas as it is presented to them (Ramsden, 1992).

Students' views of the learning environment and their experiences within it affect the approaches they adopt to future learning. Those who see good things in teaching and learning, with well-defined personal goals and who show an independent approach to learning and take responsibility for it, embrace a deep approach to learning. On the other hand, students who see the workload as being high and seek success based on rote learning adopt a surface approach to learning. Those with disjointed ideas are restricted to a surface approach to learning, while those with organised and connected ideas are likely to use a deep approach.

The result of the study conducted by Crawford *et al.* (1998) on different experiences of learning mathematics at university-level showed that university students with a surface approach to learning mathematics did not do as well as the students with a deep approach to learning. Any failure of distance and online learners to transfer the learning experiences to other contexts indicates that learning has taken place at a surface level. This connection with learning approaches has been applied in many subject areas including distance and online learning of mathematics (Wood *et al.*, 2011).
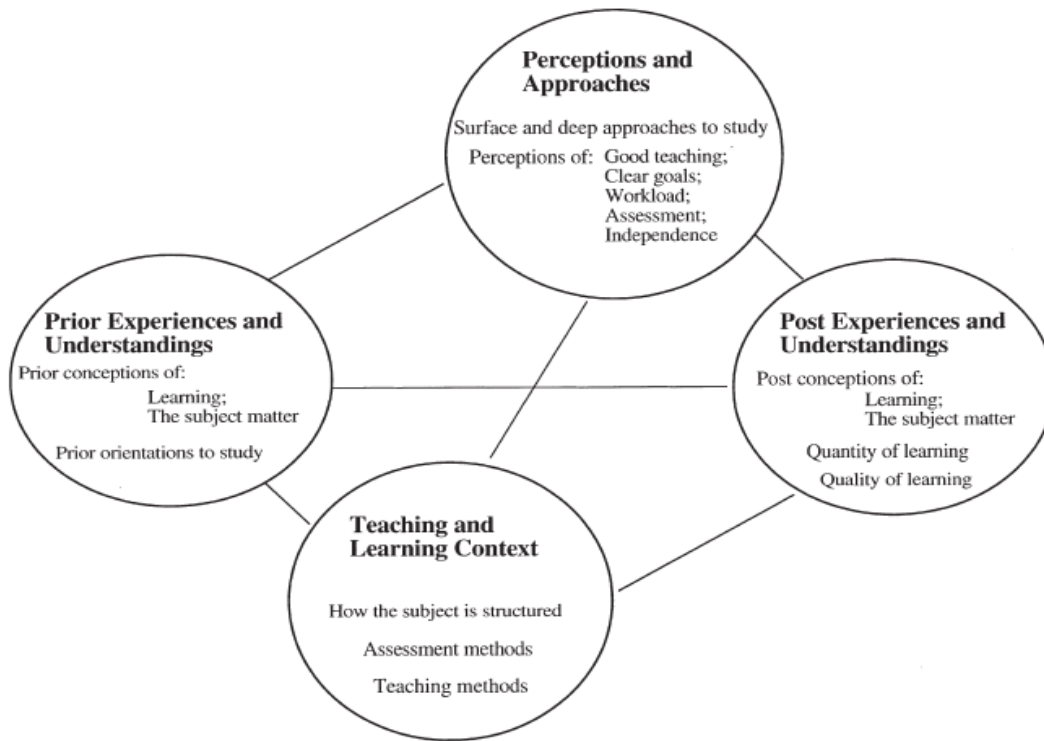
Figure 2.6: Model of student learning (Adopted from Crawford *et al.*, 1998)

The model in figure 2.5 indicates that students' learning is characterised by previous experiences and understanding and the manner in which these relate to their method of learning mathematics thereafter. This implies that we view the past, present and future awareness and activity of the students' learning as continuous interaction (Crawford *et al.*, 1998). The 'teaching and learning context' of this model was used to assess the necessary conditions under which deep learning arises in distance and online education.

Studies have shown that many students see mathematics as a disjointed form of knowledge and tend to adopt repetitive and surface approaches in learning the subject. Only a few students when entering university have a unified view of mathematics education and tend to apply deep approaches in their learning (Petocz *et al.*, 2007). Regarding the experience in learning mathematics, Crawford *et al.* (1998) argued that many students learn mathematics at university in a competitive atmosphere where mathematics is refined and polished as a finished product and where assessment often supports reproduction of statements of facts and well-known results. In this case, the students are simply presented with mathematical concepts, evidence (proofs), skills and methods but the rationale behind and procedures leading to these are concealed. This makes it difficult for students to have any personal

37

meaningful mathematical experience and thereby misrepresents the essential and rich features of the subject. Schoenfeld (1996: 16) suggested an environment that promotes "communities dedicated to exploration and sense-making". In such an environment, students are encouraged with their mathematical problem solving because the group helps them all find meaning and solutions, where the authenticity of those solutions is determined within the group.

Schwartz *et al.* (2008a), on the subject of depth versus breadth in learning, considered the issue on how to teach and cover the content of science subjects (mathematics included) for the better understanding of the high school students. The teachers in the study, at that point in time, were more concerned with covering syllabus content rather than in-depth teaching of individual topics. This was necessitated by their desire to prepare students for standard examinations where the students could perform well enough to maintain the image of the teacher. The implication of this view is that the student only learns to pass standard examinations with little or no regard for longer-term development or retention of the concepts of mathematics.

Some scholars, such as Aristotle, advocated the breadth view, covering a wide curriculum (Schwartz *et al.*, 2008a). However with the advancement of science, more authors started to campaign for lesser topics with greater depth. This idea was sustained by Hirsch (2001: 23) and Schwartz *et al.* (2008a: 799), who argued that educators subscribing to fewer topics in greater depth maintain that students should develop depth of understanding, instead of aiming for maximum coverage, declaring that the mastery of a few topics is better than failure to master any. Hirsch (2001: 23) further stated as one of his learning principles that "the best way to learn a subject is to learn its general principles and to study an ample number of diverse examples that illustrate those principles", stressing that a broad range of examples should be studied but studying too many is a waste of time. Authors such as Schwartz, Hazari and Sadler, (2008b) advocate for depth over breadth but have no experimental data to support their claim. Many were arguing based on their own school experiences or through the experiences they had as teachers of science subjects. Some other authors in Schwartz *et al.*'s (2008b) study channelled politics into the writing of science textbooks and in formulating the curriculum. According to Kesidou and Roseman (2002), the nature of science textbooks and curriculum apparently encouraged breadth rather than depth.

Despite the fact that this debate continued for some time, there was still no experimental proof to support depth over breadth. This gap led Schwartz *et al.* (2008a) to conduct research to inform the debate. This study also lend its voice to the debate by exploring the students' experiences with distance and online mathematics learning. Brady (2000) indicated that students are required to study relatively few powerful ideas in great depth, ideas that encompass and explain major aspects of the human experience. Thus, Brady's opinion also suggests that the capability of students to learn new things about mathematics in the distance and online learning mode is subject to their previous experiences. Wood *et al.* (2011) asserts that students' notion and methods of learning, previous experiences, views and understanding of the subject and learning context are among many factors that influence learning outcomes.

The strength of the debate on depth versus breadth is that it has assisted the public and policymakers in finding the best way to go about achieving educational aims and objectives. The controversial statement by Hirsch (2001: 23) that "neither the deep understanding of general facts nor the lots-of-facts is an optimal approach to teaching and learning", points to the inherent weakness in any polarised depth versus breadth debate. Again, advocating for a balanced approach as some authors have done has not actually placed increase in depth over decrease in breadth. The assertion of Hirsch (2001: 23) that "we should teach a diversity of subjects that will lead to broad general knowledge and we should also teach in some depth a moderate number of specific examples" still seems relevant in the learning of science in general and mathematics in particular.

2.4 Opportunities to learn (OTL) mathematics in the distance and online mode

The remarkable growing trend of technology in distance and online teaching and learning is having an important effect on teachers' teaching and students' learning of mathematics. The result of the development in technological capabilities controls the teaching of mathematics courses online in order to satisfy the increased number of students' need for online learning opportunities (Jones & Long, 2013). Opportunities for learning experiences may not be the same for every student as students in various localities may need a distinct approach to learning before the experiences can take effect. Experiential learning theory and students' learning models relate much to the OTL principle (NCTM, 2000). It was emphasised that excellence in mathematics education demands equal opportunity. NCTM argues that not

every student may obtain the same teaching but the educational programmes should assist the students to see the value of continued mathematical education for their own futures. As part of students' experiences to learning, Flores (2007: 37) stated that "students ought to have equitable and optimal OTL mathematics free from bias" and that "all students need the OTL challenging mathematics from a well-qualified teacher who will make connections to the background, needs, and cultures of all learners".

NCTM (2000: 24) asserts that technology is fundamental in the teaching and learning of mathematics because it affects what is taught and enhances students' learning experiences. The effect of technology on distance and online learning of mathematics depends largely on teachers' decisions when using technological devices. Teachers' decisions also depend on the knowledge obtained during teacher preparation programmes. Lee and Hollebrands (2008: 326-327) argued that teacher education programmes should give opportunities for teachers to gain the knowledge and experiences required to integrate technology in the teaching and learning of mathematics.

Teachers' knowledge and education has largely been influenced by the ideas of Shulman (1986) who categorised content-related knowledge into content knowledge, pedagogical content knowledge and curricula knowledge. The most widely accepted among the three types of content-related knowledge by the researchers is pedagogical content knowledge (PCK) and many researchers have classified curricular knowledge as a subcomponent of PCK (Großschedl *et al.*, 2014). PCK has been regarded as a mixture of content and pedagogy leading to the understanding of specific subject matter and fitting into teaching situations such as distance and online mathematics learning. These two subjects which resulted from PCK were described by Shulman (1986: 9) as "the ways of representing and formulating the subject that makes it comprehensible to others" on one hand and the knowledge about students' "conceptions and preconceptions" on the other.

In recent times, many researchers have expressed technology, pedagogy and content knowledge (TPACK), as represented in figure 2.6, as a kind of knowledge that the teachers need to understand in order to use technology successfully to teach a particular subject matter (e.g. Koehler & Mishra, 2005; Niess, 2005, 2006; Lee & Hollebrands, 2008). Koehler and Mishra (2005) emphasised TPACK as an important body of knowledge for teaching

mathematics, specifically concerning the integration of teachers' knowledge of content, pedagogy and technology. As stated by Niess, (2006: 196),

> TPACK for teaching with technology means that as teachers think about particular mathematics concepts, they are concurrently considering how they might teach the important ideas embodied in the mathematical concepts in such a way that the technology places the concept in a form understandable by their students.

In designing distance and online courses, learners will be allowed to discover the relationships that exist between technology, pedagogy and content. With technology as a universal part of daily learning experiences, mathematics teachers who are 'digital immigrants' are expected to build on the experiences of the learners who are mostly 'digital natives' (Prensky, 2002). The belief that qualified teachers devoted to the learning of their students are the single most important factor for students' success (Flores, 2007), indicates that teachers' knowledge is essential in creating appropriate opportunities for the students to learn specific subjects. That is, mathematics teachers need to be aware of how to utilise technology to prepare lessons that help learners in distance and online learning to develop their understanding of mathematics.
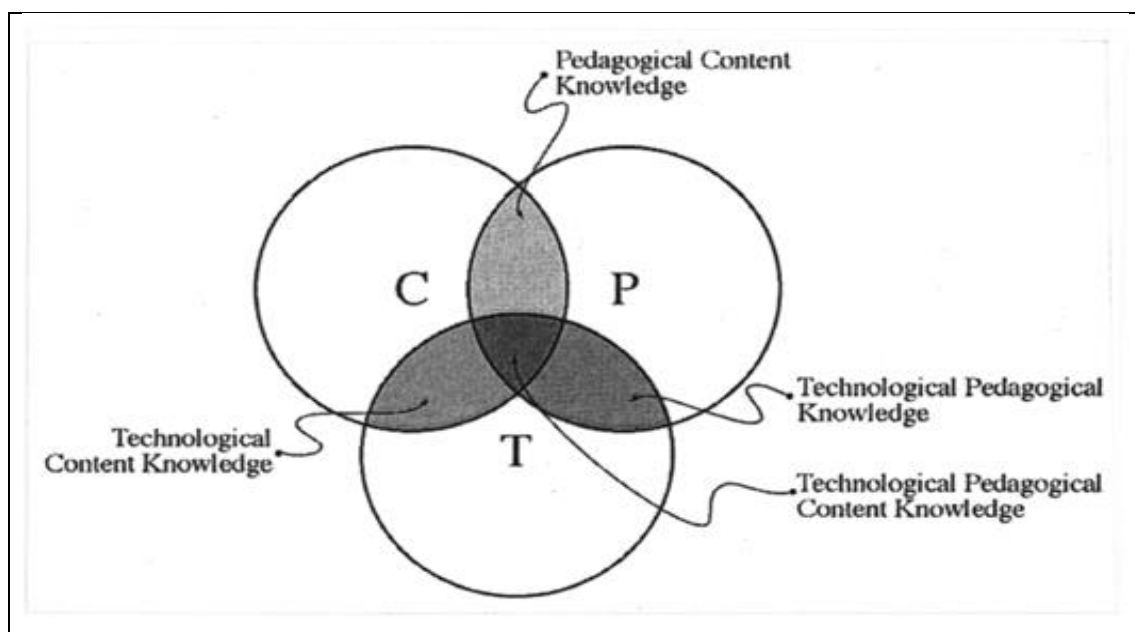
Figure 2.7: The components of technological pedagogical content knowledge (adapted from Koehler and Mishra 2005: 133)

The content is the subject matter the distance and online students are supposed to learn. Pedagogy gives the description of collected activities, strategies and method of delivery and learning, which involves knowledge of goals of instruction, the assessment procedures and learners' methods of learning. Technology comprises all forms of multimedia tools used as a vehicle of delivery in distance and online education.

Researchers have asserted that distance and online courses undoubtedly have the capacity to create opportunities of access to education for some learners but the question of creating opportunities for learning is yet to be ascertained (Jones & Long, 2013). They further stated that an individual learner in a different place may need a different combination of learning experiences but the total value of the experiences of each learner has to be equal in the discourse of OTL. The NCTM (2000: 12) maintains "excellence in mathematics education requires equity – high expectation and strong support for all students" and that the mode of instructional delivery might not be the same but the learning programmes should help the learners perceive the usefulness of studying mathematics. Hence, equal opportunity to mathematics programmes will present strong support for learning based on the learners' interests and previous experiences.

The literature affirms that the main problem determining the opportunity to learn mathematics is the unequal distribution of teachers that can emphasise high quality mathematics instruction and be knowledgeable in the use of distance and online learning resources. Such high quality teachers are determined by their qualifications, professional knowledge and experiences (Flores, 2007; Liakopoulou, 2011; Großschedl *et al.*, 2014). For students to have equal opportunity to learn mathematics, the following strategies are asserted in Flores (2007: 38):

> Help students develop a relational understanding of concepts; help students develop number sense; express a deep belief in the capabilities of students; enable students to use mathematics as a tool for examining issues related to race, ethnicity, gender, and social class; create classroom environments where students are able to find and justify their solutions, as well as question other students about their responses to the same or different questions.

Quality distance and online learning is enriched by ensuring that all learners have an equal opportunity for learning. In order to create the opportunity for students to take more advanced

level mathematics courses in a distance and online environment, the specified strategies have to be present in our ODL institutions.

Großschedl *et al.* (2014) investigated four learning opportunities for teachers that can help to ensure effective distance and online learning. These opportunities include teacher education programmes, professional development programmes such as workshops and lectures and informal development programmes, especially teaching practice and self-study in relation to content-related knowledge. The depth and breadth of development of mathematics teachers in content knowledge and pedagogical content knowledge are essential in students' experiences with online learning. Hence, Kitchen (2007) asserts that students require a qualified and committed teacher to learn mathematics. Technology, as an integral component for distance and online learning, requires that instructors have an overall understanding of the subject matter as it relates to technology and its uses in learning (Niess, 2005). The implication of this is that the teachers (ODL instructors) need the mastery of the subject matter, good classroom management and a vast knowledge of multimedia tools, in order to give genuine equal opportunities for students to learn. Researchers have suggested that preparing instructors to teach standards that are more challenging to assist learners from all backgrounds to achieve the required learning outcomes needs better professional development programmes (Loucks-Horsley & Matsumoto, 1999). They further stated that the instructors' effective learning experiences have to represent diverse types of opportunities to learn through attending workshops and conferences and examining the teaching practices intended to enhance student learning.

As supported in the argument above, Shulman's content-related knowledge ideas have offered a practical and effective foundation for research. Teachers' continuing education is significant for renewal of their content-related knowledge so that they remain relevant in the teaching profession. Nevertheless, there is still a problem in connecting the three categories of content knowledge in the areas of teacher education and professional programmes. This is substantiated by Großschedl *et al.* (2014: 2338) who maintained that although teachers' content-related knowledge is regarded as an important factor influencing students' learning progress, no agreement has been reached regarding the empirical structure of this kind of knowledge. This suggests that content-related knowledge is central to teachers' growth but then it is far from the only professional competence necessary for effective learning.

In addition, Schmidt, Cogan and Houang (2011) studied the role of opportunity to learn in teacher preparation based on three subject areas – mathematics content, mathematics pedagogy and general pedagogy. They explored the part teachers' preparation plays through the opportunities offered and utilised in developing teachers' competencies for effective classroom teaching. Teacher education is meant to prepare highly knowledgeable teachers by exposing them to courses and experiences that will help in developing their skills. Hence, for mathematics teachers to produce high achieving students, they should be able to teach the subject well. As a result of the argument above, it is easier to support Shulman's ideas of PCK as being vital to teachers' mathematical development, their teaching and also students' learning. Most studies in OTL were based on teachers, presenting them as the anchor of knowledge and leading to students' achievement in a specific field of study. The current research is mainly concerned with exploring students' experiences with distance and online learning of university-level mathematics in Nigeria.

2.5 Critical factors to students' experiences in distance and online learning of mathematics

2.5.1 Instructional delivery in distance and online mathematics learning

Instructional delivery in a distance and online learning environment is defined as an innovative method of teaching learners who are separated from the teacher using the Internet and worldwide web as the vehicle (Khan, 1997). The learners and learning processes are the focus in this mode of learning and the goal is to promote the learning experiences of the learners (Ally, 2004). Instructional delivery in distance and online learning comes in various ways, as indeed does delivery in any other formal educational setting where the needs of the learners are evaluated, content is discussed and learning activities are devised and assessed (Anderson, 2004). Some theorists such as Mason and Romiszowski (1996) argue that distance and online delivery is not the same as classroom-based teaching because the instructor assumes the position of a facilitator instead of a content provider. The captivating feature of distance and online learning is the capacity of shifting the place and time of interaction and learning. Capturing the learning content in different formats enables the use of multimedia to explore them, accessing online materials through the Internet and with the support of human and machine interaction in different forms creates a rich learning dialogue.

The characteristics and skills of instructors are central to effective distance and online instructional delivery. The distance and online instructor must be organised, compassionate, friendly and easy to talk to, creative and available to assist the learners (Testone, 2003). That is, they have the learners' interests in mind and enjoy dealing with them. Mastery of subject content will enable the instructor to create a learning environment with different types of activities to promote successful online delivery (Anderson, 2004). The preferred instructional delivery strategies in distance and online education should be selected to motivate learners, enable deep processing, promote individual learning differences, encourage meaningful learning, inspire learning interaction, offer support in the course of learning, give feedback and shape the whole learner's experiences (Ally, 2004). Hence, the facilitators can deliver with excited interest to their subjects and perform the tasks of a learning motivator with passionate interest. Teaching in a distance and online mode requires the instructors to be knowledgeable in computers and their usage. Beyond this, they also have to be extremely flexible and receptive to distance and online learners, be lifelong learners themselves by regularly updating their skills and be able to communicate effectively. Hence, Testone (2003) argues that the quality of the distance and online learners' experiences depends largely on the quality of the instructor.

The growth of distance and online education has positively affected the distance and online learning of mathematics in institutions of higher learning worldwide and has inspired the revision of instructional delivery. A quality learning programme of instructional delivery should assure positive achievement by distance and online learners (Duffy & Cunningham, 1996). The introduction of technological tools, online services, interactive programmes, multimedia tools such as video, audio-visual aids and tutorial classes have supported important initiatives in distance and online delivery (Vilardi & Rice, 2014). Considerable numbers of institutions of higher learning presently offer mathematics instruction through distance and online learning methods. Cavanaugh *et al.* (2004) are of the opinion that distance and online learning technologies present a limitless range of opportunities that help the students increase their conceptual and experiential knowledge. A real learning community is created through the emergence of new technologies that afford instructional designers and tutors the opportunities to promote and encourage interaction and collaboration among distance and online learners (Beldarrain, 2006). The creation of

distance and online communities can provide a supportive environment that brings about new kinds of learning experiences for learners.

Interaction and collaboration is achieved in distance and online learning by means of synchronous or asynchronous learning network systems. The synchronous network system has advantages of having a familiar educational pattern with face-to-face learning, bringing all learners together in real-time to participate in online interactions, increasing access to distance and online learning by spanning geographic distance. However, this restricts learners to a single time of interaction. The asynchronous system on the other hand allows learners to access learning materials in their own time but reduces the learners' real-time interaction (Swan, 2003; Anderson, 2004). Swan (2003) examined several research studies of online learning and concluded that there is a relationship connecting students' perceived learning with the level of interaction with their instructors and peers.

The availability of interactive and collaborative tools such as computers, Internet, email, chat and video-conferencing encourages constructivist–based learning that aims to inspire, support and satisfy the learners' needs. Cavanaugh *et al.*, (2004) argued that when instructional delivery of distance and online learning environments are well structured with the new technological tools, they provide more effective experiences than is obtainable in face-to-face classroom learning. Larreamendy-Joerns and Leinhardt's (2006) work does not however support this assertion. They found significant differences in achievement between the students in the face-to-face learning mode and distance and online learners. Other researchers claim that learners are learning in a distance and online mode but not at the same level as those in a face-to-face mode (Vilardi & Rice, 2014).

Educational institutions are more and more moving towards using the Internet as a means of course delivery (Ally, 2004).The major technological tool used in many African countries for instructional delivery has been radio, while some others depend on satellite transmissions in addition to physical compact disks (CDs) and print and video materials (Darkwa & Mazibuko, 2000). Pitsoe and Baloyi (2015) have argued that print is used far more than any other means of delivery in the distance and online mode of learning. Countries that lack connectivity find it difficult to integrate emerging technologies in their distance and online mathematics learning. Advancement in distance and online learning is delayed when there is a lack of government support, forcing institutions to adopt mixed methods of delivery

(Beldarrain, 2006). As stated in chapter one, distance and online learning in Nigeria has been thought of as a major and vital educational advancement. NOUN as a single mode university and the Distance Learning Institute of University of Lagos (DLI/UNILAG), a dual mode university, are considered in this study. Most academic activities of the students in NOUN such as application, admission, registration and even learning are done online except for facilitation and examinations, which are still conducted at study centres. DLI on the other hand provides learning materials in print, CDs, video and on radio. They have application, admission, registration and checking of results systems online but the greater part of teaching, assessment and examinations are done face-to-face at the university.

For effective development and delivery of distance and online learning programmes, coordinated teamwork is essential. The team, which includes instructional designers, educators, online media developers and graphic designers, are expected to work together to create an effective learning environment for the learners (Davis, 2004). In cases where instructors are left without the support team (Siragusa *et al.*, 2007) some aspects of instructional design will be undeveloped. In distance and online instructional delivery, the instructor will take into consideration the learning environment and characteristics such as their previous experiences and willingness to learn. As part of effective distance and online delivery, relevant learning resources such as course materials, feedback and assessment requirements have to be made accessible to the learners (Siragusa, *et al.*, 2007). Distance and online mathematics students need the fundamental principles of the subject; hence, the learning materials the instructor presents to them have to be comprehensive, accurate and precise. The opportunity to add questions in-between online instructional delivery to clear up any mathematical doubt in learners needed to be added (Ramasamy, 2009). This plays an essential role in ensuring that learners understand the flow of concepts because any ambiguity might lead to misunderstanding the whole idea and the opportunity to deal with the ambiguity should be available.

2.5.2 Assessment in distance and online learning

Assessment is an essential part of distance and online instructional delivery. Dikli (2003) defined assessment as procedures employed to recognise the present knowledge the learners have. It does not only influence the content the learners spend time on but also influences the type of learning they engage in. Nouwens and Towers (1997) assert that the

assessment plan employed in a distance and online environment is regulated by the available delivery technologies. Distance and online assessment gives the instructors an exclusive opportunity to relate with the learners and track their academic growth (Artino & Ioannou, 2008). That is, it enables the instructor to monitor the learners' educational progress and allows the learners to conduct self-assessment to become self-directed learners. Distance and online assessment can be conceived as summative and formative.

The purpose of summative assessment is to use it to make an evaluative decision on students' learning. Arend (2007) outlined four principles that can make summative assessment effective: using multiple methods, using various evaluators, the assessment should be done over time and assessing various aspects of learning. She further stressed that formative assessment should feature teachers providing regular and exact feedback to the learners, changing course content or methods of delivery based on the assessment and feedback received from students and learners in turn acting on teachers' feedback. Any method of assessment used in a distance and online learning system requires the instructor to be clear, unbiased and consistent and to be as objective as possible (Artino & Ioannou, 2008).

Distance and online learning has the ability to create different learning and assessment environments for the learners and allows flexible methods of delivery and evaluation (Middleton & Spanias, 1999). The flexible feature of ODL allows the learners to receive timely feedback concerning their academic progress and the adjustment they need to make in their learning. Instant feedback can have a positive effect on distance and online learning practices. Bangert (2004) argues that learners seek immediate feedback on the problems they have when relating with course management tools and submission of online assignments. Distance and online delivery effectiveness is also related to the timeliness of instructors' feedback to the learners. Feedback guides the learners and makes them ready not only for the examination but for independent learning and adjustment (Sangwin, 2002; Arend, 2007). Carter (2004: 34) argues that distance and online learning assessment "carries a virtual instructional mission" that is lacking in face-to-face "paper and pencil" assessment.

Some researchers have claimed that learners in distance and online education find mathematics more enjoyable because of the freedom provided by computers in carrying out their tasks and trying out new ideas (Nguyen & Kulm, 2005). Distance and online assessment

has the ability of attracting the learners by allowing them to have independent practices leading to mathematical self-efficacy (Morgan & O'Reilly, 2001). They further claim that distance and online assessment can be taken as a "mind tool to drive and shape" (*ibid*: 185) the learners' mathematical success, interest, attitude and commitment, which enriches learning experiences.

Despite the advancement of distance and online education across institutions of higher learning, assessment of online courses still progresses at a slow pace (Rothman *et al.*, 2011). It is necessary for the distance and online learning environment to be assessment-centred (Bransford, Brown & Cocking 1999; Nguyen & Kulm, 2005). Of course, there is a risk associated in assessment-centred learning because it can increase instructor workload. Some of the strategies that can be used to reduce this risk include using computerised assessment, collaborative learning that allows the learners to document and assess their learning in groups, availability of online instructors who support and make evaluation results known and the provision of high-tech software tools to machine-score difficult and complex materials (Anderson, 2004). Research has shown that assessment via computers can underrate learners' mathematical success irrespective of their computer knowledge (Russell, 1999) due to problems such as unstable network connectivity and low network bandwidth. Yushau and Khan (2014) argue that although there is an increase in the number of universities implementing distance and online assessment, its effectiveness is still uncertain.

Various studies have investigated and supported the connection between the assessment system in a course and the learning styles of the learner (Crawford *et al.*, 1998; Prosser & Trigwell, 1999). Not only do different assessment procedures support different learning styles but according to the authors, different learning styles also bring about a different quality of learning outcomes. Hence, assessment procedures are significant in determining the learning status of the students in a course. Studies have shown that 'low talented' learners exhibit notably higher mathematical achievement when assessed using traditional classroom methods (Brewer & Becker, 2010). Hodge, Richardson and York (2009) support this assertion by stating that many learners indicated that online assessment increased their mathematical knowledge more than face-to-face paper-based assessment. Ultimately, learners in a distance and online environment liked several features of online assessment such as the option of multiple attempts, getting instant feedback, working at their own speed

and time and obtaining right answers or correction after submitting the online assessment (Sagarra & Zapata, 2008). Knowledge of assessment procedures in distance and online mathematics education will assist in interpreting the learners' learning experiences, which is the focus of this study.

2.5.3 Facilitation and support in distance and online learning environment

Facilitation in distance and online learning could be referred to as the process employed to encourage interaction or dialogue between the learners using supportive multimedia tools in order to promote online engagement and learning (Downing, Pittaway & Osborne, 2014). They further argued that using 'facilitation' in a distance and online environment is beneficial because it brings learner-centred methods to teaching and emphasises the learners' active involvement in the learning process rather than just being a passive receiver of information. Baran and Correia (2009) assert that facilitation is a joint responsibility between the instructors and the learners. The old style where the instructor has sole control of the delivery environment has changed to involve the students as fellow learners, thereby attaching more importance to the learners' autonomy as self-supported and self-directed managers of their time and the learning process. Distance and online facilitation is an avenue for the learners to create meanings by interacting with one another and combining new knowledge into their previous experiences (Rourke & Anderson, 2002). It is therefore particularly important to keep the learning experience positive for the learners.

Some researchers have outlined the challenges affecting distance and online facilitation. Bennett, Maton and Kervin (2008: 781) pointed out that in as much as the learners may be keen to use the Internet as part of their education, it seems they tend to use a "seize and grab" method to gather information. Hence, they engage in "shallow, random and often passive interactions with text, which raises important questions about what digital natives can actually do as these learners engage with and make meaning from such technology". The skills that make learners managers of today's technology are not automatically appropriate for academic study. Hence, there is a need for a facilitation framework to guide, monitor and support the learners to develop the skills required for effective distance and online learning. Asynchronous interaction in distance and online communication depends largely on text-based information, which lacks the prompt facilitator feedback, both verbal and non-verbal (such as body language or gestures), that is an important feature of effective

communication in face-to-face learning. Similarly, when using a synchronous system, there may be less non-verbal feedback, hindering the establishment of mutual understanding (Karpova, Correia & Baran, 2009; Jones, 2010).

The facilitator plays this role of engaging learners by introducing them to activities that generate discussion with and between learners and helping them to find their way around the online environment. The facilitator also shows them how to discover the regular online materials meant for study; discusses and responds at the right time to requests for help and encourages a deep approach to learning (Baran & Correia 2009; Downing *et al.* 2014). Some researchers have categorised these roles into three, namely organisational, social and intellectual/pedagogical (Paulsen, 1995; Berge, 1995). The organisational role of the facilitator is to set the agenda, purpose and methods for posting and communicating in the online discussion. Social facilitation involves strengthening the online interaction using well-constructed welcoming messages and feedback to create social connections with and among learners. The intellectual/pedagogical facilitation role is central in pedagogical terms, hence the need to use procedures that will encourage learners' responses during the interaction. The facilitator sets off the discussion, supervises the knowledge building process and guides the interactions between the distance and online learners (Vonderwell & Zachariah, 2005). Trying as much as possible to keep the group moving together will help to achieve meaningful online discussion at all times. Every participant is responsible for maintaining a viewpoint and approach that guarantees freedom of expression to ensure a safe environment for everyone to communicate his/her different opinions.

The idea of a learning initiative is not focusing on the teaching but on the learning, which is the emphasis of this study. Similarly, the focus in providing support services to distance and online learners is directed towards the learners' needs and not on what the instructor wants or is able to give, since all learners need support. The types of support needed by the learners depend on their learning styles, previous knowledge, educational goals and background, amongst others (Simpson, 2000). Understanding the needs of the learners in providing support services is paramount in helping learners to achieve the expected learning experiences. Learners themselves need to be aware of what the facilitators and institution expects from them and the kind of services they are to receive from the institution. The support service standards have to be clear and available for the learner who may be new to

distance and online learning (Hughes, 2004). Support in distance and online education includes a comprehensive range of collaborative educational activities and services aimed at assisting and monitoring the learning process of the learners. Such services according to Brindley, Walti and Zawacki-Richter (2004: 9) include,

> tutoring and teaching; counselling and advising including such services as orientation, learning and study skills assistance, academic advising, and career and personal counselling; and administrative activities such as admission and registration, library and information systems, and infrastructure support for activities such as peer tutoring and alumni organization.

Simpson (2000) defined distance and online learning support services as all activities beyond the production and delivery of instructional materials that help in the achievement of the learners in their studies. He broadly grouped support services into academic (or tutorial) and non-academic (counselling or administrative). Each of these two groups was further sub-grouped. Academic support includes,

> defining the course territory; explaining concepts; exploring the course; feedback – both informal and formal assessment; developing learning skills, such as numeracy and literacy; chasing progress, following up students' progress through the course; enrichment: extending the boundaries of the course and sharing the excitement of learning (Simpson, 2000: 6).

Simpson stressed that defining the course territory and explaining concepts are more related to the design of the course materials than being the responsibility of the tutor. He defined the activities of non-academic support as follows,

> advising: giving information, exploring problems and suggesting directions; assessment: giving feedback to the individual on non-academic aptitudes and skills; action: practical help to promote study; advocacy: making out a case for funding, writing a reference; agitation: promoting changes within the institution to benefit students; administration: organizing student support (Simpson, 2000: 7).

The non-academic support activities of advising, assessment and action are directly related to the learner. A further three that are indirectly related complements these. Tait (2000) clarified the purpose of these support activities in a distance and online learning mode and classified them as follows:

a. Cognitive: supporting and developing learning through the mediation of the standard and uniform elements of course materials and learning resources for individual students;

b. Affective: providing an environment which supports students, creates commitment and enhances self-esteem;

c. Systemic: establishing administrative processes and information management systems, which are effective, transparent and overall student-friendly (Tait, 2000: 289).

These three classifications are important in the learners' success in a distance and online learning environment. The cognitive domain enables skills and knowledge acquisition for each specific learner using the learning materials. The affective domain refers to the atmosphere that supports the learner through the provision of a social network for learning, creating a group or community with shared interests and improving the self-confidence of the learner. The systemic domain helps to create effective learner-friendly information and administrative procedures (Tait, 2000; Hughes, 2004). Support services are provided to distance and online students to reduce the dropout rate in the system, meet students' academic, social and moral demands and to reduce isolation that characterises distance and online learning systems by providing opportunities for dialogue and interaction. It is also necessary to provide support to distance and online learners to maintain quality learning and student satisfaction. Any form of support used in distance and online education must be monitored to ensure that no barrier to learning is created and that the learners are engaged in an active learning process central to their learning experiences.

2.5.4 Technology in distance and online learning of mathematics

Technology is at the heart of distance and online mathematics learning. Some of the technologies that can be utilised by the distance and online learners include television and radio, CDs and DVDs, Internet, mobile technology, electronic learning platforms, web-based technology and video conferencing (Sife, Lwoga & Sanga, 2007). Zakaria and Daud (2013) argued that Internet technology and computers are important in education because they allow flexibility in learning and enhance the students' learning experiences. Web-based course management systems (CMS), as the newest teaching platform, are an important part of the academic system in distance and online learning. For example, Modular Object

Oriented Dynamic Learning Environment (MOODLE) is one of the learning management systems (LMS) used to enable online course delivery (Suleiman, Umar & Abdu, 2012). It enables the online instructor to plan and assign activities to the learners so that the learners are engaged in discovery learning and collaboration (Zakaria & Daud, 2013). The students' understanding of the underlying principles of these technologies will help in developing mathematical ideas in them. The four learning styles this work has cited: assimilative, accommodative, divergent and convergent can better be developed in mathematics distance and online learners through proper use of technology. Instructors lacking adequate knowledge of the use of the new technology for teaching mathematics will hinder learners' full benefit of learning (Snyder, 2009). Zakaria and Daud (2013) also report that one of the challenges identified by teachers regarding the use of modern technology in distance and online learning is the lack of training in using them. The instructor adopts whichever technological tools they have to assist in developing the learners' mathematical problem solving skills. Despite the increase in the use of distance and online learning in universities, there have been very few discussions regarding the students' experiences as they relate to distance and online learning of undergraduate mathematics in Nigeria, which is the focus of this study.

2.6 Overview of ODL

2.6.1 Historical background of distance and online learning

Undoubtedly, distance and online learning have witnessed growth and changes with the development of the technological world (Colorado & Eberle, 2010). The long-term practices witnessed in this learning environment have given it future direction.

In the past, print was one of the main means of distance education. Correspondence study, as an early form of distance education, was first documented in 1728 when Caleb Phillipps delivered his shorthand courses to his students on a weekly basis across Boston in Great Britain (GB) (Bower & Hardy, 2004). The correspondence study was conducted through postal mails; there was no instructor-learner face-to-face contact and there was very little other opportunity for instructor-learner interaction (Bates, 2004). The emergence of higher education institutions offering distance education was first witnessed at the Swedish University in 1833, approximately a hundred years later, where the opportunity was granted to the students to study composition through the post (Bower & Hardy, 2004). In 1837, Sir

Isaac Pitman adopted correspondence study as the means of delivering shorthand courses to students through the post, this being made easier by the then new rural free delivery of course materials. The Phonographic Correspondence Society was formed in England, becoming the Sir Isaac Pitman Correspondence College in the 1840s (Colorado & Eberle, 2010). Charles Toussaint and Gustav Langenscheidt set up a correspondence language school in Berlin in 1856 (Holmberg, 2002).

Within a few decades, according to Matthews (1999), correspondence study was being used in Great Britain (GB), Germany, the United States of America (USA) and Japan. In GB and USA, Anna Eliot Ticknor led in the development of distance education. She initiated the establishment of a Boston-based society in 1873 to encourage homebound women to study from home by providing courses they could complete at their own pace (Simonson *et al.*, 2009). Correspondence was the mode of delivery used, with guided readings and regular examinations to ascertain the effectiveness of the delivery. In addition, the correspondence programme of Illinois Wesleyan College in 1874 and the University of Ithaca, New York, in 1883 were among the early distance education efforts in the USA. Some regard William Rainey Harper, who developed correspondence courses in Hebrew, as the father of American distance education (Bower & Hardy, 2004). He predicted that correspondence learners would eventually outnumber classroom students (Simonson *et al.*, 2009). Thomas J. Foster also developed correspondence courses in engineering for adult workers, in particular coal miners, in need of skills improvement to earn promotions in their work places. His work led to the establishment of the International Correspondence School (ICS) in Scranton Pennsylvania, which by 1894 was offering correspondence courses to students in Mexico, America, and Australia. ICS to this day continues to deliver a significant number of correspondence distance education courses known as education direct (Bower & Hardy, 2004).

The first and second generations of distance education were based on correspondence study. This was boosted by the growth of Articulated Instructional Media (AIM) of Wedemeyer and open universities (Colorado & Eberle 2010) after the Second World War. Wedemeyer, as a naval officer in the Second World War in the 1930s, used the University of Wisconsin's radio station to deliver effective English lessons and train sailors serving on ships and stations around the world through distance education (Moore, 1999; Anderson &

Simpson, 2012). Highly refined print learning materials were used as means of instruction and there was increased flexibility in learning. Bower and Hardy (2004) stated that the first generation covered the period from the 1850s to the 1960s and was mainly characterised by the use of a single technology, through print, radio or television. They describe the second generation of distance education taking place from 1960 to 1985, which used 'multiple technologies without a computer' with delivery through video and audio cassettes, television and print. Technological improvements and the relative limitations of using postal systems resulted in the use of radio transmissions and audio recordings to deliver instruction to students at a distance. Beyond this, we enter the third generation of distance learning, from 1985 to 1995 where multiple technologies such as computers and networking were used for delivery (Sherron & Boettcher, 1997).

Simonson *et al.* (2009) stated that in the 1920s approximately two hundred American radio stations delivered distance education but audio transmission reduced with the development of television, although the televising of courses was not officially effected until the 1950s. The establishment of the British Open University in 1969 indicated a modern progression in distance education. Instruction was delivered to distance learners using 'mixed-media' technology (Matthews, 1999). The introduction of satellite technology in the 1960s and fibre-optic cables in the late 1980s presented fuller exploitation opportunities for distance learning by allowing for two-way (synchronous) live transmission of learning courses.

Online delivery started in the early 1980s after Murray Turoff's invention of computer conferencing in 1970 (Hiltz & Turoff, 1978). The British Open University was one of the institutions that used an online learning method for students who were completely off-campus. This marked a new generation of distance education. In this generation, learning instructions are delivered over the networks (video-conferencing, audio and video two-way interaction, etc.) and the Internet, which is the newest vehicle through which online courses are being delivered. It allows for synchronous and asynchronous activities used to engage the learners in various forms of learning interactions (Bower & Hardy, 2004; Moore & Kearsely, 2005). Bates (2004) stated that the first web-based institution courses started around 1995 and in 1996, the University of British Columbia, in Vancouver, Canada was the first to deliver online courses over the Internet to distance learners. With the emergence of the Internet, distance and online learners have easy access to learning materials, can do

their studies at their own scheduled time and are better able to study, circumventing geographical hindrances and personal circumstances. The Internet has led to a rapid spread of distance and online learning across the globe.

2.6.2 History of distance and online learning in Africa

African countries are not being left out with regard to distance and online education. Despite the challenges in higher education recorded in most African countries (Mackintosh, 2005), the University of South Africa (UNISA) still stands out as the oldest, largest and longest standing dedicated distance and online education university in the world. Distance and online education started at UNISA in 1946, marking them as the leading provider of distance and online learning in Africa (Tait, 2008). The advent of Internet has resulted in the increased introduction of distance and online learning in most African countries (Chiumbu, 2006).

Distance education in Nigeria can also be traced back to correspondence education used in preparing students for a General Certificate in Education (GCE), which was a precondition for the London Matriculation Examination (LME) (Ajadi *et al.*, 2008). They describe this as resulting from telecommunication e-cable connections established in 1886 by the British colonial masters from Lagos. These cables stretched to the colonial office in London. By 1887, some Nigerians had been externally enrolled in the university for the LME for the first time, to study through correspondence. In 1925, a good number of Nigerians had passed the LME, more continued to obtain London degrees in 1927 and 1929 (Omolewa, 1982). The progress made in distance education in Nigeria through the British contributed to the establishment of the University of Ibadan (UI) in 1949 and by 1950 it had already started part time courses for some of their workers in the Faculty of Education (Obilade, 2012).

As distance education continued to grow, the emergence of the Internet also brought about new developments in online learning in Nigeria. Various universities, accredited by the NUC to offer distance and online learning, have different names attached to the programme. For instance, the DLI of the University of Lagos was established in 1973 and the Centre for Distance Learning and Continuing Education of the University of Abuja was set up in 1992. More recently, 2002 marked the beginning of Centres for Distance Learning at Obafemi Awolowo University, Ile-Ife and the Federal University of Technology, Yola. The National Open University of Nigeria, which was established in 1983 and suspended in 1984, was also

restored in 2002. The main aim of establishing these distance and online learning institutions in Nigeria was to increase access to convenient learning opportunities to its ever-increasing population of learners (Aderinoye & Ojokheta, 2004; Ajadi *et al.*, 2008; Obilade, 2012).

2.6.3 Distance and online learning practices and institutional modes in Nigeria

Distance and online learning has affected and influenced every segment of society as well as educational institutions and in turn has affected the teaching and learning of virtually all the courses at university-level (Ajadi *et al.*, 2008), including mathematics. The almost-daily advance in information and communication technology (ICT) has led to increases in the use of resources such as computers, printers, radio, television, e-mail and the Internet. The use of ICTs at university has brought significant changes in teaching and learning procedures throughout the world. Oye *et al.* (2011) are of the opinion that as technology devices improve, new ones were developed and created, specifically the microprocessor and personal computer, which radically changed the scenario of learning, leading to the current distance and online learning environment of today.

There are many definitions of distance and online learning. The definition of distance education given by the United States Distance Learning Association is the "acquisition of knowledge and skills through mediated information and instruction, encompassing all technologies and other forms of learning at a distance" (Bower & Hardy, 2004: 5). Greenberg (1998: 36) defines present day distance learning as "a planned teaching and learning experience that makes use of a wide range of technologies to reach learners at a distance and is designed to encourage learner interaction and certification of learning". Keegan (1995) on the other hand gives the most thorough definition of distance learning which is adopted in this work. He states that distance education and training results from the technological separation of teacher and learner, which frees the student from the necessity of travelling to "a fixed place, at a fixed time, to meet a fixed person, in order to be trained" (Keegan, 1995: 7). Hence, the teachers and learners are separated from each other but interact through appropriate technologies. Furthermore, online learning can be referred to as the use of technology to enhance and promote teaching and learning procedures. According to sources in Colorado and Eberle (2010: 5), online learning is defined as "an open and distributed learning environment that uses pedagogical tools, enabled by Internet and web-based technologies, to facilitate learning and knowledge building through meaningful action and

interaction". Online learning can also be called e-learning, e-training, or web-based instruction and the courses taught via this platform have online components. Cavanaugh *et al.* (2004) identified some attributes of distance education experiences that affect learners' performance and achievement. These include the time spent in the programme, the role instructional delivery plays in the programme, instructors' role, the number and length of meetings, instructors' preparation for distance instructional delivery, the best moment for online interaction and the frequency of interaction, amongst others.

The establishment of open and distance learning (ODL) in Nigeria and its rapid acceptance by a number of institutions has been quite remarkable within the last decade (Reju, Alaneme & Olayiwola, 2009). It has given learners, teacher/tutors and indeed all stakeholders extra freedom to manage and transform education through technology. The implementation of distance and online learning in Nigeria has helped to a certain extent to meet the tertiary education vision, expand the boundary of knowledge and transform society by providing access to lifelong education to learners who, due to various reasons, are not able to enrol in full-time face-to-face programmes at the higher education institutions. The distance and online mode of learning has made learning more convenient and flexible in terms of time, distance, age, place, pace and all it offers. One of the main problems with distance and online education is that its practices have evolved from conventional teaching and learning and its application tends to involve variations and copies of face-to-face teaching rather than practices developed from a 'green-field' approach (Collis & Moonen, 2001).

Distance and online learning practices in Nigeria take the form of single and dual modes. NOUN was first launched in 1983 and was suspended by the then military government in 1985 but was re-launched by President Olusegun Obasanjo in 2001 to provide education to students at a distance. In Nigeria, the NOUN was rejuvenated in 2002 and is the only accredited single-mode university, providing open and distance learning education in the country (Osang, 2012). The NOUN, as of 2015, had fifty-two (52) study centres spread across the country. Most academic activities such as application, admission, registration and even learning are done online, except facilitation and examination, which are done at the study centres for now. Although the National Teachers' Institute (NTI) was also introduced as a single mode distance education institution in 1976, with the support of UNESCO, it majored in training grade two teachers (TC II). When, in 1990, the Nigerian Certificate in

Education (NCE) programme was introduced to be a minimum teaching certificate in Nigeria, NTI took up the training of grade two teachers (TC II) to teach pupils in primary schools. The institute also introduced the Postgraduate Diploma in Education (PGDE) in 2005 to train teachers with a Bachelor's degree or Higher National Diploma (HND) qualification but without a professional education background fit into the teaching profession (Ajadi *et al.*, 2008; Reju *et al.*, 2009).

The dual mode institutions in Nigeria approved by the NUC include the University of Lagos (UNILAG), the University of Ibadan (UI), the University of Abuja, Obafemi Awolowo University, Ile-Ife (OAU), the University of Maiduguri (UNIMAID) and the Federal University of Technology, Yola (FUT, Yola). At its inception, the University of Lagos had the aim of running distance and online education programmes and to actualise this aim, a Correspondence and Open Studies Unit (COSU) was established in 1973. This was later changed to the Correspondence and Open Studies Institute (COSIT) in 1983 and then the Distance Learning Institute (DLI) in 1997, the name it still bears. DLI initially began offering programmes in science education at a first degree level in biology, chemistry, mathematics, physics and a Postgraduate Diploma in Education (PGDE) for degree holders who did not possess teaching qualifications (Ajadi *et al.*, 2008).

Akinpelu (1982) stated that the Department of Adult Education at the University of Ibadan first proposed the need for distance learning in 1960 but adopted the name Distance Learning Centre (DLC) in 2002 from its earlier identity as the Centre for External Studies (CES). Distance and online education at the University of Abuja, located in the Federal Capital Territory (FCT), is as old as the university itself. The university was established in 1992 with distance and online education managed under the Centre for Distance Learning and Continuing Education (CDLCE). OAU and FUT Yola established their Centres for Distance Learning (CDL) in 2002. This was in response to Nigeria's increasing need for higher education. UNIMAID was among the second generation universities established in 1995. The seventh vice-chancellor of the university set up a ten-man committee on distance learning, which submitted their report in 2003 and led to setting up the CDL. This made the university an institution providing conventional academic programmes and by way of distance learning. One of their core objectives, similar to other distance learning institutions in Nigeria and elsewhere, is to provide access to university education to a large number of

potential adults who have missed the opportunity of higher education at earlier stages of their lives.

The dual mode institutions in Nigeria have similar methods of operation. They all still use face-to-face modes as the major method of delivery. They provide learning materials in print and on CDs but not in all the courses. Some, such as UNILAG, have their application, admission, registration and checking of results done online but part of the teaching, assignment and examination are done face-to-face. This is not entirely in line with the mission and vision of distance and online education in Nigeria. As distance and online learning providers, they are expected to consider the need for learner support services and to use appropriate technologies to satisfy the needs of the learners.

In Nigeria, students who engage in distance and online learning are mostly adult workers, women or people marginalised and living in a remote area. In some instances, they are learners who were unable to secure admission to conventional universities due to limited spaces (Ambe-Uva, 2006; Adesoye & Amusa, 2011). Literature on distance and online learners in Nigeria is somewhat inconsistent. Ambe-Uva (2006) and Ukpo (2006) stated that these learners are mainly in their 30s but Ojo and Olakulehin (2006), who studied attitudes and perceptions of students to open and distance learning, indicated that ages range between 24 and 65. They also pointed out from the same study that the majority of distance and online learners were unemployed (*ibid*) compared to the findings of Ambe-Uva (2006) and Ukpo (2006), who stated that the majority of learners were employed full-time or were part-time workers. This study, based on students' experiences with distance and online mathematics learning in Nigeria using DLI and NOUN, is intended to contribute to this debate.

2.6.4 Applications and benefits of distance and online learning

The benefits of online learning are related to those generalised through all distance learning (Colorado & Eberle, 2010). Provision of instructional course material is considered the lifeblood of distance education. Quality is ensured since the preparations of distance learning materials are done in a team involving experts in that field, unlike face-to-face teaching where teachers are expected to individually prepare for their own lessons. The involvement of teams in material preparation offers them the opportunity to produce high quality materials

that are used within and perhaps throughout the distance and online learning system. One approach to distance and online learning is the separation of teacher and students in time or place or both. In order to use this approach effectively, mixed media such as print, television broadcasts, radio lessons, video and audio cassettes, telecommunications and computer-based learning are used.

Distance and online learning allows learners to achieve their educational objectives at affordable costs because it is a means of attending school without necessarily leaving their places of work. For employers, distance and online learning offers the possibility of organising in-service training for their staff without necessarily releasing them for long periods. With a sufficient number of employees being trained, distance and online learning is often the most cost-effective means (Ojo, Ogidan & Olakulehin, 2006). Hence, distance and online learning offers more freedom of access and a wider range of opportunities without affecting the normal learners' schedule for learning and qualification. This is because it knows no time zones, while location and distance are not a problem (Ally, 2004). It also provides the learner economies of scale by expanding the enrolment rates, which lower the unit cost per learner.

In distance and online learning, the learners can access the learning materials at all times through asynchronous online learning while they can interact with their peers and instructor in real time through synchronous means. Relevant and up-to-date materials can be accessed using the Internet and the students can communicate with experts in the field of their studies.

These benefits are summed up by some researchers to include enhanced learning experiences of the students, efficient management through LMSs, accessibility, convenience, innovative course materials, transformed teaching, opportunities to access multiple learning resources, flexibility, cost, increased efficiency, increased enrolment and crucially, the opportunity for collaboration among the students (Sife *et al.,* 2007; Colorado & Eberle, 2010; Bichsel, 2013). Distance and online learning is accessible to non-traditional learners such as prisoners, offshore oil workers and the military (Okoronkwo & Jegede, 2010). Okoronkwo and Jegede (2010) further stated that ODL is suitable for marginalised and under-represented groups such as full-time homemakers, women in certain cultures, physically challenged persons, nomadic cattle farmers, fishermen and rural or remote dwellers. It gives the learner skills, autonomy and independence for lifelong learning.

Distance and online learning is gradually gaining importance in many institutions in developing countries because it is recognised as a cost-effective way to increase access to university or higher education. In most cases, the advancement of distance and online learning by institutions of higher learning is mostly perceived as a matter related only to such institutions. Some countries have established national initiatives for distance and online learning (e-learning) with the goal of delivering education to students that cannot attend lectures due to distance and time limitations and to enable more students to access higher education at a lesser cost. Bichsel (2013) is of the opinion that practically all institutions have at least some units, departments or even programmes with a main interest in e-learning. She also identified further benefits such as institutional enrolment expansion, increased revenue, reputation enhancement and restructuring of curricula derived from offering distance and online learning programmes which utilise different approaches in organising and managing the distance and online learning services and technological tools.

Distance and online learning can be offered through single, dual, mixed and virtual modes of learning (Okoronkwo & Jegede, 2010). This study will be limited to single and dual modes. The single mode is where instruction and facilitation are purely done at a distance (Okoronkwo & Jegede, 2010). Examples of single mode distance learning institutions are the Open University of the UK (UKOU), Indira Gandhi National Open University (IGNOU) in India, NOUN and UNISA. Single mode institutions are wholly dedicated to offer distance and online learning forms of education. They have total control over their own curricula and there is no institutional barrier to developing pedagogy and new modes of learning. However, they may face challenges involving funding, especially upon start-up.

Dual mode universities on the other hand are those that offer distance and campus-based programmes of study (Aguti, 2009; Muyinda, Lubega & Lynch, 2009). The institution offers programmes of study as either distance/external or face-to-face/internal learning programmes or both. Usually, the curriculum for a programme being offered in either mode, face-to-face or distance is the same. However, the time for completing the programme may be slightly longer or flexible on the distance programme (Muyinda, 2012). The existence of distance/online and face-to-face modes of learning in the same institution might present institutional barriers in the development of a new pedagogy for distance and online learning, which could conceivably negatively affect the distance and online learning students.

Examinations and regulations are generally applied in the same way to both types of learners in dual mode institutions. Okoronkwo and Jegede (2010) stated that distance education within an existing institution might be treated similarly to an orphan child under the care of a cruel stepmother, particularly when a number of issues are competing for restricted funds. Examples of dual mode institutions are the University of Lagos, the University of Ibadan, the University of Buea in Cameroon, Namibia University of Science and Technology (NUST), the Open Learning Institute of Charles Sturt University, the University of Nairobi, the University of Botswana and the University of Zambia.

The following table demonstrates how the concepts of flexibility of time and place characterise ODL practices. The time and place coordinates are numbered and match four scenarios for open and distance learning.

Table 2.1: The concept of time and place

	Same place	**Different time**
Same place	Classroom teaching, face-to-face tutorial and seminars, workshops and residential schools	Learning resource centres that learners visit at their leisure.
Different place	Audio conferences and video conferences, television with one-way video, two-way audio, radio with listener-response capability and telephone tutorials.	Home study, computer conferencing, tutorial support by e-mail and fax communication.

Source: (COL, 2000)

Distance and online programmes go along with two scenarios of time and space. The same place coordinate at one end has the learners and instructors gather at a place to learn and at the other end, they are at different places for the same purpose of learning. The time coordinate has at one end the learners and the instructors interacting at the same time (synchronous) and at the other end, all of them are interacting at different times (asynchronous). Different media as (represented in table 2.1) are used to communicate learning in each of the coordinates and these helped to increase flexibility in learning through this mode. Most open and distance learning providers use a combination of the four scenarios shown in table 2.1.

2.6.5 Challenges of distance and online learning

In spite of the noticeable benefits of distance and online learning in the teaching and learning experiences of students in higher education, the system still faces many challenges in carrying out these processes. Carver *et al.* (2007) argued that despite the speedy growth of experiences in distance and online learning, the challenge is that it is hindered by classroom styles of learning. The issues discussed here are challenges facing distance and online learning in general and in Nigeria in particular.

Teaching quality or instructional delivery in distance and online education is paramount and cannot be compromised. Quality in most cases depends on the attitude of the ODL institutions, the teachers and the learners themselves. Doug (2002) states that data collected in a 1999 study by Elliot Inman and Michael Kerwin indicated that teachers had conflicting attitudes about teaching distance education. They reported that many were eager to teach again after teaching a course but rated the quality of the course taught to distance and online learners as equal or lower in quality than courses taught face-to-face. It appears as if the teachers have confidence that the technology on its own will enhance the quality of the class but "technology does not teach students; effective teachers do" (Palloff & Pratt, 2000). They pointed out that technology is not what matters but the design and delivery of distance and online courses matter. Most of the time, distance and online learning teachers do not design the course materials using the most appropriate technologies. This affects the quality of teaching and learning. The teachers should understand the students' needs while designing the learning materials for maximum effective impact in the whole distance and online learning experience. Teaching distance and online learning students demands skills and pedagogies different from those used in the traditional, face-to-face environment (Bower & Hardy, 2004).

As stated by Murphrey (2010), the character of distance and online course delivery poses challenges in relation to building experiential experiences. The experiential study comparing face-to-face and online course delivery conducted by Karatas and Simsek (2009) indicates that limited time for online learners to state their thoughts and to read and write on computers are the possible reasons they score slightly lower than the students in the face-to-face learning mode.

Funding of distance and online education is an important factor in the implementation of the programme in the institutions of higher learning. Researchers have shown that the potential cost-effectiveness of using online technologies in distance education is still uncertain and that the ideas of costs and effectiveness are not as simple as they first appear (Ng, 2000: 306; Doug, 2002). Ng (2000: 306) further noted that "it is possible for a programme to be efficient but not cost effective if the outputs which are actually produced do not contribute to the programme objectives" and students' experiences. Areas that require funding include start-up capital, training of teachers and technicians; and acquiring and maintaining technological equipment. It can be quite costly to acquire multimedia equipment for distance and online courses, especially that which needs to be imported and has been designed to suit a different system (Ajadi *et al.*, 2008: 68; Adu *et al.*, 2013: 208).

Research has identified technology as a serious challenge in accessing distance and online learning programmes. Apart from the cost involved in acquiring technology, there is also the possibility of underutilisation of its potential by untrained teachers. Availability of Internet connectivity to access distance education courses and information that would lead to entering an educational programme is also vital. Ajadi *et al.* (2008) are of the opinion that the cost of accessing the Internet is still very high in West Africa compared to what is obtainable in other developed countries. Furthermore, not every distance and online learner has access to personal computers (PCs) in their homes, thereby making them rely on shared computers at local community or learning centres, where available, (Kawalilak *et al.*, 2012) at high costs. Lynch (2006) stated that access to technology is increasingly a fundamental issue in terms of a fair distribution among distance and online learners. The representation seen in developed countries is that of increasingly technology-rich schools where learner-to-computer ratios are favourable. In spite of this positive assertion, studies have shown that there are many areas where the familiarity and confidence with technology of students in countries such as the USA and Australia were also limited (Kennedy *et al.*, 2006). It is asserted that in developing countries with problems of unstable electricity and communication infrastructure, distance and online mathematics learning are not likely to be as effective (Hawkridge, Jaworski & McMahon, 1990; Lynch, 2006). Some have put the number of computers in Africa in the population as low as 1:500 (African Internet Status, 2002).

Technicians play a considerable role in the practical delivery of distance and online courses but Doug (2002) stressed that staff levels are often insufficient to maintain the system; this makes it costly for the few students with PCs to maintain them when a technical problem arises.

Kawalilak *et al.* (2012) argued that the educational system does not make adequate provisions to accommodate the unique learning styles of distance and online learning students. They stated that simply providing technological access to distance education programming is not sufficient to ensure learners' success but that cultural sensitivity to learning styles and linguistic traditions of online learners are important. Other challenges faced in the delivery of distance and online education are summarised by some researchers to include mass unawareness, low computer literacy levels, energy related problems and teachers and students' attitudes towards the technology of distance and online learning environments (Doug, 2002; Ajadi *et al.,* 2008; Kawalilak *et al.*, 2012). Other researchers identified a lack of feedback, frustration with the use of technology and anxiety (Chen, Bennett & Maton, 2008; Miller & King, 2003) as factors influencing distance and online learners' experiences.

2.7 Distance and online mathematics learning in Nigeria

Mathematics as a science of numbers and space has been expressed as a pillar of almost all the streams in academic and human development to deal with the challenges of life (Tsanwani, 2009; Salman *et al.*, 2012). It helps to empower people and provides a basis for other courses, especially in engineering and other related technical subjects. Despite all the usefulness of mathematics, it is still considered a difficult and abstract subject involving symbols and multiple ways of presenting its concepts, especially for adult learners. Awokoya (1975) and later Fafunwa (1980) as cited in Salman *et al.* (2012: 80) argued in their different research studies that, "everyone lives in a world where science and technology have become an integral part of the world culture, therefore for any nation to be relevant; it must not overlook the importance of mathematics in her educational system". In light of this, the distance and online learning institutions in Nigeria offering mathematics at university-level are expected to ensure well-measured quality programmes in mathematics. Little existing research focuses on the distance and online mathematics students in general but especially those of large Nigerian universities such as the University of Lagos and the National Open

University of Nigeria. This study is aimed at providing further insight into ODL by exploring students' experiences with mathematics learners in this mode of learning. The lessons concerning distance and online learning of mathematics may well not be particular to the Nigerian situation only.

Effective pedagogy, associated with distance and online teaching and learning of mathematics, will lead to the achievement of learning purposes. Learning progress is highly dependent on the teachers' content-related knowledge. Studies have shown that an "in-depth training in teacher education, professional development, and teacher self-study are positively related to particular categories of content-related knowledge" (Großschedl *et al.*, 2014: 2335). Technology, pedagogy and content are the most important forms of knowledge the teacher needs in order to use technology effectively in the distance and online learning environment. What the teachers of mathematics do to influence the mathematical ability of the distance and online students depends on what they experience and believe about the distance and online mathematics themselves. This in turn relies on their understanding about the teaching and learning of distance and online mathematics. Studies have shown that teachers' resistance to integrating technology into mathematics classes for distance and online learning was associated with their beliefs about mathematics teaching and learning and their existing pedagogies (Niess, 2006). If their content-related knowledge is weak, it will reflect on the kind of students they will produce. Hence, the relevance of Polya (1965) who pressed mathematics teachers to teach people to think, indicating that mathematics teachers should not merely pass on knowledge to distance and online learners but try to develop the ability of the students to use the knowledge they impart.

Distance and online learning of mathematics through technology has become necessary for students in our world of today. The teachers apply its uses in diverse ways to develop and improve distance and online mathematics learning. The NCTM's (2000) emphasis on distance and online learning standards is that technology can facilitate mathematical problem solving, communication, reasoning and proof, as well as provide students with opportunities to deal with various representations of mathematical ideas and support them in making connections within and outside mathematics (Niess, 2006). Research has shown that the identification of students' learning styles and adapting such in distance and online learning is vital. This suggests that the effectiveness of distance and online mathematics

delivery to students depends considerably on the nature of students' learning activities, the amount and engaged learning time experienced by the students, the learning environment and the quality of feedback provided to the students. The teacher should be able to create a pleasant, relaxed and controlled environment in the classroom for students' effective mathematics learning. The general pedagogical knowledge (GPK) according to Shulman (1986: 8) comprises those broad principles and classroom management strategies and organisation that go beyond the subject matter, which the teacher needs to integrate in distance and online learning of mathematics.

Another important feature of distance and online learning of mathematics is the identification of successful teaching strategies requiring an organised approach to teaching, where material is taught until it is mastered. This is in line with the depth and breadth study of Schwartz *et al.* (2008a). Though depth of study is accepted more among the researchers, many still argue that the breadth of study will better serve the learners. Schwartz *et al.* (2008a) have stated that in spite of lengthy past accounts of depth and breadth studies, little experimental literature exists that supports either method or places one above the other. My position in this case is that distance and online teachers should apply their experiences and professional judgement in deciding the best strategy to enable students to achieve maximum learning experiences. Some argue that educational standards may not be enhanced only by mere provision of educational resources such as books, infrastructure and other learning resources but by teachers' understanding and interpretation of the learning styles of the students and thereby appropriately adapting teaching and learning methods to match those learning styles.

Further discussions on distance and online mathematics place the teachers at the centre of the discussions. They have the role of imparting knowledge, skills, attitudes and mathematical concepts to the learner using technological tools. This still stresses the importance of the content-related knowledge of Großschedl *et al.* (2014) in teachers' teaching. A study by Makewa *et al.* (2012) has shown that most teachers teaching distance and online mathematics are not trained and lack expertise in using technology for teaching. This is the reason why teacher training is essential to improve teachers' understanding and to prepare them to adapt to the online learning of mathematics. Darling-Hammond and Ball (1998) in their research work found that teachers who spent more time studying teaching

were more effective overall and strikingly so, in developing higher-order mathematical thinking skills in students. Hence, they need technological advancement and the employment of teaching strategies to be able to promote a high level of student participation and involvement in distance and online mathematics learning.

Again, the school environment plays an important role in distance and online mathematics learning. It involves leadership, a professional community, programme planning, consistency and appropriate teaching resources to be available for the students (Newman, King & Youngs, 2000). The support of institutional leadership is crucial in establishing and providing a favourable environment and good conditions for teaching and learning to take place. Newman *et al.* (2000) are of the opinion that programme planning and consistency are the extent to which the school's programmes for students and staff learning are coordinated. They focus on clear learning goals that can be sustained over time. The professional community according to Ingvarson *et al.* (2004) is the mutual relationship that exists between teachers within a school or a department in larger schools. It involves collaboration at different levels to enable effective learning.

The observation of Ali (2008) that a lack of empirical proof on the benefits of distance and online education makes it difficult to determine its progress, is not limited to distance and online learning in general but is also applicable to the study of specific subjects such as mathematics. Very little research has been conducted (especially in developing countries such as Nigeria) to explore distance students' experiences with specific university subjects in general. Although there is clear evidence that distance and online education is used abundantly in Nigerian universities, there is a lack of research on the conditions and experiences of learning mathematics through distance and online modes. How these experiences occur among learners in dual and single mode institutions are yet to be ascertained. This study sets out to fill these gaps.

2.8 Chapter summary

The literature review in this chapter focussed on the students' experiences with distance and online learning of university undergraduate mathematics in Nigeria. Three theories namely, Kolb's (1984) experiential learning theory (ELT), Moore's (1972) transactional distance theory (TDT) and Mayer's (1999) cognitive theory of multimedia learning (CTML) serve as

lenses to understand mathematics students' learning in this environment. The literature review also provided an overview of other attempts to address issues associated with distance and online mathematics learners. In the context of this study, instructional delivery, assessment, facilitation and support services were elaborated on. Some historical background of distance and online learning was given and there was a discussion on the perceived practices for distance and online learning and institutional modes in Nigeria. The research methodology and design that guided this study are discussed in the next chapter.

CHAPTER 3

Research methodology and design

3.1 Introduction

In this chapter, I present a comprehensive research description of the methodology used to investigate the questions raised to direct this work. The research questions that guide the work are as follows:

i. What are the students' experiences with instructional delivery in the distance and online learning of university-level mathematics?

ii. How do assessment procedures shape the students' experiences with distance and online learning of university-level mathematics?

iii. How does learning facilitation influence the students' experiences in distance and online mathematics education at the university?

iv. How do support services, using newer and/or advanced technologies affect the students' experiences with distance and online learning of mathematics at the university?

v. How can the university-level mathematics students' experiences with instructional delivery, assessment, facilitation and support in distance and online environments be understood and/or explained?

vi. What suggestions can be made to enhance the students' experiences with university-level mathematics in distance and online environments?

The main objective of this study is to examine the students' experiences with distance and online learning at university-level undergraduate mathematics in the two main ODL institutions in Nigeria. The broad objectives that guided the study were firstly examining the students' experiences with distance and online learning at university-level mathematics in two major Nigerian universities with respect to instructional delivery. The second objective was to explore how assessment procedures shaped the students' experiences with distance and online learning of university-level mathematics in Nigeria. Thirdly, to assess how learning facilitation influenced the students' experiences in distance and online mathematics education at university-level in Nigeria. Fourthly, to identify support services using accessible

and advanced technologies that affect the students' experiences with distance and online learning of mathematics at university-level in Nigeria. Fifthly, to explore how university-level mathematics students' instructional delivery, assessment, facilitation and support in distance and online environments can be understood and/or explained and finally to suggest how students' experiences with university-level mathematics in distance and online environments can be improved in ODL institutions in Nigeria.

In order to achieve the stated objectives of this study, I determined the specific methodology, strategy and design that would help me to collect as much data as possible to answer the research questions. This chapter begins with a short explanation and justification of the research paradigm and research approach used in this study. The chapter then further discusses the research design, sampling procedures, data collection approaches and instruments, methods of data analysis, pilot study, rationale and ethical issues. A chapter summary is provided.

3.2 Paradigm and approach of the research

The research paradigm is discussed first before the research approach.

3.2.1 Research paradigm

Many researchers define the concept of a research paradigm, which was popularised by Kuhn in 1962 as the "basic belief system or worldview" that guides the researcher's investigation (Creswell & Plano Clark, 2007; Teddlie & Tashakkori, 2009). According to Schwandt (1989), problems arise if the elements that characterise the worldview, as seen in the definition of a paradigm, are not explicitly specified. The worldview in this research was primarily focused on the students' experiences with distance and online learning of university-level undergraduate mathematics in Nigeria. Creswell and Plano Clark (2007) and Teddlie and Tashakkori (2009) identified positivism, post-positivism, constructivism, transformation and pragmatism as the more common research paradigms in quantitative and qualitative research. The transformative paradigm and pragmatism are suited to mixed methods research, which this study focused on (Hall, 2012). Pragmatism, which has gained significant support in mixed methods research, focuses on solving practical research problems rather than just concerning itself with assumptions about the nature of knowledge (Johnson & Onwuegbuzie, 2004; Feilzer, 2010). Since quantitative and qualitative approaches can draw support from pragmatism, some elements of pragmatism are used

while conducting this study. Objective and subjective positions are maintained by applying a combination of different views in interpreting the data (Guba & Lincoln, 2005; Saunders, Lewis & Thornhill, 2009). The key issue is to identify the nature and quality of the experiences students have through distance and online learning environments and what the outcomes are from the learners' perspectives. The aim in using pragmatism as a guiding paradigm is to contribute to existing work and to give suggestions on how pragmatism enables research to be conducted on students' experiences and how the use of qualitative and quantitative approaches helps to answer complex practical research questions.

3.2.2 Research approach

This study adopts a mixed methods approach for data collection. Questionnaires, interviews and documents are used. It uses qualitative and quantitative strategies in data collection and analysis that are appropriate in a sequential design (Saunders *et al.,* 2009). In a mixed methods approach, the nature of research questions initiates the choice of the methods to be used. Johnson and Onwuegbuzie (2004: 17-18) define mixed methods research as follows

> ...the class of research where the researcher mixes or combines quantitative and qualitative research techniques, methods, approaches, concepts or language into a single study. Mixed methods research also is an attempt to legitimate the use of multiple approaches in answering research questions, rather than restricting or constraining researchers' choices.

In this study, a quantitative approach was used to determine the level of access to technology that affects the delivery, facilitation, assessment and support services that influence students' experiences with distance and online learning of mathematics at university. The qualitative approach on the other hand, was used to explore how these experiences occur and how they are characterised by students. Both approaches are meant to complement each other's findings. Together they strengthen, detail, expand and develop the analysis for further provision of fresh insight in the study (Rossman & Wilson, 1991). Caracelli and Greene (1997) also noted that mixing qualitative and quantitative methods allows the researcher to test the agreement of findings obtained from the various measuring instruments to explain the results of one method using another method and to establish how inferences can be drawn from the results.

3.2.2.1 Qualitative research

Qualitative research has been defined by many researchers and defies a single definition. Myers (2009) stated that qualitative methods are useful in helping the researchers understand people and the social and cultural contexts where they live. Kaplan and Maxwell (1994) argued that the understanding of the participant's social and cultural context is lost when the textual data is itemised. Qualitative research focuses on discovery, conceptualisation and understanding of experiences of the participants and uses numbers in a minimal way (Kura, 2012). Denzin and Lincoln (2000: 3) provide the most cited definition of qualitative research, stating that,

> Qualitative research is a situated activity that locates the observer in the world. It consists of a set of interpretive, material practices that makes the world visible. These practices […] turn the world into a series of representations including field notes, interviews, conversations, photographs, recordings and memos to the self. At this level, qualitative research involves an interpretive, naturalistic approach to the world. This means that qualitative researchers study things in their natural settings, attempting to make sense of, or to interpret, phenomena in terms of the meanings people bring to them.

The unique characteristic of this method is the importance given to the naturalistic and interpretive approach to the individual understanding of meaning within social contexts. Its unique feature is also seen in the use of non-statistical data to arrive at results and conclusions (McNabb, 2004). Since qualitative data are not usually numerical, statistics cannot be used in analysing it. The beauty of this is that data are presented in words using descriptive narration while attempting to understand events in 'natural settings' (Denzin & Lincoln, 2000). Events are studied in their natural settings and interpretations are given in terms of the meaning the participants bring to the events. In this research, non-statistical techniques and processes were applied to collect data regarding the students' experiences with distance and online learning of mathematics. Data collection on the qualitative research aspects of this study was conducted using interviews, documentation/open-ended survey questions and observations of the group (Yin, 2003). Semi-structured interviews and open-ended survey questions were used to allow the interviewees (students) the freedom to elaborate on their experiences with distance and online mathematics learning (Mathers *et al.*, 1998).

From the discussion on qualitative research, its features and strengths, as they relate to this study on the students' experiences with distance and online learning of mathematics at university are as follows:

a)   The use of a qualitative method in this study helped to provide a deep and interpretive understanding of the delivery, facilitation, assessment and support services issues, allowing the development of a deeper insight into students' experiences with distance and online mathematics learning.

b)   Provision for the effective use of small-scale samples that are purposefully selected using relevant standards was deliberate. Ten (10) third year mathematics students were drawn from two (2) different ODL institutions used in this study to measure students' experiences with distance and online mathematics learning.

c)   Data collection (interview, documentation/open-ended survey questions and observation) involved close contact and interactions between the researcher and participants and allowed for a careful investigation of the experiences encountered by mathematics students' learning through the distance and online mode.

d)   Data analysis made it possible to correlate the different factors and ideas that emerged from the respondents, detailed narration and interpretation is given concerning students' experiences with distance and online learning.

e)   The results and findings are based on the interpretation and representation of collective meaning from the distance and online learners that were studied.

The above discussion shows how qualitative research methods added to the present study of students' experiences with distance and online learning of university-level undergraduate mathematics.

3.2.2.2 Quantitative research

Quantitative research is also defined in different ways by different researchers. Concisely, Creswell (1994) defined quantitative research as a type of research that explains phenomena through the collection of numerical data that are subsequently analysed using mathematical methods. Therefore, it uses the language rules of mathematical operations to represent data

in a numerical form (Abbas, 2006). Unlike a qualitative approach, quantitative approaches are deductive, deterministic and experimental in nature. They are guided by the statement that human behaviour can be described by 'social facts' capable of using deductive reasoning (Horna, 1994). It is often described as deductive because the inferences from the statistical tests based on a sample are used to draw general inferences about the wider population in the study (Harwell, 2011).

Statistical tools are employed in the collection and interpretation of data. Surveys and questionnaires are the main methods of quantitative data collection employed by this study, leading to a determination of the traits of the population being studied. The essential aim is to be able to generalise the facts found in the samples to the population (Sukamolson, 2007). Quantitative research greatly depends on reliability and validity in order to guarantee its duplicability and generalisability. Reliability is related to dependability of measures. In this study, data triangulation worked as a reliability measure. It should be noted that all the research procedures used in this study can be retrieved and analysed by external evaluators and have been kept by the researcher. Validity is concerned with the degree to which the research reflects the social experience being studied (Wahyuni, 2012).

In this study, the use of qualitative and quantitative methods helps to increase the validity of the research because one method checks the other. Furthermore, data collection from multiple sources supports the validity standard of the research findings. Harwell (2011) stated that quantitative research tries to make the best use of objectivity, duplicability and generalisability of the results to make predictions. He further stressed that the researcher's experiences, views and biases should be set aside in order to achieve objectivity when conducting research. With all the strengths found in quantitative research methods, it is still seen as overlooking the reality of the social world of the participants. Numbers alone, without the involvement of qualitative explanation, cannot provide a complete explanation of research events (Kura, 2012).

3.2.2.3 Integration of a qualitative and quantitative research approach

The integration of qualitative and quantitative research methods emphasises and strengthens facts, reliability, applicability and objectivity while using various research procedures to guarantee quality (Lincoln & Guba, 1985). There are clear benefits associated with the integration of the two approaches. O'Cathain, Murphy and Nicholl (2010) suggest

that data collected while using qualitative research methods can be employed to assess the validity of quantitative results, leading to the formation and refinement of quantitative data. Data collected from a quantitative approach can equally be used to produce the qualitative sample or explain results from the qualitative data. Despite the benefit of integrating qualitative and quantitative research methods, the extent to which mixed methods studies effect the integration is still inadequate (Bryman, 2006; Lewin, Glenton & Oxman, 2009). The integration of approaches can be done at different points in the research such as the methodology, data collection, analysis, interpretation of results etc. (Fetters, Curry & Creswell, 2013). Exploratory sequential, explanatory sequential and convergent are the three basic designs that are involved in integrating qualitative and quantitative research methods. This study used the explanatory sequential design, which is discussed in the next section.

3.3 Mixed methods research design

Research design can simply be defined as the plan of research that directs how a study can be conducted. This study used an explanatory sequential design as described in Creswell (2003). It involved collecting quantitative (numeric) data using a survey instrument in which theories are tested. This is followed by interviews, which are used to collect qualitative data for a detail exploration of numeric data. Through an explanatory sequential design, qualitative data are used to improve, complement and in some instances, follow up on unexpected quantitative results (Harwell, 2011). The explanatory sequential design in this study focused on interpreting and explaining relationships between the variables, which are students' experiences of distance and online learning of mathematics as it relates to experiential learning theory. The study proceeded based on the explanatory sequential design in the following stages: collection of quantitative data (through a questionnaire) followed by gathering and analysing qualitative data (collected through a semi-structured interview and open-ended survey questions). The aim is to use the findings of the quantitative data to explain and interpret the findings of the qualitative data (Creswell, 2003). Hence, qualitative and quantitative data are not integrated or mixed in the data analysis process but are integrated at the point of interpreting the findings. The idea of separating data collection and analysis of qualitative and quantitative data are considered strengths in this study because this procedure was easy to conceptualise, explain and narrate and was

reasonably simple to manage. The weaknesses of this method lie in the time and resources that were involved in collecting the separate data sets.

3.4 Data collection approaches and instruments

The main data collection techniques used in this study was questionnaires, interviews, documenting and audiotaping. Specific instruments used for data collection were closed and open-ended questionnaires, semi-structured face-to-face interviews followed by documentation of the interviews. The semi-structured face-to-face interviews were recorded and were conducted with a sample of students (see section 3.4.3) that filled in the questionnaire. The questionnaire was analysed using statistical methods and the interviews, documents and recorded tapes were used to generate narrative data in the form of word-for-word transcripts and interview summaries.

3.4.1 Data collection approaches

The study adopted a mixed approach in data collection (questionnaires, interviews and interview documentations). The sampling strategy best suited for this study is purposive sampling as it is a non-probabilistic sampling method (Cohen *et al.*, 2007). In this study, one dual mode institution and the only single mode institution in the country was used. Purposive sampling was used to ensure that only third year students studying mathematics in distance and online modes were selected. Therefore, the purposive sampling method helped the researcher to understand the situation and to recognise and distinguish the needs of the group being researched. It also aided in selecting a group with specific characteristics (such as active duration of study and course of study) that were important for the study.

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          ┌─────────────┐       ┌─────────────┐
          │    NOUN     │       │     DLI     │
          │ • Single mode│       │ • Dual mode │
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                  │ Third year mathematics│
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    ┌────────────────────────┐  ┌────────────────────────┐
    │ Semi-structured interview│  │ Open-ended questionnaire │
    │     • face-to-face      │  │    • self-administered   │
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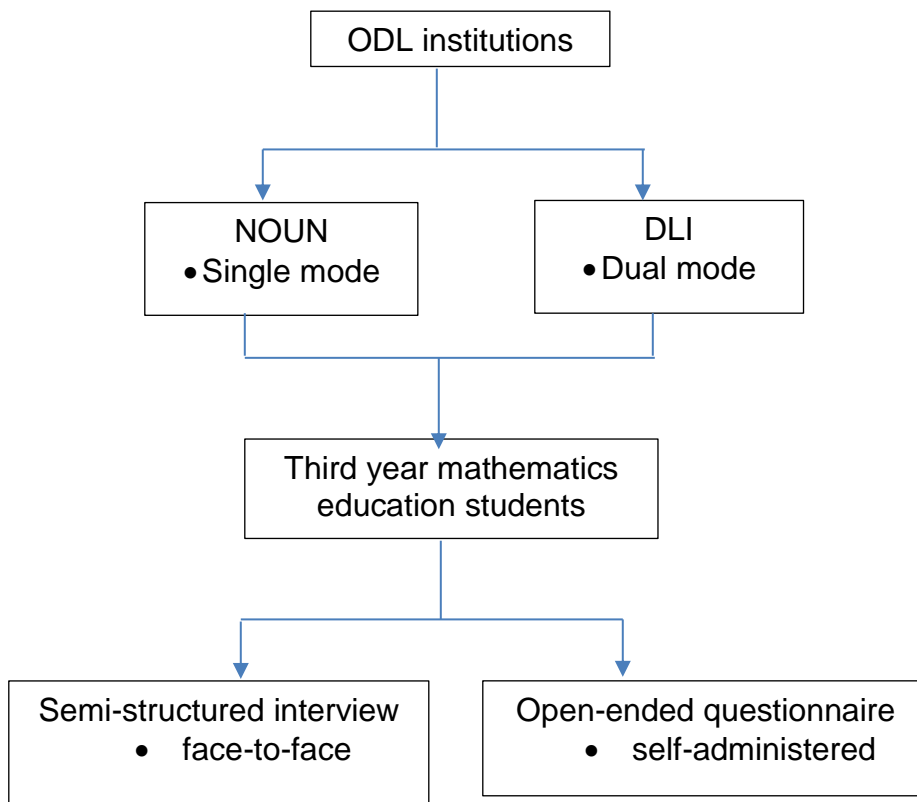
Figure 3.1: An overview of data collection approaches

The third year mathematics students in DLI and NOUN who participated in the study were informed at the beginning of the data collection process that participation was voluntary and that they had the right to withdraw at any point in time. A consent form to this effect was given to participants to sign. Permission to conduct the study was obtained from the two ODL institutions. The questionnaire was administered to all the third year students in the mathematics programmes at these two institutions because they have had two years of experience in the programmes. The number of third year mathematics students at the DLI was thirty-eight (38), of whom thirty were chosen to complete the study questionnaire. The learners in this mode gather fortnightly at different centres located at the University of Lagos for face-to-face delivery and facilitation. The researcher administered the questionnaire to them in one of their regular visits. The eight (8) students who did not participate in the main study were used earlier for the pilot study.

NOUN, on the other hand, has three study centres located in different parts of Lagos (Agidingbi-Ikeja, McCarthy-Obalande and a NOUN special centre – Nigerian Navy NNS Quorra Apapa). The learners are allowed to register at the centre nearest to them. The

questionnaires were conveniently administered at these centres. The short message system (SMS) method was used to invite the students at their various centres to complete the questionnaire since they do not have a specific day and time to gather at the centre. Proper transport arrangements, which were not aimed at influencing the participants' responses, were made with the participating students to and from the centres for the completion of the questionnaire. This is because some of the students are workers or are married and need to attend to other issues. Thus, they visit the centre at their convenience. The questionnaire helped to understand and explain how instructional delivery, assessment procedures, facilitation and support using technologies were carried out in the two institutions.

In addition to the questionnaire, semi-structured face-to-face interviews were conducted to obtain additional information regarding students' experiences with distance and online learning of university-level undergraduate mathematics in Nigeria. The interview items were formulated around the themes of the questionnaire used in this study. Five students in each of the two institutions from among those who completed the questionnaire were selected and interviewed. Appointments for each interview were fixed with the students after completing the questionnaire. The interview was recorded with the permission of the interviewee. The researcher documented the interview. The aim was to solicit understanding and ways in which the students' distance and online mathematics learning experiences could be improved.

3.4.2 Instrument for data collection

The researcher formulated instruments in the form of protocols regarding the questionnaire, interview and documentation to guide the collection of data. Though, the researcher who actually gathered the information for this study was not compelled to use instruments developed by other researchers (Creswell, 2007), some aspects of the questionnaire such as clarity of objectives of learning, assessment, the learning resources and support services was in line with Ramsden's (1991) course experience questionnaire (CEQ). The instrument used was adjusted to suit the purpose of this study. All data collected from the participants were reviewed and categorised to make sense in the context of the present study.

3.4.2.1 Questionnaire

A questionnaire was constructed based on a careful review of literature on experiences of students engaged in distance and online mathematics learning. The tool, which is in line with

some part of CEQ, was revised numerous times, approved by the researcher's supervisor and the university committee in charge. The questionnaire used in this study was one of the main sources of empirical data that strengthened the analysis and results of the work.

Mathers *et al.* (1998) define a questionnaire as a set of questions used to collect data. Bulmer (2004: 354) gave a more comprehensive definition of a questionnaire as,

> ...well-established tools in social science research for obtaining information on participant social characteristics, present and past behaviour, standards of behaviour or attitudes and their beliefs and reasons for action with respect to the topic under investigation.

The participants in the study were confronted with the same questions devoid of ambiguity to minimise misinterpretation. Simple and short words that the participants were familiar with were used in framing the items in the questionnaire.

For the purpose of this study, a questionnaire was designed to include closed and open-ended questions and was administered by the researcher to the participants. The closed questions took the form of Likert scale with responses of strongly disagree (SD), disagree (D), neutral (N), agree (A) and strongly agree (SA), while the open-ended questions involved filling in the gaps. The questionnaire required participants to supply their email addresses that were separated from the questionnaire during the analysis but were used to ascertain the number of the learners with an email address who were studying in this mode. The questionnaire was also designed to include items that distance and online mathematics students understand well.

The survey instrument included eighty-eight (88) closed questions of students' experiences with distance and online learning of university-level undergraduate mathematics in Nigeria. The survey, which was divided into three sections, required the students to supply their basic demographic information (section A), choose the online learning environment and platform available in their institution (section B) and share their experiences of learning mathematics through the distance and online mode (section C). The latter was formulated in themes such as students' mathematics experiences with instructional delivery, students' experiences with assessment procedures, students' experiences with distance and online mathematics facilitation and the technologies that influence support services. The last part of the survey

included open-ended questions that required participants to suggest how distance and online learning of university-level mathematics could be improved.

The questionnaire took the students approximately 45 minutes to complete. Scores were assigned to the students' responses and were entered into a Statistical Package for the Social Sciences (SPSS, version 20) database. The data was analysed to answer the research questions on students' experiences with distance and online learning of university-level mathematics in two major Nigerian universities with regard to instructional delivery (research question 1). It further explored how assessment procedures shaped the students' experiences with distance and online learning of university-level mathematics in Nigeria (research question 2). It assessed how learning facilitation influenced the students' experiences in distance and online mathematics education at university-level in Nigeria (research question 3) and identified support services using accessible and advanced technologies that affect the students' experiences with distance and online learning of mathematics at university-level in Nigeria (research question 4).

The merits of using a questionnaire, highlighted by Phellas, Bloch and Seale (2011), include that they are relatively inexpensive to administer except for the cost of printing and they can be used to cover a wide geographical area, especially when a geographically scattered population is involved in the research. It also helps to reduce bias because of the presence of the researcher and allows for anonymity of the participants. Phellas *et al.* (2011) also stated that despite these merits, questionnaires still have disadvantages. There is no opportunity to investigate or explain misunderstandings hence the questions have to be simple and short. The researcher has no control over who fills in the questionnaire and so cannot be sure if the right person has done so. For this study, the high return rate of the questionnaire was due to the prior arrangements made with the students who were asked to complete the questionnaire. My physical presence at the point of completion of the instrument, to provide explanations where necessary, helped in ensuring that the right participant filled in the questionnaire. This also helped in the high return rate recorded in this study.

3.4.2.2 Interview

Interviews were used to obtain in-depth information relating to the participants' experiences and viewpoints on distance and online learning of mathematics. The interview is an essential

data collecting technique that entails oral interaction between the researcher and the researched (Mathers, Fox & Hunn, 2002) in order to gather data that deals with the study goals. Interviews can be categorised into three types: structured, semi-structured and unstructured (Phellas *et al.*, 2011, Dicicco-Bloom & Crabtree, 2006).

A semi-structured interview was used to gather information for the study. Semi-structured interviews have the characteristics of allowing the researcher to organise the questions in a structured (closed) and unstructured (open-ended) format based on the themes used in formulating the questionnaire. Attention was given to using the semi-structured interview in this work because a structured interview has the tendency of producing quantitative data (Dicicco-Bloom & Crabtree, 2006). Furthermore, the semi-structured interview is flexible in allowing unanticipated responses from the participants to be explored. The researcher can be flexible in probing the students' experiences and stories in more detail. The aim was to ensure that the general area of students' mathematics distance and online experiences were gathered from all the interviewees. The benefit of using an interview in this study was to be able to obtain constructive and specific responses and suggestions on the subject of the study and to obtain sufficient detailed, comprehensive, rich data and information while using relatively few participants (Shneiderman & Plaisant, 2004).

For this study, an individual in-depth face-to-face interview was conducted with ten third year mathematics students drawn from two different ODL institutions. This helped to enrich data collection and to capture as much information as possible on the students' experiences with distance and online learning at university-level undergraduate mathematics. A good rapport was established with the participants by creating an enabling environment for them to share their experiences of distance and online learning of mathematics (Douglas, 1985). The students were allowed to narrate and tell the stories of their experiences. Their responses were not prepared or arranged in advance. Each semi-structured interview took approximately 20 minutes. The items that served as a guide to the interviewer were formulated to obtain information related to instructional delivery, assessment procedures, facilitation and support services as indicated in the research questions posed in this study.

3.4.3 Participants and selection procedures

The success of this work is a result of the support of the two ODL institutions involved and the contributions made by the distance and online mathematics students from the two institutions. The participant characteristics and selection are presented in table 3.1 below.

Table 3.1: Number of participants and selection procedures

Institutions	Participants	Year of study	Number	Interview participants	Location	Sampling method
A single mode ODL institution	Mathematics students	Third year	Thirty(30)	Five(5)	Urban	Purposeful/ Convenience
A dual mode ODL institution	Mathematics students	Third year	Thirty(30)	Five(5)	Urban	Purposeful/ Convenience
Total			**60**	**10**		

The institutions and the students were purposefully selected to participate in the study. This was done to ensure that only ODL institutions were selected and that only third year mathematics students were used. The sixty students were selected to complete the survey instrument while the ten students that participated in the face-to-face interviews were conveniently selected from among those who completed the questionnaire. The study was also based on the students in their third year who would have had reasonable distance and online learning experiences. The study was done using participants from an urban area having widely diverse backgrounds, working environments and age groups.

3.5 Method of data analysis

The study involved the use of mixed qualitative and quantitative methods. Teddlie and Tashakkori (2009) systematically recommend four types of mixed analysis: parallel, sequential, conversion and multilevel. This study used parallel analysis (PA). Quantitative analysis was independently conducted of qualitative analysis; neither data analysis was built on the other. Following the approach suggested by Onwuegbuzie and Leech (2004), the

results from each separate analysis was compared and consolidated at the completion of data analysis to provide information about the experiences of students studying mathematics in the distance and online environment and the findings of the two research approaches were integrated at that point.

3.5.1 Quantitative analysis

According to Amaratunga *et al.* (2002), quantitative analysis is based on the nature of knowledge procedures for determining the true value of propositions and permits flexibility in data handling. They further stated that "quantitative data analysis often deals with statistical data analysis techniques, specifically in the analysis of behavioural elements of performance" (Amaratunga *et al.*, 2002: 23). Steps in quantitative analysis by Pacitti (1998) adapted in this study include evaluation of raw data, looking for patterns from the data to establish hypothetical connections, entry and transfer of data, processing of data, interpretation of data and communication of findings.

The survey instrument contains eighty-eight (88) closed questions items, which were divided into three sections. Section A required the participants to supply their basic demographic information. The participants had to indicate the online learning environment and platform available in their institution in section B and share their experiences (as it applied to them) of learning mathematics through a distance and online mode in section C. The latter was formulated in themes such as students' mathematics experiences with instructional delivery, students' experiences with assessment procedures, students' experiences with distance and online mathematics facilitation and the technologies that influence support services.

The survey instrument was collected through categorical data with a measurement scale consisting of a set of categories (strongly disagree, disagree, neutral, agree and strongly agree) (Agresti, 2002). Hence, the categorical data used in this study falls within an ordinal variable. The responses were categorised into agree/strongly agree disagree/strongly disagree. The demographic information of the students was analysed using descriptive statistics involving the frequency, percentage and mean. One-sample binomial test, which is a non-parametric test, was employed to analyse the data in section C of the questionnaire. Since the emphasis of the study is not on the students with indifferent opinions, neutral was therefore regarded as a missing variable during the descriptive analysis of the data. The

binomial test was used because the number of participants (n=60) was fixed and was independent of each other's responses; the data is ordinal categorical data and all the participants were distance learners. This analytical method was used to answer the research questions that touched on the students' experiences with instructional delivery, assessment procedures, learning facilitation, support services, use of newer and/or advanced technologies. Partial Least Squares Regression (PLSR) was adopted in analysing the relationships between technology and instructional delivery, technology and assessment procedures and technology and facilitation. This is useful to predict the students' experiences (dependent variable) from instructional delivery, assessment, facilitation and support (independent variables).

3.5.2 Qualitative data analysis

Qualitative data analysis can be inductive or deductive where the researcher's goal is to find an answer to the research questions. A qualitative mode of analysis has to do with textual analysis that is either verbal or written (Myers, 1997). The analysis may include creating new ideas and theories, explaining events and investigating relationships between students' behaviours and experiences (Green & Thorogood, 2009). Green and Thorogood (2009) listed thematic content analysis, grounded theory, framework analysis and narrative analysis as the common approaches to qualitative analysis. Narrative analysis and content analysis were employed to see how the respondents in interviews make sense of learning mathematics through the distance and online mode. The participants' own words were used to bring out this understanding of students' experiences with distance and online learning of university-level undergraduate mathematics in Nigeria. Some elements of thematic content analysis were also used to generate and categorise the occurring themes from the data contents.

In accordance with Creswell (2007) and Miles and Huberman (1994), the qualitative data (interviews) collected for this study were prepared and organised by transcribing the text data for analysis. The data were coded by grouping them into meaningful sections or themes and further analysis was done using a narrative approach. This narrative analysis was intended to provide an understanding of how the participants make meaning of phenomena (Riessman, 1993). Riessman (1993: 64) stated, "individuals make sense of their world most effectively by telling stories". In using this approach, the essential stories of personal

experiences in learning mathematics through a distance and online mode were collected. The students' voices were captured word-for-word and rewritten to incorporate the essence of their distance and online learning experiences (Creswell, 2007). The notes, kept in the form of a document during the interview, were used with the narrative and content analyses to work through all the emerging themes in this study.

3.5.2.1 Document analysis

Bowen (2009: 27) defined document analysis as "a systematic procedure for reviewing or evaluating both printed and electronic materials". It can also broadly be described as a written text (Ahmed, 2010). Documentary data include different files, interviews, diaries, field notes or broader entities such as groups and cities (Mayring, 2014). It is an important source of data that can be used in various ways in research. Document analysis was used as the main method of data collection and analysis in this study. The aim of using document analysis is that it has the capacity to deal with a broad range of texts (Ahmed, 2010). It also involves examining and interpreting data in order to draw out meaning, gain understanding and establish practical knowledge experiences (Bowen, 2009). The documentary data were generated from the open-ended survey questions of the questionnaire, which was completed by the third year undergraduate distance and online mathematics learners. The interviews were recorded, transcribed and converted into written form, which eventually became documents. The transcription system used in this study was smooth verbatim transcription (Mayring, 2014). The transcription was done word-for-word but sometimes the decorating words such as "you know, yea, ah", etc. were left out. The analysis involves skin-deep or surface examination, thorough examination and interpretation of the documentary data (Bowen, 2009). In this study, content analysis and some elements of thematic analysis are used for this repeated process of document analysis.

3.5.2.2 Content analysis

Content analysis is a mixed method research approach and one of the several qualitative methods used to analyse documentary data (Mayring, 2014). It is defined as a "systematic procedure of assignment of categories to portions of text" where words are the basic elements of texts (Mayring, 2014: 31). Cole (1988: 54) also defined it as a "method of analysing written, verbal or visual communication messages". The aim of using content analysis in this study is to explain the experiences of distance and online undergraduate

mathematics learners by developing categories from the data (Elo & Kyngäs, 2008). Therefore, as a method of analysing documentary data, it serves as a practical guide in providing knowledge, fresh insights and representation of facts in this study (Krippendorff, 1980). This research is based on the application of deductive content analysis, which is used when the structure of analysis is operationalised based on previous knowledge and the purpose of the associated study is answer the research questions (Elo & Kyngäs, 2008). Hence, the category systems are developed deductively (as a directed content analysis approach) for this study.

Elo and Kyngäs (2008) and Mayring (2014) listed preparation, organisation and reporting as the three stages of content analysis. The data collected for this study was transcribed word-for-word, coded according to categories, subcategories and themes, which can be refined as the analysis proceeds (Hsieh & Shannon, 2005; Elo & Kyngäs, 2008). The analysis was done by summarising the findings identified during the coding and detailing. They were then restated for easy understanding and the patterns and relationships in the coding were identified from the findings and were used to answer the research questions (White & Marsh, 2006). The findings were presented in a descriptive narrative form discussed below. The strength of content analysis can be seen in the various steps involved in the data analysis resulting in identifying which category system is central (Kohlbacher, 2006).

3.5.2.3 Narrative analysis

This research studied students' experiences with distance and online mathematics learning. Narrative analysis according to Riessman (2000: 24) allows for systematic "study of personal experience and meaning". It enables the researcher to study the participants' thought, creates and refashions their personal identity through story telling (Riessman, 2000). The students were asked to provide stories about their experiences and the information they provided was retold into a narrative order of events (Creswell, 2009). The following steps were used for the narrative analysis in this study: the story of their personal experiences with distance and online learning of mathematics were collected through a face-to-face interview and open-ended questionnaire (transcript). The stories were rewritten in chronological order, coding generated categories and sub-categories leading to the formulation of themes. Narratives were created using the coding, categories and themes in the participants' words. Member-checks were carried out with some of the participants to verify the correctness of

the captured data and the researcher brought her own understanding in while interpreting the text data (Creswell, 2007; Huynh & Rhodes, 2011). Following the idea of Riessman (2005: 1), "events in this research were selected, organised, connected and evaluated as meaningful". This was done for distance and online mathematics learners.

3.5.3 Criteria for evaluating the trustworthiness of the study

The methods employed in this work may not be complete without taking into account the basic issues relating to the assessment or measures of the trustworthiness of this research outcome. Lincoln and Guba (1985) and Guba and Lincoln (1989) developed four criteria to measure trustworthiness in mixed methods research. These are credibility, transferability, dependability and confirmability. Trustworthiness forms an essential part of the design of this study with constant verification of the processes involved in this research. The researcher periodically re-examined the processes by consulting established literature to support the employed procedures (Creswell, 2009*)*.

3.5.3.1 Credibility

Credibility relies on the study testing what it is meant to test. The interpretive explanation parallels the internal validity of the research, as it applies to the research group (Morrow, 2005). Credibility was ensured in this study using multiple methods of data collection (interviews, documentation and questionnaires). This form of triangulation increases the rigour of the research (Patton, 2002) and provides a holistic understanding of participants' experiences with distance and online learning of mathematics at the undergraduate level. The inclusion of data triangulation in the study helped to establish a thorough description of data across multiple sources and enriched the analytical strategy that was employed. Member-checks by presenting the transcribed data to some participants also helped establish the credibility of this research (Creswell, 2007).

3.5.3.2 Transferability

Transferability relates to the degree of applicability of the research in other settings; it is the interpretive equivalent of external validity or generalisability (Guba & Lincoln, 1994; Morrow, 2005). Since this study used an explanatory sequential approach, the findings could easily be transferred to ODL institutions elsewhere in Nigeria and other African countries. This is because of the thick description employed in data analysis (Creswell, 2003).

3.5.3.3 Dependability

Dependability on the other hand, is also an interpretive construction that parallels with the reliability of the study (Guba & Lincoln, 1994). It matches up with the duplicability or replicability of the research by narrating all the changes that took place and how the research is affected by those changes. Dependability was maintained throughout by the researcher in being consistent with the use of time and analysis techniques (Gasson, 2004). Data triangulation using multiple analytical strategies further helped increase the dependability of this study.

3.5.3.4 Confirmability

Confirmability corresponds to the extent to which others can authenticate the findings of the research; this parallels with objectivity (Morrow, 2005). This study ensures confirmability using recordings to capture the opinions of the students. Documentation made it easier to track the participants' views. All these criteria are observed in this study in order to ensure soundness of the research.

3.6 Pilot study

A pilot study is used in two different ways in social science research (van Teijlingen & Hundley, 2001). Feasibility studies are conducted in small populations and a trial study is performed in preparation for the main study (Polit *et al.*, 2001). Arnold *et al.* (2009) define a pilot study as "a small study for helping to design a further confirmatory research". The purposes of pilot studies can be to test the study procedures and ascertain the validity or trustworthiness of the instrument (e.g. questionnaires, interviews, etc.). They can also be used to assess the success of the main study, establish the effectiveness of the sampling method, identify structural problems that might occur using the planned methods, test the planned data analysis methods and prepare the researcher on the research processes for the study (van Teijlingen & Hundley, 2001; Arnold, *et al.*, 2009).

Conducting a pilot study in research is a vital component of any quality study plan; it may not assure success in the main study but it can be used to increase the chance of success in the study. Another benefit that can be derived from piloting a study is that it has the potential of warning the researcher where problems might be experienced in the main study, where research procedures might not be kept and where the instrument of the study is faulty (van

Teijlingen & Hundley, 2001). Information regarding the possible response rate, time and cost in data collection for a study can also be determined using a pilot study (Phellas *et al.*, 2011).

For the purpose of this research, a pilot study was conducted using mathematics students of the DLI of the University of Lagos to ascertain the suitability of the adopted research instruments. The pilot study was based on the quantitative and qualitative data used in this study. Hence, a questionnaire and interviews were used to collect descriptive data on the instructional delivery, assessment, facilitation and support services using newer and/or advanced technologies. The students were also allowed to suggest how the instructional delivery, assessment, facilitation and support services could be understood and explained. The questionnaire was administered to eight (8) DLI mathematics students while two (2) amongst those who completed the questionnaire were interviewed. The interview was audio-recorded based on the students' consent. The results of the pilot study underscore the need for a more extensive research study on examining the students' experiences with distance and online learning of university-level undergraduate mathematics in the two main ODL institutions in Nigeria. The results from the analysis of the pilot study did not form part of the results of the core analysis of the main study. This was done in order to avoid any bias that might arise due to a small sample being used and to avoid collecting new data from the pilot participants who might not be novel participants (van Teijlingen & Hundley, 2001). The pseudonyms Cherry and Charity were used to report the documented data from the questionnaire and interviews for the pilot study.

Table 3.2: Emerging themes and data extracted from the pilot study

Themes	Data extract	
	Cherry	Charity
1. Why ODL	• I really love to study mathematics through a distance mode because of my job.	• I need to work to sponsor myself in in this programme.
2. Delivery method	• The way the school is going about it is not really impressive. • I don't really enjoy it because what I was expecting is not what I saw at the end of the day.	• The materials/modules are not simplified enough to take care of the abstract nature of mathematics. • Some of the materials I have are not well explained, so you

		• Eighty per cent in the instructional delivery is traditional but now they are improving the online programme. • I don't have easy access to mathematics course materials online. I don't have at all. • The school is not hundred per cent online but the way things are for this year, I can now give them 60% to online and 40% to traditional method.	just need to make some research, meet some friends who could help me, just for me to understand the course outlines.
3.	Resources availability	• No Internet availability except when you come to school and it is not even easy to get. • I have my personal laptop. • At the moment, I provided resources by myself to study undergraduate mathematics in this mode.	• I have Internet access for my school need at home but it cost me more, it is very expensive. • I have access to Internet almost 5 hours a day for my school needs. • I do not have enough resources to learn.
4.	Method of assessment	• Both online and traditional assessment. • I will still give online assessment sixty per cent and traditional forty per cent in preference.	• The assessment is online and traditional. • The traditional is better because in traditional, you will be able to meet the lecturers one-on-one and explain to them the areas of difficulties you have rather than solving it online. • Sometimes you see some question online, before you click it would have wiped off, so I don't really enjoy online as such.
5.	Support received	• No Internet support and you don't meet the lecturers online.	• The materials are not readily available.

	• I get support through the traditional way by meeting the lecturer one-on-one.	• The school gives us module as their own support and I go online to get the topic of what I want to do.
6. Facilitation	• I can say that facilitation is difficult because most of our lecturers don't even put things online and they themselves are not even equipped enough to post the things online for you.	• Facilitation in my university is not effective due to lack of resources.
7. Experience	• My experience so far I have not really been enjoying it but just because of the people that usually assist me that is why I am trying to cope gradually, I have not really been enjoying it at all, at all.	• I think the extra effort I am putting in will help me to compete with other mathematics students elsewhere.
8. Interacting with others online	• I was expecting to see and meet a lecturer one-on-one in day-to-day activities online but I just find it difficult, just only few lecturers you meet once in a while online.	• You just need to make some research, meet some friends face-to-face who could help me, just for me to understand the course outlines.
9. Collaboration	• I don't meet the lecturers and students online, I just try to contact other students on phone to assist when I have problems.	• There is a need for students' online collaboration.
10. Challenges	• I have challenges studying through this mode.	• It is very difficult learning maths through this mode.

Source: Pilot data

The students interviewed during the pilot study suggested that the programme should be interactive enough for better understanding of the course. The school should also make Internet connections available for easy collaboration among the students and lecturers.

The purpose of the pilot study was to test the methods, the research instruments and prepare the researcher for the main study. Hence, the instruments were tested during this period. Some of the problems encountered during the pilot study were:

- Getting to know the period the DLI students come together at the study locations since being distance learners imposed some challenges.

- It was discovered that they only meet fortnightly and not all of them attend the centre meetings as scheduled. This is because the majority of the students are married and have jobs with diverse responsibilities. The work schedule keeps some of them busy even on weekends.

- The questionnaire and interview was administered the same day due to the difficulty in assembling the students. The questionnaire took 45 minutes to complete due to the portion that required their suggestions on how delivery, assessment, facilitation and support services were handled in their institution. The interview on the other hand, lasted between 8 to 10 minutes of the planned 30 minutes due to the time already taken to complete the questionnaire and the students were eager to see their facilitators before returning to work for the day. Nevertheless, all the interview items were presented for discussion.

The difficulties stated above necessitated the need for suitable strategies devised by the researcher in carrying out the main study. It also assisted the researcher as a novice researcher to know how to engage the participants in discussions, asking probing questions and in effective time management. The researcher liaised with the students' class representative after getting permission from the university to conduct the study. The class representative acted as a go-between in coordinating his colleagues at the researcher's directives for the main study. The instruments used for the pilot study were the same as the one employed for the main study. Since the major aim of the pilot study was to test the instruments and prepare the researcher for the main study, the result was not included in the analysis.

3.7 Ethical issues of the study

Research must be designed to be ethical (Harwell, 2011). Resnik (2013) defined ethics as the norms for conduct that differentiate pleasing from an unpleasing manner. In designing the ethical form for this study, the following issues were made clear to the participants: the purpose of the study and what the participants would do (filling in the questionnaire, participating in an interview, answering open-ended questions and consenting to tape recordings of the interview protocols). The risks and benefits of the study, confidentiality, the

decision to quit at any point in time and how the findings would be used were also explained. Reasons why ethical norms should be observed in research include the promotion of the goal of the study to avoid errors, encouraging the values that are necessary for collaborative research and encouraging public support for research (Resnik, 2013).

The purpose of this study is to investigate students' experiences with distance and online learning of university-level undergraduate mathematics in Nigeria. In order to meet the purpose, ethical conduct involved obtaining a clearance letter from the two ODL institutions in Nigeria, DLI at the University of Lagos and NOUN, whose student population samples were used. Following the approval received from the two institutions, a consent form was distributed to all the participants. Data were gathered using a questionnaire, a one-on-one interview and tape recordings. Participation involved a recorded one-on-one interview and completing an open-ended questionnaire. The participants and their responses were protected by observing maximum confidentiality of the data. Participants were allowed to ask questions and show their worries during the survey and interview regarding the nature of the research.

The interview recording was intended to assist the researcher in capturing the participants' own words for the purpose of the study and was not to be disclosed to any other person. The name and identity of each participant was not used in the writing of the research in order to ensure confidentiality. The participants were also required to complete a copy of the questionnaire to ascertain their experiences in distance and online learning of mathematics. The individual responses were not shared with anyone else. Thus, there were no risks expected from participating in this study. The participants were allowed to withdraw at any time they wanted to without any penalty, as participation was voluntary.

The quality of the results of the study was ensured by constant maintenance of honesty, objectivity, openness and integrity all through the study. The participants' involvement was aimed at contributing to the knowledge of students' experiences with distance and online learning of university-level mathematics in Nigeria. The results of the study will be expected to help ODL institutions in Nigeria to structure the students' mathematics experiences in distance and online learning environments. The results of the study will also be published in a professional journal in the field of distance and online learning or will be presented in a learned conference.

3.8 Summary of the chapter

This study was conducted to investigate students' experiences with distance and online learning of university-level undergraduate mathematics in Nigeria. The methods used to generate and analyse the data were explained. The research objective was based on examining the students' experiences with distance and online learning at university-level undergraduate mathematics in the two main ODL institutions in Nigeria. The research questions examined how instructional delivery, assessment, facilitation and support services influence the students' experiences in this mode.

The study, which was conducted using mixed methods (qualitative and quantitative) and an explanatory research design, was discussed. The issues identified in the research questions were examined using this method. Data collection and analysis were done using quantitative and qualitative research methods. This helped the researcher to provide a comprehensive interpretation of the research questions of this study. The methods employed in analysing the quantitative and qualitative data were discussed. A pilot study was conducted to test the instruments and prepare the researcher for the main research processes. Trustworthiness was evaluated to ensure quality through credibility, transferability, dependability and confirmability. Moreover, the ethical issues associated with this study were considered. This was done to protect the participants from any risks. The diagrammatic summary of the research methodology is presented in figure 3.2 below. In Chapter 4, the analyses of quantitative and qualitative data are presented and findings integrated as shown in table 4.12.
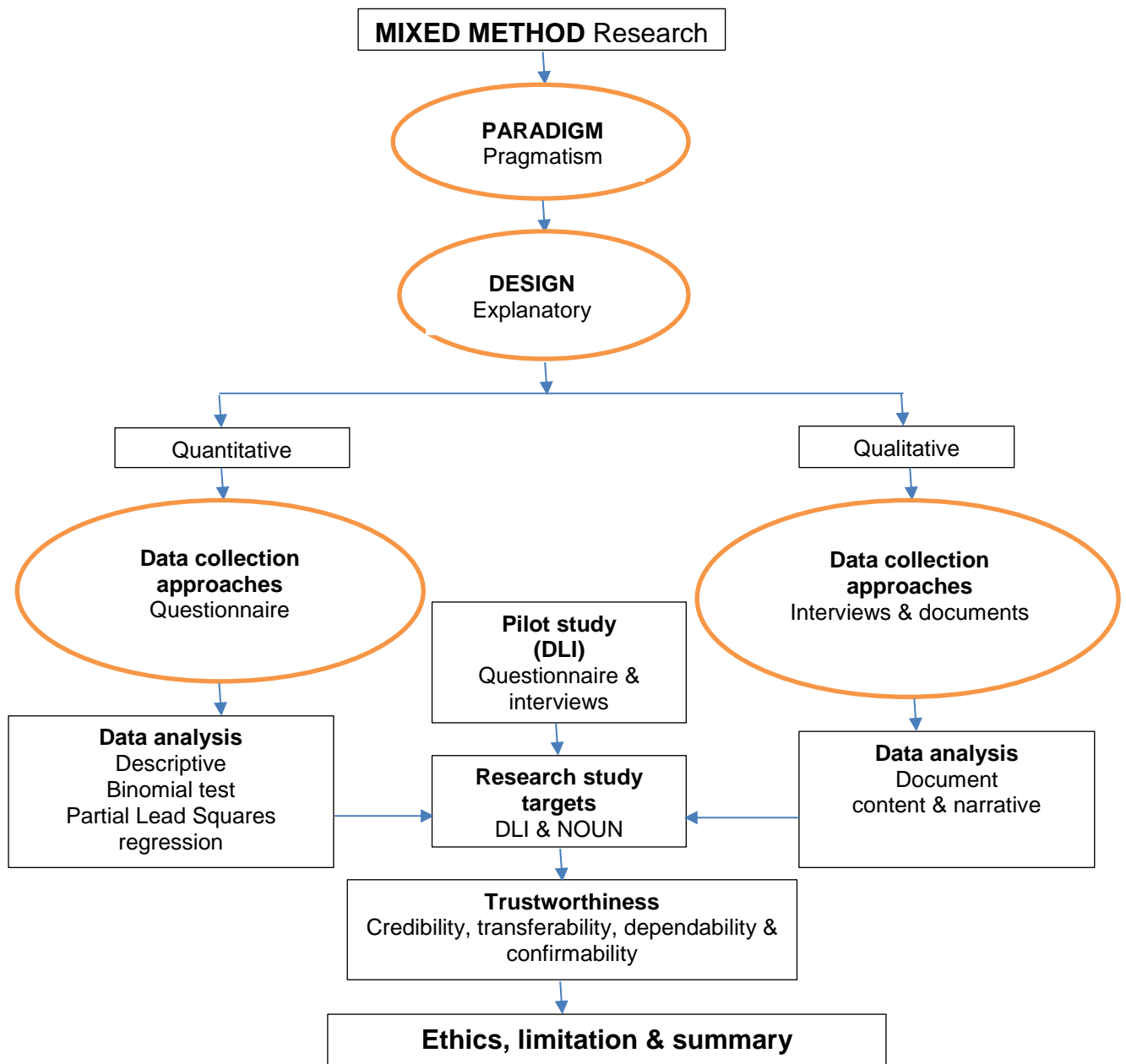
Figure 3.2: An overview of the research methodology for the study

Chapter 4

Data analysis and presentation

4. Introduction

The aim of this study was to investigate students' experiences with distance and online learning of university-level undergraduate mathematics in Nigeria. It also sought to determine the level of access to technology that affects the delivery, facilitation and assessment experiences of undergraduate mathematics students with distance and online learning. Quantitative and qualitative data were collected and are presented in this chapter. The data analysis included descriptive methods for summarising and assimilating the information and inferential statistics, specifically Partial Least Squares (PLS) regression were used to test for relationships between the variables.

The sampled population comprised 60 third year distance and online learning mathematics students from two ODL institutions in Nigeria, one a dual mode (DLI) and the other a single mode (NOUN) university. A 5-point Likert scale survey (strongly agree, agree, neutral, disagree and strongly disagree) was used to collect data. The procedures that were used and a description of the participants' demographics are included in the analysis. The participants' responses to the interview protocol and the open-ended questions were analysed and integrated in the discussion.

The results of the students' responses to each of the research questions outlined in chapter three were explored.

A summary of the research findings is presented at the end of the chapter.

4.1 Reliability and validity in this study

Despite the fact that some aspects of the questionnaire (clarity of objectives of learning, assessment, the learning resources and support services) were in line with Ramsden's (1991) course experience questionnaire (CEQ), reliability and validity of the instrument was still obtained and is presented in the table 4.1. This is in line with Streiner (2003), who cautions that the researcher should find the alpha measurement of the administered test and

not rely on the published alpha estimate. Hence, before dealing with the study questions, Cronbach alphas were examined for the four scales that represented different dimensions of student experiences.

Table 4.1: Reliability statistics for the scale used in this study

Construct	Cronbach's Alpha	Number of items
Instructional delivery (ID)	0.72	29
Assessment procedures (AP)	0.40	12
Learning facilitation (LF)	0.74	9
Available technologies	0.93	27

Source: Survey data

Cronbach's alpha coefficient was used as a measure of internal consistency-reliability. It provides a measurement of internal reliability for multi-item summated rating scales, ranging between 0 and 1; the higher the score, the more reliable the scale.

Although Cronbach's alpha coefficient is widely used as a measure of reliability, there is no fixed rule with regard to what score of reliability should be considered acceptable (Gliem & Gliem, 2003). Nunnally (1978) recommended that the minimally acceptable reliability for explanatory research should be in the range of 0.5 to 0.6, while higher values, such as 0.8 generally indicate that the measure is highly reliable (Sekaran, 1992). For the value of alpha to be considered acceptable, it has to be related to the purpose of the research; lower scores are acceptable for explanatory research, though these scores are used only as an indication rather than a test of reliability (Hair *et al.*, 2006). As indicated in table 4.1, the scale used was reliable (Sekaran, 1992) and acceptable for the total number of students involved, although some caution has to be exercised when interpreting data on the measures of assessment experiences of the students.

4.2 Demographic information of the participants

The survey instrument contained questions that produced basic demographic data about the participants. The questions include the name of the institution, sex, age, marital and job status, email address, estimated number of hours per week using a computer for academic purposes, online exploring of the Internet for school purposes and exploring the Internet for other (non-school) purposes. The results are presented in table 4.2.

Table 4.2: Basic demographic information of the participants

Basic demographic information (n=60)			
Item		Frequency	Per cent
Sex	Male	46	76.7
	Female	14	23.3
Age	Less than 25	18	30.0
	25-34	37	61.7
	35-44	4	6.6
	45-54	1	1.7
Marital status	Married	14	23.3
	Single	46	76.7
Job status	Applicant	23	38.3
	Employed	37	61.7
Email address	Have	57	95.0
	None	3	5.0
Estimated number of hours I spend per week using a computer for academic purposes	Less than 1	9	15.0
	1-5	32	53.3
	6-10	12	20.0
	11 and above	7	11.7
Estimated number of hours I spend per week online exploring the Internet for school purposes	Less than 1	11	18.3
	1-5	31	51.7
	6-10	10	16.7
	11 and above	8	13.3
Estimated number of hours I spend per week online exploring the Internet for other (non-school) purposes	Less than 1	16	26.6
	1-5	31	51.7
	6-10	6	10.0
	11 and above	7	11.7

Source: Survey data

All sixty participants in this study were third year distance and online mathematics students chosen from the two ODL institutions (DLI and NOUN). About 77% of the participants were males. The imbalance between males and females is in line with what Yukselturk and Bulut (2007) found, where male enrolment was double the female enrolment in distance and online learning, while Ali and Ahmad (2011) also indicated that more male students are taking online classes. Could this be related to the lower numbers of females enrolling for university-level mathematics? This could be a question for further research.

The ages of the students indicated the majority were between 25-34 years old. Researchers have shown that distance and online students were habitually 22 years old or older (Ashby,

Sadera & McNary, 2011), while Dabaj and Basak (2008) found that distance and online learners over 30 years of age prefer face-to-face modes of learning. Jimoh (2013) found that the failure of younger students to secure space in conventional universities in Nigeria has led to many opting for distance and online education. Fifty-seven or 95% of the participants have an email address, indicating their readiness to learn mathematics through this mode.

Table 4.2 revealed that about half of the participants spent between 1-5 hours per week on each of the following activities relating to distance and online learning (a) using computer for academic purposes (b) online exploring the Internet for school purposes and (c) online exploring the Internet for other (non-school) purposes. One of the effective indicators of readiness to engage in distance and online learning is that the learner should be able to dedicate eight to ten hours per week and set aside a class period each day for distance and online course work (Colorado & Eberle, 2010). This expectation seemed to be a bit high for the participants in this study as suggested by the data in table 4.2.

The tables defining the specific demographic information as it related to DLI and NOUN, as individual institutions are included in the appendix.

4.3 The online learning environment and platform

An online learning environment refers to distance and online tools where learning can be delivered, while an online learning platform is a digital resource, which can be re-used to support learning (Moore, Dickson-Deane & Galyen, 2011). They are the media through which learning materials are passed on to the students. It allows students to track the learning materials, interact with the materials, collaborate and be assessed (Sneha & Nagaraja, 2013). The students are encouraged to continue learning outside the lecture hall since the platform can be accessed while on and off campus.
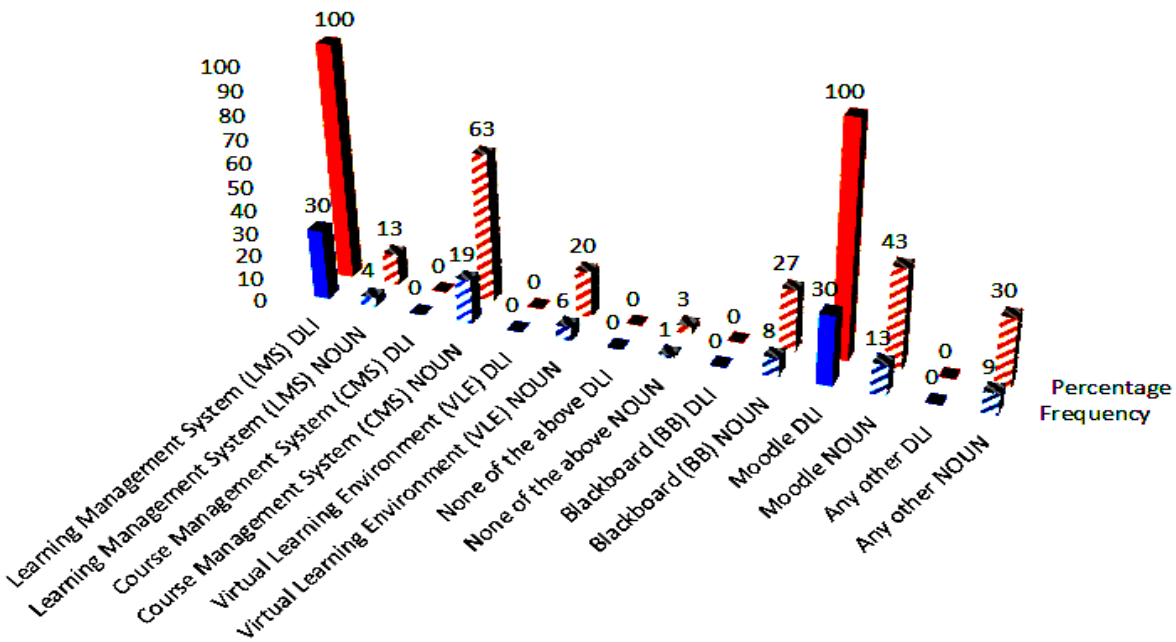
Figure 4.1: Online learning environment platforms, DLI (solid) and NOUN (striped)

Figure 4.1 illustrates the reported availability of learning environments and platforms in DLI and NOUN. At DLI, distance and online learning activities are carried out through a learning management system (LMS), as confirmed by all 30 students who also identified Moodle as the sole online learning platform (no-one chose Blackboard or 'other'). The main interface is clearly the LMS.

At NOUN, the responses were more varied. The course management system (CMS) was the most commonly identified online learning environment, followed by the virtual learning environment (VLE) and LMS. The online learning platforms identified were Moodle, Blackboard and i-learn, in decreasing order of recognition. NOUN appears to be using multiple learning environments and platforms.

4.4 Descriptive analysis

The students' responses regarding instructional delivery, assessment procedures, facilitation and available technologies are described in this section. The instruments used contained 88 items. Twenty-nine items were used to obtain information about instructional delivery, twelve were based on assessment, nine related to facilitation and twenty-seven covered technology and support. The survey instrument used a 5-point Likert scale of strongly agree, agree, neutral, disagree and strongly disagree. The data was analysed using a non-parametric test

(binomial test) based on agree (consisting of strongly agree and agree) (A) and disagree (consisting of strongly disagree and disagree) (D). Neutral (N) was ignored since the emphasis is not on students with indifferent opinions. The interest in using the binomial test is to determine the number of participants that agree and disagree in each questionnaire item. The Likert score mean (M) and standard deviation (SD) was calculated and used for each item. The significance level is 0.05, so that p-values below 0.05 are deemed significant.

4.4.1 Investigation of research questions

The students' responses to the data collected using the questionnaire according as they relate to the research questions are explored in this session.

4.4.1.1 Research question 1

The first research question asked, "what are the students' experiences with ID in the distance and online learning of university-level mathematics"? The results, as presented in table 4.3, show overall experiences of students in ID.

Table 4.3: ID responses of DLI and NOUN students

N	Questionnaire item	A (%)	D (%)	N (%)	M	SD	B.T (p-value)
12	My tutor clearly indicates the objectives of learning mathematics at a distance and online.	33 (55.0)	12 (20.0)	15 (25.0)	3.33	1.05	.003
13	Distance and online learning of mathematics is difficult because I do not understand it.	19 (31.7)	29 (48.3)	12 (20.0)	2.72	1.26	.194
14	Learning mathematics through a distance and online mode in my institution is frustrating.	19 (31.7)	28 (46.7)	13 (21.6)	2.82	1.37	.243
15	Many mathematical problems cannot be solved through distance and online learning.	33 (55.0)	22 (36.7)	5 (8.3)	3.20	1.36	.178
16	I enjoy learning mathematics through distance and online.	20 (33.3)	25 (41.7)	15 (25.0)	2.83	1.30	.551
17	Learning mathematics through a distance and online mode saves time and effort for learners.	32 (53.3)	18 (30.0)	10 (16.7)	3.32	1.19	.066
18	I have reliable access to Internet for my school needs.	30 (50.0)	15 (25.0)	15 (25.0)	3.23	1.21	.037
19	The course materials are well developed for learning mathematics in my university.	36 (60.0)	12 (20.0)	12 (20.0)	3.50	1.13	.001

20	The course materials are sufficient for learning mathematics in my university.	24 (40.0)	26 (43.3)	10 (16.7)	2.93	1.21	.888
21	The course materials challenge and arouse my curiosity to learn new mathematical concepts.	40 (66.7)	12 (20.0)	8 (13.3)	3.62	1.17	.000
22	The course materials challenge and arouse my curiosity to learn difficult mathematical concepts.	36 (60.0)	12 (20.0)	12 (20)	3.53	1.11	.001
23	The abstract nature of mathematics is not simplified in the design of the course materials.	23 (38.4)	26 (43.3)	11 (18.3)	2.95	1.24	.775
24	I have access to course materials online over the Internet.	45 (75.0)	9 (15.0)	6 (10)	3.92	1.20	.000
25	The contents covered in the mathematics course materials are adequate for the period the student is required to complete the course work.	26 (43.3)	19 (31.7)	15 (25.0)	3.10	1.05	.371
26	ODL course materials in my institution meet students' mathematical and experiential needs for personal mathematics interest.	31 (51.6)	14 (23.4)	15 (25.0)	3.30	1.06	.017
27	ODL course materials in my institution meet students' mathematical and experiential needs for skills development.	34 (56.6)	13 (21.7)	13 (21.7)	3.38	1.03	.004
28	ODL course materials in my institution meet students' mathematical and experiential needs for requirements for degree award and certification	48 (80)	3 (5.0)	9 (15.0)	3.90	0.84	.000
29	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.	19 (31.7)	32 (53.3)	9 (15.0)	2.65	1.12	.000
30	When the mathematics course material is difficult to understand, I give up or study only the easier parts.	17 (28.3)	34 (56.7)	9 (15.0)	2.48	1.23	.025
31	The course materials are interactive for me to understand.	33 (55.0)	15 (25.0)	12 (20.0)	3.27	1.02	.014
32	Even when the mathematics course materials are not interactive enough, I manage to continue working to understand and finish them.	46 (76.7)	5 (8.3)	9 (15.0)	3.78	0.92	.000
33	The following can help to improve the students' experiences further in distance and online learning of mathematics in my institution: Access to efficient Internet facilities.	51 (85.0)	9 (5.0)	20 (10.0)	4.32	0.85	.000

34	The following can help to improve the students' experiences further in distance and online learning of mathematics in my institution: Access to my mathematics tutors/ lecturers.	50 (83.4)	5 (8.3)	5 (8.3)	4.25	1.04	.000
35	The following can help to improve the students' experiences further in distance and online learning of mathematics in my institution: Flexible teaching and learning.	52 (86.6)	4 (6.7)	4 (6.7)	4.22	1.01	.000
36	The following can help to improve the students' experiences further in distance and online learning of mathematics in my institution: Using different forms of media – print, audio, video, etc.	50 (83.3)	6 (10.0)	4 (6.7)	4.22	1.06	.000
37	Distance and online learning gives access to ENOUGH resources to learn undergraduate mathematics at my university.	30 (50.0)	20 (33.3)	10 (16.7)	3.27	1.26	.203
38	Distance and online learning gives access to QUALITY resources to learn undergraduate mathematics at my university.	30 (50.0)	14 (23.3)	16 (26.7)	3.30	1.12	.024
39	Face-to-face remains the dominant method of teaching and learning of mathematics in my institution.	31 (51.7)	18 (30.0)	11 (18.3)	3.40	1.39	.086
40	Learning of mathematics through the distance and online mode is not efficient.	28 (46.7)	19 (31.7)	13 (21.6)	3.20	1.27	.243

*Binomial test; Source: Survey data

There are mixed reactions among students studying in this mode. Many agreed that items 12, 19, 21, 22, 24, 26, 27, 28, 31, 32 to 36 and 38 have significant effects on their mathematics experiences. This indicates that provision of instructional material is considered the lifeblood of distance education for their degrees and certification. As Murray *et al.* (2012) observed, effectively designed course materials assist in the achievement of desired learning outcomes for distance and online learners.

About 60% of the participants agreed with items 19 and 22. The p-values are less than 0.05, indicating that the course materials are well designed and encourage the learning of difficult mathematical concepts. Two thirds agreed with items 24 and 32, showing persistence of the learners in studying mathematics in this mode, while 80% agreed with item 28 with p=0.000 (rounded). Even higher percentages, with significant p-values, agreed with items 33, 34, 35

and 36, indicating the need for effective Internet connectivity, access to tutors, flexible teaching and the use of different forms of media in distance and online mathematics learning.

The findings are in agreement with the results of previous studies by Lee (2014) and Ku *et al.* (2011), which indicated that students pay more attention when the online course materials are presented with clear guidelines and expectations. On the other hand, students who are learning in this mode become frustrated when the course is poorly designed, leading to poor learning outcomes (Young & Norgard, 2006).

Items 29 and 30 also seemed to have significant biases, indicating student persistence in learning mathematics through the distance and online mode.

There were mixed responses to items 15, 17, 37 and 39 as the binomial test shows no significant differences in the responses. The results show balanced opinions between those who agreed and those who disagreed. These results show an advocacy for institutional strategies aimed at students' higher quality learning because of the extra time and efforts required for learning mathematics through the distance and online mode.

Preferences were more evenly spread (p-values well above 0.05, so not deemed particularly significant) in items 13, 14, 16, 20, 23, 25 and 40. The results from these items expressed no significant difference between those that agree and those that disagree. This suggests the need for improvement, even though some deem it adequate in designing course materials to cover content, tackle the abstract nature of mathematics, remove frustration and provide ease of learning in this mode (Ku *et al.*, 2011).

The next section deals with the second research question which focused on students' experiences with AP.

4.4.1.2 Research question 2

The second research question asked the students, "how do AP shape the students' experiences with distance and online learning of university-level mathematics"? Table 4.4 shows student responses in relation to AP.

Table 4.4: AP of DLI and NOUN students

N	Item	A (%)	D (%)	N (%)	M	SD	B T (p-value)
41	Assessment procedures are well specified and included in the design of mathematics course materials in my institution.	40 (66.6)	10 (16.7)	10 (16.7)	3.63	1.12	.000
42	There are no adequate resources to support student assessment procedures.	24 (40.0)	25 (41.7)	11 (18.7)	2.95	1.24	1.000
43	The guiding principle on mathematics assessment is not well understood by the students.	16 (26.6)	25 (41.7)	19 (31.7)	2.83	1.11	.212
44	The students' assessment guidelines involve too much paper work (i.e. traditional method of assessment) compared to distance and online activities.	22 (36.7)	24 (40.0)	14 (23.3)	2.90	1.13	.883
45	Online assessment of mathematics students is the only form of assessment procedure used in my institution.	15 (25)	33 (55.0)	12 (20.0)	2.62	1.11	.014
46	My institution uses online and traditional assessment procedures in assessing the mathematics distance learners.	41 (68.3)	15 (25.0)	4 (6.7)	3.50	1.23	.001
47	I prefer traditional methods of assessment as opposed to online assessment.	31 (51.7)	11 (18.3)	18 (30.0)	3.50	1.08	.003
48	It is better to use online and traditional procedures to assess distance and online mathematics students.	49 (81.7)	5 (8.3)	6 (10.0)	4.02	0.97	.000
49	Access to assessment procedures in my institution's distance and online platform is very easy.	31 (51.6)	13 (21.7)	16 (26.7)	3.38	1.08	.010
50	I enjoy doing mathematics assessment online.	27 (45.0)	23 (38.3)	10 (16.7)	3.10	1.28	.671
51	Assessment feedback is promptly obtained online.	30 (50.0)	18 (30.0)	12 (20.0)	3.25	1.19	.112
52	Distance and online assessment procedures in my institution are very effective.	31 (51.7)	19 (31.6)	10 (16.7)	3.23	1.18	.120

*Binomial test; Source: Survey data

The table shows that students agreed that items 41, 46, 48 and 49 have a significant effect on the assessment experiences, with very low p-values. For these responses, greater percentages of the participants agreed to the assertions. A further significant response by the students in terms of their assessment experiences is also seen regarding item 45, where

33 (55.0%) acknowledged that it was not just online assessment procedures that were used. Responses to item 47 suggest that participants preferred traditional assessment over the online assessment procedures utilised in their institutions. Could this be related to the issue of prompt feedback? This is yet another question for further research.

Mixed responses could be seen from items 42, 43, 44, 50, 51 and 52 in which approximately half, or fewer, agreed with p-values well above 0.05. This shows there is no statistically significant difference in the responses of the students in these items, indicating that they have diverse experiences with AP. The result showed that the participants need resources, prompt feedback and clear guiding principles of AP to improve their experiences in the learning of mathematics. The assertion that assessment feedback should be made available to the learners on regular bases (Arend, 2007) is supported in this study.

4.4.1.3 Research question 3

The third research question asked the students, "how does LF influence the students' experiences in distance and online mathematics education at the university"? The results are presented in table 4.5.

Table 4.5: Facilitation responses of DLI and NOUN students

N	Item	A (%)	D (%)	N (%)	M	SD	B T (p-value)
53	I work with other students from my university to complete course assignments.	40 (66.7)	13 (21.6)	7 (11.7)	3.52	1.07	.000
54	I prefer setting aside time to discuss course materials with a group of mathematics students in my school.	50 (83.3)	3 (5.0)	7 (11.7)	3.98	0.85	.000
55	I work together with my instructor to clarify the abstract concepts of mathematics.	31 (51.7)	14 (23.3)	15 (25.0)	3.33	1.10	.017
56	When I have difficulty learning mathematics concepts in my school, I try to remain a self-learner without obtaining help from anyone.	13 (21.7)	41 (68.3)	6 (10.0)	2.23	1.16	.000
57	Collaborative activities with other mathematics students help to improve my performance in mathematics.	51 (85.0)	1 (1.7)	8 (13.3)	4.25	0.75	.000

58	Online collaboration is very effective in my school and it fosters mathematics learning.	34 (56.7)	15 (25.0)	11 (18.3)	3.37	1.21	.010
59	I have opportunity to experience academic collaborative activities with other ODL mathematics students in other institutions such as online collaborative learning of mathematics concepts.	18 (30.0)	29 (48.3)	13 (21.7)	2.75	1.24	.145
60	I have opportunity to experience academic collaborative activities with other ODL mathematics students in other institutions such as face-to-face collaborative learning of mathematics concepts.	29 (48.3)	18 (30.0)	13 (21.7)	3.22	1.25	.145
61	I have opportunity to experience academic collaborative activities with other ODL mathematics students in other institutions such as the sharing of mathematics course materials.	28 (46.7)	21 (35.0)	11 (18.3)	3.02	1.24	.391

*Binomial test; Source: Survey data

The results show that items 53, 54, 56 and 57 are the most significant in terms of their p-values and in polarising student responses. Mixed responses are seen from items 55 and 58 despite their low p-values. Studies have shown that in order to retain engagement and provide students with a pathway to successful distance and online study, their expectations have to be addressed through effective facilitation (Downing *et al.*, 2014).

There seems to be no statistically significant effects on items 59, 60 and 61. The proportions in these questions show diverse perceptions with regard to facilitation. The result suggests that mathematics tutors are not always available for collaboration and that online facilitation is not efficient. Collaborative activities, both face-to-face and online, are not effective.

4.4.1.4 Research question 4

In this research question, students were asked, "how do SS, using newer and/or advanced technologies, affect the students' experiences with distance and online learning of mathematics at the university"? Table 4.6 revealed the overall picture of the experiences of the students towards technology and support services.

Table 4.6: Technology that influences SS responses of DLI and NOUN students

N	Item	A (%)	D (%)	N (%)	M	SD	BT (p-value)
62	Support services are available for mathematics students throughout the week (24 hours/7days).	21 (35.0)	24 (40.0)	14 (25.0)	2.98	1.21	.766
63	Support services are provided only during the working hours of the week.	16 (26.7)	23 (38.3)	21 (35.0)	2.85	1.02	.337
64	The following technologies are provided to meet the mathematical needs of students in my university: Computer.	26 (43.3)	29 (48.3)	5 (8.4)	2.77	1.43	.787
65	The following technologies are provided to meet the mathematical needs of students in my university: Internet.	29 (48.3)	22 (36.7)	9 (15.0)	3.10	1.35	.401
66	The following technologies are provided to meet the mathematical needs of students in my university: Audio and video conferencing.	12 (20.0)	34 (56.7)	14 (23.3)	2.40	1.20	.002
67	The following technologies are provided to meet the mathematical needs of students in my university: Intranet.	12 (20.0)	31 (51.7)	17 (28.3)	2.52	1.05	.006
68	The following technologies are provided to meet the mathematical needs of students in my university: Print materials.	43 (71.7)	12 (20.0)	5 (8.3)	3.70	1.05	.000
69	The following technologies are provided to meet the mathematical needs of students in my university: CD/DVD.	10 (16.7)	34 (56.6)	16 (26.7)	2.42	1.12	.001
70	The following technologies are provided to meet the mathematical needs of students in my university: Radio lessons.	6 (10.0)	39 (65.0)	15 (25)	2.17	1.01	.000
71	The following technologies are provided to meet the mathematical needs of students in my university: Television lessons	3 (5.0)	40 (66.7)	17 (28.3)	2.08	0.94	.000
72	The following media are used to support mathematics students in my institution: E-mail.	27 (45.0)	26 (43.3)	7 (11.7)	3.00	1.40	1.000
73	The following media are used to support mathematics students in my institution: Telephone.	22 (36.7)	30 (50.0)	8 (13.3)	2.78	1.30	.332
74	The following media are used to support mathematics students in my institution: Chat.	21 (35.0)	28 (46.7)	11 (18.3)	2.88	1.32	.391

75	The following media are used to support mathematics students in my institution: On-site tutorial.	26 (43.3)	22 (36.7)	12 (20.0)	3.12	1.33	.665
76	The following media are used to support mathematics students in my institution: Mobile text messages.	25 (41.7)	22 (36.6)	13 (21.7)	3.02	1.35	.770
77	The following media are used to support mathematics students in my institution: Learning Management System e.g. Blackboard or Moodle	40 (66.6)	10 (16.7)	10 16.7)	3.63	1.07	.000
78	The following media are used to support mathematics students in my institution: Facebook or other social media platforms.	23 (38.3)	23 (38.3)	14 (23.4)	2.97	1.22	1.000
79	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: Admission.	41 (68.3)	6 (10.0)	13 (21.7)	3.70	1.12	.000
80	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: Registration.	48 (80.0)	5 (8.3)	7 (11.7)	3.90	0.97	.000
81	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: Result checking.	43 (71.6)	7 (11.7)	10 (16.7)	3.77	1.08	.000
82	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: Course materials and resources.	47 (78.3)	3 (5.0)	10 (16.7)	4.00	0.86	.000
83	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: Technology related challenges e.g. login problems or software compatibility, etc.	37 (61.7)	10 (16.7)	13 (21.6)	3.60	1.09	.000

84	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: Solving major problems encountered by distance and online mathematics learners.	27 (45.0)	15 (25.0)	18 (30.0)	3.22	1.19	.090
85	There are sufficient library resources for mathematics distance and online learners to use.	28 (46.7)	15 (25.0)	17 (28.3)	3.18	1.14	.067
86	There are accessible library resources for mathematics distance and online learners to use.	29 (48.3)	15 (25.0)	15 (26.7)	3.22	1.17	.050
87	I am able to access the library resources online from anywhere in the world.	22 (36.7)	23 (38.3)	15 (25.0)	2.95	1.29	1.000
88	My institution provides access to career counselling for distance mathematics students.	26 (43.3)	14 (23.3)	20 (33.4)	3.22	1.18	.082

*Binomial test; Source: Survey data

The table shows that the participants agreed that questionnaire items 68, 77, 79, 80, 81, 82 and 83 have significant effects on their mathematics experiences as related to technology and support services. The results from these questions (p = 0.000, rounded) indicate there are some measures of SS available for distance and online mathematics learners that participated in this study.

The finding indicating the use of print materials was consistent with the study conducted by Manjulika and Reddy (2007) at Indira Gandhi National Open University (IGNOU) in India, where they found that print remains a predominant media for distance and online learning. In addition, Pitsoe and Baloyi, (2015) demonstrated that students studying through distance and online modes still depend on print materials.

Participants disagreed outright with the availability of intranet, audio and video conferencing, CD/DVD and radio and television lessons. The responses suggest that these technologies are not utilised in learning mathematics in the two ODL institutions that participated in this study. This is contrary to Sife *et al.*'s (2007: 65) assertion that:

so far most of the universities in developing countries possess basic ICT infrastructure such as Local Area Network (LAN), internet, computers, video, audio, CDs and DVDs, and mobile technology facilities that form the basis for the establishment of e-learning.

Furthermore, Manjulika and Reddy (2007) listed computers, the Internet, audio and video tapes, intranet, telephone, radio, television and teleconferencing as the variety of media available to learn in the distance and online environment in their institutions. This view is not supported by the findings of this study for the two distance learning institutions in Nigeria.

Participants gave mixed responses to the utilisation of computers, the Internet, email, telephone, chat, on-site tutorial and mobile text messages as SS in their institutions. Mixed responses were also seen on the availability of library resources and career counselling. There seems to be no significant difference in the associated question items. The participants expressed different experiences.

4.5 Descriptive analysis of relationships between the variables

Students' experiences with instructional delivery (ID), assessment procedures (AP), learning facilitation (LF) and available technologies (AT) are described in this section. A composite score was obtained for each construct corresponding to each research question by totalling the individual mean scores of the items in the relevant table and calculating their mean (table 4.7). Table 4.8 provides a summary of the key statistics of the composite variables.

Table 4.7: The key statistics of composite variables (SPSS results)

Variable (Table)	N	Mean	SD	95% Confidence interval for mean		Min	Max
				Lower Bound	Upper Bound		
Instructional delivery (4.3)	60	97.930	11.187	95.362	101.171	52	118
Assessment procedures (4.4)	60	38.920	5.003	37.624	40.209	21	47
Learning facilitation (4.5)	60	29.670	5.695	28.196	31.138	18	42
Available technologies (4.6)	60	83.130	18.755	78.563	88.371	37	115

Source: Survey data

Table 4.8: Summary of descriptive statistics of composite variables

Variable (Table)	N	Min	Max	Mean	SD	Average %	No. of items
Instructional delivery (4.3)	**60**	1.793	4.069	**3.377**	0.386	**82.99**	**29**
Assessment procedures (4.4)	**60**	1.750	3.917	**3.243**	0.417	**82.81**	**12**
Learning facilitation (4.5)	**60**	2.000	4.667	**3.297**	0.633	**70.64**	**9**
Available technologies (4.6)	**60**	1.370	4.259	**3.079**	0.695	**72.29**	**27**

Source: Survey data

As indicated in tables 4.7 and 4.8, for example, a total score was computed from 29 questionnaire items for ID. The theoretical range being 29 to 145, a score of 87 is the middle point, so higher scores indicate students' strong experiences with ID. ID had scores higher than 87 (Mean = 97.930, SD = 11.187, score range: 52-118, 95% CI = 95.362-101.171). A large proportion of third year mathematics students had higher scores toward distance and online delivery. Hence, the participants seem to show high positive student experiences with distance and online mathematics delivery.

Following the same analysis as for ID above, the other results suggest that a large number of students have positive experiences with distance and online mathematics learning in terms of AP, LF and AT.

Moreover, the mean scores and average percentages indicated in tables 4.7 and 4.8 showed that ID, AP, LF and AT all have significant effects on the students' experiences in terms of the average level of agreement with the relevant questions. The above results confirm Doug's (2002) argument that despite the problems students encounter when learning through the distance and online mode, they are reasonably satisfied with what they are learning. Furthermore, the results equally support the evidence that the shortage of infrastructure in Africa has not stopped the continent from making progress in the application of distance and online learning in their educational systems (Tapfumaneyi, 2013).

This result is presented in figure 4.2.
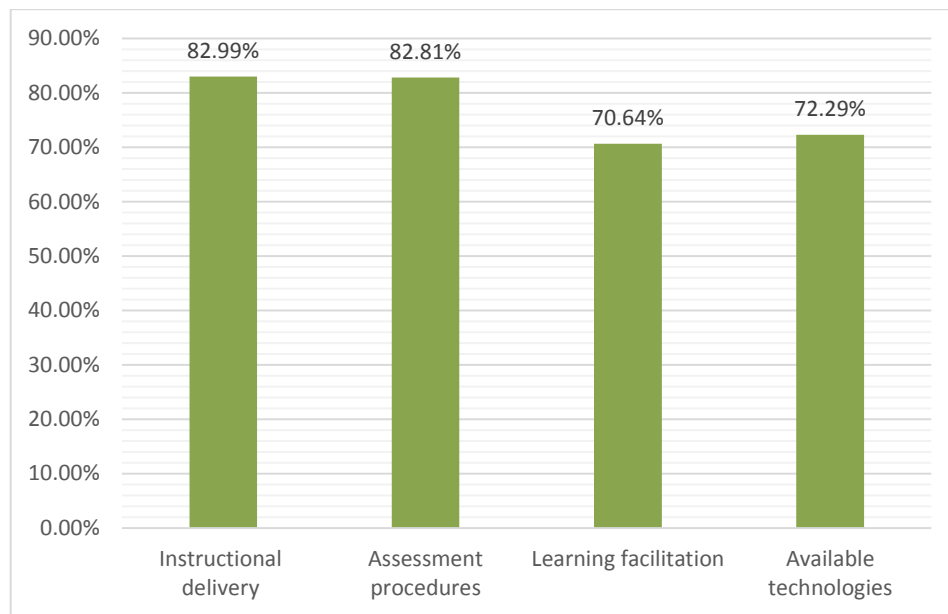
Figure 4.2: Mean score percentages for composite variables

Correlation analysis, which explores the degree to which changes in one variable are associated with changes in another (McDaniel & Gates, 2001), was used to determine whether a linear relationship exists between the variables. The most commonly used measure of relationship is the Pearson product moment correlation (Hair *et al.*, 2006). This technique is normally used when two or more scales measure an interval or ratio. The Spearman correlation coefficient is used for ordinal data and it was used in this study to determine the influence of available technologies on ID, AP and LF.

A summary of Spearman correlation coefficients (ρ) and p-values for the different variables is provided in the table below.

Table 4.9: A 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

Source: Survey data, (n=60)

116

The table above shows positive correlations between AT and ID (ρ=0.396), between available technologies and AP (ρ=0.564) and between available technologies and LF (ρ=0.632). All these are significant (p<0.05). This aligns with the findings reported by Rhema and Miliszewska (2014) who found that students with better access to technology and the Internet display positive attitudes to distance and online learning. Nevertheless, Bichsel (2013) argues that not all institutions are meeting the technological demands of distance and online learning students, despite increases in non-traditional education. This is confirmed in the present study by the preferences shown in table 4.4 that traditional forms of assessment persist (item 45) and are still preferred by most students (item 47).

To show the degree of significance by relationship, the Partial Least Square (PLS) regression method of constructing predictive models, when the factors are many and highly collinear was used (Wold 1981, 1985). The significance of the paths and path coefficients in the PLS model is assessed using bootstrap confidence intervals. Efron and Tibshirani (1993) recommend that the bootstrap interval's lower and upper limits should not include 0. The bootstrap confidence intervals used to determine the statistical significance for the paths and path coefficients in the PLS model are presented in the table below.

Table 4.10: 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

Source: Survey data

The path, strength and significance of the path coefficients assessed by Partial Least Squares (PLS) are shown in the figure 4.3.

The findings support Liyanage *et al.*'s (2013) result that students demand the inclusion of technology in the ID, AP and LF of distance and online mathematics learning. Institutional failure to satisfy this demand is one major finding of this study.

Figure 4.3: Path, strength and significance of the path coefficients assessed by PLS (n=60)

Figure 4.4 below summarises students' experiences based on ID, AP, LF and AT that influence SS.

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                          ┌─────────────────────────┐
                          │   Students' experiences  │
                          └─────────────────────────┘
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┌──────────────────────┐ ┌──────────────┐ ┌──────────────┐ ┌──────────────────────┐
│ Instructional delivery│ │ Assessment │ │   Learning   │ │ Available technology │
│   │ │ procedures │ │ facilitation │ │   │
└──────────────────────┘ └──────────────┘ └──────────────┘ └──────────────────────┘

Instructional delivery

- The course materials are well developed for the learning of mathematics in my university.
- The course materials challenge and arouse my curiosity to learn new mathematical concepts.
- The course materials challenge and arouse my curiosity to learn difficult mathematical concepts.
- I have access to course materials online over the Internet.
- ODL course materials in my institution meet students' mathematical and experiential needs for requirements for degrees and certification.
- 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.
- When the mathematics course material is difficult to understand, I give up or study only the easier parts.
- Even when the mathematics course materials are not interactive enough, I manage to continue working to understand and finish them.
- The following can help to improve the students' experiences further in distance and online learning of mathematics in my institution: Access to efficient Internet facilities.
- The following can help to improve the students' experiences further in distance and online learning of mathematics in my institution: Access to my mathematics tutors/ lecturers.
- The following can help to improve the students' experiences further in distance and online learning of mathematics in my institution: Flexible teaching and learning.
- The following can help to improve the students' experiences further in distance and online learning of mathematics in my institution: Using different forms of media – print, audio, video, etc.

Assessment procedures

- Assessment procedures are well specified and included in the design of mathematics course materials in my institution.
- Mixed reactions on the mode of assessment
- My institution uses online and traditional assessment procedures in assessing the mathematics distance learners.
- It is better to use both online and traditional procedures to assess distance and online mathematics students.

Learning facilitation

- I work with other students from my university to complete course assignments.
- I prefer setting aside time to discuss course materials with a group of mathematics students in my school.
- When I have difficulty learning mathematics concepts in my school, I try to remain a self-learner without obtaining help from anyone.
- Collaborative activities with other mathematics students help to improve my performance in mathematics.

Available technology

- The following technologies are provided to meet the mathematical needs of students in my university: Audio and video conferencing.
- The following technologies are provided to meet the mathematical needs of students in my university: Intranet.
- The following technologies are provided to meet the mathematical needs of students in my university: Print materials.
- The following technologies are provided to meet the mathematical needs of students in my university: CD/DVD.
- The following technologies are provided to meet the mathematical needs of students in my university: Radio lessons.
- The following technologies are provided to meet the mathematical needs of students in my university: Television lessons.
- The following media are used to support mathematics students in my institution: Learning Management System e.g. Blackboard or Moodle.
- 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: Admission.
- 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: Registration.
- 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: Result checking.
- 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: Course materials and resources.
- 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: Technology related challenges e.g. login problems or software compatibility, etc.

Figure 4.4: Summary of the students' responses as it relates to the variables

From figure 4.4, it can be seen that out of 88 questions presented to the participants, only 12 items each of instructional delivery (ID) and available technology (AT) for support services significantly influenced students' experiences; while four items each of assessment procedures (AP) and learning facilitation (LF) significantly influenced their experiences.

The next section used qualitative data to verify the findings of the quantitative analysis in order to discover new meanings from the study. It also provides another approach to understanding student experiences and seeks to make sense of the multiple realities gathered from their narratives. The qualitative data collection included semi-structured face-to-face interviews, open-ended questions in the questionnaire (documents) and informal conversations with students.

4.6 Findings from qualitative interviews

The results from the quantitative analysis described the general picture of students' experiences with instructional delivery (ID), assessment procedures (AP), learning facilitation (LF) and available technology (AT) that influence SS in distance and online learning of mathematics at the university. The purpose of using semi-structured interviews was to present detailed information and provide a deep understanding of the students' distance and online learning experiences. The interview protocol was organised around ID, AP, LF and AT that influence SS. Analysis of the data brought out some interesting patterns for each theme.

Pseudonyms are used where necessary in the qualitative data analysis. Ten third year mathematics students drawn from two different ODL institutions (DLI and NOUN) were interviewed. This was done to capture as much information as possible on the students' experiences with distance and online learning of university-level undergraduate mathematics. The pseudonyms Ido, Femi, Faith, Abia and Isi are used in reporting the quoted data from DLI students while Jerry, John, Kemi, Ade and Ike are used in reporting the narration from the NOUN students. The pseudonyms are consistently used and referred to the same person throughout the work. The responses, which are arranged to correspond with the interview protocols, are presented in this section.

The broad themes that emerged from the study are as follows:

1. ID in distance and online learning of undergraduate mathematics
2. AP in distance and online learning of undergraduate mathematics

3. LF in distance and online learning of undergraduate mathematics
4. SS in distance and online learning of undergraduate mathematics
5. Improvement strategies of students' experiences with distance and online learning of university-level undergraduate mathematics

The emerging themes, sub-themes and the categories are summarised using figures and tables for a better understanding of the results.

1.1 Reasons for choosing distance and online mode of learning
1.1.1 Working and learning at the same time
1.1.2 Enjoyment of learning mathematics through a distance and online mode
1.2 Instructional material accessibility issues in distance and online learning of undergraduate mathematics
1.2.1 Non-availability of Internet to access learning materials online
1.2.2 Availability of printed and online learning materials (resources)
1.2.3 Ease of getting printed course materials from the institutions
1.3 Quality assessment of instructional materials in distance and online learning of undergraduate mathematics
1.3.1 Simplicity and clarity of the course materials
1.3.2 Mathematics content coverage in the available learning materials
1.3.3 How easy is it to study course materials and compete with other mathematics students outside?
1.3.4 Suggestions for improving instructional delivery experiences of mathematics distance and online learners

2.1 Mixed mode (face-to-face/online) assessment procedures and challenges
2.1.1 Assessment mode and preference
2.2 Quality and flexibility assessment practices
2.2.1 Getting feedback on assessment and examinations
2.3 Peculiar challenges of online assessment
2.3.1 Internet, login and online submission of assessment
2.3.2 Suggestion for improvement

5.1 Internet connectivity challenges and institutional mitigation strategies
5.1.1 Provision of Internet facilities for distance students
5.1.2 Funding
5.2 Facilitation skill development
5.2.1 Training lecturers to understand what online learning means
5.2.2 Provide avenue/motivation for the students to go online
5.2.3 Mathematics cannot be restricted online
5.2.4 Create a collaborative environment for distance and online learners
5.2.5 Provision of audio and visual mathematics lectures for distance and online learners
5.2.6 Provision of tutorial centres

Instructional delivery

Improvement strategies

Students' Experiences with Distance and Online Learning

Assessment procedures

Support services

Learning facilitation

3.1 Institutional facilitation strategy
3.1.1 Availability of tutors and adequacy of facilitation skills
3.1.2 Regularity of online facilitation
3.2 Collaboration and peer support in distance and online learning of undergraduate mathematics
3.2.1 Availability of an online collaboration platform
3.2.2 Collaboration during holidays
3.3 Technology and media for support services
3.3.1 Availability of technology and media to support facilitation
3.3.2 Effectiveness of technology and media to support facilitation

4.1 Accessibility of newer and/or advanced technologies for support services
4.1.1 Availability of support services
4.1.2 SMS, video recording of lectures, CDs
4.2 Internet connectivity issues
4.2.1 Availability of Internet for distance and online learning
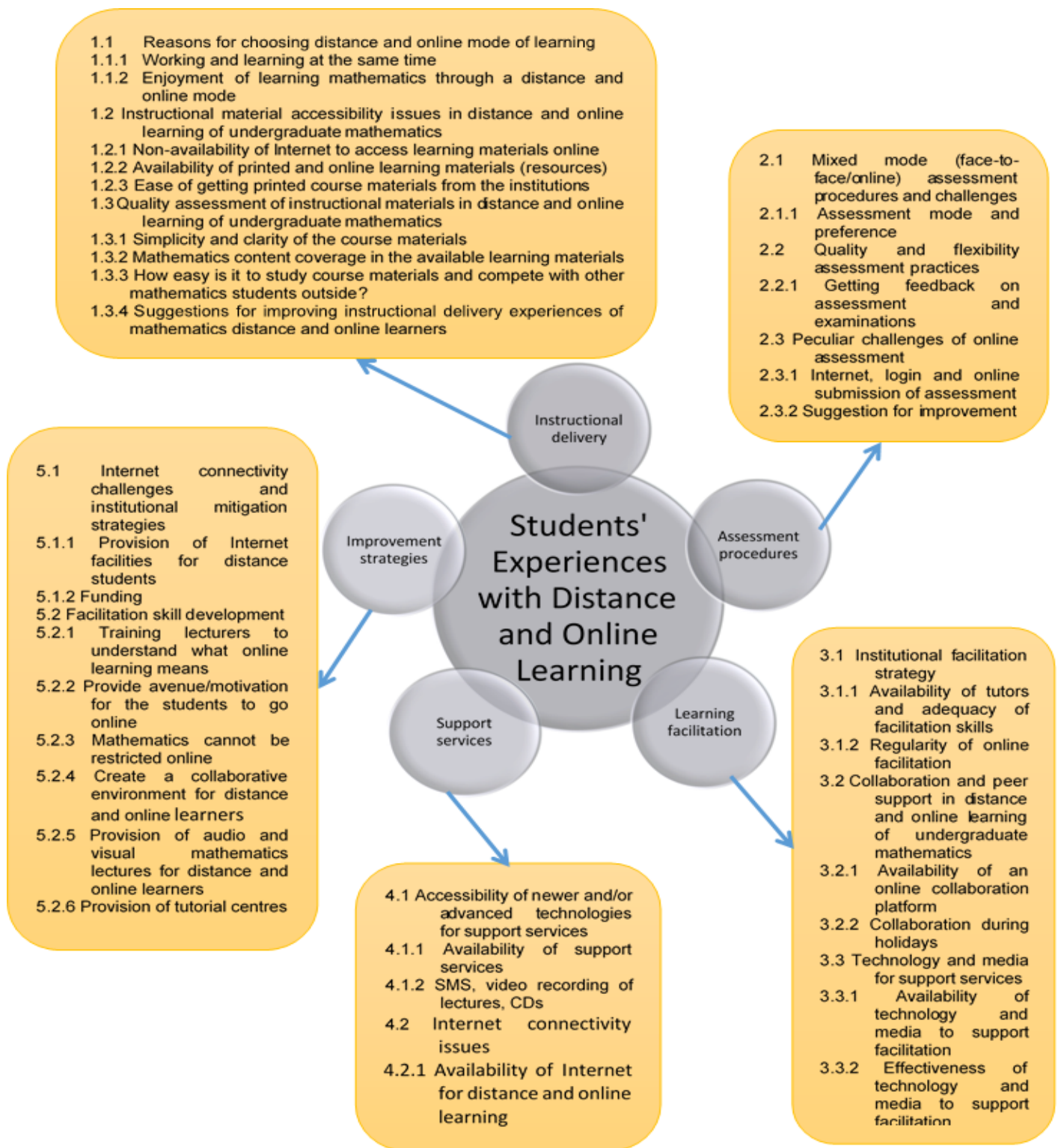
Figure 4.5: Outline of emerging themes, sub-themes and categories

Table 4.11: The summary of emerging themes from qualitative data

Research questions, themes, sub-themes and categories			
Research questions	Themes	Sub-themes	Categories
What are the students' experiences with ID in the distance and online learning of university-level mathematics?	ID in distance and online learning of undergraduate mathematics	**1.1** Reasons for choosing distance and online mode of learning	Working and learning at the same time.
			Enjoyment of learning mathematics through a distance and online mode
		1.2 Instructional materials, accessibility issues in distance and online learning of undergraduate mathematics	Non-availability of Internet to access learning materials online
			Availability of printed and online learning materials (resources)
			Ease of getting printed course materials from the institutions
		1.3 Quality assessment of instructional materials in distance and online learning of undergraduate mathematics	Simplicity and clarity of the course materials
			Mathematics content coverage in the available learning materials
			How easy is it to study course materials and compete with other mathematics students outside
			Suggestions for improving instructional delivery experiences of mathematics distance and online learners
How does AP shape the students' experiences with distance and online learning of university-level mathematics?	AP in distance and online learning of undergraduate mathematics	**2.1** Mixed mode (face-to-face/online) AP and challenges.	Assessment mode and preference
		2.2 Quality and flexibility assessment practices in distance and online learning of undergraduate mathematics	Getting feedback on assessments and examinations
		2.3 Peculiar challenges of online assessment	Internet, login and online submission of assessment
			Suggestions for improvement
How does LF influence the students' experiences in distance and online mathematics education at the university?	LF in distance and online learning of undergraduate mathematics	**3.1** Institutional facilitation strategy in distance and online learning of undergraduate mathematics	Availability of tutors and adequacy of facilitation skills
			Regularity of online facilitation
		3.2 Collaboration and peer support in distance and online learning of undergraduate mathematics	Availability of an online collaboration platform
			Collaboration during holidays
		3.3 Technology and media for support services	Availability of technology and media to support facilitation

			Effectiveness of technology and media to support facilitation
How do SS, using newer and/or advanced technologies, affect the students' experiences with distance and online learning of mathematics at the university?	SS in distance and online learning of undergraduate mathematics	**4.1** Accessibility of newer and/or advanced technologies for support services	Availability of support services
			SMS, video recording of lectures, CDs
		4.2 Internet connectivity issues	Availability of Internet for distance and online learning
What suggestions can be made to enhance the students' experiences with university-level mathematics in distance and online environments?	Improvement strategies of students' experiences with distance and online learning of university-level undergraduate mathematics	**5.1** Internet connectivity challenges and institutional mitigation strategies	Provision of Internet facilities for distance students
			Funding
		5.2 Facilitating skills development	Training lecturers to understand what online learning means
			Avenue and motivation for students to go online
			Mathematics cannot be restricted online
			Create a collaborative environment
			Provision of audio and visual mathematics lectures
			Provision of tutorial centres

Source: Survey data

4.7 ID in distance and online learning of undergraduate mathematics

This theme (instructional delivery in distance and online learning of undergraduate mathematics) was considered an important aspect of the distance and online learning environment. This is because learners and learning processes that promote the experiences of the learner are the focus. The theme is divided into: (i) Reasons for choosing a distance and online mode of learning, (ii) Instructional materials and accessibility issues and (iii) Quality assessment of instructional materials. The summary of the sub-theme and its categories as ascertained from the students' responses are discussed below.

4.7.1 Reasons for choosing distance and online mode of learning

The sub-themes are arranged into: (i) Working and learning at the same time and (ii) Enjoyment of learning mathematics through a distance and online mode. The categories described the students' narrative on their reasons for choosing to study mathematics through a distance and online mode.

4.7.1.1 Working and learning at the same time

Seven out of the ten students interviewed opted to study mathematics through the distance and online mode due to their work schedules. They include Ido, Femi and Abia from DLI, while John, Kemi, Ade and Ike are from NOUN. The students indicated that they lack time and sponsorship to attend conventional university. Owing to the convenience and the flexibility of the system, they can study through this mode; the system gave them time to strike a balance between work and study. Their feelings were captured in the following statements:

Ido: The nature of my work necessitated the choice of studying through distance and online mode.

Femi: I choose to study mathematics through distance and online mode just because it permits me to do other things like my job.

Abia: It gives me time for me to do my work and do some other work that can also engage me in getting money. Again, I choose it due to my interest in mathematics right from my secondary school.

John: I chose it because it's convenient for me especially because of my work, some people like me are not buoyant enough, they don't have a sponsor, so I have to sponsor myself, that is why I chose it.

Kemi: I think it is the most flexible way to combine work with learning, so that is why I chose it.

Ade: It gives room for somebody that is working, so that I will be going to school and also doing my work together.

Ike: One of the advantages is that it gives me chance to work and learn. While the second advantage is that it helps me to teach myself on how to tackle some problem.

Ido further explained that he could not enrol for a fulltime programme because of his age. He would have preferred learning mathematics fulltime if he had the opportunity. He said,

Because of my age I discovered that going fulltime will not favour me, if I had a better means I would have gone for fulltime because this mode is more tasking and consume a lot of money than when learning mathematics full time.

Jerry saw distance and online learning as a way of acquiring knowledge as the system is meant for mature people who can engage in independent learning. In his words, "actually, it is a way of acquiring knowledge due to the fact that this now is system for people who have mature mind and mature heart, so this why I went for it".

They all expressed the need for career development and improvement, which necessitated their choice of studying through the distance and online mode of learning.

4.7.1.2 Enjoyment of learning mathematics through a distance and online mode

The students' expressed diverse opinions with the level of enjoyment experienced in learning mathematics in a distance and online mode. Many of the participants stressed that they had not been aware of the way the programme runs prior to starting and furthermore, what they expected was not what they found. Femi from DLI said,

> Hmmm, I enjoyed it before I registered but now I am in it, it seems somehow difficult because of the way they run the system. When I heard distance learning, I thought it will be a mode whereby you learn through the Internet and also meet your lecturers in class, at least to discuss and have the experience of reading in the class and solve one or two problems which you cannot solve online.

Faith (DLI) initially saw this mode as an exciting means to improve her academic career but lamented that she was not enjoying the programme because she does not receive adequate information on what is going on. She stated that,

> I don't enjoy studying mathematics through this mode because I don't get information of what is going on in the school. There is no enjoyment at all, there are so many problem involved in studying maths through this mode. I have not been enjoying it because I have not gotten clue that will link me up to do more work on computer.

Despite the negative comments about distance and online mathematics learning from Femi and Faith, another student from DLI, Abia, indicated that he enjoyed the programme when he started, though his enjoyment did not last as the school introduced online learning. He expressed his feelings by saying,

> I really enjoy it being to the fact that is the kind of face-to-face interaction just as the way they started it initially and at the point I met them it was all face-to-face in such a way that we come

every week on Saturday for face-to-face lectures but now with this online thing, I don't understand.

Another student, Isi from DLI, expressed his surprise that online learning was involved,

actually from the beginning I wasn't aware it was online not until I got into DLI before I knew it was online but then even after knowing, I was thinking it is going to be enjoyable, so but since I am in it already, I have no option, I will not pull out.

The five students from NOUN that were interviewed expressed their experiences in the following statements:

Jerry: I am enjoying the programme, it just there are some difficulties here and there and this may be due to the new development going on in this school but maybe with time, they will improve the more.

John: To reasonable extent I am enjoying it because it's convenient for me.

Kemi: It's partial, not fully because they didn't put in the right structures to make sure this thing is effective, they make other conventional schools to under-rate it. They are not doing well enough, they call it distance and online learning whereas they are not making it really-really online learning. Go to online, look at what they put in there, there are not enough video, lectures, course materials, then the i-learn they made is not… there are not enough for mathematics, they did not put right provision for mathematics students and they even excluded maths in their i-learn and they know mathematics is a very hard task to do.

Ade: Well, let me say I am enjoying it.

Ike: I will say that I don't really enjoy it, I enjoy it partially. I enjoy it because of the advantage that it makes me to tackle some difficulties in mathematics. The challenges of searching materials to study on my own to meet up solving difficult problems in mathematics is what I am enjoying most.

Although some learners who were learning through the distance mode were quick to point out experiences that hinder their enjoyment of the programme, which includes not putting the right structure in place, there seems to be some level of enjoyment among the students learning mathematics through this mode.

4.7.2 Instructional material accessibility issues in distance and online learning of undergraduate mathematics

This sub-theme described the distance and online learners' narrative on their present experiences with instructional materials in terms of accessibility issues in learning mathematics at undergraduate level. The categories formulated from this sub-theme were as follows: (i) Non-availability of Internet to access learning materials online (ii) Availability of printed and online learning materials (resources) and (iii) Ease of getting printed course materials from the institution.

4.7.2.1 Non-availability of Internet to access learning materials online

The students who were learning mathematics through the distance and online mode narrated their experiences on the challenges they are facing in accessing learning materials through the Internet. A number of comments demonstrated the need for improvement in access to the Internet. Most of the students mentioned that they have to pay for Internet use themselves and this negatively affects their distance and online mathematics learning.

Ido from DLI lamented the frequent non-availability of Internet at his institution. He said, "Internet access is not available all the time in my school. And getting access to Internet is very expensive in Nigeria". Femi from DLI stated, "I have personal way of accessing Internet only in my office. No access to Internet at home. I study online only when in the office. No access to Internet in the school. The school doesn't provide". Faith's case is sad, as she categorically stated, "I don't really have personal Internet to study, I tried to find out how to get it but I have not got one". Abia confirmed, "There is no reliable Internet and being the fact you know the condition of our country due to light issues that is not all that stable, so instability of light doesn't make that Internet as well to be efficient enough". Isi, in agreement with his colleagues, stated, "No, I don't have reliable Internet, our services here are very bad, and sometimes you get frustrated".

The situation among the DLI students is not too different to the distance and online students at NOUN. Jerry said, "what happen is that I subscribe every month for Internet and that is what I use to check things on my laptop to understand things better". Ike said, "No, I provide the Internet on my own, school did not provide for me. I will say the one I provide for myself is reliable because I use it to source my materials online". Kemi indicated, "yea, I have my

own personal access to Internet it's not from school and none from them at all". John gave clearer and more comprehensive information of what is obtainable at NOUN by stating that,

> I have access to Internet, personal one, I provided that by myself. When it comes to the institution's Internet connection, if you have your system or you have your phone in the school environment, there's access to Internet that is LAN. We use the Internet to do all the schoolwork, especially in NOUN, there is nothing you want to do that you cannot do on the Internet. You can use it to do your registration, you can use it to get your course materials, you can use it to solve your assignment; there is a particular test we do here in NOUN which is tutor marked assignment (TMA). We do use that specifically for it and every other thing, to check our personal result and do other things too. Yea, so far so good we should be realistic, it been convenient. There are at time the Internet fumbles that is when too many people are trying to register or do the same thing at a time but most of the time, it is convenient.

Ade also narrated his experience by stating that,

> No, school doesn't provide Internet for you except now there are a lot of benefit the school is upgrading now unlike when we started the programme. For instance, the issue of e-learning, e-library are not there when we started. Everything used to be on your own, you learn on your own, you want to access Internet, it is on your own, everything on your own, but now, with the new development e-library, e-learning, you can have access to the Internet but it will be on your own. You can't get it provided for you by school except you chose to come to school's e-library, you decide to leave your home to come to school to come and learn from them but your personal place you want to read, you need to access majorly on your own.

These comments from DLI and NOUN's distance and online mathematics learners demonstrate the gap between the expectations and service provisions by the institutions. This may have affected how students experience learning through this mode.

4.7.2.2 Availability of printed and online learning materials (resources)

The data suggest that the participants in this study are not entirely satisfied with learning resources at their institutions. The majority felt that mathematics resources are not available and they have to source learning materials on their own or by liaising with students at other universities. The points raised by DLI students, for example, were captured in the following statements.

Ido: There are no enough resources available for studying mathematics through this mode. Most time we work with other institutions like NOUN students, doing joint work, comparing and sourcing for materials where one can get. It is more like you the student studying, sourcing and getting learning materials yourself.

Femi: I think the resources are not there. I have a personal computer to study online. No e-library in my school. I am not aware of e-library but we use LMS. Even the normal library of DLI, we don't have mathematics textbooks which we can study. No course materials are readily available for one to use but some are available while some are not available but majority of it are not available.

Faith: I have my tablet I normally make use of. No resources to learn mathematics, the only thing I know and I am seeing are just this face-to-face method, not enough resources. I cannot really access course materials online for now because I am not making use of it. (When she was asked about the printed material, she responded): yea - yea, the hard copy materials are the only material I have.

Abia: Eh we have it, most time they do provide us with course material, most especially modules but it is not all the courses that we offer that have the module but the ones we don't have the modules on, we have the materials provided by the lecturer to go and practise just to get ourselves busy. The modules are made available to us on the LMS but not all the courses that have their materials on LMS; it is only some of them that are there.

Researcher: How functional is the LMS?

Abia: Eh the LMS has not just been functioning well may be because they have not put down the right structure but I believe with time things will be better. He further stated, I don't have personal computer but I do make use of my phone. I mean, I use that to download materials and documents. I also do go to business centre if that requires me to go to business centre, probably I need to print something on PDF, I mean probably I have to do assignment on PDF folder, we need to send it through PDF so we need to go to business centre to get it done.

Isi: Normally I make use of somebody's laptop or I go to café to do my online assignments. I don't have personal laptop. At the moment, I believe I have resources to study undergraduate mathematics education in this mode, because, at the moment I go

online and get the modules, though most of the available modules online are education courses. No … No. I don't have easy access to mathematics course materials online. I don't have at all.

Jerry: Though they give resources like course materials, we have it but it is like mathematics is something that is very - very detailed so they find it difficult to put everything down. I think they are even trying; it is not easy to even write mathematics.

As can be read from the above quotes, DLI mathematics distance and online learning students seemed disappointed regarding the availability of the printed and online resources in their institution. The students suggested improvements in this area so that their experiences in learning mathematics through this mode could be improved.

However, in NOUN the mathematics students studying in this mode generally had a different story to tell. They appreciated the availability of online course materials. Their concerns were only that the learning materials are not produced on CDs and DVDs. Their observations were as follows:

John: Online our course materials are available, very much available. Yea, that's in my course, in my personal course.

Ade: Yea, the school provide course materials and we have them online and majorly, we have hard copy and soft copy. It's just that we don't have them on CDs and DVDs.

It is clear from the data that the students generally lack access to learning resources. This may have led to them sourcing materials on their own, thereby increasing their capacity to develop their mathematical skills and widen their intellectual ability.

4.7.2.3 Ease of getting printed course materials from the institutions

The students that participated in the study were worried about the ease of getting the printed course materials from the university. Their experiences in this regard seem to have affected their learning of mathematics through the distance and online mode. Ido (DLI) had the following to say,

Access to mathematics course materials are very difficult getting them because you have to pay and even after paying, the stress of getting it is so much. The queue is

just too much that sometimes you just have to abandon the whole thing and source for the materials online and elsewhere.

Similar responses were obtained from Kemi and Ade (both NOUN),

Kemi: Just look at the queue right there (pointed in the direction where the course materials are distributed), they are queuing for course materials; the last time I queued for course materials was in 100 level (first year). When you queue for it, you waste your money to come and queue for course materials whereas, they won't give it to you and you paid for it, except you go online to download that is the only way you can get your course materials. Don't rely on the hardcopy they are going to give to you, except you go and buy because they sell outside there as well.

Ade: When you pay for the course materials, the school make provision for hard copy but sometimes you come around to queue, you might not succeed in getting them. So before waiting to get the hard copy the best thing is to go and get the soft copy from the Internet and from there you will be able to read them from your own system.

Ido further brought in a dimension from the modules, stating that the ability to get access to the modules is a crucial step to success. He articulated this as follows,

What I learnt about the module is that once you can have them, you will definitely pass the course once you can read the module very well because everything the lecturer will ask for the course are in the module but getting the module is just the problem.

The learners stated that despite the limited number of course materials, the process of obtaining the available modules from the school even after paying for the material is very taxing and requires queuing for a long time to get them.

4.7.3 Quality assessment of instructional materials in distance and online learning of undergraduate mathematics

This sub-theme captures the findings made by the distance and online mathematics students who participated in the study on (i) simplicity and clarity of the course materials and (ii) mathematics content coverage in the available learning materials. It also focuses on (iii) how easy it is to study course materials and compete with other mathematics students outside

and on (iv) suggestions for improving instructional delivery experiences of mathematics distance and online learners.

4.7.3.1 Simplicity and clarity of the course materials

Students' experiences in distance and online learning of mathematics are likely to improve if the simplicity and clarity of the materials that support quality learning are considered in their design. There were mixed experiences among the students I interviewed. While some appreciated the fact that the course materials are simplified and easy to understand, others seem to be disappointed and argued that the materials were not simple and clear enough for learning mathematics through this mode. On the positive side, for instance, Ido (DLI) felt that the available course materials are simplified. Isi (DLI) corroborated Ido's view, saying, "The available modules are easy to understand when studying them on my own. It is easy." Femi (DLI) also agreed saying, "The course materials are easy to read on my own, it is simplified and there are even questions for you to practise."

Abia (DLI) on the other hand did voice concern by saying,

> The simplicity is there but not in all the modules, most especially mathematics modules, it's not all of them that are very simple for someone to read and understand on his or her own. No, the materials are not simplified enough to take care of the abstract nature of mathematics. Except you can get that face-to-face, asking question from the lecturer because some of them are not even Internet oriented, sorry! (Laughs)

Students from NOUN, in general, were critical when it came to simplicity and clarity of course materials. Some of their concerns were captured in the following sentiments.

> Jerry (NOUN): Some of the available course materials are not well explained too on the net. The materials are not simplified enough for mathematics. But what we do is to sort a way to help ourselves, that is by creating a group learning or getting somebody, maybe going to meet an uncle or a friend that is better in that area to help out in it.

> John (NOUN): The way the maths, being the mathematics education, the way our materials are being done on the Internet, we are not very convenient, to me it is not satisfying enough because it is not well explanatory the way we want it to be.

Kemi (NOUN): For the simplicity, I think that is the area they have to work on because they said our course materials are our lecturers and it is not all that simple enough, they have to find a way to simplify it. The abstract nature of mathematics is not fully taken care of, so they need to work on that as well.

Ade (NOUN): Some of the materials I have are not well explanatory, so you just need to make some research, meet some friends who could help me, just for me to understand the course outlines. That is why some lecturers have references inside the course materials, we prefer to go through those references to get more help.

Ike (NOUN): It depend, not all are clear and simple to read and understand on your own.

It is clear that the students placed much value on their course materials. Hence, these materials could be expected to play a crucial role in their mathematics learning. Nevertheless, from the students' point of view, these materials need to be well prepared, clarified, simple and explained well enough for them to study on their own. In addition, due care has to be taken in designing the course materials in order to increase the students satisfaction in learning mathematics through this mode.

4.7.3.2 Mathematics content coverage in the available learning materials

This category describes content coverage issues in the available course materials. For Ido (DLI), mathematics content is well covered in the available learning materials and for Femi (DLI), "the content of mathematics in the few course materials are okay".

Faith (DLI) acknowledged that even though the content is well covered, more explanations are needed for better understanding. However, she attends tutorials outside the school schedule, spending more money to get more clarity on the content. Her concerns were captured as follows,

> The contents are well covered but not explanatory to that extent because, at times there are topics that might really need assistance of a teacher to explain to me, then in situation like that I have to go here and there, go for tutorial just to cover up and now spending extra money just for that. I spend more money to fit into the programme.

Learners in NOUN expressed similar concerns.

Jerry (NOUN):

> The content that are covered in the course materials are okay but they are abstract. To understand those abstract areas, I combine with so many materials.

Kemi (NOUN):

> Not all the contents are covered but some are well covered.

Ike (NOUN):

> Yes the content in the course materials are really enough, but the only thing is that they are not explanatory very well. The abstract nature of mathematics are not tackled completely in the course contents presented in NOUN course materials.

Clearly, the students interviewed seem to have some issues with the level of mathematical explanations provided in their course material, even while they try to be polite and acknowledge the adequacy of the material at the same time. Their comments refer to the need to explain the "abstract" concepts better in the material. While they are concerned, it is clear that the students do not want to appear to be too critical or negative in their comments.

4.7.3.3 How easy is it to study course materials and compete with other mathematics students outside?

The narratives of the DLI students show that although the study materials are not easy to study from, through personal effort, they are confident of competing with other mathematics students elsewhere.

Ido:

> There are still a lot of ground to cover in distance and online delivery of mathematics in my university. The students learning in this mode are just enduring most times and not enjoying the delivery because how we want it is not what we are getting. Through my personal effort to learn the subject, I can compete with other students in other schools.

Femi:

> It is not all that easy o-o to do mathematics online because mathematics is not a course which you can just … it's not every topic you can just easily digest on your own, you understand, so-o I think it really need one to meet instructors in the class also to complement what you have learnt online. My experience studying mathematics online is that if one is not the type that is focused, this DLI is not easy,

it is, it is I don't know how to put it but one needs to endure. Sure I can be able to compete with other mathematics students outside.

Faith: Studying mathematics in this mode is very – very difficult, I have to go through pains in learning it and most times I am not being taught by the lecturer. There is nothing like having face-to-face contact with your lecturer, it makes work easier for you but in this case, you have to start reading on your own. So as not to have problem later in the future and competing with other mathematics students outside, I now have to make another option available for myself by going for tutorial and paying extra to learn it.

Abia: I mean to teach mathematics online is not even – even advisable when it comes to mathematics area because most mathematics area needs class interaction, give and take, something like that. it is not something that you can restrict everything to be done online when it comes to mathematics because there is some area that we may try to read on our own that we will not get clear except one expert in that field will come to see us, then we rub mind together, but the issue of mathematics education cannot be restricted totally online but there must also be face-to-face. So, the face-to-face should be more than issue of online.

Isi: Learning mathematics in this mode, hmmm, I don't know. It is frustrating. The first disappointment you will get is the Internet issue, the network are so bad and by the time you are set to go online and study, you find out that the network is messing up, so it makes one tired of studying at that moment. Well, I try not to be left out in competing with other mathematicians by getting materials on my own and study with some of my colleagues.

The comments from NOUN on this matter also echoed the sentiments on the challenges of learning mathematics through distance or online.

Jerry: In maths department, it is quite difficult learning mathematics in this mode. We don't have tutors, we don't have i-learning lecture at all too and we are only few in number doing the programme. So we face so many challenges here. Everybody is bearing his own cross here. What is even helping most of us, I get materials from the Internet, and I solve my mathematics at times with my colleagues. That is the thing that boost my effort and give me better chance to compete with other mathematics students.

Ike: It is so difficult to learn mathematics through this mode. What normally help me is the opportunity I have to consult other textbooks, meet other students face-to-face to discuss some of the difficult areas of this mathematics and that help me to compete with other students in other universities.

From the students' narratives, it is apparent that in order to compete with other mathematics students elsewhere, they take advantage of extra reading, source materials online and they solve mathematics problems with their colleagues. Such arrangements are strategic on the part of the students. It could also be deduced therefore that the students do have some difficulties learning through this mode since the materials are not available and, to some, have not been simplified and made easy to learn from.

4.7.3.4 Suggestions for improving ID experiences of mathematics distance and online learners

The students of distance and online learning further suggested how their experiences with the ID of mathematics in this mode could be improved. Their comments show that learning mathematics in this mode allows them to read widely on their own. The suggestions they made were captured by the following comments.

> The online learning can be improved by making sure that all lecturers are also an online person so as to give the student the adequate support needed for the programme. I mean the lecturers should be engaged in constant training to aid proper delivery of their courses in distance and online learning mode.

> ID of mathematics is cumbersome and could be frustrating due to low level of technology but it could made easy and interactive if the management put available resources to it. It can be achieved by making modules and every course materials available to students before the official date of resumption (That is immediately after resumption). The modules should be made very simple and easy for us to study on our own and understand. Make course material (printed) available to students in good time

Some other suggestions made by the learners include using face-to-face lectures to provide solutions to their mathematical problems, employing different forms of media for teaching and interaction, providing learning resources and effective learning platforms, providing the

necessary information to the learners through orientation and greater availability of online mathematics tutors for effective online learning.

From these suggestions, it is clear that students are not entirely satisfied with the way things stand. Nevertheless, they believe that if their suggestions are considered, learning will be improved.

4.8 AP in distance and online learning of undergraduate mathematics

This theme describes AP in the distance and online learning of undergraduate mathematics in DLI and NOUN. Assessment, which is regulated by available delivery technology, is a vital part of distance and online instruction. The sub-themes are (i) Mixed mode (face-to-face/online) AP and the challenges (ii) Quality and flexibility assessment practices (iii) Peculiar challenges of online assessment.

2.1 Mixed mode (face-to-face/online) assessment procedures
        and challenges
2.1.1 Assessment mode and preference
2.2 Quality and flexibility assessment practices
2.2.1 Getting feedback on assessments and examinations
2.3 Peculiar challenges of online assessment
2.3.1 Internet, login and online submission of assessment
2.3.2 Suggestions for improvement
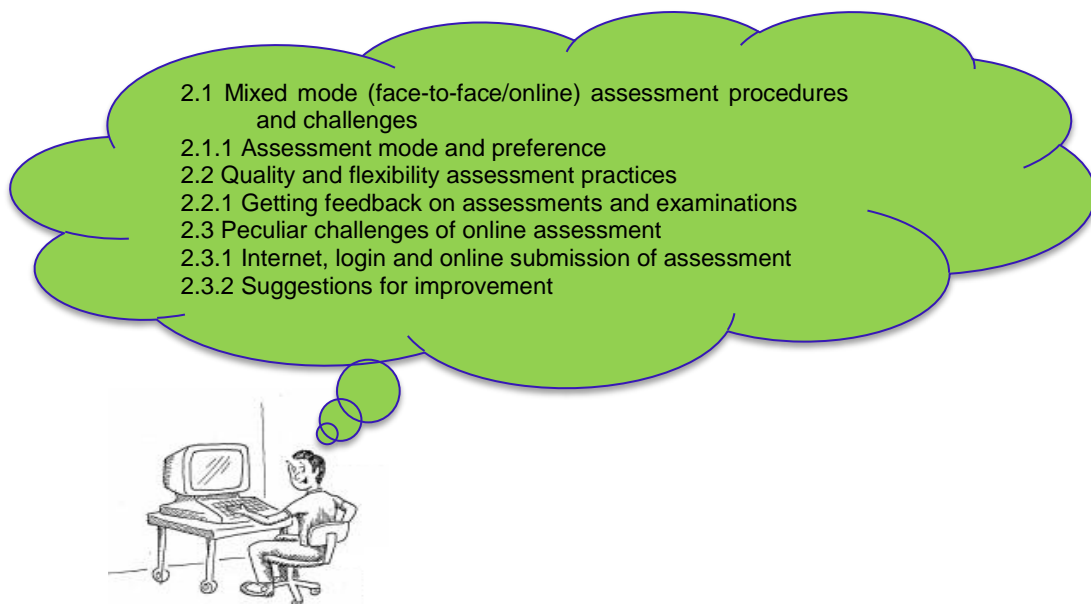
Figure 4.6: Sub-themes and categories of students' assessment experiences
(Source: own fig. based on Toos, 2004)

4.8.1 Mixed mode (face-to-face/online) AP and the challenges

The assessment procedures (AP) of distance and online mathematics learners were described using this sub-theme. Students' assessment mode and preference was the only category identified in this sub-theme.

4.8.1.1 Assessment mode and preference

As reflected in the responses, mixed reactions were observed pertaining to mode and preference of AP in these institutions. From the narrations of most students, from both institutions, they do both online and traditional pen-on-paper (POP) or face-to-face modes of assessment. While some prefer online, the majority stated that the traditional POP mode of assessment is the best. This is because traditional modes allow them to express their mathematical knowledge on paper.

Ido from DLI categorically stated that he prefers online modes of assessment but because they do not receive feedback, he directed his preference to the traditional mode. In his words,

> The assessment is done face-to-face, it's just few lecturers do assessment online. I prefer online mode of assessment if there will be feedback but sometimes you submit assessment online to get feedback, you will not. I prefer pen and paper assessment if there would be no feedback for the online assessment. I will want them to give online assessment sixty percent and traditional forty percent in preference.

Similarly, Femi, also from DLI, said they do online and traditional assessment but online mathematics assessment normally causes difficulty while submitting. The difficulty was because of the Internet connectivity.

> We do some assessment online and we do some through traditional means. I think the traditional means is better and I prefer traditional means because at times we do have difficulties in submitting assessment online. You know I can't go online anytime I wish, I have to wait till when I am in the office because that is where I have Internet access and even with that, it is not all that easy. Supposing one has access to Internet at any time, it might be better because you will keep on trying submitting until you succeed.

Faith was not happy with the way AP are carried out at DLI. She seemed to be disappointed with the structure in place when she stated,

> Assessment is only on traditional means, I have never done any assessment online in my present year three, the only thing online I have done here is doing assignment on LMS. I did it when I was in year two.

She was so agitated in recounting her experiences that she had to be calmed down by the researcher in order to be able to express her preferences for assessment modes in her school and to narrate her experiences. She said,

> I think I will prefer traditional means of assessment. The reason is because most time online, before you log in, they keep asking for pass code, your password here and there and that usually take time. I could remember there was one particular course we did last session (year two), some were able to submit their assessment successfully online while some of us were not, we were there the whole night doing the assignment, at the end of the day, the lecturer asked those us that were not able to submit online to write it traditionally. In a way I feel if they can just make it so compulsory for us to do our assessment traditionally if they cannot get the system right that will be fine.

Abia also expressed his opinion concerning the mode of assessment at DLI. He commented that online and traditional assessment is welcome and stressed that online assessment should not be used more than traditional modes.

> Yes, they make use of both traditional and online assessment. Eh, both of them are okay. I am at the point of saying both are okay. Because you going online to do your assignment will expose you to some other things and as well you doing it traditionally, it help you to express yourself by doing step by step kind of thing that is needed in solving mathematics problem. Some students will not have the means of coming to school all the time to submit assignment to the lecturer face-to-face like some will like everything to be traditional, so both are okay. From my observation with what is going on in this my school, they want to restrict assignments and assessment online alone. That cannot be easy for mathematics education and it can't really help at all. The issue of online assessment shouldn't be more than the traditional one.

Isi's view on AP at DLI was similar to Abia's. He preferred traditional modes so that the stress of submitting the assignments online will be diminished.

> The two modes (traditional and online assessment) are used in my school. Hmmm, I will say I prefer the traditional mode. So things like that, to me I still prefer the traditional way of coming to class and assessing us, so to save us that stress of

roaming up and down seeking for how to go about submitting the work online after managing to type set them.

Jerry (NOUN) brought in another dimension. He commented that online assessment takes place in the 100 and 200 levels, while POP is used in the 300 and 400 levels. Jerry preferred online because of the exposure to likely examination questions.

> I prefer that online because what you have seen on TMA if you study your TMA by yourself very well, you won't find the exam difficult but one thing about paper and pen, you have to be very detailed from the beginning to the end. Most of us go to TMA, the topic you don't understand you go through it very well. Once you can attempt TMA very well you can pass your exam. The exams are done on paper that is only for 300 level and 400 level but years 1 and 2 do everything online.

Kemi, also from NOUN, confirmed the assertion by Jerry. However, she maintained her preference for the two modes of assessment, as she said,

> We do both online and traditional assessment. We do online exams when we are in 100 and 200 levels but come to 300 level it is pen and paper all through. I think both are preferable because online can't test the capability of the students enough, so you wouldn't be able to explain certain things online. It is better the way they do it. The simpler ones are in 100 and 200 level and the more complex one, you can be able to explain better in 300 level and 400 level on pen and paper.

Similar to Kemi, Ike maintained that he preferred traditional and online assessments equally. He said,

> I prefer both because 100 level and 200 level is just like a preparation, then, you know is just like a child, you can't continue giving a child milk, a time will come you try to teach the child how to take a strong food. So the paper own is also advisable, it will also help you to know how to write and solve mathematics problems on paper not just online because it will help you to break down the process of calculating the mathematics on paper. So both are advisable. I can say that assessment mode in NOUN is effective, I like it.

For John (NOUN) too, online assessment is easier and faster, for him to show his skill, he stressed that traditional assessment is important. He said,

I think online and traditional assessment are both good, I prefer them both because they test different skills in student. If I say I want online assessment though it is faster and easier for me but when I have traditional mode, it is easy for me to know the real skill that is in me. You can really get me very well, then you can assess me better than online. Online is programmed and it is not enough to assess mathematical skills in me, so I prefer the traditional so let me just take that.

Ade (NOUN) prefers traditional assessment because he feels that will enable his tutor to discover the extent of his mathematics knowledge.

Yea, our assignment is always online in our lower class. I prefer traditional mode of assessment because from my pen on paper, it will really going to help you to know as much mathematics I can do as a student of mathematics and that is the beauty of maths. Those who are in 100 to 200 levels, their mode of assessment is only online but from 300 level upward, it is both on traditional and online. Well, as a mathematics student and to be able to get the best out of mathematics I think paper is very important because it helps the students to express themselves on paper.

Many of the students maintained their preference for the two modes of assessment (online and traditional) since the two are aimed at developing different mathematical skills in learners. The learners are more satisfied with AP at NOUN since the structure is well defined for the students, unlike the experiences of the students at DLI.

4.8.2 Quality and flexibility assessment practices

This sub-theme described the narrative of the students regarding quality and flexibility of assessment practices at DLI and NOUN. Four students from DLI and NOUN responded in terms of getting feedback on assessments and examinations.

4.8.2.1 Getting feedback on assessments and examinations

For Femi (DLI), the systems for getting feedback on assessments and examinations are not yet effective. His expectation of getting instant feedback was not met. His view is seen in his narrative,

I think they have a lot to do in the area of giving feedback on assessment to the students. This DLI stuff, assessment feedback supposed to be instant something since they said it is online. Also, like you doing your exam and getting your result

immediately since it is online and there is nothing of such. It takes months to get the result after the exams and it is not good because, there is no difference between you and those doing traditional exams and at times when the result will come out, it won't be complete. They will tell you missing result.

The researcher asked, what happens in cases of missing results. Femi responded as follows,

Most of the time, you sit back and wait until they release it. Just using the online something for now is not the best, the online something should continue alongside with that traditional way whereby when people are now absorb the online thing they can be withdrawing traditional method gradually, it is not something one can just drop.

For Ido (DLI) online assessment is not good enough. He emphasised the lack of feedback as follows,

There is no feedback from the tutors when we do assignment online. Sometimes you submit assessment online to get feedback, you will not and they said it is online. You wait for ages to get feedback on your exams.

Jerry and John were happy with the online assessment at NOUN. They experienced effective online assessments in years 1 and 2 but in years 3 and 4 they did POP. By then, their confidence has been built to tackle challenging questions traditionally. For Jerry, "I can tell you that the online quiz we do in my school is very effective. The assessment mode I will say is okay. It is okay in the sense that we easily submit the assessment online without any hindrances." John stated that, "due to the way the assessment is organised, confidence has been built in us to solve mathematics problem. It's very okay."

Ade (NOUN) was also satisfied with the assessment feedback when they were in the 100 and 200 levels of this programme. He said,

Yea, our assignment is always online and it is easy to do them online and submit online. You are not typing any mathematical functions, so it is easy.

We see mixed experiences from students in terms of getting feedback on their assignments. While most of the DLI mathematics students were not satisfied, NOUN students appear to be pleased with the way feedback is handled at their school.

4.8.3 Peculiar challenges of online assessment

This sub-theme addressed two categories of issues (i) Internet, login and online submission of assessment and (ii) suggestions for improvement.

4.8.3.1 Internet, login and online submission of assessment

Four responses were recorded in this category. Abia (DLI) simply said that if assessment is restricted to online alone, students learning mathematics in this mode will not be as successful. He is of the opinion that the standard will be lowered for the students as they will struggle to cope with online assessment. He elaborated on his point as follows,

> Yes, if they strictly go online, mathematics education students cannot learn much because simple questions will be asked for the student to be able to solve and get the answer within the limited time. The problem of Internet connectivity is still there hindering us from submitting at the stipulated time interval. Mode of assessment is poor because feedback is not usually given immediately solutions are proffered by students and this is caused by Internet problem.

Isi (DLI) narrated his case as follows,

> I remembered while we were in year two when we were given assignment, and we are to type it, we have to go through hell because a-aha, we have to go back to network issues and again, at times you log-in, it will tell you something like error, and all those things may be that the code they've given you has an error, so you have to look for a way to come back to the lecturer and report. It takes time to resolve. It is of two ways, if the university can really improve the online assessment system, we will be okay with it. Because I was saying there is a course, I won't mention the name of the course, so far with the online it is a maths course, we never had issue with it, we never had issues, we did everything online, we even had test, 30 minutes online and immediately you click, it open and you do your test online and we enjoyed it. So if they can actually improve like that we will enjoy it.

For Ike (NOUN), doing assessments online is still challenging. The problem of questions disappearing before giving the answer remains an issue. He commented,

> Sometimes you see some question online, before you click it would have wiped off, so I don't really enjoying online assessment as such. The mode of assessment

supposed to be quite interesting and brain tasking and more importantly provides hints to examination questions, but all these do not come to be due to problem of submitting.

The availability of the Internet and its connectivity is another issue raised by Femi (DLI). He found it difficult to submit assessments online, due to a lack of Internet connectivity.

> I have difficulties in submitting assessment online because I cannot at any time I want go online due to lack of Internet connectivity. I can only have access to Internet after office hour, I have to wait till when I am done with the office work to go online and even with that, it is not all that easy. Supposing one has access to Internet at any time, it might be better.

The students lamented that poor Internet connectivity and availability is a big challenge hindering the online login and submission of assessments. The improvement in Internet connectivity will help ease this problem.

4.8.3.2 Suggestions for improvement

From the open-ended questionnaire, students suggested that the level of feedback given for online assessments should be improved. However, they were also of the opinion that assessing through this mode has its advantages. For example, the assessment will be done in such a way that students can do it anywhere. Furthermore, they suggested that if the online examinations must be done using university facilities, the examinations should also be available during weekends.

4.9. LF in distance and online learning of undergraduate mathematics

Figure 4.7 shows three sub-themes associated with learning facilitation (LF) categories identified from students' narratives. The three sub-themes are (i) institutional facilitation strategy in distance and online learning of undergraduate mathematics (ii) collaboration and peer support in distance and online learning of undergraduate mathematics and (iii) technology and media for support services.
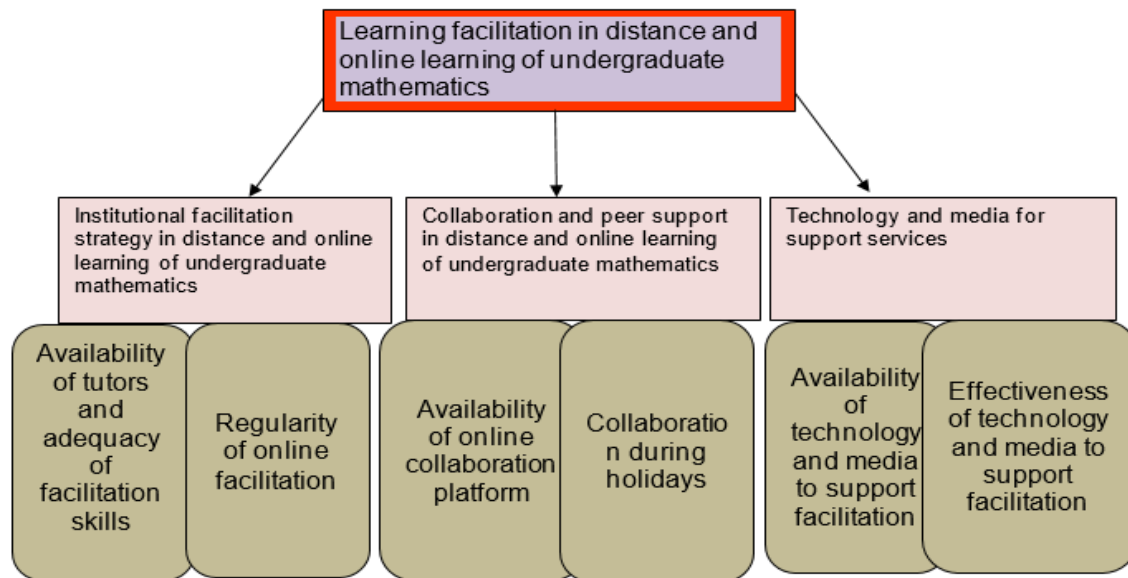
Figure 4.7: Sub-themes and categories associated with learning facilitation

4.9.1 Institutional facilitation strategy in distance and online learning of undergraduate mathematics

In this sub-theme, aspects of LF, as narrated by the participants, are presented. Their opinions come from interviews and the open-ended questionnaire (survey document). The categories are (i) availability of tutors and adequacy of facilitation skills and (ii) the regularity of online facilitation.

4.9.1.1 Availability of tutors and adequacy of facilitation skills

The students narrated how a lack of mathematics tutors to facilitate their programme affects their experiences in learning through this mode.

For Ido (DLI), facilitation is not adequate. Students do not have free access to tutors to help them with their mathematics. He narrated his experience as follows,

> Just few lecturers make themselves accessible and so very difficult to approach lecturers to obtain help when in problems. The facilitators are not there to help students to understand and solve mathematical problems they are facing. Students are not having free access to facilitators. So facilitation is on but not yet adequate.

Femi (DLI) also explained,

There are some topic you need to consult tutor because such topics need face-to-face handling but you can't find them. Me and my colleagues, we do support ourselves by sharing experiences of what we have read. The major challenge is that one really need a tutor contact to collaborate with at any time. Not having interaction with facilitators is really affecting our learning.

Faith (DLI) lamented,

I have not had collaboration with other students online or my lecturer, the only thing I know is one lecturer that asked us to visit LMS and he gave us scores for doing that. They claimed support is given through LMS but it is not working well and it is not accessible to students.

However, Abia (DLI) indicated that some tutors do help to facilitate student learning stating,

There are one or two lecturers that do help us in clarifying those things that are not clear to us about the school and the programme we are running. They normally come to clear issues for us. In a way, facilitation is very effective with some courses but not all courses. So, one can just conclude that facilitation is partially available since not all the lecturers are involved.

Isi (DLI) maintained there is no facilitation going on with the tutors. He stated that they organise themselves (students-to-students) to discuss problems,

There is no online facilitation from tutors, students only organise to see ourselves face-to-face to discuss our mathematics problems. Distance and online facilitation is not just readily available.

Jerry (NOUN) corroborated this,

We have student-to-student online collaboration but there is nothing like tutor collaboration with maths education students, we don't even have tutors to start with but they do have tutors in other subjects but not in maths.

Further reports of not having tutors for facilitating student learning included the following,

Except seeing other students one-on-one, collecting their phone numbers to call ourselves to see how we get together to solve mathematics problems affecting us.

147

> Meeting teachers online? That one is absolutely zero. To start with, we don't even have tutor in mathematics not to talk of meeting them online (Kemi, NOUN).

> Talking about the tutor, we don't have any, we can just forget about that because they are not available, it is another issue. But when we talk among ourselves, we normally meet face-to-face, sometimes we need to come around, discuss some topics (Ade, NOUN).

> There are no tutor–student collaboration online because we don't have tutors. […] My opinion is that if they can just make it interaction, maybe 2 weeks in school, then 2 weeks online (Ike, NOUN).

Students' frustration regarding a lack of mathematics tutors for facilitating activities can be gleaned from their comments. For DLI learners, facilitation is partially provided by few lecturers, while NOUN learners' experiences are more disturbing as they lamented the lack of mathematics tutors at their institution. The learners seem to take responsibility for their own learning by collaborating and supporting themselves.

4.9.1.2 Regularity of online facilitation

Some responses showed that students find it difficult to interact online. The difficulties faced by Faith (DLI) hinder her regular participation in the online facilitation,

> If the lecturers can really make it a point of duty to always give out something [assignment] that will always take us online to collaborate, that would have been nice. I have tried times without number just to participate and educate myself on this online thing, it has not been so easy for me. So if they can just give us a lecture or seminar on how to do it easily and still making it compulsory for us to always visit online and give us something to do online, I think that will help me.

Faith was not alone in this experience at DLI. Isi spoke of the need to educate the students and lecturers on how to use online platforms for regular facilitation. Students agreed that facilitation is not regular. Some of their responses were as follows.

Isi (DLI): I still believe that we should be enlightened the more, we the students and even the lecturers. The system should enlighten the lecturers on how to use the online platform to facilitate the students learning regularly, even we ourselves because most of us

148

don't know how to use it. I see a lot of people asking questions on how to use the LMS and those things to collaborate.

John (NOUN): Facilitation is not regular at all, it's once in a while we see our lecturers online.

Kemi (NOUN): Do you say regular? Like our own mathematics education department, you can hardly see mathematics tutors. We will like them to give us regular time for online and face-to-face facilitation that will help us to learn.

The narratives of the students on the regularity of online facilitation show similar experiences. In general, there is no regular facilitation.

4.9.2 Collaboration and peer support in distance and online learning of undergraduate mathematics

This sub-theme captures the students' current collaboration and peer support experiences. The sub-theme was further categorised into 'availability of an online collaboration platform' and 'collaboration during holidays'.

4.9.2.1 Availability of an online collaboration platform

Students commented on the availability of online collaboration platforms as follows,

> They have a platform where they collaborate with one another and to discuss their mathematics problems. The platform is somehow effective when the institution is in session but not effective when the school is not in session. The learning management software is available but most times the lecturers do not upgrade them for learning to take place, it is not effective enough (Ido, DLI).

Most learners confirmed the availability of an online collaboration platform but have not had the experience of online collaboration either among themselves as students or with tutors. Others reported that the school created the platform but it is not effective for collaboration due to a lack of tutors and a lack of time on the part of the learners to explore the platform.

4.9.2.2 Collaboration during holidays

Only a few students commented on being able to collaborate during holidays. The others simply did not want to waste time on this because it just appeared impractical.

At DLI, Ido felt "the platform for holiday collaboration is not functional" while Femi suggested, "they should work really on the Internet connectivity so that on holiday or immediately after resumption we can start collaborating".

Abia (DLI):   Yes there is always interaction between us in order to share opinion. It is not done online or during the holiday. We call ourselves on phone when the school is in session and arrange when to meet in our study centre to collaborate and this is not all that regular as many of us are busy with our work.

John (NOUN) commented:

No I don't meet…either the students or lecturers online for collaboration during the holiday. I just try to contact some students I know on phone to assist when I have some issues during the holiday. We do not meet during the normal school time like that talk less of holiday. There is no provision for holiday collaboration ma.

The students' responses indicate their struggles to collaborate with each other, especially during the holidays.

4.9.3 Technology and media for support services

This sub-theme discusses technology and media that assist in facilitating students' learning. This is categorised into: (i) the availability of technology and media to support facilitation and (ii) the effectiveness of technology and media in supporting facilitation.

4.9.3.1 The availability of technology and media to support facilitation

Students indicated that they are not exposed to a variety of technologies in their universities. The main media for interaction is through the Short Message System (SMS) in which the content is sometimes unclear. Some of them lamented that Internet availability and connectivity is a major problem hindering involvement in facilitation.

There is no other means except the SMS. The SMS sometimes is not clear enough but thank God for our governor (class representative) who is on ground to pass available information. You know we cannot interact through the SMS sent to us by the school because it is customised but we can interact with our governor. He is doing nice job to update us in what we suppose to know in this programme (Ido, DLI).

Another learner who responded to this stated,

> The ID of mathematics which has to do with interaction online with facilitators and through all modern technology for the students are not available. They contact us through our governor and at times the deputy director (DD) even sent text to us and no other means of contacting me (Femi, DLI).

This learner further described his experiences by saying,

> The first problem we have in learning maths in this mode is the Internet issue. The network are so bad. If I don't have Internet connection, how do I collaborate online even if the platform is there? The first thing first. I only interact with my classmates face-to-face (Isi, DLI).

Similarly, Abia (DLI) relayed his own experience in the following comments,

> In terms of that technology to collaborate, I buy data through my phone so that I can get my materials online and study and not that it is for collaboration. No other technology.

When he was probed for LMS, radio, TV and others, Abia said,

> Hmmm, well, I just feel that since the LMS is not working, let me just make do with the books, my traditional way of doing things. I feel that since all these technologies we are talking about are not available or put into use, the rate of using technology to study maths, especially maths to that of face-to-face should be 30% to 70%.

Most of the participants at NOUN stated that there are no technologies for online collaboration. Therefore, they opted to collaborate among themselves most of the time. Kemi simply said, "we don't get any facilitation support from teachers at all, we contact ourselves using our personal technology". The findings from the students suggest that they are only familiar with SMS support and interaction with their peers.

4.9.3.2 The effectiveness of technology and media in supporting facilitation

Some of the students commented that the most important factor that can make collaboration effective is availability and connectivity of the Internet, availability of online tutors and continuous improvement of the system. Some participants felt that there is a need for some sort of face-to-face even after meeting online, for the whole facilitation to be effective. Their points were captured in the following sentiments.

Ido (DLI):

> The facilitation support is not encouraging enough and when it is not enough you cannot say it is effective. Support is not enough even on the LMS. It can only be effective if the system can do more work and improve Internet provision. Accessing the internet actually in this part of the world is very difficult, if we can do more in that front accessing the Internet everywhere you go, you can use your WiFi, you can easily receive lectures wherever you find yourself.

Faith voiced her dissatisfaction by saying, "in short I don't accept that facilitation is effective when the help is not enough in learning of mathematics here in DLI".

Isi (DLI) felt that the best way to ensure effective facilitation is by making sure that all the communication avenues are utilised. He said, "to me I feel that even after studying online and teacher explain online and we see what teacher has done, I feel we should get opportunity of talking to our lecturers in face-to-face classroom environment". He continued, optimistically,

> Yes, facilitation is getting better for mathematics students and science students generally. We do have support now and thanks to a man but I will not mention his name, actually, they have support for especially science as a whole now. Maths and science education in the past are seen as a minor department, because of the number of students doing the course. We are being treated somehow but at least for now that has ended because right now whenever we need anything, we know who to go to, so we have support now. If they continue on this note the difficulties we are having on learning mathematics and facilitation will not be there any longer.

For Jerry (NOUN), "no one supports us using any technology, lecturers are not available. It is not effective". Ade (NOUN) added,

> ….but with the new i-learning, I think there is room for effectiveness. The new students who are just coming in are going to benefit more in this new technology (i-learning) than we who have already move away from it to POP and that is why like those who are in 100 level now, they are the one exploring.

Kemi (NOUN) in her own narrative revealed that, "facilitation is not effective". John upheld her assertion as he stated, "distance and online facilitation using modern technology is not effective in the study of mathematics in my university".

The students admitted that facilitation is not effective due to Internet problems and a lack of mathematics tutors but were optimistic that things will get better soon with the ongoing development in the universities.

4.10 SS in distance and online learning of undergraduate mathematics

Support services (SS) in distance and online learning of undergraduate mathematics are reviewed in this section. This theme throws light on how the students learning mathematics in this mode experienced SS. The theme dwelled on the following sub-themes (i) Accessibility of newer and/or advanced technologies for SS and (ii) Internet connectivity issues. The theme, sub-themes and categories are represented in figure 4.8.
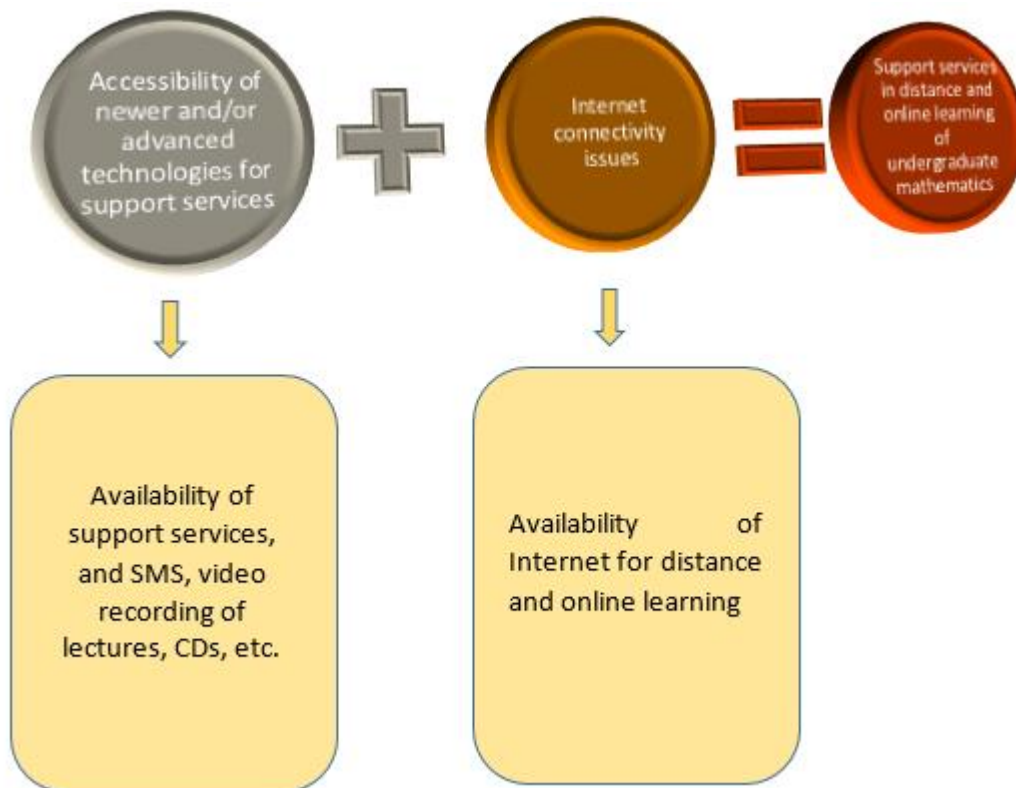

Figure 4.8: Sub-themes and categories associated with support services

4.10.1 Accessibility of newer and/or advanced technologies for SS

This sub-theme captured student narratives as they related to accessibility of technologies that support their learning. The sub-theme is categorised into: (i) availability of SS and (ii) SMS, video recording of lectures, CDs, etc.

4.10.1.1 Availability of support services

The data used for this category came from student narratives including responses to open-ended questions. Students expressed concern regarding learning in this mode and had mixed reactions concerning the availability of SS. Some stated outright that there was a lack of support; some said it was partial and some others stated they are not aware of its availability. Many reported common experiences. Hence, the following narratives represent their responses from DLI.

> I have never got any support, so if such support will really be made available for students, I will really appreciate that. I don't even have personal computer, I source Internet by myself whether in school or at home.

When asked about e-library:

> I have heard about e-library but I have never tried it and because I have not gone there I don't even know what is available there.

For others, "I am not aware of e-library but we know and use LMS. Even the normal library of DLI, we don't have mathematics textbooks" and,

> Yes, we do have support through LMS. Last year it was really difficult, nobody to teach us and educate us on how to use the LMS, we have to struggle through it ourselves. So they should give us a better enlightenment on how to use it, then they should enlighten the lecturer also on how they can video conference their lectures for students.

The view categorically stated that support services are not available at DLI,

> No I have no idea if there is any support services provided by my school. I do not know any support services apart from lectures. No video conferencing, radio lessons and televising our lectures.

The reported experiences of mathematics students at DLI on the availability of SS were not too different from what NOUN students said. Their narratives follow.

> No one supports us, lecturers are not available, and I provide all the technology I need to study in this mode by myself. Students and students alone provide the technology they study with, like computer, Internet and the like. The i-learn they said they have, well it is a good idea but it is not well planned to bring in mathematics students. There is no radio and television lessons in my school, I have not seen/heard anything like that.

Further explanation was expressed as follows,

> They may have video conferencing, radio programme, and others for other courses they run here but not in mathematics education as it were. They designed the platform and that is all. Since I have been here, I have not received any technological help like that. In fact, SS are frustrating and requires improvement.

Others at NOUN confirmed that they receive some measure of support, even though it is not sufficient or satisfactory,

> Yes, some support are provided that is Internet, online tutoring etc. but not radio and television lessons. I also admit that Internet and online tutoring are not provided 24/7 and the students cannot give it 100% satisfactory, not sufficient enough and not too effective.

In general, the students interviewed felt demotivated by the lack of appropriate technology to support their learning. It seems very challenging for them to provide these things by themselves without help from the university. As far as the lack of technology to learn mathematics in this mode is concerned, the qualitative data collected for this study contained no explanation for this. Further investigation would be needed to explain this.

4.10.1.2 SMS, video recording of lectures, CDs

Many learners simply did not bother to respond to this because they said they had already indicated there is no support and the only course materials they have are the modules. Of the few who responded, Isi (DLI) said, "I receive SMS at times, I can see information posted at the LMS but for videotaping our lectures and putting them on CDs/DVDs is out of it". John

(NOUN) commented, "Our materials are not in CDs/DVDs. They do not produce videotape of our lectures". Kemi (NOUN) echoed this, "haven't seen anything of such. That is burning course materials on CD for the students? No way". For Ade (NOUN), "we don't have CD, DVD and videos of our course materials. We don't have latest technology to facilitate online studies".

Many students requested audio and video lessons. This would enable students to understand and correctly pronounce mathematical symbols. They stressed that with CDs/DVDs or through access to audio and visual recordings, it would be easier to play and listen to them at their convenience.

4.10.2 Internet connectivity issues

This sub-theme captured the students' narratives on Internet connectivity issues. The category considered is availability of Internet for distance and online learning of mathematics.

4.10.2.1 Availability of Internet for distance and online learning

Learners only have access to Internet made available and paid for by themselves. One learner categorically stated that she does not have access to the Internet despite making efforts to obtain Internet connectivity. Opinions were captured as follow.

Ido: Internet access is not available all the time and getting access to it is very expensive in Nigeria.

Faith: I don't really have personal Internet to study but I am trying to find out how to get one.

Abia: There is no reliable Internet especially in this part of the world. It is frustrating.

Isi: No, I don't have reliable Internet. Is not that I don't have access to it hundred per cent but the services here are very bad, sometimes you get frustrated.

Jerry: What happen is that I subscribe every month for Internet because there is none from the school and I must learn.

John: The Internet access I have is personal, I provided that myself for my school work. The school did not provide any one that I am aware of.

Kemi: I have my own personal access to Internet that is not from school.

Ade: No school doesn't provide Internet for you. I use to subscribe to make sure that I am online regularly to learn.

Ike: No way. I provide the Internet on my own, school did not provide for me.

The consistent issue of Internet connectivity recurs in all the student responses. Distance and online learning depends heavily on technology, with Internet access being an important determining factor. Fast and reliable access to Internet is thus essential for the learners to make progress in their studies.

4.11 Improvement strategies of students' experiences with distance and online learning of university-level undergraduate mathematics

This theme presents improvement strategies concerning the experiences of the students studying in this mode at the two universities and by extension to other ODL institutions. The students' responses in the document analysis, complemented by the interviews mainly provided the data for this section. Figure 4.9 diagrammatically indicates two sub-themes. The two sub-themes are 'Internet connectivity challenges and institutional mitigation strategies' and 'facilitation skills development'.
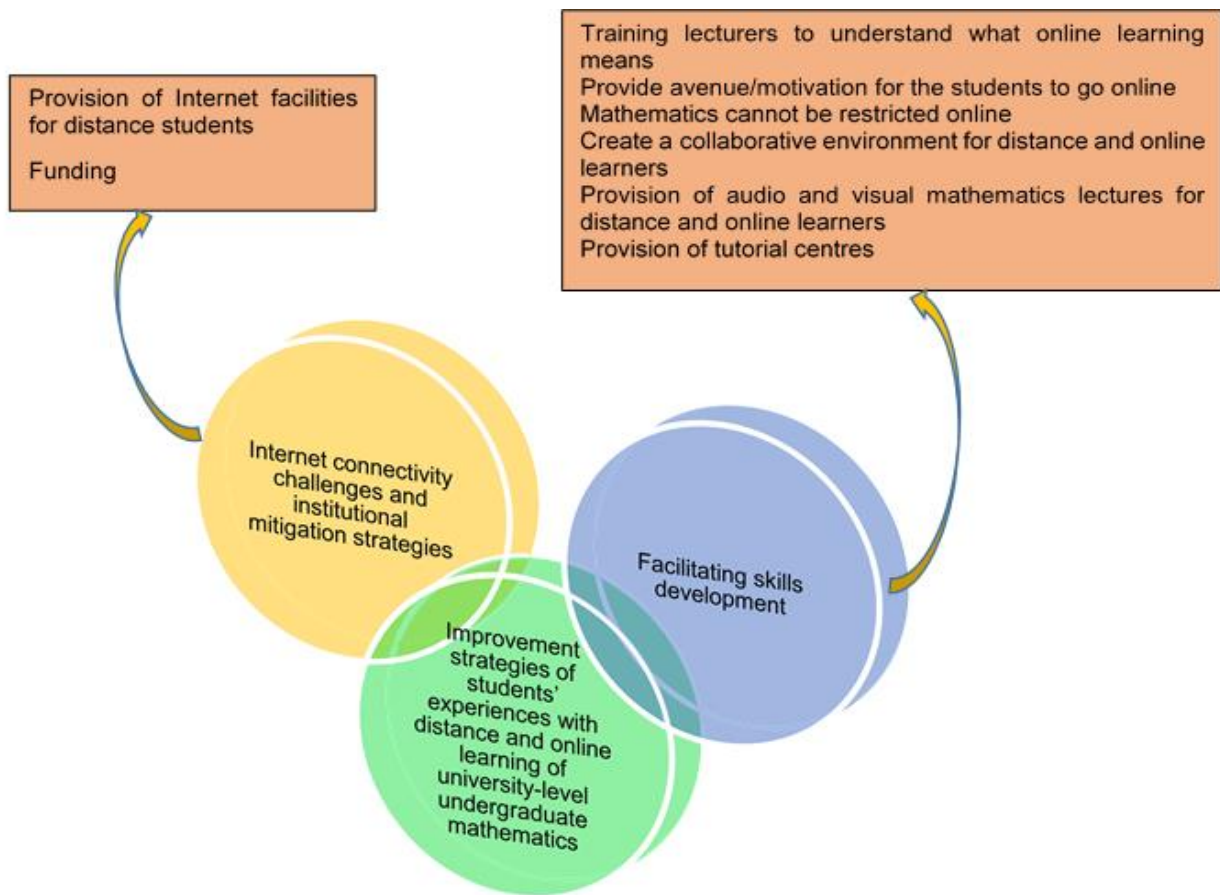
Figure 4.9: Improvement strategies of students' mathematics learning

4.11.1 Internet connectivity challenges and institutional mitigation strategies

This sub-theme covers what could be done to alleviate the Internet connectivity challenges to boost students' learning experiences. The sub-theme is further arranged into 'provision of Internet facilities for distance students' and 'funding'.

4.11.1.1 Provision of Internet facilities for distance students

For an improved experience, students identified Internet connectivity as the major issue that must be addressed by their universities.

For Ido (DLI) the "number one thing is provision of Internet facilities for student at least distance learning students so that we will be able to access learning management software at all times".

Similarly, at DLI Faith's comment corroborates this, "all that I can say is that the school should improve Internet connectivity and other technologies that we need to learn in this mode and make them available for the students". Femi agreed, "they should work really on the Internet method so that we can have access online at all time for us to have better experiences of learning in this mode" as did Isi, who said, "our Internet network, I don't know if anything can be done because that is the major problem. If anything can be done on our network, the other ones will follow".

The opinions expressed by NOUN learners were similar. Most of them commented that in order to improve online learning, efficient and affordable Internet was needed.

4.11.1.2 Funding

Students' suggestions concerning improvement strategies related to funding were summarised in the following comments,

> The federal government of Nigeria too needs to invest more in education so that most of our youths nowadays who want to improve themselves, get more education and get job can do so. The cost of going through distance and online learning in Nigeria is very high. The government should lower the cost by providing scholarship to the students so that it will be easy for everyone to have access (DLI).

Another DLI learner stated,

> In Nigeria, the government has to raise funds in our educational sector first because even apart from the distance and online mode learners, education sector generally is lacking, so government should raise/generate funds for them.

Moreover, at NOUN,

> Government should invest in the online learning of mathematics. I will say it again, the government should support distance and online programmes in Nigeria by providing costless accessible personal computers for the students and library facilities in all the study centres for effective learning of mathematics.

The students placed emphasis on government providing funds for distance and online programmes in Nigeria in particular and for education in general. The government should provide technology and scholarships to facilitate learning in this mode, in particular.

4.11.2 Facilitating skills development

This sub-theme considered suggestions made by the participants on how skills facilitation can be used effectively to improve the students' distance and online mathematics learning experience. The sub-theme is further arranged into the following categories: (i) training lecturers to understand what online learning means (ii) avenues and motivation for students to go online (iii) mathematics cannot be restricted online (iv) create collaborative environments (v) provision of audio-visual mathematics lectures and (vi) provision of tutorial centres.

4.11.2.1 Training lecturers to understand what online learning means

Training in distance and online education is important because it helps the tutors/instructors to design and use the platform effectively to impart knowledge to the learners. The suggestions on how training the lecturers will positively affect their experiences were seen in the following narratives.

> My own thinking is that our lecturer should be trained and equipped with modern technologies in order for them to have a good delivery of their mathematics course when they go online or teach face-to-face in the class (DLI).

> Again, there is need to get the right people who can easily handle this thing for us because this online mode was not there before, it is only traditional. Since distance and online mode is introduced, let the university train and get the right people that understand this mode of learning to teach us. The students should be enlightened also to use the platform effectively. In fact, both lecturers and students should be trained and enlightened on the use and technical know-how of the LMS (DLI).

> They can look for someone that is very sound in mathematics that can easily assist us and help us. The government can create personnel for online learning of mathematics that can train us (NOUN).

> This is called distance and online learning, the school or government should train or bring people that are well certified in InfoTech, so that they can design websites purposely for learning, even social media platform purposely for this online learning of mathematics. And the lecturers should be engaged in constant training to aid proper delivery of their course and expose them to very new technologies for learning.

Again, online mathematics learning can be made better by giving orientation which is a form of training to students at inception (NOUN).

One of the invaluable suggestions made by the students is for constant training of the tutors and the students on the use of modern technology to learn mathematics. Training of the instructors on how to design effective websites and social media platforms for mathematics learning will help enhance student experiences.

4.11.2.2 Provide avenue/motivation for the students to go online

This category was captured in the following statements from the participants,

Yea, I was once discussing with my other colleagues too that the only way we can be motivated to constantly visit online platform is for our lecturers to post all our learning materials online for us to download, be there also online to facilitate our learning and conduct assessment online. If they are online, we as students will definitely go there too. We do hear about video conferencing, our visit to online platform will increase if they can bring that in (NOUN learner).

The narrative from a DLI learner is similar to the opinions of the NOUN learner,

Yea, you know what? If the lecturers can make it a point of their duty to give us work to do online, that will encourage us to always visit there. So if they can be organising lectures or seminars online make it compulsory for us to participate, it will help us. That is to say that adequate online facilitation using latest technology can increase our motivation to visit online. They should be sure to always upload fresh and updated study materials from time to time to boost our morale (DLI learner).

The students suggested including relevant activities that will serve as motivation for them to go online. Such activities include posting all the mathematics learning materials online, ensuring availability of lecturers online to facilitate learning and organising video conferencing and seminars, amongst others.

4.11.2.3 Mathematics cannot be restricted online

The learners' experiences, from the document analysis were consistent with the fact that face-to-face should still be prominent in the distance and online learning of mathematics. Some of their reasons included feeling as if mathematics could not be learnt effectively online

and because resources are not available. Their views were reflected in the following statements.

> The distance and online learning of mathematics education cannot be restricted totally online for now but there must also be face-to-face. When mixing online with face-to-face, face-to-face should be more than online. They can make it 60% face-to-face and 40% online.

> Using the distance and online environment should not be more to that of face-to-face delivery. Face-to-face will always be the best in learning and delivery of mathematics. This is because mathematics is not just like other subjects. Restricting it online will not be easy for mathematics education students, it can't really help at all.

Another view was,

> Using technology to study maths to that of face-to-face should be 30% online to 70% face-to-face. I will want it face-to-face because maths is a subject that require explanation for us to understand. And it is better face-to-face so that we can express ourselves. If it is made face-to-face, learning will be more effective and that will improve our experience.

Owing to their preference of face-to-face interaction over online delivery, the researcher probed if they felt that the online delivery of mathematics should be stopped. The learners declined to say that the online delivery should be stopped entirely. They were of the opinion that it could be improved by providing the necessary resources:

> Yea, I think, they shouldn't stop the online deliver but improve on what is obtainable now. For the fact that the programme is online, that is what attracted most of us even though we have many challenges due to the structure that is not in place.

4.11.2.4 Create a collaborative environment for distance and online learners

The suggestions gathered from the participants on creating a collaborative environment for the learning of mathematics were outlined below,

"By providing easy communication between tutor and student."

"Establishing good and cordial relationship between the tutors and students."

"By making group discussion available and compulsory for students."

"Creating time to meet with the lecturers for questions and explanations on difficult topics.".

"More routes of sending information to students should be made available, that is SMS, telephone calls, email and others."

"I will implore the management to upgrade the mode of facilitation that is online interaction."

"To ensure stability in the school administration."

Communication and interactivity are vital in distance and online learning because they facilitate the formation of an effective learning relationship between the learner and the instructor. The understanding of mathematical concepts depends on the way they are communicated to the learners. Thus, for effective distance and online mathematics learning, as indicated in the responses above, there is a need for institutions to enhance all communication platforms and accessible technologies that encourage peer support (student-student interaction) and academic facilitation (student-tutor interaction), amongst others.

4.11.2.5 Provision of audio and visual mathematics lectures for distance and online learners

All students who completed open-ended questions identified a need to provide audio-visual lectures for their mathematics courses. They stated that this would help them listen to step-by-step methods of doing mathematics at their convenience. Their suggestions were captured in the statement below.

> Yea, I told my other colleagues too that the way we can have better experience in this programme is, if we can get a visual or audio support from our tutors, you know, they can just provide video of our mathematics lecturers and make them available for us to use and learn on our own. So provision of audio-visual aid in all our mathematics courses will surely increase our mathematics experiences in this mode. Comprehensive video and audio DVD should be provided to us.

Provision of audio-visual support is in line with the views of learners who regard this as essential in distance and online modes of learning.

4.11.2.6 Provision of tutorial centres

Provision of tutorial centres was one of the points the learners raised that could improve their distance and online learning experiences. They believe that meeting instructors in a good classroom with a well-equipped library will leave a good mathematics memory in them. They acknowledged the availability of tutorial centres but they are uncommon and do not meet their mathematical needs since most of the tutors in those centres are not mathematics tutors. Their views were captured in the following comments.

> What I can suggest is that the school should provide more tutorial centre in order to help the students to learn fast because learning on your own cannot make you to really know all your mistakes. So they need to provide tutorial centres with mathematics tutors whereby students can go, learn and clear difficult issues.
> Practical sessions with maths tutors are really needed in the study centres especially for mathematics students. And this should be made available in all the centres aside from the headquarters. The study centres should have equipped library for students to make use of.

> Online mathematics learning can be improved by organising class discussion, have regular time for online tutorials.

Provision of tutorial centres and library resources helps tackle the problematic mathematics issues of the students studying through this mode. The students are given the opportunity to physically meet their tutors and peers. This may help to reduce the frustration of learners.

4.12 Integration of the quantitative and qualitative results

This section presents the significant findings relating to quantitative and qualitative analysis as identified in the study. The findings are summarised in table 4.12.

Table 4.12: Integration of the quantitative and qualitative results

Integration of quantitative and qualitative results from students' experiences in distance and online learning of undergraduate mathematics at two higher education institutions in Nigeria.			
Theme	Sub-themes	Categories	Integrated results:
ID in distance and online learning	Reasons for choosing a distance and online mode of learning	Working, learning at the same time and enjoyment scale	• The results from the two categories (working and learning at the same time) are related. • 61.7% of students have jobs. This was revealed during the interview when seven of them indicated they lack time and sponsorship to attend conventional university and that the programme allows them to face their work while studying. • Mixed reactions were seen in the enjoyment scale
	Instructional materials accessibility issues	Non-availability of Internet to access learning materials online	• Students have access to Internet table 4.3 provided by individual students. • They lack institutional Internet accessibility.
		Availability of printed and online learning materials (resources)	• Printed material is available but they lack other resources. • The queue is usually too long while trying to obtain hardcopies of the module
		Ease of getting printed course materials from the institution	
	Quality assessment of instructional materials	Simplicity, clarity and ease of the course materials	• There are mixed reactions as some accept the simplicity of course materials, others do not. • The content is covered but the clarity is limited (table 4.3). • They use other materials to study to be able to compete with other mathematicians. • The limitations experienced in the course materials are a motivating factor for them to learn on their own.
		Mathematics content coverage in the available learning materials	
		Suggestions for improving instructional delivery experiences of mathematics distance and online learners	• Increase learning resources • Make modules available on or before resumption • Combine traditional modes of teaching with online • Educate the tutors on the need to teach online using modern technology like video conferencing and others.

	Mode of AP and challenges	Assessment mode and preference	• Online and traditional assessment procedures (question 48).
AP in distance and online learning	Quality and flexibility of assessment practices	Getting feedback on assessment and examinations	• The learners like the methods provided, there will be feedback when it is done online. • Lack resources for effective online assessment
	Peculiar challenges of online assessment	Internet, login and online submission of assessment	• Poor Internet connectivity affects login and • hinders online submission of assignment
		Suggestion for improvement	• Provide prompt feedback on assessment (table 4.4) • Increase online assessment • Online examinations to be done on weekends to allow all students to participate.

	Institutional facilitation strategy	Availability of tutors and adequacy of facilitation skills	• Students accept that collaborative activities with other mathematics students help improve their performance in mathematics (table 4.5).
LF in distance and online learning		Regularity of online facilitation	• They lack mathematics tutors for effective facilitation
	Collaboration and peer support	Availability of online collaboration platform	• Facilitation is not regular even though the platform to collaborate is available.
		Collaboration during holidays	• There is no provision to collaborate during the holiday
	Technology and media for SS	Availability of technology and media to support facilitation	• Interaction with the students with the use of modern technology is not made available except that they send SMSs and put some information on LMS.
		Effectiveness of technology and media to support facilitation	

SS in distance and online learning	Accessibility of newer and/or advanced technologies for SS	Availability of support services	• The findings as can be seen in table 4.6 and students narratives on SS showed mixed reactions on the part of the learners • Some admit out right lack of support • some said it is partial and • some others stated they are not aware of its availability • Apart from lack of video recording of lectures, CDs/DVDs of their lectures, university does not provide internet for their learning.
		SMS, video recording of lectures, CDs	
	Internet connectivity issues	Availability of Internet for distance and online learning	

Improvement strategies of students' experiences with distance and online learning	Internet connectivity challenges and institutional mitigation strategies	Provision of Internet facilities for distance students	• Provision of Internet connectivity/facilities • Government to invest in the online learning of mathematics, train and equip the lecturers with modern technologies for distance and online learning • Engagement of the students with online assessment that will motive their constant visit to the online platform • Learning of mathematics should not be restricted online to ensure learning effectiveness • establishment of good and cordial relationship between the tutors and students for effective collaboration to take place • Provision of audio and visual lectures of all mathematics courses • Provision of more tutorial centres equipped with mathematics resources.
		Funding	
	Facilitation skills development	Training lecturers to understand what online learning means	
		Provide avenue/motivation for the students to go online	
		Mathematics cannot be restricted online	
		Create collaborative environment for distance and online learners	
		Provision of audio and visual mathematics lectures for distance and online learners	
		Provision of tutorial centres	

Source: Data analysis

4.13 Chapter summary

This chapter has provided insight into the students' experiences with distance and online learning of university-level undergraduate mathematics in Nigeria, using third year ODL mathematics students from DLI and NOUN. The themes under which the findings were generated for quantitative and qualitative analysis were similar. Nevertheless, the findings of the quantitative and qualitative analysis were presented separately and a summary of the integration was presented for a better understanding. The overall findings showed significant differences between technology for support services and instructional design, assessment

procedures and learning facilitation. There were also significant differences in some specific areas such as the development and design of course materials, mode of assessment, collaborative activities, technology and improvement of students' experiences. Interviews and open-ended questions enabled the interpretation of the quantitative findings. An in-depth discussion of the findings and their implications for distance and online undergraduate mathematics learners' experiences and suggestions for improvement are presented in chapter five.

Chapter 5

Conclusions and recommendations

5. Introduction

This study has sought to contribute to an understanding of student experiences with distance and online learning in a university-level undergraduate mathematics programme at DLI and NOUN ODL institutions. It was therefore a case study. It has gathered and examined relevant information on instructional delivery (ID), assessment procedures (AP), learning facilitation (LF) and support services (SS), using accessible and advanced technologies for distance and online mathematics students at DLI and NOUN. In this chapter, an overview of the study is presented, followed by a summary of the findings on each of the research questions posed. Based on the findings, recommendations are developed followed by a discussion on the limitations of the study and implications for further research.

5.1 Overview of the study

The study utilised mixed methods, employing quantitative and qualitative approaches to data collection, analysis and integration of the results within the contextual setting involved. Information was gathered via open-ended questionnaires, interviews and documents. The quantitative instrument consisted of five-point Likert scale items and open-ended questions. Sixty (60) third-year mathematics students of DLI and NOUN completed the questionnaire. Interviews were conducted with ten of the participants who completed the survey. Purposive sampling was used to select the students to complete the survey, while the interviewed students were selected based on convenience sampling. This was done to collect each student's experience and story about learning mathematics through the distance and online modes. Each story was then used to compliment the findings from the quantitative analysis, through a process of integration.

The data generated from the instruments were analysed quantitatively using tables as presented in chapter 4 and qualitatively under five themes. The themes were ID in distance and online learning of undergraduate mathematics, AP in distance and online learning of undergraduate mathematics, LF in distance and online learning of undergraduate mathematics, SS in distance and online learning of undergraduate mathematics and

strategies to improve students' experiences with distance and online learning of undergraduate mathematics. The important contributions of the results shown in the tables in chapter 4 and the themes formulated, were explored, integrated and reflected upon in order to identify some of the implications for distance and online learning of undergraduate mathematics. The following section presents a summary of the findings and discussions from the integration of the quantitative and qualitative analysis.

5.2 Summary of the findings and discussions

The present study was based on the students' experiences with distance and online learning of university-level undergraduate mathematics. Furthermore, the study would have wanted to test the assumption that because DLI students came from a dual mode institution, while NOUN is a single mode university, their experiences of distance and online learning of mathematics would be different. The results of the study, however, contradict this assumption. Apart from the arrangements on the mode of assessment in NOUN, few differences were found in the responses and narratives of the students regarding ID, LF and SS. The experiences described by the mathematics students learning through the distance and online mode were integrated in table 4.12 and are discussed below.

5.2.1 Demographic data

The demographic characteristics of the students that participated in the study were presented in table 4.2 of chapter 4. The number of male students (n=46) was much greater than the number of female students (n=14). The imbalance between males and females is not out of sorts with what Yukselturk and Bulut (2007) found where male enrolment is double female enrolment in distance and online learning. Similarly, Ali and Ahmad (2011) also indicated that more male students appear to be taking online classes than females. The International Mathematical Union (IMU) (2014) observed that the enrolment gap in mathematics persists despite what could be called gender discrimination at the point of entry to school. Clearly, something seems to discourage females from mathematics studies at the higher levels. Could this be the result of the belief that males have a more positive attitude to mathematics than their female counterparts (Hall, 2012) hence labelling mathematics a male subject? Further research may be warranted to move beyond the present study of mathematics undergraduate students' experiences and disaggregate them by gender or

examine only the experiences of female students with distance learning in the field of mathematics.

The ages of the participants indicated that most were between 25-34 years old, which also supports the results by other researchers on the age range of distance and online education students. For example, Ashby *et al.* (2011) indicated that distance and online students were habitually 22 years old or more, while Dabaj and Başak (2008) found that distance and online learners over 30 years of age prefer face-to-face modes of learning. Jimoh (2013), in particular found that the failure of younger students to secure space in conventional universities in Nigeria has led to many opting for distance and online education. Evidently, the cohorts of distance and online students are getting younger and younger with declining numbers of mature students registering. The changing nature of the cohort is likely to bring with it new challenges and opportunities especially with respect to the need to use more emerging technologies and social media.

The number of unmarried students (n=46) was also greater than the number of married (n=14) students, once again dispelling the myth that the distance and online learning mathematics programme may be for mature, married, working students or students with many of life's commitments in general. The change in the cohort also means that the groups are becoming more diverse in terms of their social circumstances. According to Akuamoah, Boateng and Boadu (2013), this might serve as an advantage to the students to concentrate on their studies without family distractions. More than half of the participants were employed even though there were some who were not. Junk, Deringer and Junk's (2011) assertion that unemployment may instigate students' preference to distance and online education is therefore not supported by the data in the present study.

The majority (95%) of the sample had email addresses, which is one of the basic requirements for successful engagement with distance and online learning these days. Table 4.2 revealed that about half of the participants spent between 1-5 hours per week on each of the following activities: (a) using a computer for academic purposes, (b) online, exploring the Internet for school purposes, and (c) online exploring the Internet for other (non-school) purposes respectively. It was important for me to explore the amount of time the learners have available for their studies. Owing to Cororado and Eberle's (2010) assertion that one of the effective indicators of distance and online learning is learners' ability to dedicate eight

to ten hours per week and set aside a class period each day for distance and online course work. This expectation was, however, not achievable for many of the participants in this study, with the challenges they have with Internet access as a possible cause as was the case for the distance education students in the South African study by Pitsoe and Baloyi (2015).

The main online learning interface between DLI students and the university is that an LMS, Moodle is the sole learning platform. The responses from NOUN, on the other hand, indicated that the university uses multiple learning environments and platforms. For example, it is evident from the NOUN website that learning materials are simply uploaded learning resources not specifically resident on any LMS such as Moodle. The learning environments available for distance and online students identified by Moore *et al.* (2011) included a Learning Management System (LMS), a Course Management System (CMS), a Virtual Learning Environment (VLE) or even a Knowledge Management System (KMS). These platforms provide access directly to the learners, facilitated, assessed and supported outside the lecture hall throughout the days of the week (Sneha & Nagaraja, 2013). Lack of effective utilization of the platforms hinders active participation of mathematics students learning in this mode.

5.2.2 ID in distance and online learning of undergraduate mathematics

The summary of response to the question, "what are the students' experiences with ID in the distance and online learning of university-level mathematics?" indicated the availability of a learning environment and platform to enable distance and online course delivery. This is one of the basic requirements for distance learning as identified by Suleiman *et al.* (2012). Suleiman *et al.* (2012) however, concurred with other researchers that even though students may have access to course content over the Internet and through print (Pitsoe & Baloyi, 2015), the abstract nature of mathematics is not easily tackled and the content is often not explanatory enough to meet students' mathematical needs (table 4.3). This came through in the qualitative analysis with comments such as "No, the materials are not simplified enough to take care of the abstract nature of mathematics" (section 4.7.3.1). Students had to push beyond the basic resources provided by seeking and combining mathematical materials such as textbooks and course materials from other ODL institutions. This is why Ohene and Essuman (2014) have made the assertion that course materials could, in some cases,

constitute a barrier to distance and online learning if they are not specifically and well-modified for the context.

The evidence in the study suggests that students still require printed materials, even for this mode of learning, despite the difficulties of getting them from the university. The process of obtaining the printed materials demands extra time due to long queues experienced by the students. The students thus had to absorb the extra costs of printing in order to have hard copies of their own (section 4.7.2.3).

Studying mathematics through the distance and online mode is also made problematical by the lack of tutors and resources (such as Internet connectivity, video and CDs/DVDs). The findings, as reported in table 4.3, indicate the need for access to tutors in order for effective learning to take place. Yet again, this was an unresolved problem for most of the participants in the study. Comments such as "Talking about mathematics tutors, we don't have any, we can just forget about that because they are not available" (section 4.9.1.1), speak to the need and the despair by the distance education students in this study. Akkoyunlu and Soylu (2008) have also identified the need for a human presence in distance and online learning because it allows a personal touch to help with problems, maintain interest and inspire. Testone (2003) argues that the quality of distance and online learners' experiences largely depends on the availability and quality of the instructor even when that instructor is not available face-to-face. Hence, to further improve the students' experiences in distance and online learning of mathematics, access to helpful tutors is not only necessary but perhaps critical. The study revealed that most students chose to study through this mode due to work commitments however, the lack of essential resources for complete course delivery may be affecting them negatively in their studies.

A closer observation from the quantitative (table 4.3) and qualitative (see section 4.7) data indicated that the challenges experienced with the course materials might have motivated the students to learn on their own, by consulting other useful mathematics materials. One student commented as follows, "The challenges of searching materials to study on my own to meet up solving difficult problems in mathematics is what I am enjoying most". The challenges with delivery may have inadvertently nurtured in the students a sense of agency that leads to autonomous action and taking of responsibility for their own learning, as argued for by Moore (1984, 1993), in her writing on Transactional Distance Theory (TDT). The main

application of the Experiential Learning Theory (ELT) model by Kolb (1984); which is about empowering students to manage and gain control of their own learning by developing personal learning styles, is also evident in this finding. Nevertheless, students still suggested the need for access to more forms of media, modern technology and Internet connectivity in order to improve their experiences in the distance and online learning of mathematics.

These findings suggest the need for improvement in the development and provision of distance and online mathematics course materials by DLI and NOUN. Considering student fears that many mathematics problems cannot be fully explained on the Internet, emphasis should be placed on simplicity, clarity and self-explanatory course materials that will enable students to study on their own. Such developments in instructional delivery will help to improve the students' experiences and increase levels of satisfaction about the distance and online mode of learning. Generally, students were not satisfied with the experiences they had with the ID of mathematics through the distance and online mode. The results point to the need for improvements specifically in terms of Internet connectivity, access to tutors, flexible teaching and the use of different forms of media in distance and online mathematics ID, all with highly significant responses to questions 33-36 in table 4.3.

5.2.3 AP in distance and online learning of undergraduate mathematics

Summarising student responses to the question on "how do AP shape the students' experiences with distance and online learning of university-level mathematics?" the following result emerged, it would appear as if traditional and online modes of assessment are used in the two ODL institutions. The different modes of assessment often work well if feedback is given (or dialogue is created as argued in Moore, 1984) on the assessment, as is the case when assessments are done online (table 4.4 and students' narratives in 4.8.1.1). In a situation where feedback is not provided when assessment is done online, the learners prefer the traditional mode of assessment where they can express their mathematical skills in a face-to-face mode, or, as reported by a student, "I prefer pen and paper assessment if there would be no feedback for the online assessment". They stressed that Internet connectivity issues adversely affect logging in and the submission of online assessments. The advantages of online assessment, which include instant feedback, are sometimes negated by a lack of immediate feedback and/or poor Internet connectivity.

From the evidence provided, AP seem to be more organised at NOUN than at DLI (section 4.8.2.1). Online assessment procedures are strictly enforced for the first and second years of study, while the traditional mode of assessment seems to dominate in the third and final years of the programmes. As one student put it,

> We do both online and traditional assessment. We do online assessments when we are in 100 and 200 levels (first and second years) but come to 300 level (third year) upwards, it is pen and paper all through. I think both are preferable because online can't test the capability of the students enough.

In order to ensure quality and flexible AP, research literature points to the need to employ multiple methods of assessing students and providing them with regular and exact feedback (Arend, 2007; Bangert, 2004). However, the variant of AP in NOUN, for different levels of students, is an interesting development that has not been explored as much in the literature on distance and online learning. It may be interesting to explore further, through systematic research and the challenges and opportunities for expressing and assessing high-level mathematics through online modes of assessment.

Students rely on feedback to measure their learning progress (Mampane, 2015), hence the need for prompt feedback on assessments. Researchers have claimed that students in distance and online education find mathematics more enjoyable because of the freedom provided by computers in carrying out their tasks and trying out new ideas (Nguyen & Kulm, 2005). This is not universally the case, as demonstrated in this study, due to a lack of resources to support AP as indicated by the mixed responses to question 42 in table 4.4 and the students' narratives in 4.8.3.1. Once more, students in a distance and online environment were positive about several features of online assessment, such as the option of multiple attempts, getting instant feedback, working at their own speed and time and obtaining right answers or corrections after submitting the online assessment (Sagarra & Zapata, 2008). The students' preference for different modes of assessment is supported by this study, as reflected by the response, "I think online and traditional assessment are both good, I prefer them both because they test different skills in student" (section 4.8.1.1).

Despite an increase in the number of universities implementing distance and online assessment, its effectiveness is still uncertain (Yushau & Khan 2014). One of the problems

might be the issue of poor Internet connectivity. One of the participants interviewed in this study commented that the "mode of assessment is poor because feedback is not usually given immediately, solutions are proffered by students and this is caused by internet problem" (section 4.8.3.1). Ajadi *et al.* (2008) and Ohene and Essuman, (2014) stressed that the cost of accessing Internet is still very high in most African countries compared to developed countries. The results in table 4.4 showed that the participants need better access to resources, prompt feedback and clear guiding principles on AP to improve their experiences in learning mathematics.

5.2.4 LF in distance and online learning of undergraduate mathematics

This sub-section presents the summary of the response to the question "how does LF influence the students' experiences in distance and online mathematics education at the university?" LF plays an important role in distance and online undergraduate mathematics learning. The findings from the quantitative and qualitative analyses show that there is provision of an interface for online collaboration even though there was a shortage of tutors to facilitate face-to-face and online mathematics programmes. Collaboration is mainly organised by the students themselves, at their own time and using their own resources and technologies.

The findings indicated that despite the creation and provision of the interface for collaboration, students still experienced challenges with facilitation. The collaboration interface is not updated regularly (see table 4.5 and section 4.9.2.1). This does not attract students to the platform on a regular basis. Sneha and Nagaraja (2013) stated that the motivation for, and goal of, the learning platform should be to increase access to learning, widen participation, utilise technology for distance and online delivery and update the nature of teaching for learning to take place. The provision of an online platform without the presence of tutors to facilitate, through planning and assigning activities, is not enough in itself to create the necessary mathematical learning experiences for the learners. This was emphasised in one of the student's responses, who said, "The learning management software is available but most times the lecturers do not upgrade them for learning to take place, it is not effective enough". Zakaria and Daud (2013) also recommend that the platform should enable the online instructor to plan and assign activities to the students so that the

students are engaged in discovery learning and collaboration. The results of this study do not completely match these expectations.

The fact that tutors are often unavailable to guide either face-to-face or online facilitation undermines the distance and online mathematics students' experience. The findings indicate that there is little or no tutor-learner online facilitation (see section 4.9.1.1). This finding goes against the dialogue in TDT, which makes it clear that communication transactions need to exist between instructors and learners for effective distance and online learning (Moore, 1993; Mbatha & Naidoo, 2010; Shearer, 2010). The students in this study often found it difficult to clarify mathematical issues with their tutors due to a lack of access. Hence, they arranged, though not on a regular basis, to collaborate and discuss mathematical problems among themselves (students-students). The difficulties were highlighted in a student's response, "The facilitators are not there to help students to understand and solve mathematical problems they are facing".

Recent literature has shown that distance and online learning practices in Nigeria were limited by the inadequate skills to handle problems associated with pedagogy in distance and online modes (Ajadi *et al.*, 2008). This is critical in mathematics due to the perceived difficulty of the subject itself. It is easy to conclude that the four dimensions of interaction (Chen, 2001; Fresen & Hendrikz, 2009) namely learner-instructor, learner-learner, learner-content and learner-interface linking device or technology were not supported substantially in this study, largely due to the unavailability of mathematics teachers (tutors).

The data in section 4.9.2.2 suggests that collaboration is mainly conducted by arrangements among the students. They contact each other by telephone to meet up and tackle their mathematical problems. This arrangement is not regular, due to their employment, as captured in the following comment,

> Yes there is always interaction between us in order to share opinion. It is not done online or during the holiday. We call ourselves on phone when the school is in session and arrange when to meet in our study centre to collaborate and this is not all that regular as many of us are busy with our work.

This indicates that the students are not physically available at the same place at all times, they are generally on their own and arrange at times to come together to resolve their learning problems, matching the findings of Yukselturk (2010).

Online student-student collaboration is also hampered by poor Internet connectivity. Students clearly stated that even though they meet face-to-face to collaborate, online collaboration still needed to be improved. Creating more online activities might help attract the students to the platform to collaborate. This was reflected in one of the students' responses, "If the lecturers can make it a point of their duty to give us work to do online, that will encourage us to always visit there" (section 4.11.2.2). Students felt, as reported in table 4.5, that collaborative activities with other students can help to improve performance in mathematics.

The students learning mathematics through distance and online modes were not exposed to many effective technologies and media formats for supporting facilitation in either university. The main media for interaction is through SMSs from the school and/or the students' representatives. According to one of the students, "There is no other means except the SMS. The SMS sometimes is not clear enough but thank God for our governor (class representative) who is on ground to pass available information" (see section 4.9.3.1). The SMS does not encourage interaction since the communication is one-way, except when relating with class representatives. Garrison and Cleveland-Innes (2010) have stated that interaction using technologies and media is central to an educational experience and hence, is a primary focus in distance and online learning as highlighted in the cognitive theory of multimedia learning (CTML) (Mayer, 1999).

5.2.5 SS in distance and online learning of undergraduate mathematics

In summarising the response to the question regarding support services, "how do SS, using newer and/or advanced technologies affect the students' experiences with distance and online learning of mathematics at the university?" the findings are consistent between quantitative and qualitative analyses. The learners indicated that print materials, the learning management system, online processing of admission, registration, result checking and availability of course materials online all have significant effects on their learning

experiences. These sentiments can clearly be seen from table 4.6 and in the narrative of the qualitative data (in sections 4.7.2.1 and 4.9.2.1).

Although getting printed materials from the institutions is not always easy, this remained one of the practical means of meeting the mathematical learning needs of the students in this mode of learning. This was reflected in the following response,

> What I learnt about the module (print) is that once you can have them, you will definitely pass the course once you can read the module very well because everything the lecturer will ask for the course are in the module but getting the module is just the problem (see section 4.7.2.3).

The observation by Pitsoe and Baloyi (2015) that print is used far more than any other means of delivery in a distance and online mode of learning is upheld in this study. The findings in this study present print as the predominant media in learning mathematics in this mode.

Apart from uploading the course materials and leaving occasional information on the LMS, many of the mathematical activities are not available on the platform. This is reflected in the following student's comments in sub-section 4.7.2.2, "Eh the LMS has not just been functioning well maybe because they have not put down the right structure but I believe with time things will be better" and "Support is not enough even on the LMS". The findings by Heirdsfield *et al.* (2011) indicating that the learning environment offers an interactive means of learning that can be customised to meet individual student needs, is not upheld in this study. The fact that students have to access this platform through the Internet makes it more difficult in this context. They appreciated the convenience of studying through this mode but were less satisfied with the functioning of the LMS. Some features of a learning environment that encourage the type of student-centeredness promoted in ELT, were lacking, as the environment is not supported.

The study did find evidence of the provision of SS such as online processing of admissions, registration and result checking for the learners. These findings were consistent with those of Brindley *et al.* (2004), who found that essential services assisting and monitoring the process of learning were a priority.

According to Vilardi and Rice (2014), multimedia tools such as video, audio-visual aids and tutorial classes have supported important initiatives in distance and online delivery. Towhidi (2010) also identified Internet, audio and video tapes, intranet, telephone, radio, television, teleconferencing and electronic mails, as among the forms of multimedia support provided for ODL students. The students who participated in the present study, however, struggled to access support and strongly disagreed that the utilisation of these technologies in their institutions was prevalent (table 4.6). This was captured in their narrative in sections 4.10.1.1 and 4.10.1.2, "We don't have CD, DVD and videos of our course materials". "We don't have latest technology to support online studies". Claims by DLI and NOUN that they provide CDs/DVDs, video and radio services are only partially confirmed by student responses, "They may have video conferencing, radio programme and others for other courses they run here but not in mathematics education as it were", indicating the availability of these services, although not to mathematics students. The question of why other subjects are given priority over mathematics, considering the importance of the subject in our educational system, may well be related to the lack of mathematics tutors to drive and support the learning processes in the subject.

The statistics in table 4.6 further revealed varied experiences regarding the utilisation of computers, Internet, email, telephone, chat sites, on-site tutorials and mobile text messages as SS in their institutions. The claim in the African Internet Status report (2002) and UNESCO-UIS (2015) that put the number of computers in Africa in the population as low as 1:500 appears to be obvious from this study. Not every distance and online student seems to have access to a computer, as indicated in the narratives of the students (see section 4.10.1.1), thus making them reliant on shared computers at local community centres or Internet cafés (Kawalilak et al., 2012) in less than ideal conditions. According to a student, "Yea, I have my own personal access to Internet it's not from school and none from them at all". While some students have their own Internet, others lack access to the hardware, "I don't even have personal computer". Hence, the support services that encourage constructivist–based learning that aims to inspire, support and satisfy students' needs, should be improved for the students attempting to study in this mode.

5.2.6 Improvement strategies for students' experiences with distance and online learning of university-level undergraduate mathematics

This sub-section summarises the responses to the following question, "What suggestions can be made to enhance the students' experiences with university-level mathematics in distance and online environments?" A number of suggestions were made by the students, which they believed if considered, could boost their learning experiences in this mode. One of the key suggestions is the provision of efficient and affordable Internet facilities, as reflected by a student in section 4.11.1.1,

> The "number one thing is provision of Internet facilities for students at least distance learning students so that we will be able to access learning management software at all times.

Many students provide their own Internet access, even when they are on or off campus. Research clearly indicates that the lack of access to Internet technology hinders distance and online facilitation, support services, interaction and communication (Fresen & Hendrikz's, 2009; Pitsoe & Baloyi, 2015). Internet availability is essential for the students' access to distance and online learning.

Many of the participants indicated that funding support for distance and online education is necessary for the development of learners. A student noted this as follows, "The cost of going through distance and online learning in Nigeria is very high" (section 4.11.1.2). The learners in this mode can be supported through the provision of scholarships to lower the personal cost and grant easy access to mathematics education. While Ojo *et al.* (2006) argued that distance and online learning is often the most cost-effective means of acquiring education, Ng (2000) and Doug (2002) showed that the potential cost-effectiveness of using online technologies in distance education is still uncertain and the ideas of costs and effectiveness are not as simple as they first appear. Hence, learning mathematics through a distance and online mode may be efficient but lacks effectiveness, if the outcome fails to meet the programme objectives.

Zakaria and Daud (2013) report that one of the challenges identified by teachers regarding the use of modern technology in distance and online learning is the lack of training in using

them. Hence, training for the tutors and the students on the use of modern technologies was emphasised by the students. As one commented,

> My own thinking is that our lecturer should be trained and equipped with modern technologies in order for them to have a good delivery of their mathematics course. In fact, both lecturers and students should be trained and enlightened on the use and technical know-how of the LMS.

The findings in this study are consistent with Makewa *et al.* (2012) in showing that most teachers of distance and online mathematics are not trained and lack expertise in using modern technology for teaching. This might lead to an underutilisation of its potential by the untrained teachers/students. This could also explain why some learners in this mode get frustrated in using modern technologies.

The students also suggested that provision of avenues and motivation for them to go online would increase their mathematics experiences in this mode of learning as evident in section 4.11.2.2. This can be done by posting learning materials online, organising lectures and seminars online and make it mandatory for students to participate. As emphasised in the literature, mastery of subject content will enable the instructor to create a learning environment with different types of activities to promote successful online delivery (Anderson, 2004). Heirdsfield *et al.* (2011) also stated that tutors who do not have the motivation or time to become expert users of online systems limit themselves in the creative use of technology for teaching. The organisation, by the instructor, of discussion forums on different mathematical topics, assessment issues and other matters might help to increase students' motivation and desire to participate.

Some other findings that emerged from this study include that the study of mathematics cannot be solely restricted to online work (see section 4.11.2.3 for details), the need for the creation of effective collaborative environments for the students, the need for the provision of audio and visual mathematics lectures and tutorial centres. Practical sessions with mathematical tutors are needed for effective mathematical learning. For example, the opportunity to ask questions in between teaching sessions is often missing when learning online (Ramasamy, 2009), hence, student assert that mathematics learning should not be limited to online modes. The students in this mode stated that face-to-face is still needed as

a method of delivering mathematics. Students' desire for audio and visual versions of their mathematics lectures is supported Mayer (2005) in the assertion that students learn more deeply when words and pictures are used compared to when either the words or pictures are used alone, aligning with CTML (Mayer, 1999).

5.2.7 Major contributions and understanding of students' experiences with ID, AP, LF and SS in distance and online mathematics learning

This sub-section summarised the responses to the question "how can the university-level mathematics students' experiences with ID, AP, LF and SS in distance and online environments be understood and/or explained?" The findings in this study clearly showed the experiences of students learning mathematics through a distance and online mode and the major contributions of the study are highlighted.

The correlation analysis, which indicates the degree to which changes in one variable is associated with changes in another was used to determine the influence of AT on ID, AP and LF as reported in tables 4.9 and 4.10 and figure 4.3. The lower p-value ($p<0.01$) in table 4.9 indicated that AT has a significant positive influence on ID, AP and LF. This result showed what is desirable in an ideal situation but in practical terms as revealed in this study, students are not satisfied with AT, ID, AP and LF in their institutions. Student demands for the inclusion of technology in ID, AP and LF of distance and online learning of mathematics is consistent with the findings of Liyanage *et al.* (2013). It is evident from the findings of this study that there remain many challenges in learning mathematics using technology, despite the rapid development of ICT in our present time.

This study adds to the empirical understanding of the validity of ELT, TDT and CTML in the distance and online learning of mathematics. ELT is learner-centred and empowers students to manage and gain control of their own learning. Student-centeredness helps develop students' mental inquisitiveness, problem-solving capabilities, creative imagination, leadership expertise, reasoning and vitality (Henson, 2003). This is evident in this study through the motivation the students have in sorting learning materials on their own. The procedures for learning are pictured in a cycle where the learners are involved in experiencing, reflecting, thinking and acting. It is observed from the theory that the entire student's senses, feelings, personality and not just the brain are involved in learning (Andresen *et al.*, 2000). This is true of this study because the opportunities for the students

to write and deliberate on their experiences and reflect on their thought all through the learning process are witnessed from their stories. The theory also emphasised that every learner produces "rules and mental patterns" they can use to make meaning of their experiences (Cavanaugh *et al.*, 2004). This was demonstrated on how they regulated their mental mind to adapt to new experiences by contacting themselves and meeting to solve problems affecting their learning in this mode. Noteworthy from this theory is the teacher/tutor availability to facilitate and regulate learning instead of just giving out information. This expectation was, however, not achievable for many of the participants in this study, with the challenges they have with access to helpful tutors in order for effective learning to take place is not only necessary but possibly critical.

In addition, the study contributes to the understanding of the three variables namely dialogue, structure and learner autonomy of TDT. Dialogue as a key variable in the theory, is the communication transaction (collaboration, interaction) that exists between the instructors and the learners during the course and is purposeful, constructive and valued by the learners and instructors (Moore, 1991; 1993). In the present study, the unique findings include the collaboration interface that is not updated regularly with new information to attract students to the platform. Other findings include little or no tutor-learner online facilitation, making it difficult for the students to clarify mathematical issues facing them with their tutors; collaboration that is mainly conducted by arrangement among the students and online student-student collaboration that is also hampered by poor Internet connectivity. These confirmed that the four dimensions of interaction (Chen, 2001; Fresen & Hendrikz, 2009) learner-instructor, learner-learner, learner-content and learner-interface linking device or technology were not substantially supported in this study.

Structure on the other hand, as the second variable in TDT determines how the course design and teaching programmes are organised so that they can be delivered with a variety of communication media (Moore, 1993). The present study clearly indicated that even though students may have access to course content over the Internet and through print, the abstract nature of mathematics is not easily tackled and the content is often not explanatory enough to meet students' mathematical needs. In addition, studying mathematics through a distance and online mode is also problematical because of the lack of resources (such as Internet connectivity, video, CDs/DVDs). The advantages of online assessment, which include instant feedback, are sometimes negated by a lack of immediate feedback and/or poor

Internet connectivity. There is a need for improvement of the DLI and NOUN mathematics course structures to increase students' learning experiences in this mode.

Learner autonomy, which depends on dialogue and structure, refers to students' control over the learning activities and processes and uses the teaching materials and programmes to achieve their learning goals in their own way (Kang & Gyorke, 2008; Shearer, 2010; Falloon, 2011), thereby making learning more learner-centred than instructor-centred. The administrators of ODL programmes need increased learner autonomy for a successful educational environment. This is because high levels of learner autonomy can be associated with low levels of structure and dialogue (Kang & Gyorke, 2008; Shearer, 2010). The availability of a learning environment and platform to enable distance and online course delivery support learner autonomy of Moore (1991) and Suleiman *et al.* (2012) but they do not offer an interactive means of learning that can be customised to meet individual student needs. This contradicted Heirdsfield *et al* (2011) findings. Again, the course content does not easily tackle the abstract nature of mathematics and is often not explanatory enough to meet students' mathematical needs. Moreover, students absorb extra costs of printing course materials in order to have hard copies of their own and provide Internet on their own, while tutors are often unavailable to guide either face-to-face or online facilitation among others. These do lead to low level of autonomy thereby allowing high level of dialogue and structure. Thus, these findings do not completely match the expectations of learner autonomy of TDT.

Furthermore, this study contributed significantly to the existing understandings of CTML of distance and online education. CTML exists when the learner uses visual and verbal systems to process information (Mayer 1999). The rationale of the theory is that students learn more deeply when using words and pictures to teach compared to when words or pictures are used alone (Mayer, 2005; Vilardi, & Rice, 2014). The students who participated in the present study struggled to access the multimedia (Internet, audio and video tapes, intranet, telephone, radio, television, teleconferencing and electronic mails) as identified by Towhidi (2010) and hence, strongly disagreed that the utilisation of these technologies in their institutions was prevalent. Claims by DLI and NOUN that they provide CDs/DVDs, video and radio services were only partially confirmed in this study. This is because these services are available in other subjects but not obtainable to mathematics students. Students' desire for

audio and visual versions of their mathematics lectures is supported by Mayer (2005) but was inconsistent with this study.

Therefore, the ELT, TDT and CTML models of learning, which all call for distance and online students' maximum commitment to the learning experience, are relevant to this study in terms of their emphasis on enabling understanding, content sharing and online interaction using technologies. In brief, with respect to the contribution of this study, for example, teacher/tutor availability to facilitate and regulate learning instead of just giving out information was however, not achievable for many of the participants in this study. In addition, the TDTs four dimensions of interaction were not substantially supported. The findings equally do not completely match the expectations of learner autonomy for TDT. Finally, the students' desire for audio and visual systems, as advocated in CTML, also did not find its consistency in the findings of this study. Thus, the three models of learning do not find unified evidence from this study.

Moreover, a specific and major contribution to knowledge from this study was obtaining the degree of significance by relationship via the Partial Least Square (PLS) regression method of constructing predictive models of many factors that are highly collinear (Wold, 1981, 1985). This method had usually been employed in general Structural Equation Modelling (SEM), (Marcoulides, 1998; Monecke & Leisch, 2012). The significance of the paths and path coefficients in the PLS model was assessed using bootstrap confidence intervals. Efron and Tibshirani (1993) recommend that the bootstrap interval's lower and upper limits should not include zero. The bootstrap confidence intervals used to determine the statistical significance for the paths and path coefficients in the PLS model are presented in table 4.10. The path, strength and significance of the path coefficients assessed by Partial Least Squares (PLS) are shown in figure 4.3.

The findings, using this method, support Liyanage *et al.'s* (2013) result that students demand the inclusion of technology in the ID, AP and LF of distance and online mathematics learning. Institutional failures to satisfy this demand are therefore one major outcome of this study.

5.3 Limitations of the study

There were some limitations to this study, which emanated from the sample and instruments for data collection. There is thus a need for caution when generalising some of the specific

findings of this study, some of which do not match the findings elsewhere in the existing literature.

A mixed methods research approach employed quantitative and qualitative aspects. The study was conducted in dual and single mode ODL institutions that, in my own assessment, are complex environments to conduct mixed methods research due to the varied nature of distance learners. All the participants were third year undergraduate mathematics students with prior experience with distance and online modes of learning and hence are not entirely representative of the whole mathematics learner population in DLI and NOUN. The study was not directed to a particular topic in mathematics. Although the findings may not be generalisable to other educational contexts, especially outside Africa, the in-depth combination of analyses provided in this study, supported by students' own words, may make the findings relevant and transferable to other ODL institutions, especially where technological and support levels are quite similar.

Collecting quantitative and qualitative data in a distance and online learning environment proved to be difficult. Difficulties were experienced when organising to meet participants for research purposes. The researcher was able to achieve the goal with the help of the directors of the involved study centres. Repeated visits to the study centres had to be made to get the students to complete the survey and to be interviewed. As experienced in this study, mixed methods approaches that address research problems in multiple ways in the hope of providing a better understanding, can also be time consuming.

5.4 Conclusion

The primary aim of this study was to investigate students' experiences with distance and online learning of university-level undergraduate mathematics in Nigeria. The findings revealed that the learning environments and platforms are vital and can influence mathematics learning through distance and online modes. The students depended more on printed materials (modules) despite the difficulty they experience in getting them from the university. As one commented:

> Just look at the queue right there (pointed in the direction where the course materials are distributed), they are queuing for course materials; the last time I queued for course materials was in 100 level (first year). When you queue for it, you waste your money to come and queue for course materials whereas, they won't give it to you and you paid for it, except you go online

to download that is the only way you can get your course materials. Don't rely on the hardcopy they are going to give to you, except you go and buy because they sell outside there as well (pointing outside) (section 4.7.2.3).

The fact that students have access to modules over the Internet and print does not remove the abstract nature of mathematics if the contents are not explanatory enough to meet the students' mathematical needs. One of the students commented as follows, "No, the materials are not simplified enough to take care of the abstract nature of mathematics". Students also experience great difficulties in accessing resources such as the Internet, computers, mathematics tutors, stocked libraries and other support services. This is reflected by some students in sections 4.11.1.1, 4.7.2.3 and 4.7.22.3 respectively.

> The number one thing is provision of Internet facilities for students at least distance learning students so that we will be able to access learning management software at all times.

> Normally I make use of somebody's laptop or I go to café to do my online assignments. I don't have personal laptop.

> I think the resources are not there. I have a personal computer to study online. No e-library in my school. I am not aware of e-library but we use LMS. Even the normal library of DLI, we don't have mathematics textbooks which we can study.

Government's failure to fund distance and online education in Nigeria adequately has worsened the situation. One of the students commented in section 4.11.1.2, "Government should invest in the online learning of mathematics. I will say it again, the government should support distance and online programmes in Nigeria by providing costless accessible personal computers for the students and library facilities in all the study centres for effective learning of mathematics".

It seems less consideration has been given to improving the distance and online mathematics learning environments than other subjects. For example, mathematics as a course is excluded in the provision of television and radio programmes while CDs/DVDs of mathematics lectures are not produced for student use. This is echoed by students in sections 4.10.1.1 and 4.10.1.2, "they may have video conferencing, radio programme, and others for other courses they run here but not in mathematics education as it were. I haven't seen anything of such. That is burning course materials on CD for the students? No way". This is likely to

limit the experiences of mathematics students of DLI and NOUN. A guiding principle that will help improve the students' mathematical experiences in the distance and online learning mode is obviously to enhance ID, AP, LF and SS.

Finally, as Tapfumaneyi (2013) observed, no nation in the world has been able to accomplish the promise of giving access to education for all its citizens. A similar challenge, in terms of access and success in university mathematics, can be observed across many of Nigeria's higher education institutions. Despite limitations observed, some recommendations have been made as implications of this study. The implications for future research, recommendations for DLI, NOUN and the government, is that there is still an opportunity to pursue further research to gain vital knowledge about students' experiences with distance and online learning of university-level undergraduate mathematics in Nigeria.

5.5 Implications of the study

Although there has been an increase in the use of distance learning among institutions of higher education (Slagter van Tryon & Bishop, 2009) the major concern remains that of the quality of the educational provision in many of the distance learning institutions (Jones, & Long, 2013). Despite the increase in the use of distance and online learning in universities, there have been very few studies of students' experiences as they relate to distance and online learning of undergraduate mathematics. It is also clear that no research has been done based on a combined investigation of dual and single mode programmes with large populations of students, having widely diverse backgrounds, working environments and age groups such as those from the DLI and NOUN mathematics programmes. This study therefore addressed a gap by examining student experiences with distance and online learning of university-level undergraduate mathematics in Nigeria. The study is unique because it is based on the voices of the students who are the consumers of the online and distance programmes, especially in the area of mathematics. The research has produced findings that have contributed to theoretical and practical knowledge of the students' experiences in mathematics through the distance and online mode.

The results of this study have implications for future research, policy and practice in the field of mathematics education, as discussed below.

5.5.1 Implications for future research

The findings detailed in chapter 4, while acknowledging limitations in terms of the sample and time involved in using mixed methods as discussed in sections 1.11and 5.3, present the following implications for future research in this area.

This study focused on third year mathematics students at DLI and NOUN. Future research could include a larger sample of students (across the years) studying mathematics through this mode to see if more and extended findings will be obtained when larger samples are used.

DLI and NOUN was used for the study. Future research can therefore be extended to include other ODL institutions in Nigeria, especially dual mode institutions with distance student populations residing in less metropolitan environments. This will help generalise the findings of such research to all institutions offering distance and online learning in Nigeria.

A comparative study could also be conducted across ODL institutions in Nigeria to evaluate the relative experiences of students studying mathematics using technology in these institutions.

In-depth research can also be done using specific mathematical topics to explore student experiences in learning specific topics in a technology-supported mode. In addition, further study can be done to explain the reasons why technologies to learn mathematics are lacking while they are available in other subjects, at least at the universities in this study.

Most importantly, a more detailed study can be conducted to investigate the role of the four dimensions of interaction (learner-instructor, learner-learner, learner-content and learner-interface), as proposed in TDT (Moore, 1993), on mathematics distance and online learning. The results would be valuable to mathematics distance and online administrators, educators and instructional material designers in improving students' learning in this mode.

5.5.2 Recommendations for practice – at DLI and NOUN

The findings also have important implications for DLI, NOUN and by extension, ODL institutions in Nigeria that offer mathematics programmes through a distance and online mode. For example, the findings of this study revealed the need for restructuring and improvement of the universities' learning environments and platforms to be more learner-centred, with the aim of accommodating mathematics students in this mode. Relevant

activities that will serve as motivating factors for the students' constant visitation of the learning environments are essential to their learning in this mode (Section 4.11.2.2).

Distance and online mathematics course designers and developers should make the materials (modules) as simple as possible for the students to study and to understand on their own (see section 4.7.2). This is because of the findings, which suggest that students depend heavily on printed learning materials. Furthermore, self-explanatory course materials will help address the abstract nature of mathematics. The materials should also be made available to the students in good time with service delivery structures that allow for easy distribution of study materials to eliminate the frustration of long queues at the study centres.

Technologies (such as the Internet, audio/video media, CDs/DVDs, computers, library resources, radio and television) to support ID, AP and LF should be improved and made available to the learners. Students, in their narratives in section 4.10.1, stated that these technologies are made available in other subjects but are lacking for mathematics learners. Owing to the importance of mathematics in other science and engineering professional courses, the institutions need to prioritise the adoption of these technologies to the learning of mathematics.

Moreover, since support services are central to the students in this mode, the institutions need to employ qualified mathematics tutors who will facilitate support, provide well-equipped study centres that will deal with the issue of distance and provide guidance and counselling opportunities specifically for mathematics students. They also need to make library resources in all study centres available and create avenues for mathematics students to seek help from their tutors when facing problems as the students narrated in section 4.11.1 of this study. These resources will help promote positive student experiences in studying mathematics through this mode. They will also enhance a good mathematics memory in the learners. Supportive facilities such as computers and Internet connectivity should be provided and made available in all study centres to help mathematics students succeed in their studies through the distance and online mode. There is also the need for the institutions to enhance communication platforms to encourage peer support (student-student interaction) and academic facilitation (student-tutor interaction).

The universities should engage the tutors in constant training (see section 4.11.2.1) to expose them to new learning technologies and their effective uses in the teaching and

learning of mathematics. This is vital because some tutors lack adequate skills in the application of new technologies, as pointed out by students. Modern technologies should be provided for the lecturers to use in their course delivery. Attending development programmes to enhance instructional design will help them be more sensitive in designing distance and online mathematics courses. Training the instructors on how to design effective online learning content and social media content for mathematics learning will also help enhance student experiences. Orientation should also be given to students to inform and familiarise them with the university learning environment, platform and resources available for their mathematics learning.

The universities should also strengthen distance and online collaborative and facilitative activities of mathematics students by providing the necessary technologies and learning resources. They should also use face-to-face sessions when necessary to provide solutions to mathematical learning problems and utilise different forms of media for delivery and interaction. The right structure and continuous improvement of the system to build mathematics experiences and confidence in students' learning in this mode is necessary. Considering the development of distance and online education in Nigeria, especially at the University of Lagos and its current stage with mathematics students, much more should be done to improve the experiences of students learning through this mode.

DLI and NOUN mathematics learners need to be supported in the construction of their own knowledge, as outlined in ELT, TDT and CTML and as highlighted in this study (chapter 2).

5.5.3 Recommendations to the government (policymakers) and ODL regulatory agencies

DLI (dual mode) and NOUN (single mode) are public universities in Nigeria whose operations are highly dependent on financial support from the government. The improvement of the financial status of these universities is essential for expanding the learning support systems of mathematics students. The deficiencies witnessed in the available technologies for support services and infrastructure that is accessible to mathematics students in this study could be a result of inadequate funding.

Government needs to invest more funds (see section 4.11.1.2) in distance and online education, especially to provide the necessary technologies and media to sponsor and train

mathematics teachers on the use of the modern technologies in mathematics learning and to lower the cost of studying through this mode by providing scholarships and subsidising the purchase of personal computers and laptops. Government policies on distance and online mathematics programmes in the universities should receive more support from public funds, as is evident in some developed countries such as the United Kingdom, Australia and France (Oye *et al.,* 2011; Jimoh, 2013). Moreover, the regulatory agencies of the government such as the National Universities Commission (NUC) in Nigeria set up as quality assurance and regulatory agencies need to oversee the support of mathematics learning at university-level to strengthen the understanding of the subject and its applications in other sciences, engineering and other courses that require mathematical literacy.

5.6 Final thought on the study

The study provided me an opportunity to investigate students' experiences with distance and online learning of university-level undergraduate mathematics in Nigeria. My goal was to understand how ID, AP, LF and SS might influence the students' mathematics experiences as a distance and online learning mathematics educator. This is important to a mathematics learning context and requires constant examination in order to maintain its adequacy. All the processes involved in conducting this study (data collection instruments, data collection procedures, methods of data analysis, interpretation and presentation of the data, etc.) were fundamental because they helped clarify thoughts and generate new insight into the distance and online learning of mathematics in Nigeria.

For effective representation of participants in this study, I focused on third year mathematics students because they have had two years of experience in the programme. The students' responses helped in understanding their distance and online learning mathematics experiences, thereby making me an active participant in the widespread research efforts associated with distance and online mathematics learning in tertiary institutions. The question of what the future holds for distance and online mathematics learning in DLI and NOUN can be resolved by taking into consideration the core processes (ID, AP, LF and SS) employed in the study, since the study clearly revealed many inadequacies in the present institutional procedures due to the difficulties the students are experiencing. The pedagogical issues of ensuring that the mathematics students at distance and online learning are not disadvantaged should be resolved by not placing higher priority on other subjects. Overall,

the study has initiated a personal motivation into further investigation of significant factors to the improvement of effective learning of mathematics through this mode.

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Appendix 1: Letter of clearance from the University

Faculty of Education

30-Jun-2015

Dear Mrs Comfort Reju

Ethics Clearance: Students' Experiences with Distance and Online Learning of University-Level Undergraduate Mathematics in Nigeria

Principal Investigator: Mrs Comfort Reju

Department: School of Higher Education Studies (Bloemfontein Campus)

With reference to you application for ethical clearance with the Faculty of Education. I am pleased to inform you on behalf of the Ethics Board of the faculty that you have been granted ethical clearance for your research.

Your ethical clearance number, to be used in all correspondence is:

UFS-HSD2015/0275

This ethical clearance number is valid for research conducted for one year from issuance. Should you require more time to complete this research, please apply for an extension.

We request that any changes that may take place during the course of your research project be submitted to the ethics office to ensure we are kept up to date with your progress and any ethical implications that may arise.

Thank you for submitting this proposal for ethical clearance and we wish you every success with your research.

Yours Sincerely

Dr M.M. Nkoane
Chairperson: Ethics Committee
Faculty of Education

Appendix 2: Letter to DLI

Distance Learning Institute
University of Lagos
9th May, 2015

The Dean
School of Education
National Open University of Nigeria

REQUEST FOR PERMISSION TO CONDUCT RESEARCH

Dear Sir/Madam

I hereby request permission to conduct research in your institution.

My name is Comfort Reju, and I am presently studying for a PhD degree with the University of the Free State, South Africa. As part of my Doctoral programme, I am required to conduct research on an aspect of interest with a view to making a contribution to our knowledge and understanding of the issue under study. The title of my research project is:

Students' Experiences with Distance and Online Learning of University-Level Undergraduate Mathematics in Nigeria

The purpose of the study is to examine the students' experiences with distance and online learning of university-level undergraduate mathematics in two main Open and Distance Learning (ODL) institutions in Nigeria. I am particularly interested in studying the experiences of mathematics students in Distance Learning Institute (DLI), University of Lagos and National Open University of Nigeria (NOUN). The study has the potential to benefit ODL institutions in Nigeria to be able to effectively support Mathematics students learning in this mode and policy makers by pointing out the challenges, the successes of learning mathematics at a distance and through the online.

The study will involve 1) filling out of self-completion questionnaire by thirty (30) third year undergraduate mathematics students of your institution; and 2) interview with five (5) of them for the purpose of understanding instructional delivery, assessment, facilitation and support in distance and online environment. The interviews are expected to last no more than 30 minutes per student, and the self-completion questionnaire that will not take more than one hour will be distributed to them in their study centres to fill and return to the researcher.

I undertake to observe confidentiality and to protect participants from physical and/or emotional harm. No name of persons shall be used in any reports of the research. All participants will be asked to participate voluntarily in the study and may withdraw at any time should they so wish.

Upon the completion of the study, I undertake to provide the University of Lagos library with a copy of the research report through the Director, Distance Learning Institute (DLI) and to share my findings with the National Open University of Nigeria (NOUN) through the published results of the study in professional journals in the field of distance and online learning and/or

proceedings of any learned conference where the results are presented, as the case may be.

I attach a letter of recommendation from my research supervisor regarding the study and my progress.

If you need any further information and/or have suggestions, please do not hesitate to contact me and/or my research supervisor Professor Loyiso C. Jita at jitalc@ufs.ac.za or +27514017522.

Thank you for your kind consideration of my request.

Yours sincerely

Comfort Reju
Cell: +264XXXXX/+234XXXXX
(E-mail: okwyrej@gmail.com)

Appendix 3: Letter to NOUN

Distance Learning Institute
University of Lagos
9th May, 2015

The Director
Distance Learning Institute
University of Lagos

REQUEST FOR PERMISSION TO CONDUCT RESEARCH

Dear Sir

I hereby request permission to conduct research in your institution.

My name is Comfort Reju, and I am presently studying for a PhD degree with the University of the Free State, South Africa. As part of my Doctoral programme, I am required to conduct research on an aspect of interest with a view to making a contribution to our knowledge and understanding of the issue under study. The title of my research project is:

Students' Experiences with Distance and Online Learning of University-Level Undergraduate Mathematics in Nigeria

The purpose of the study is to examine the students' experiences with distance and online learning of university-level undergraduate mathematics in two main Open and Distance Learning (ODL) institutions in Nigeria. I am particularly interested in studying the experiences of mathematics students in Distance Learning Institute (DLI), University of Lagos and National Open University of Nigeria (NOUN). The study has the potential to benefit ODL institutions in Nigeria to be able to effectively support Mathematics students learning in this mode and policymakers by pointing out the challenges, the successes of learning mathematics at a distance and through online.

The study will involve 1) filling out of self-completion questionnaire by thirty (30) year 3 mathematics students of your institution; and 2) interview with five (5) of them for the purpose of understanding instructional delivery, assessment, facilitation and support in distance and online environment. The interviews are expected to last no more than 30 minutes per student, and the self-completion questionnaire that will not take more than one hour will be distributed to them in their study centres to fill and return to the researcher.

I undertake to observe confidentiality and to protect participants from physical and/or emotional harm. No name of persons shall be used in any reports of the research. All participants will be asked to participate voluntarily in the study and may withdraw at any time should they so wish.

Upon the completion of the study, I undertake to provide the University of Lagos library with a copy of the research report through the Director, Distance Learning Institute (DLI) and to share my findings with the National Open University of Nigeria (NOUN) through the published results of the study in professional journals in the field of distance and online learning and/or

proceedings of any learned conference where the results are presented, as the case may be.

I attach a letter of recommendation from my research supervisor regarding the study and my progress.

If you need any further information and/or have suggestions, please do not hesitate to contact me and/or my research supervisor Professor Loyiso C. Jita at jitalc@ufs.ac.za or +27514017522.

Thank you for your kind consideration of my request.

Yours sincerely

Comfort Reju
Cell: +264XXXXX/+234XXXXX
(E-mail: okwyrej@gmail.com)

Appendix 4: Permission letter from DLI

Director:
Prof. Ganiyu G. Oke
B.Sc. (Edu), M.A. Ed (Municie, Indiana), Ph.D. (Lagos)
E-mail: gghills@yahoo.ca
          dlidirector@unilag.edu.ng
www.unilag.org, www.unilag.edu.ng
Tel.: 08022899159

DISTANCE LEARNING INSTITUTE
UNIVERSITY OF LAGOS
LAGOS, NIGERIA

Ref. No.: AD/ADM/DLI/S.1

This supersedes my memo Ref. No. AD/ADM/DLI/S.1 of 18th August, 2015.

20th August, 2015

Mrs. Comfort Reju,
Distance Learning Institute,
University of Lagos,
Lagos.

Dear Mrs. Reju,

RE: REQUEST FOR PERMISSION TO CONDUCT RESEARCH

Reference to your memo of 9th May, 2015 on the above– named subject matter.

Please be informed that approval has been given by the Director for you to conduct your research.

Thank you.

Ifueko O. Bello-Fadaka
Institute Secretary

Appendix 5: Permission letter from NOUN

NATIONAL OPEN UNIVERSITY OF NIGERIA
(OFFICE OF THE REGISTRAR)

Mrs. Josephine Olasumbo Akinyemi, FAUA
B.Sc. (Hons), MPA, MNIM

Headquarters:
14-16 Ahmadu Bello Way,
PMB 80067, Victoria Island,
Lagos, Nigeria.
Mobile: +234 806 310 2206
E-mail: registrar@noun.edu.ng

REF: NOUN/REG/HR/INFO/023/29

14th August, 2015

Mrs. Comfort Reju
Distance Learning Institute
University of Lagos
Lagos

Dear Mrs. Reju,

RE: REQUEST FOR PERMISSION TO CONDUCT RESEARCH

I write to acknowledge receipt of your letter dated 9th May, 2015 on the above subject matter.

Please be informed that Management has considered your request and granted approval for you to conduct your PhD research using the undergraduate Mathematics students of NOUN as sample.

You are required to liaise with the Dean, School of Education in this regard.

Thank you.

Omorogieva E. Ileka (Mrs.)
Deputy Registrar (Academic)
For Registrar

Abuja Office: 5, Dar-es Salaam Street, Off Aminu Kano Crescent, Wuse II, Abuja. PMB 581, Garki-Abuja, Nigeria.
Tel: +234-9-671 1929, URL: www.noun.edu.ng

231

Appendix 6: Invitation letter to DLI students

<div align="right">
Distance Learning Institute
University of Lagos
9th May, 2015
</div>

The Year Three (3) Student
Distance Learning Institute
University of Lagos

INVITATION TO PARTICIPATE IN A RESEARCH STUDY

Dear Student

My name is Comfort Reju, and I am presently studying for a PhD degree with the University of the Free State, South Africa. As part of my programme, I am conducting a research study entitled:

Students' Experiences with Distance and Online Learning of University-Level Undergraduate Mathematics in Nigeria

The purpose of the study is to examine your experiences with distance and online learning of university-level mathematics.

You have been identified as one of the student studying mathematics in this mode and whose experiences I would like to understand and explain. The study has the potential to benefit you and other students who are learning mathematics through the distance and online mode by pointing out the challenges and the successes of learning mathematics at a distance and through online in Nigeria.

The study will involve 1) you filling out a self-completion questionnaire and 2) interviewing you for the purpose of understanding instructional delivery, assessment, facilitation and support in distance and online environment. The interview is expected to last no more than 30 minutes, and the self-completion questionnaire that will not take more than one hour will be given to you to fill. With your permission, a recording device will be used to record the interview.

I undertake to observe confidentiality and to protect all participants from physical and/or emotional harm. No name of persons shall be used in any reports of the research. Your participation is entirely voluntary and you may withdraw at any time should you wish to do so.

Upon the completion of the study, I undertake to provide the University of Lagos library with a copy of the research report and to share my findings with your director.

 I have already received permission from the director of your institution to conduct the study.

If you need any further information and/or have suggestions, please do not hesitate to contact me and/or my research supervisor Professor Loyiso C. Jita at jitalc@ufs.ac.za or +27514017522.

Thank you for your kind consideration of my request.

Yours sincerely

Comfort Reju
Cell: +264XXXXX/+234XXXXX
(E-mail: okwyrej@gmail.com)

Appendix 7: Invitation letter to NOUN students

<div align="right">
Distance Learning Institute
University of Lagos
9th May, 2015
</div>

The Year Three (3) Student
Mathematics Education
National Open University of Nigeria

INVITATION TO PARTICIPATE IN A RESEARCH STUDY

Dear Student,

My name is Comfort Reju, and I am presently studying for a PhD degree with the University of the Free State, South Africa. As part of my programme, I am conducting a research study titled:

Students' Experiences with Distance and Online Learning of University-Level Undergraduate Mathematics in Nigeria

The purpose of the study is to examine your experiences with distance and online learning of university-level mathematics.

You have been identified as one of the students studying mathematics in this mode and whose experiences I would like to understand and explain. The study has the potential to benefit you and other students who are learning mathematics through the distance and online mode by pointing out the challenges and the successes of learning mathematics at a distance and through the online mode in Nigeria.

The study will involve 1) you filling out a self-completion questionnaire and 2) interviewing you for the purpose of understanding instructional delivery, assessment, facilitation and support in distance and online environment. The interview is expected to last no more than 30 minutes, and the self-completion questionnaire that will not take more than one hour will be given to you to fill. With your permission, a recording device will be used to record the interview.

I undertake to observe confidentiality and to protect all participants from physical and/or emotional harm. No name of persons shall be used in any reports of the research. Your participation is entirely voluntary and you may withdraw at any time should you wish to do so.

Upon the completion of the study, I undertake to provide the University of Lagos library with a copy of the research report and to share my findings with your Dean.

I have already received permission from the Dean, School of Education of your institution to conduct the study.

If you need any further information and/or have suggestions, please do not hesitate to contact me and/or my research supervisor Professor Loyiso C. Jita at jitalc@ufs.ac.za or +27514017522.

Thank you for your kind consideration of my request.

Yours sincerely

Comfort Reju
Cell: +264XXXXX/+234XXXXX
(E-mail: okwyrej@gmail.com)

Appendix 8: Consent form

If you agree to participate in the research study entitled:

Students' Experiences with Distance and Online Learning of University-Level Undergraduate Mathematics in Nigeria

Please complete the attached consent form

- *I hereby give free and informed consent to participate in the abovementioned research study.*
- *I understand what the study is about, why I have been approached to participate.*
- *I understand what the potential benefits and risks are.*
- *I give the researcher permission to make use of the information collected from my participation, for research purposes only.*

Participant's Signature: _____ Date: _____

Researcher's Signature:_____ Date:_____

Appendix 9: Students questionnaire survey

Questionnaire for Distance and Online Learning (DOL) Mathematics Students
Please Note:
- Answer all the questions as honestly as possible
- Your responses will be used for research purpose only
- Information will be treated as anonymous and with high confidentiality
- Place an (x) on the answer of your choice
- Your email address will be separated from the questionnaire during the analysis
- Thank you for your participation in this study

_____

A.   Basic Demographic Information

1.   Name of your Institution: (a) DLI, UNILAG [ ] (b) NOUN [ ]

2.   Sex: (a) Male [   ] (b) Female [   ]

3.   Age: (a) Less than 25 [ ] (b) 25- 34 [ ] (c) 35- 44[ ] (d) 45- 54 [ ]

      (e) 55 & above [   ]

4.   Marital Status: (a) Married [ ] (b) Single [ ]   (c) Widow/Widower [ ]

      (d) Divorced [   ]

5.   Job Status: (a) Applicant [ ] (b) Employed [ ]

6.   Your email address: --

7.   Estimated number of hours I spend per week using a computer for academic
      purposes: (a) less than 1 (b) 1 – 5   (c) 6 – 10   (d) 11 & above

8.   Estimated number of hours I spend per week online exploring the Internet for school
      purposes: (a) less than 1 (b) 1 – 5   (c) 6 – 10   (d) 11 & above

9.   Estimated number of hours I spend per week online exploring the Internet for other
      (non-school) purposes: (a) less than 1 (b) 1 – 5   (c) 6 – 10   (d) 11 & above

B. The online learning environment and platform

Place an (X) in the table cell in front of your choice.

10	The learning environment available in my institution for distance and online mathematics learning is:	
	(a) Learning Management System (LMS)	
	(b) Course Management System (CMS)	
	(c) Virtual Learning Environment (VLE)	
	(d) Knowledge Management System (KMS)	
	(e) None of the above	
11.	The Online Learning Environment (OLE) or web-based platform for learning mathematics in my institution is:	
	(a) Blackboard (BB)	
	(b) Moodle	
	(c) Any other_____(please specify)	

C.   Distance and Online learning of mathematics at undergraduate Level

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
12.	The objectives of learning mathematics at distance and online are clearly made known by my tutor.					
13.	Distance and online learning of mathematics is difficult because I do not understand it.					
14	Learning of mathematics through distance and online mode in my institution is frustrating.					
15.	Many mathematical problems cannot be solved through distance and online learning.					
16	I enjoy learning mathematics through distance and online.					

17.	Learning mathematics through distance and online mode saves time and effort for learners.					
18.	I have reliable access to internet for my school needs.					
19.	The course materials are well developed for learning of mathematics in my university.					
20	The course materials are sufficient for learning of mathematics in my university.					
21.	The course materials challenge and arouse my curiosity to learn new mathematical concepts.					
22.	The course materials challenge and arouse my curiosity to learn difficult mathematical concepts.					
23.	The abstract nature of mathematics is not simplified in the design of the course materials.					
24.	I have access to course materials online over the internet.					
25.	The contents covered in the mathematics course materials are quite adequate for the period the student is required to complete the course work.					
26.	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.					
27.	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.					
28.	When the mathematics course material is difficult to understand, I give up or study only the easier parts.					
29	The course materials are fairly interactive for me to understand.					

30.	Even when the mathematics course materials are not interactive enough, I manage to continue working to understand and finish them.					
31.	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.					
32.	Distance and online learning gives access to ENOUGH resources to learn undergraduate mathematics at my university.					
33	Distance and online learning gives access to QUALITY resources to learn undergraduate mathematics at my university.					
34.	Face-to-face remains the dominant method of teaching and learning of mathematics in my institution.					
35.	Learning of mathematics through the distance and online mode is not efficient.					
	Students' Experiences with assessment procedures in distance and online mathematics learning environment					
36.	Assessment procedures are well specified and included in the design of mathematics course materials in my institution.					
37.	There are no adequate resources to support student assessment procedures.					
38.	The guiding principle on mathematics assessment is not well understood by the students.					

39.	The students' assessment guidelines involve too much paper work (i.e. traditional method of assessment) than distance and online activities.					
40.	Online assessment of mathematics students is the only form of assessment procedure used in my institution.					
41.	My institution makes use of both online and traditional assessment procedures in assessing the mathematics distance learners.					
42.	I prefer traditional method of assessment than online assessment.					
43.	It is better to use both online and traditional procedures to assess distance and online mathematics students.					
44.	Access to assessment procedures in my institution's distance and online platform is very easy.					
45.	I enjoy doing mathematics assessment online.					
46.	Assessment feedback is promptly obtained online.					
47.	Distance and online assessment procedures in my institution are very effective.					
	Students' experiences with distance and online mathematics facilitation					
48.	I work with other students from my university to complete course assignments.					
49.	I prefer setting aside time to discuss course materials with a group of mathematics students in my school.					
50.	I work together with my instructor to clarify the abstract concepts of mathematics.					
51.	When I have difficulty learning mathematics concepts in my school, I try to remain a self-learner without obtaining help from anyone.					

52.	Collaborative activities with other mathematics students help to improve my performance in mathematics.					
53.	Online collaboration is very effective in my school and it fosters mathematics learning.					
54.	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					
55.	Support services are available for mathematics students all through the week (24 hours/7days).					
56.	Support services are provided only during the working hours of the week.					
57.	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.					
58.	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					
59.	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.					
60.	There are sufficient library resources for mathematics distance and online learners to use.					
61	There are accessible library resources for mathematics distance and online learners to use					
62	I am able to access the library resources online from anywhere in the world					
63.	My institution provides access to career counselling for distance mathematics students.					

64. Briefly explain how you understand:

(a) Instructional delivery of mathematics in distance and online environment

_____

_____

_____

(b) Mode of assessment

_____

_____

_____

(c) Distance and online facilitation

_____

_____

_____

(d) Support services in distance and online environment

_____

_____

_____

65. From your own experiences, give two or three suggestions on how distance and online learning of undergraduate mathematics can be improved.

_____

_____

_____

_____

Thank you.

Appendix 10: Students interview questions schedule

INTERVIEW PROCEDURES FOR DISTANCE AND ONLINE MATHEMATICS STUDENTS

1. Your name

2. Why did you choose to study mathematics through distance and online mode?

3. Do you really enjoy studying mathematics through this mode? (Probe for How/Why?)

4. Do you have reliable access to internet for your school needs? (Probe how it is being accessed)

5. Do you have enough resources necessary to study undergraduate mathematics in your institution? Yes/No. If 'No', then probe how he/she learns mathematics through this mode. If 'yes', then:

   i.   What resources do you have access to learn mathematics in this environment?

   ii.   How do you access them?

   iii.   Which learning activities do you perform using them? Doing assignment, collaborating with others, etc. (Probe for detailed descriptions of each activity)

   iv.   How useful are the resources to you in learning mathematics? Give specific examples to illustrate.

   v.   How easy are the resources in using them to learn distance and online mathematics? (Can you give detailed descriptions)?

6. Do you have easy access to your mathematics course materials? Talk to me about the nature of the materials you use for your mathematics modules.

   i.   Are the mathematical contents well covered in the development of your course materials? (Explain).

   ii.   Are the materials simplified enough to take care of the abstract nature of mathematics? (Explain with examples).

7. What is your experience with the instructional delivery of mathematics through the distance and online mode of learning in your institution? (Give me examples to illustrate).

8. Does your institution make use of both online and traditional assessment procedures in assessing the mathematics distance learners? Yes/No. If 'Yes' Explain using examples.

   i.   Which of the mode do you prefer?

   ii.   Why do you prefer that mode?

If the answer is 'No', state the mode of assessment in your institution. Give me examples.

iii. What is your opinion about the assessment procedures in your institution?

9. Do you have any difficulties learning mathematics through distance and online mode? Yes/No. If 'Yes', describe each one of these difficulties for me. Give me a specific example to illustrate.

    i.   For each difficulty identified, ask: How do you overcome the difficulty?

    ii.   Discuss the opportunities you have to collaborate with other students. Probe for specific examples.

    iii.   How effective is online collaboration in your institution? Illustrate what you mean with examples.

If the answer is 'No',

    iv.   What are your motivating factors in learning mathematics through distance and online mode?

    v.   How do you perceive distance and online facilitation in your university? (Illustrate what you mean with examples).

10. Do you obtain support for your distance and online mathematics learning from your institution?

    i.   What are the technologies available in your institution for learning of mathematics? Explain how each technology is used in your institution.

    ii.   Through which media do you normally receive support from your university? Give me an example to illustrate.

    iii.   What are your experiences of learning mathematics using technology and can you give suggestions on how technology can affect distance and online mathematics learners?

11. What are the major challenges you have studying mathematics through the distance and online mode? (Illustrate each challenge with an example).

12. Finally, can you please suggest how distance and online mathematics learning can be improved in your institution and Nigeria?

Thank you

Appendix 11: Demographic data of DLI mathematics students

Basic demographic information of DLI participants

Basic demographic information DLI (n = 30)			
Item		Frequency	Percent
Sex	Male	21	70.0
	Female	9	30.0
Age	Less than 25	1	3.3
	25 – 34	25	83.3
	35 – 44	4	13.4
	45 - 54	-	-
Marital Status	Married	9	30.0
	Single	21	70.0
Job Status	Applicant	6	20.0
	Employed	24	80.0
Email Address	Have	28	93.3
	None	2	6.7
Estimated number of hours I spend per week using a computer for academic purposes	Less than 1	6	20.0
	1 – 5	17	56.7
	6 - 10	6	20.0
	11 and Above	1	3.3
Estimated number of hours I spend per week online exploring the Internet for school purposes	Less than 1	6	20.0
	1 – 5	19	63.3
	6 - 10	4	13.4
	11 and Above	1	3.3
Estimated number of hours I spend per week online exploring the Internet for other (non-school) purposes	Less than 1	8	26.7
	1 – 5	18	60.0
	6 - 10	3	10.0
	11 and Above	1	3.3

Appendix 12: Demographic data of NOUN mathematics students

Basic demographic information of NOUN participants

Basic demographic information NOUN (n = 30)			
Item		Frequency	Percent
Sex	Male	25	83.3
	Female	5	16.7
Age	Less than 25	17	57.7
	25 – 34	12	40.0
	35 – 44	-	-
	45 - 54	1	3.3
Marital Status	Married	5	16.7
	Single	25	83.3
Job Status	Applicant	17	57.7
	Employed	13	43.3
Email Address	Have	29	97.7
	None	1	3.3
Estimated number of hours I spend per week using a computer for academic purposes	Less than 1	3	10.0
	1 – 5	15	50.0
	6 - 10	6	20.0
	11 and Above	6	20.0
Estimated number of hours I spend per week online exploring the Internet for school purposes	Less than 1	5	16.7
	1 – 5	12	40.0
	6 - 10	5	16.7
	11 and Above	7	23.6
Estimated number of hours I spend per week online exploring the Internet for other (non-school) purposes	Less than 1	8	26.7
	1 – 5	13	43.3
	6 - 10	3	10.0
	11 and Above	6	20.0