Exploring students' conceptualisations of technology through their experiences of it (in and out of school)

Godwin Ndukaego Osakwe

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Abstract

The aim of this study was to explore students' experiences and conceptualisation of technology. The study employed a qualitative case study approach, with a sample comprising 16 students and four teachers from two schools, as the researcher believed that looking at more than one school would lead to a better understanding of technology education in the classroom. The data were collected using semi-structured interviews for both students and teachers and lesson observation notes, and transcripts were analysed using an inductive thematic analysis technique developed by Braun et al. (2014).

The findings indicate the existence of a huge disconnect between the students' experience of technology and their perspectives on technology, which seemed to suggest that more efforts are needed to introduce learning activities that reflect existing literature's views of the meaning of technology. This study found that outside school, students conceptualised technology in terms of technological artefacts, which was indicative of their limited perspectives on technology. The findings also showed that in the classroom, most students' experience of technology aligned more with theoretical aspects of technical drawing (construction of different angles, bisection of lines and angles), which is similar to what students are taught in technical and vocational education that aims to prepare them for specific jobs, while technology education leads them to develop technological literacy – the ability to use, manage, understand and evaluate technology in general. This difference highlighted the need to develop a framework for understanding technological concepts in order to help students understand not only familiar aspects of technology, but also unfamiliar things and ideas or concepts that have not been discussed much in the literature (De Vries, 2005; Collier-Reed, 2009; DiGironimo, 2011).

Consequently, this study proposed a model for conceptualising technology that has potential educational benefits, which could be developed to help future research, policy and practice to enhance students' strengths and reduce their weaknesses in learning about technology. If we are educating students to be technologically literate, we must encourage them to advance their understanding of technology for real-world learning and help them to become global citizens.

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Abbreviation	**Meaning**
DT	Design and Technology
FGN	Federal Government of Nigeria
FME	Federal Ministry of Education
ITEA	International Technology Education Association
JSS	Junior Secondary School
PATT	Pupils' Attitudes Towards Technology
NEDRDC	Nigerian Education Research and Development Council

SSS	Senior Secondary School
STL	Standard for Technological Literacy
TVE	Technical and Vocational Education
TVET	Technical and Vocational Education and Training
UBE	Universal Basic Education
UNESCO	United Nations Educational Scientific and Cultural Organisation

Chapter 1: Introduction and overview of this study

This chapter describes the background to this study, alongside the research problems encountered. The methodology used is described briefly and justified, and the limitations are outlined. Moreover, a detailed description of the study's contribution to the body of knowledge is provided. The chapter concludes by outlining the chapter structure of this thesis and providing some key definitions.

1.1: Introduction

This section presents the background to this study. It focuses on technology and technology education in Nigeria to gain insights into what we can learn from the students' experiences and how they can use their knowledge to enhance their employability skills and reduce the poverty rate in Nigeria. The researcher for this study has taught technology education in Nigeria and the United Kingdom (UK) and has more than 20 years' experience of working both in teaching and in the industry. Also, the researcher has two daughters who relocated from Nigeria to join him in the UK and often talk about their experience of technology since they arrived here, but lack interest in becoming a technology education teacher in the future. This is not surprising, because according to Ardies et al. (2015), "young people are interested in technological products, but their opinions about education and careers in technology are not particularly positive" (p. 44).

However, the researcher's interest in undertaking this study has been aroused through the disparate views expressed by most educational literature regarding the rising rate of youth unemployment and poverty in Nigeria and the extent to which these issues are affecting development. National statistics and previous studies reveal that unemployment and poverty are on the rise. That said, various researchers have argued that technology education has been an integral part of national development strategies because of its impact on productivity and economic development. This is because it could help people gain employable skills, thereby leading to economic growth. However, many technology education graduates seem not to possess the level of knowledge and skills demanded by potential employers (Okonjo-Iweala, 2012; Jayaram and Engmann, 2014; Ayonmike, 2016), which suggests that the programme of study in technology education may need a review. Despite this strategic direction, the literature reveals that relatively little is known about student perceptions of technology.

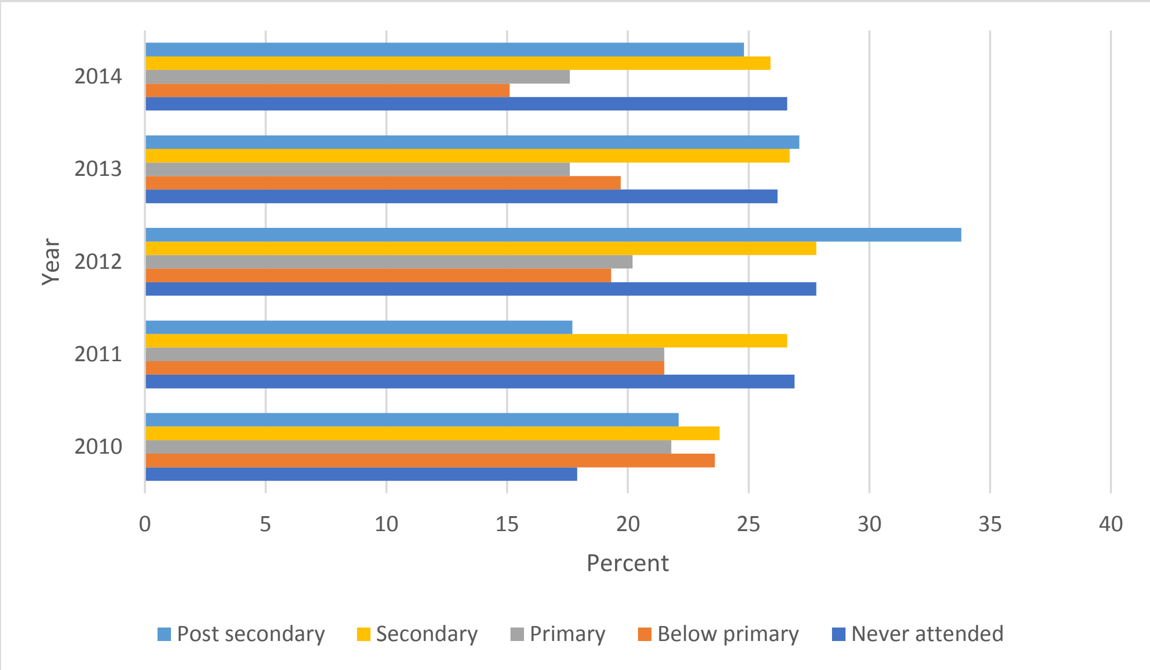
However, there is a lack of clarity in the field (Ayonmike, 2016). Ogbondan and Wobi (2014) noted that the public has a negative perception towards technology education in Nigeria because they think that technology education is aimed at people with potentially poor academic skills, but in Okoye and Okwelle's (2017) view, technology education in Nigeria is flawed for many reasons, including in the past the design of its curriculum, which focused on preparing students for specific skills. Pavlova (2009) strongly supported the need to change the teaching paradigm of technology education, which is currently focused on competency development, to emphasise moral values through technical and vocational training. For Ayonmike (2016), there is a general agreement that all young people need a set of skills that will prepare them for employment and further learning, and yet there is a lack of consensus about what those skills should be – especially in light of the challenges facing Nigerian industry (Ayonmike, 2016). Thus, this study explores the students' conceptualisations of technology through their experiences both inside and outside school. The researcher believes that the results may inform the development of an intervention to help students' technology learning and enhance their employability skills, as demanded by most employers.

Unemployment

Unemployment is the state of being without any work yet looking for work (Soanes and Hawker, 2008). Internationally, some nations' unemployment rates are muted or appear less severe due to the number of self-employed individuals (Sorrentino, 2000). Indeed, turning unemployment into self-employment has become a major focus of German active labour market policy in recent years (Baumgartner and Caliendo, 2008). The fact remains, however, that the situation might be different elsewhere (Baumgartner and Caliendo, 2008). The scope of this section must remain limited to the context of Nigeria.

Unemployment in general and youth unemployment in particular are rising in Nigeria (Asaju et al., 2014; Olateru-Olagbegi, 2015). Data from the National Bureau of Statistics (NBS) showed that there is a higher incidence of unemployment among youths. Youth unemployment in Nigeria is largest among the age group 15–24 years at 35.9%, while 23.3% of those aged 25–34 years and 16.8% of those aged 35–44 years are unemployed (NBS, 2010). Innocent (2014) noted that the population of youths aged between 15 and 35 years in Nigeria is estimated to be 64 million, of which more than half (about 54%) are unemployed, which translates to 35 million young people. As can be seen from Figure 1.1, the unemployment rate is generally high among those who have secondary and post-secondary education.

Figure 1.1 Unemployment rate by educational group, 2010–2014



Source: Index Mundi, 2018.

The figure above highlights the need to encourage and support young people to develop skills that would help them to gain employment. According to the International Labour Organisation (ILO), unemployed people can be defined as those people without a job who have been actively seeking work in the past four weeks and are available to start work in the next two weeks. It also includes those who are out of work but have found a job and are waiting to start it in the next two weeks. The proportion of the active population that was without work but was actively seeking work increased from 21.1% in 2010 to 23.9% in 2011. According to Central Intelligence Agency (C.I.A) world factbook and related data from the International Monetary Fund (IMF), the unemployment rate was 13.6% in 2001, 14.8% in 2003, 14.9% in 2008, 19.7% in 2009, 21.1% in 2010 and 23.9% in 2011. To remedy the situation, Nigeria first needs to create more decent jobs, according to Ajakaiye et al. (2016), who argued that the World Bank has estimated that the Nigerian economy needs to create between 40 and 50 million jobs between 2010 and 2030 as a result of the continued high fertility rate, which is set to rapidly increase the working-age population by some 66 million people between 2010 and 2030, compared to an increase of 35 million people between 1990 and 2030.

Poverty

Nigeria is rich in resources such as oil and different minerals (Oshewolo, 2010). However, Nigeria has not been able to reduce poverty and provide adequate education and infrastructure services to its population. Okosun et al. (2010) argued that although the country is endowed with considerable resources, unequal distribution of wealth kept a large percentage of people poor in terms of income, education, health care, employment, nutrition, housing and access to basic facilities. Poverty has risen in Nigeria, with almost 100 million people living on an income of less than $1 a day and the number of Nigerians living in poverty increasing from 68.7 million (54.7%) in 2004 to 112.47 million (60.9%) in 2010 (Foster and Pushak, 2011; British Broadcasting Corporation, 2012; Litwack, 2013). Okonjo-Iweala (2012) noted that many graduates are unemployed because they lack the skills required by most Nigerian employers, concluding that education and associated learning outcomes are inappropriate. Similarly, Ayonmike (2016) posited that most of the graduates were unemployable because they lack employable skills. However, most authors in this area (Uwaifo and Uwaifo, 2009; Uwaifo, 2010; Adeoye and Olabiyi, 2011) have noted that a key issue is that the curriculum for technology education lacks any relationship with the workplace and social needs. Educational institutions annually produce graduates who are largely unemployable because they lack employable skills (Okonjo-Iweala, 2012). In light of the problems mentioned above, the important question to be raised is how this issue can be better tackled to reverse the increase in unemployment and poverty.

Employability skills and poverty amelioration strategy

If a new strategy for addressing Nigeria's poverty and employment problem is to be effective, Nigeria should be focused on a specific target population. Okosun et al. (2010) argued that since the benefits of general development policies take a long time to trickle down to the poor, a development plan should be focused on a specific target and reflect the state of unemployment/underemployment in the population in order to be effective. Considering the background to this study, the researcher felt it appropriate to focus on students at the junior secondary school level – that is, 11- to 14-year-olds (Stables, 1997). The researcher believes that with adequate encouragement, students within this age bracket are more likely to have time left to learn and develop before they enter the labour market. In accordance with this mindset, Gylfason (2001) and Barro (2013) suggest that education is an indispensable and essential condition for economic growth and development because it helps increase the knowledge and skills of the labour force. Hayward and James (2004) opined that there is an observable relationship between education and training and social and economic growth. Education and training are vital for any nation in attaining employability skills and long-term poverty amelioration for social and economic growth (Hayward and James, 2004). Hayward and James (2004) augment this view by arguing that education and training policy is the key lever through which to enhance "employability skills" (p. 3). Hayward and James's (2004) view is significant and relevant to this study because it suggests that a key element in national development is to improve the education and training of citizens. Individuals attend school to learn skills that will enable them to acquire the knowledge and skills required to make a decent living. Thus, the argument made by Hayward and James (2004) suggests that an exploration of the knowledge expressed in the classroom, together with students' everyday experience, is vital and might be the way forward.

Furthermore, De Meulemeester and Rochat (2014) emphasise “knowledge and skills” (p. 35) as the key issue pertinent to economic growth. De Meulemeester and Rochat (2014) suggest that the nature of the course of study should be relevant to the needs of the economic system, and they insist that problem-solving ability rather than knowledge accumulation is key, which is less centred on the acquisition of degrees. They contend that reliance on the accumulation of knowledge per se is not sufficient; rather, there is a need to bring the knowledge to bear on the aspirations of students and their parents. Given that the context of this study is Nigeria, it is appropriate to provide an overview of the geography of the country, which is given in the next section.

An overview of the geography of Nigeria

Nigeria is located on the western coast of Africa. It is the largest country on the continent, with a land area of 923,768 square kilometres. From an estimated 42.5 million people at the time of independence in 1960, Nigeria’s population has more than quadrupled to reach 186 million people in 2016 (Index Mundi, 2018). Nearly half (42.8%) the population is under 15 years of age (Index Mundi, 2018), of whom 40,744,956 are male and 38,870,303 are female. Figure 1.2 presents the 36 states and the federal capital territory, Abuja, and four countries that share their international borders with Nigeria. They are Benin, Cameroon, Chad and Niger.

Figure 1.2 Map of Nigeria showing the international boundary, the 36 states and the Federal Capital Territory, Abuja

Source: Maps of world, 2014.

1.2: Research question issues

This section emphasises the whole research problem that provides justification for the research questions (RQs). The focus of this study is students' perceptions of technology in relation to their everyday lives and technology in the classroom. Hence, this study is centred on the following two key RQs:

RQ1. How do students conceptualise technology in their everyday lives outside of school?

RQ2. In what ways and to what extent, if any, does student experience of technology align with learning about technology in the classroom?

These research questions are intended to gain a better understanding of how to meet the changing needs and requirements in terms of ensuring technology education is relevant to real-world situations. Although there are two questions to be investigated, the researcher's interest lies in what students know about technology and how their ideas align with the normative component of technology. For example, one of the normative components of technology is characteristics of technological knowledge that are distinct from scientific knowledge (De Vries, 2005). Therefore, gaining insights into students' experiences of characteristics of technology has the potential to open the curriculum to possibilities that are obscured by a more restricted view, such that the term 'technology' is viewed beyond a mere aspect of technology – for example, technological artefacts or technological knowledge. Hence, this study might be useful to those with responsibilities in the field of technology education.

The two research questions are discussed in turn below.

RQ1 pertains to students' experiences of technology outside the classroom, which consist of the ways in which they are likely to act, think and feel about technology on a daily basis as part of their normal life. The linkages between individuals' experiences of technology and how these might relate to an individual's conception of technology can arguably be a vehicle for introducing children to creativity or problem-solving (Lewis, 2009). For example, learning activities could challenge students in the context of real-world problems such as practical activities. Besides understanding how students conceptualise technology outside school, the benefits of their experiences could nurture a passion in students and encourage them to pursue a career in the technology field. Moreover, it can feed into how activity outside school can benefit activity inside school.

RQ2 relates to technology in the classroom. The goal of technology education is to produce students who have a more conceptual understanding of technology (ITEA, 2000), and to create a distance from vocational education, which seems to best describe the current practice of technology education (Sanders, 2001). Indeed, Williams (2011) argues that vocational education has had a significant impact on schools, as it provides less scope for the achievement of the general goals related to creativity and lateral thinking because it is more constrained. Williams (2011) further argues that these characteristics of vocational education contrast with technology education, which is a more appropriate curricular vehicle for the achievement of general technological skills. For Lewis (2009), technology education literature often includes design challenges, such as setting a project where students are required to create and realise a product. This suggests that narrow educational curricula that create boundaries between curriculum areas and real-world experiences are likely to inhibit innovation and creativity.

From the perspectives of the arguments above, it seems there is a need to capture some of the issues that relate to students' experiences of learning and teaching and to draw out some implications for technology education. However, the rationale behind the development of the above-mentioned research questions was prompted by a scant research base with respect to qualitative research in students learning technology (Zuga, 1994; Lewis, 1994; Hoepfl, 1997;

ITEA, 2000; De Vries, 2005), in addition to the background to this study as previously discussed in Chapter 1.1. The research questions will be discussed in detail in Chapter 2.

1.3: Research methodology issues

Research paradigm

Technology education in Nigeria is new and needs more than the previously believed fact about students' perceptions of technology. When the researcher commenced this study, two important paradigms (positivist and interpretivist) in social sciences research (Pring, 2002) were explored. From the perspectives of the research questions, the researcher became aware of the limitations of the positivist position; for example, rich and detailed data in relation to understandings of students' experiences of technology would not be effectively captured through administering surveys and quantitative data analysis. Conversely, an integral aspect of the interpretivist paradigm is that interviews are considered useful for discovering more about the strategies and intentions of study participants, which may be difficult to elicit from other sources of data collection (Patton, 1990). Furthermore, after significant reading about research methodologies and attending research methods courses, alongside considering the fact that the research questions are formulated to investigate the participants' perspectives in their own words, the researcher concluded that the interpretivist position was an appropriate philosophical paradigm for this study. In light of this understanding, this study adopted the interpretivists' paradigm (Mack, 2010), because it emphasises the ability to understand the participants' interpretation of the phenomenon (in this case technology) through the meaning they assign to it and has the potential to facilitate the exploration of general and new areas of interest, one's view of reality and how one acquires knowledge (Mack, 2010). This is discussed in more detail in Chapter 3.

Research methods and data analysis

A qualitative method of study was adopted to realise the primary goal of this study, which was to explore students' perceptions and experiences of technology and answer the research questions. Creswell and Creswell (2017) explained that the best way we can understand any phenomenon in context and in detail is through qualitative inquiry. The research questions determined the method selected on the basis that the technique used for data collection should gather information that will allow the research questions to be answered, consider the characteristics of the sample and provide information linked to the focus of the research questions. In order to gather rich and detailed data, multiple sources of evidence were used, such as lesson observations and interviews (individual and student group interviews). These were collected using purposive and convenience sampling. Details justifying the chosen methodological approach (case study approach) and sampling are described in Chapter 3. Also, the choice of approach for the data analysis was explored and a justification for using inductive thematic techniques (Braun et al., 2014) was discussed. The data was interpreted using the researcher's construct of interpretation of technology derived from De Vries (2005), as explained in Chapter 2 in this thesis. Further detail is provided in Chapter 4.

1.4: Limitations of this study

This study had three significant limitations, namely issues related to the use of small sample size, the accuracy of data collected and the presented conceptual framework. The purpose of this study is to provide detailed descriptions of how students in Nigerian schools conceptualise technology in their everyday lives and the classroom. On this basis, this study does not claim to provide a complete picture of what technology education is like in Nigeria. However, the limitations of this study will help future researchers to avoid facing the same shortcomings.

One of the limitations is that the number of schools and student participants was relatively small. However, the researcher in this study argued that it is likely that the same findings may emerge if this study was conducted in other schools. Therefore, this study suggests that future studies include samples from a wider geographic area.

Another limitation is the accuracy of the data collected. The researcher believes that there were several potential biases. For example, participants may have given answers that they thought were desirable. The responses an individual provided may not have been accurate, but it is very difficult to prove this, given that the study originated on mutual trust and open discussion. Furthermore, the participants may not have wanted to display any negative aspects and may, therefore, have responded positively for the sake of the study. In light of this, the data collected could be misleading.

Finally, this study considers the limitations inherent in the presented conceptual framework. The researcher argued that it is not as comprehensive as it could have been. Therefore, this study is limited to some extent, as all relevant views may not have been well-thought-out. However, this limitation is inevitable. The limitations of this study are discussed further in Chapter 5.5.

1.5: Contribution to knowledge

In addition to the provision of some directions for future research (see Chapter 5.6), this study has made four major contributions to the literature on technology education by throwing fresh light on students' experiences and conceptualisation of technology.

1) This study raises awareness about students' learning in technology. It reveals the existence of a disconnect between the students' experience of technology and their perspectives on

technology (real-world views about technology), which seemed to suggest that perhaps more efforts are needed to introduce learning activities that reflect existing literature's views of the meaning of technology. Thus, it could be argued that students learning technology are doing so in name only. If students are learning about technology to keep in touch with the real world, they should be encouraged to focus on gaining a conceptual understanding of technology by trying to learn something based in reality. Students are aware that a good understanding of technology is associated with the ability to create things that could appeal to society and enable them to earn money by utilising their knowledge and skills. Therefore, this study suggests it would benefit the students and the national economy if we started to encourage the teaching of technology in a way that enables students to easily identify and connect with reality – that is, with the objects around them that they frequently use. To do that, we must seriously consider transforming technology subjects into something that has a conceptual understanding. Given that this study focuses on junior secondary school, there is a need for students to have some exposure to the real industry in which they will later work.

2) The researcher's investigation into the conceptualisation of technology contributes to the originality of this study. Although concepts of technology appear unfamiliar to students and teachers in this study, the researcher hopes that the findings of this study could attract technology teachers' attention to the proposed model for conceptualising technology developed after De Vries (2005) from the perspective of philosophy of technology. This could be used to provide students with modes of thinking that are creative.

3) This study could be used to form a basis for a new technology curriculum in Nigeria, by providing a practical framework for implementing technology in the classroom in terms of what is to be learnt and how it relates to the context in which it will be used. This study has found something that will benefit society, is interesting and is of potential value to teachers and policymakers considering that technology plays an important role in almost every aspect of

people’s lives today. The notion that technology education represents a completely new ‘paradigm’ is well documented (Sanders, 2001; ITEA, 2000). The importance of the role of teachers in the implementation of the technology curriculum is also well established in technology education literature (Moreland and Jones, 2001; Bungum, 2006; Männikkö-Barbutiu, 2011). Meanwhile, educational experts are trying to find a new paradigm of technology education that would meet the requirements of the 21st century and beyond (De Vries, 2005). Consequently, the findings of this study should encourage teachers and policymakers to explore the conceptual understanding of technology as a new aspect of the curriculum design and instructional strategy for current and future technology education.

4) This study could have the potential to contribute to the techniques that qualitative researchers use. For researchers on issues pertaining to the development of technology education, this study will help them to develop areas that need to be explored in the future, as there are few research agendas in technology education (Jones, 2001). For example, some areas of need that have received little attention include problem-solving, cognition, instructional methods and strategies, and technological literacy (Lewis, 1999). These overlooked features of technology education imply that there is likely to be a considerable amount that still needs to be explored. As we saw, this study offers a new and relatively easy way to corroborate the ideas of study participants in a qualitative research. The methodological approach used to examine students’ ideas in this study is unique in that the methodology is new. Although a case study approach was adopted, it combined some aspects of the concept of intentionality in the phenomenological tradition (Moustakas, 1994). The concept of intentionality, as applied in this study, has proved to be a useful one in the interpretation of students’ ideas that were expressed less explicitly. To the best of the researcher’s knowledge, this methodological innovation has not been used in any study before in Nigeria, thereby increasing the originality of this study.

Also, some concerns have been expressed about insufficient use of qualitative methodology in technology education (Zuga, 1994).

1.6: Outline of the chapters in this thesis

A five-chapter structure was used to present this thesis.

Chapter 1 introduces the thesis and considers the background to this study. The chapter briefly discusses the literature (Oshewolo, 2010), which positions Nigeria as a resource-rich country with oil and different minerals. Notwithstanding this natural endowment, there are concerns about unemployable skills and poverty (Ayonmike, 2016), but there is a widespread consensus that adequate technology education is a strategic requisite for countries aspiring to meet the basic needs of their populations. However, researchers seem to have paid less attention to the learning of technology, which will be the focus of this study. In particular, it is not clear how students learn technology as a school subject in a way that might help them relate to technology in real-world situations – not only in Nigerian society, but also in societies worldwide. In this chapter, the researcher discusses issues pertaining to the research questions that focus on learning technology and the potential for junior secondary students aged 11–14 years to develop appropriate knowledge and skills before they enter the labour market.

Chapter 2 contextualises the study in the relevant literature and provides an indication of areas of interest to explore. The chapter explores the development of education in Nigeria, drawing on the pattern of education reforms in the country, which started before independence. The theories of learning are described together with their stance on knowledge and knowledge production. These are significant to this study, because understanding theories of learning helps in making informed decisions about how children learn, and about the design, development and delivery of learning (Hawkins, 2017). This chapter discusses the national goals of technology education in Nigeria (Federal Ministry of Education, 2007), which emphasise achieving the inculcation of technological literacy. The chapter continues by discussing technology education both in Nigeria and internationally, alongside the notion of technological literacy. This chapter examines the concepts of technology and technology education in terms of their definition and meaning and presents what could be termed the ‘researcher’s model of conceptualising technology’, derived from De Vries (2005). The chapter concludes by examining previous literatures on students’ perceptions of technology and then presenting the two key research questions formulated for this study.

Chapter 3 explains the methodology employed for this study. It also discusses how the researcher came to use a case study approach that features two schools and 16 student participants. The chapter provides a profile of study participants and explains how data was collected through observations of technology lessons and interviews with students and teachers. In this chapter, students are interviewed about their interpretation of technology, using their experiences to generate ‘thick descriptions’ in their own words of their use of technology outside and inside school. Teachers are also interviewed in order to provide insights into what they are doing and what technology classes look like in Nigeria. Moreover, this chapter elaborates on the rationale for the design of the student interview and teacher interview protocol, and explains why a qualitative method was chosen as opposed to an alternative such as a quantitative or mixed-method technique.

Chapter 4 presents the data analysis and findings. The students’ perspectives of technology are the primary focus of this chapter. However, because this study is concerned with providing a rich and thick description of students’ experiences of technology, in which the research makes explicit interpretations and relates them to real-world views of technology, as the literature suggests, the chapter begins by searching for the most appropriate method of analysing the data collected for this study. Inductive thematic analysis was chosen as the best method for organising the data and answering the two research questions (Braun et al., 2014). The chapter addresses the process of analysis in detail and looks at how each data set was analysed for each research question using multiple illustrative examples from the data for each analysis step. The chapter provides a concise summary of findings related to the two research questions and concludes by explaining how the analysis is informed by existing literature (the conceptual model presented in the literature review).

Chapter 5 provides a discussion of the findings and the conclusions of this study, albeit within the context of existing literature. In this chapter, the researcher

reflects on the research goals and questions, then proposes a framework for conceptualising technology education, which was developed based on existing literature and the proposed framework for conceptualising technology. Moreover, the chapter presents a model of how a framework for conceptualising technology might benefit students who are learning and teaching technology. The researcher emphasises that the model has the potential to aid conceptual thinking and help students understand more about how they can think about and make sense of new experiences. Moreover, detail and critique regarding the limitations, and implications for future research and policy and practice, are provided and reflected upon. The final part provides the concluding remarks, including a detailed description of the study's contributions to existing knowledge.

1.7: Definitions of key terms adopted in this study

Definitions of technology, technology education, technological literacy, conceptualisation of technology and technology as a curriculum subject are discussed further in Chapter 2, as they may have broader meanings in different contexts. However, the following brief working definitions are provided in reference to the key terms used in this study.

Conceptualisation of technology: refers to the formation of ideas or principles about technology, especially in the human mind and should be understandable to the mind of another person (Purkovic, 2018). In the context of this study, conceptualisation of technology refers to clarifying ideas or concepts about technology with words and examples and arriving at a precise verbal definition.

Technology: a multidimensional phenomenon determined by the interplay of four fundamental dimensions – namely, technological artefacts, technological knowledge, technological processes and human desire to improve our lives. This definition was derived from De Vries (2005).

Technology as a curriculum subject: based on an educational rationale comprising a series of planned topics, each of which provides students with direct experience to solve individual and societal problems. According to Raizen et al. (1995), one of the guiding principles of technology as a curriculum subject is the ability to enable students to develop a basic understanding of fundamental technology concepts and skills.

Technology education: in accordance with the International Technology Education Association (ITEA) (2000), this refers to "a study of technology, which provides opportunity for students to learn about the process and knowledge related to technology that are needed to solve problems and extend human capabilities" (p. 241).

Technological literacy: in accordance with ITEA (2000), this refers to "the ability to use, manage, understand and assess technology" (p. 241).

Chapter 2: Literature review

2.1: Introduction

This chapter discusses the relevant literature that underpins this study and explores the development of education in Nigeria, including the pattern of education reforms, which started pre-independence. It considers views on the meaning of the term ‘technology’ and different definitions from scholarly works on students’ perceptions of technology and the theoretical orientation for this study. It also discusses the conceptualisation of technology and technology education, drawing on the work of De Vries (2005) within the philosophy of technology, to produce a conceptual framework and a definition of the term technology. In this chapter, learning theories (constructivists and behaviourists) are examined to understand how students learn and also discuss technology education both in the Nigerian and international contexts, and technological literacy. The chapter concludes by presenting the research questions that emerged from the literature review and to which this study sought answers.

2.2: Education reforms in Nigeria

Nigeria gained independence from Britain in 1960 and operates a federal system of government, with a central government and 36 subnational governments called states. The educational system that was in place in the late 1970s, after independence, provided six years for primary education, five for secondary and four for tertiary institutions, referred to as a 6-5-4 system of education (Akudolu, 2012). However, it has been claimed by Woolman (2001) that education during the period of British rule was limited regarding the expectations of development in Nigeria. For example, Woolman (2001) argued that the educational policy at independence was most concerned with using schools to develop a workforce for the civil service. Similarly, Imam (2012) claimed that the British education policy could be described as narrow in scope and did not meet the hopes and aspirations of Nigerians. Other criticisms of the educational policy include that it involved irrelevant curricula, obsolete methods, and high drop-out and repetition rates (Nwomonoh, 1998; Rwomire, 1998).

In 1977, the Federal Government of Nigeria launched the National Policy on Education, which was the first curriculum developed in Nigeria. The second version of the curriculum was published in 1981 (Ivowi, 2012). The curriculum policy objectives were noticeable, because they emphasised that the broad aims of secondary education were to be preparation of young people towards self-realisation, individual and national efficiency, national unity, and social, cultural, economic, political, scientific and technological development (Federal Republic of Nigeria, 1981).

In 1983, the Nigerian formal education system changed from the 6-5-4 system (explained above) to the 6-3-3-4 system of education, which comprised four distinct levels: six years of primary education, followed by three years of junior secondary education (JS1–3) (the equivalent of Year 7 to Year 9 in the UK), three years of senior secondary education (SS1–3) and tertiary education (university, polytechnic or college) of varying periods (Uwaifo and Uddin, 2009). This was modelled on the American system (Nwagwu, 1998). The 6-3-3-4 system required that all children between five and six years old registered for primary education, which was compulsory and free (Federal Government of Nigeria, 2004). The system was perhaps the main innovation (Adamu, 1994) in Nigerian post-independence educational development. For example, Fafunwa (1991) noted that there was no formally organised technology education at the secondary school level until the adoption of the 6-3-3-4 system of education, when technology became a core subject to be taught at the junior secondary school level. Okujagu (2013) noted that the curriculum for the junior secondary (JS) level was more technical and vocationally oriented, whereas that of the senior secondary (SS) level was more academically oriented. Similarly, Uwaifo and Uddin (2009) noted that the curriculum emphasised the acquisition of skills that would produce skilled manpower in science and technology, and Nwagwu (1998) noted that technology as a subject was unfamiliar not only in that it marked the establishment of a new subject, but also because it was profoundly multidisciplinary, incorporating home economics and business studies. Students at the JS level were introduced to pre-vocational subjects – including metalwork, electronics, mechanics, local crafts, home economics and business studies – which were intended to equip students to have a broader perspective and field of choice for both further academic work and employment purposes (Nwagwu, 1998; Uwameiye and Onyewadume, 1999). To obtain the JS certificate, students underwent continuous assessment and sat a final examination (Igbokwe, 2015). Ibiwumi (2011) noted that the JS curriculum was content-driven and examination centred and that teachers worked towards ensuring that the examination syllabi were covered. Ibiwumi (2011) further noted that at the end of JS, students were ill-equipped to go into the workplace, because they were not properly tutored in the pre-vocational subjects (metalwork, electronics, mechanics, local crafts, home economics and business studies) as envisaged in the new National Policy on Education. Considering, as Ibiwumi (2011) argued, that Nigerian children are likely to demonstrate high cognitive skills but are less likely to demonstrate practical skills, the types of skills that they do acquire may not be relevant to most employers.

Current structure of education in Nigeria: the 9-3-4 system

In 2004, the 6-3-3-4 system of education was modified and replaced with a new system known as the 9-3-4 education system. The new system consists of continuous schooling for nine years – six years in primary school and three years at the JS level – followed by three years at the SS level and then four years in tertiary institutions (Figure 2.1). This took effect from September 2008. The secondary school levels (JS and SS) have the main function of supporting students in gaining integrated growth and basic skills that enable them to understand the world around them (Federal Government of Nigeria, 2008).

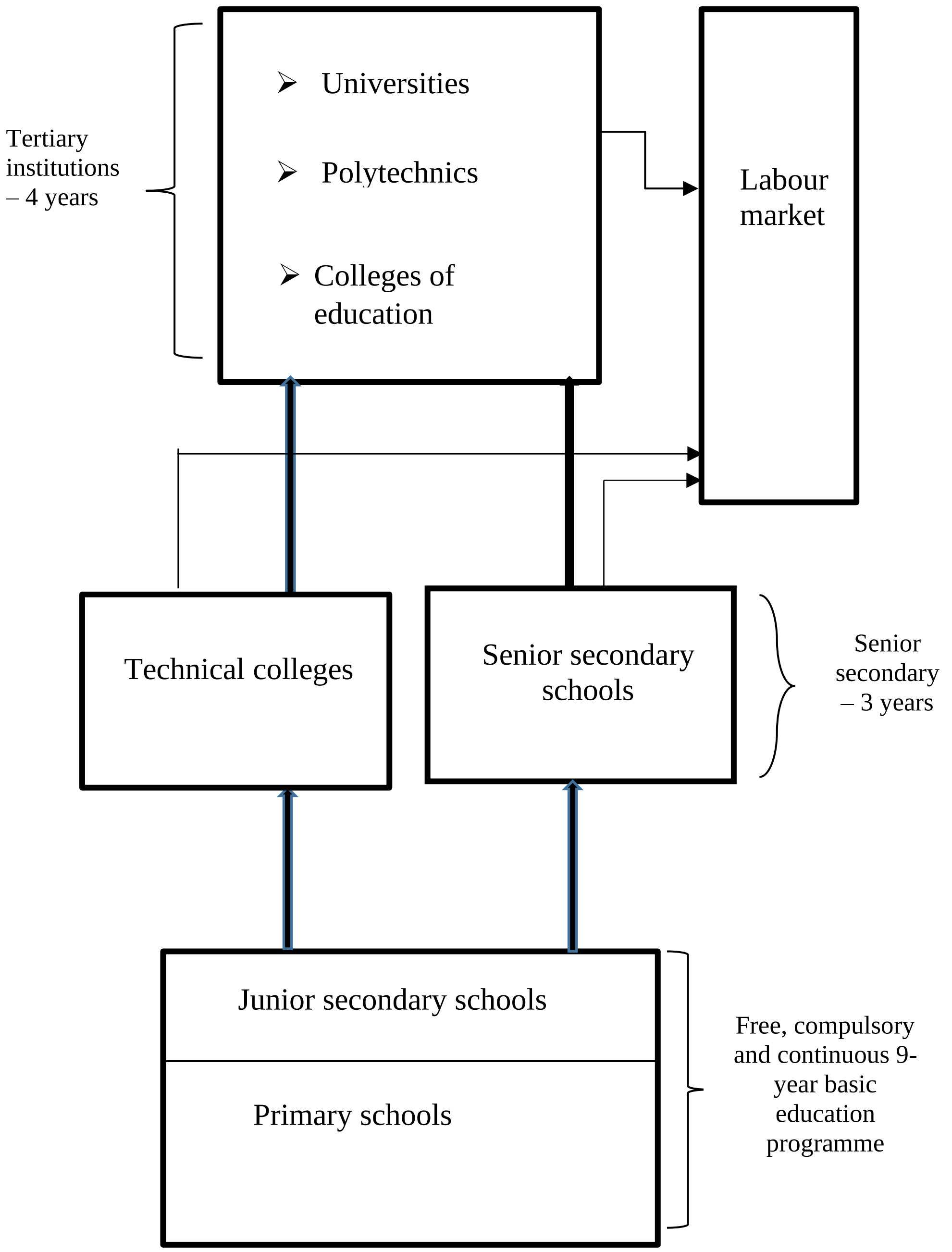


Figure 2.1 Current structure of education in Nigeria – the 9-3-4 system

Unlike the 6-3-3-4 system, in which the first six years were free and compulsory for all children in primary schools, in the new system the first nine years (six years primary and three years JS) are free. The newly adopted 9-3-4 system is charged with the implementation of the Universal Basic Education (UBE) programme to meet the ideas of the Millennium Development Goals and Education For All (EFA) goals, which are intended to empower individuals for self-employment (Olateru-Olagbegi, 2015). The secondary education core and compulsory subjects are English studies, one Nigerian language, mathematics, basic science and technology (basic science, basic technology, physical and health education, and information technology), religious and national values, cultural and creative arts, pre-vocational studies, French, and business studies (Igbokwe, 2015). The provision of facilities and equipment such as classrooms, laboratories, workshops, equipment and tools, which can facilitate the effective implementation of a pre-vocational education curriculum, will help students to gain a broader understanding of technology and their own individual interests and aptitudes. Uwameiye and Onyewadume (1999) argued that, for example, instructional materials aid learning in an authentic and real-world environment. The issue of poor teaching facilities, laboratories, equipment and workshops is still hindering curriculum development and implementation in pre-vocational education. Many schools lack the required learning infrastructure, such as libraries, workshops and laboratories, which can enhance quality pre-vocational education. Oviawe (2017) posited that stakeholders in pre-vocational education – namely, supervisors of schools, school administrators, school guidance counsellors, teachers, students and parents – need to be made aware of the need for them to play their roles in the implementation of UBE (Oviawe, 2017).

The broad goals of the 9-3-4 system of secondary education in Nigeria are to prepare people to be self-reliant through the acquisition of knowledge and skills in line with the government policy document (FGN, 2004), as follows:

“(a) Provide all primary school leavers with the / an opportunity for education of a higher level irrespective of sex, social status, religious or ethnic background;

(b) Offer a diversified curriculum to cater for the differences in talents, opportunities and future roles;

(c) Provide a trained workforce in the applied sciences, technology and commerce at sub-professional grades;

(d) Develop and promote Nigerian languages, art and culture in the context of world’s cultural heritage;

(e) Inspire students with a desire for self-improvement and achievement of excellence;

(f) Foster national unity with an emphasis on the common ties that unite us in our diversity” (pp. 18–19).

After the nine-year period of continuous schooling – six years in primary school (for students aged 6–11 years) and three years at the JS level (for students aged 12–14 years) – students are expected to sit the Basic Education Certificate Examination (BECE).

According to the Federal Government of Nigeria (2004), the national policy of education minimum requirement for entry into a technical college shall be the junior school certificate (JSC), and the length of course in a technical college, like other senior secondary schools, shall be three years.

Similarly, the senior secondary (SS) level is a three-year programme for 15- to 17-year-olds. Technology is optional only in SS1–3. Students in SS (1–3) are not the focus of this study; however, there could be a need to highlight points that bring them into focus. At the SS level, recommended vocational and technical subjects include technical drawing, general metalwork, basic electricity, electronics, auto-mechanics, building and construction, woodwork, clothing, textile, home management, and food and nutrition (Adejuyigbe and Adejuyigbe, 2016). At senior secondary level, students will study for three years (SS1, SS2 and SS3) and take their final examination in their chosen subjects; these might include technology education subjects, which are optional. At the end of SS3, students take the senior secondary school certificate examination (SSCE). Depending on the examination used, the West African Examination Council (WAEC) or the National Examination Council (NECO) would award a certificate to the successful student. Alternatively, after obtaining the basic education certificate, students could choose to go to a technical college rather than follow the SS pathway. At this point, the student would decide whether to stay in education or training or to leave, typically to enter the labour market. In both cases, successful students, who have achieved the necessary requirements, could get into a tertiary institution (university, polytechnic or college of education) (Figure 2.1). For example, a university education aimed at a first degree would last for four years; a polytechnic education runs for two years, leading to a National Diploma, and for another two years for a Higher National Diploma; and college of education programmes run for three years and lead to a National Certificate of Education (NCE).

2.3: Views on the meaning of the term ‘technology’

A study of the literature (Hansen and Froelich, 1994; Chandler and Munday, 2011; Gibson, 2009; 2012) shows that the term ‘technology’ is not used consistently, and there is a lack of a single agreed-upon definition, as researchers examine different definitions and uses of the word in different contexts. While the term ‘technology’ is widely used, Hansen and Froelich (1994) point out that “a widely accepted definition remains obscure” (p. 179) and suggest that this is largely related to misunderstanding of the meaning of the term ‘technology’. For instance, the term ‘technology’ is used for daily communication relating to telephones, computers, electronic mail, facsimile and text messaging tools in order to remain in contact with friends and family. Also, companies use communication technology tools to enhance their businesses, for instance to promote new products or services to targeted consumers. Another example is information technology, such as hardware and software tools, which help people perform all tasks related to information processing and management, such as a company’s Management Information System (MIS). It is not the purpose of this study to describe these technologies in detail; rather, attention will be focused on the meanings of technology for the purpose of learning and teaching technology as a curriculum subject.

Gibson (2012) argued that “the determination of a definition for the word ‘technology’ is complex because of the variations in meanings that exist within the English language to explain it” (p. 19). Similarly, Chandler and Munday (2011) noted that the term ‘technology’ is commonly used as a synonym for computers and computer networks, but also encompasses other tasks related to information processing and management and/or distribution of information electronically, including television and telephones. Defining ‘technology’ from a word structure perspective, Schatzberg (2006) stated that the term derives from a combination of two Greek words: *techne* and *logo*. While *techne* here refers to the skill, art or knowledge associated with the practical activity by which something is achieved or created, *logos* refer to the description of art by which inward thought is conveyed. In Schatzberg's (2006) view, technology refers to “a body of knowledge about the useful arts, referred principally to as a field of study concerned with the practical arts” (p. 487). However, Fores and Rey (1986) argued that *techne* is the origin of the words ‘technik’ in German and ‘teknik’ in Sweden, which translate to *technologie* and *teknologie* respectively; however, these are different from the English idea of 'technology'. Fores and Rey (1986) further claimed that this has "led to a situation that can only be rectified by restricting the word 'technology' in English language meaning the scientific study and teaching of techniques" (p. 37). However, for Ropohl (1997), 'technology' denotes the science of 'technics': the field of engineering work and its products. As can be seen from the arguments above, meanings can vary when comparisons are made among the most common English language meanings of technology. For example, one meaning of the English language word *technology*, from the explanation provided by Ropohl (1997), equates technology with engineering. However, according to Barlex (2000) and Owen-Jackson (2002), equating engineering with technology is difficult. On the one hand, Naughton (1986) claims that the definition of technology as engineering has its uses, but it also has severe limitations, because it would require human engagement to manage and direct the combined effort of all the people and social organisation involved. On the other hand, Gibson (2012) claims that engineering and technology are "inextricably intertwined" (p. 19). What follows from the arguments above is that technology encompasses the production of objects, the people who use them and other elements required to put those objects to use (Kline, 1985). However, Cutcliffe (1981) presented a different view from previous arguments. In Cutcliffe's (1981) view, "Technology is a social process in which abstract economic, cultural and social values shape, develop and implement specific artefacts and techniques that emerge from a distinct technical problem-solving activity called engineering which is embedded in that process" (p. 36). In the above quote, the word *abstract* suggests that the nature of technology is conceptually less restrictive and allows for a broader range of conceptual approaches. Indeed, there is a relationship between Cutcliffe's (1981) view and the views of Custer (1995) and De Vries (2005), who argued that technology cannot be adequately conceptualised regarding tangible things alone. This means that the term *technology* could also represent intangible things, such as services that enhance human intellectual capabilities. For example, computer hardware is a tangible thing, but the operating and application software or programmes that make the computer system work are intangible things. Whereas something tangible can be felt, intangible objects cannot. In other words, technology can be tangible (hardware), intangible (software), or a combination of both (a computer unit or system).

As we saw in the discussion above, it seems these views of the word *technology* correspond to the way we talk about technology using common (everyday) language usage. However, Cutcliffe's (1981) view, underpinned by the ideas of Custer (1995) and De Vries (2005), is different from other views insofar as it does not mean the same thing in all contexts. For example, Cutcliffe's (1981) view suggests technology is a combination of fundamental elements: artefacts, sociotechnical systems, tangible and intangible things. However, such a view of the meaning of technology might be considered overly broad, particularly for the purposes of this research. Therefore, it is important to conceptualise technology in this study in order to develop some basic understanding that could be clearer and easily applicable to students learning technology as a subject. More detail is presented in section 2.6.

Relationship between technology and science

Over some years, there has been considerable debate (Kline, 1985; Fores and Rey, 1986; Hawthorne, 1971; Bunge, 1972; Skolimowski, 1972; Gardner, 1994; Stokes, 1997; Feenberg, 2006; Dugger, 2007; Norström, 2011) as to whether technology and science are separate fields or linked. For the purpose of this thesis, the researcher is confining himself to science and technology, which can be studied, and the educational implications, informed by Hine (2009), who claimed that during the 2000s, there was a rapid change in the teaching of technology in schools. For example, Hine (2009) claimed that "most technology teaching could be identified as being from one of a number of traditions including technology with science, which may influence the conceptions of technology which are presented to students in school" (p. 210). Since this study is related to students' conceptions of technology, it was decided to examine the distinction between technology and science to gain further insight into their relationship. On the one hand, technology is perceived by Soanes and Hawker (2008) as "the application of scientific knowledge for practical purposes; machinery and equipment developed from such scientific knowledge; the branch of knowledge concerned with applied sciences" (p. 1063). Similarly, authors such as Bunge (1972) and Hawthorne (1971) view technology as a derivative of applied science related to what Kline (1985) described as an application of scientific knowledge to particular classes of problem. Thus, it could be suggested that the view of Bunge (1972) refers to the body of knowledge, specifically scientific knowledge, that is used to solve technological problems but is largely derived from science. Bunge (1972) argued that in many cases, technology solves some of the problems by approaching them scientifically. For Hawthorne (1971), technology is the application of science to solve well-defined problems in the sense that technology is associated with the practical application of knowledge to solve problems or manufacture artefacts. For example, it has been claimed by Fraser (1986) and Shepherd (1996) that most electronic devices that are currently in use originated from the development of semi-conductor materials – things such as diodes, transistors and light-emitting diodes (LEDs) – and analogue and digital electric circuits can be built, making them materials of interest in industry. Therefore, semi-conductor materials are a significant part of material science, which is a branch of solid-state physics. Solid-state physics is the study of rigid matter which has direct applications in modern electronic devices, for example in the technology of transistors mostly used in a variety of electronic circuits (Hemminger, 2010). From the arguments above, it is evident that there is a role for scientific knowledge and that scientific knowledge could be a crucial part of technology education.

On the other hand, other authors (Skolimowski, 1972; Gardner, 1994; Stokes, 1997; Feenberg, 2006; Dugger, 2007; Norström, 2011) are in agreement that technology is different from science and argue that the definition of technology could not be the application of science. Rather, technology and science are distinct and unique, both in definition and status within society. These authors contend that an application of scientific knowledge could not encapsulate the full range of knowledge and abilities that are associated with technology. Indeed, Gardner (1994) stated that “the relationship between technology and science is complex, and the nature of their relationship has changed over the course of history” (p. 15). Gardner (1994) went on to contend that technology is both historically and ontologically before science, and that what they attempt to accomplish is different. Skolimowski (1972) argued that “science aims at enlarging our knowledge through devising better theories; technology aims at creating new artefacts through devising means of increasing effectiveness. Thus, the aims and the means are different in each case” (p. 45). Also, Gibson and Johnson (1970) believed that the relationship between science and technology is one in which science is a subset of technology rather than the other way round.

Although the relationship between technology and science is complex due to how scientists and technologists (experts in the field of technology) work (Gibson, 2012), both areas have some educational implications. De Vries and Tamir (1997) and Compton (2004), supported by Gibbons and Johnson (1970), Layton (1993) and Lebeaume (2011), claimed that both technology and science share a similar rationality based on empirical observation and knowledge of natural causality. For example, Gibbons and Johnson (1970) claimed that the relationship between science and technology benefits both in the sense that scientists and technologists make progress by learning from each other and that many of the things that concern technologists are also important to those affected by a close association with science, such as engineers (McGrann, 2008). The term ‘engineers’ here refers to experts in the field of engineering, considered in terms of its perceived linkage with science (Knight and Cunningham, 2004; Schiaffonati, 2008), although, according to Fores and Rey (1986), “British official statistics tend to group all engineers as ‘technologists’ and to show that most technologists are engineers” (p. 46).

Lebeaume (2011) argued that “technology is a school matter based on execution and experimental sciences” (p. 79) and contended that technology education and science coexist, in the sense that the curriculum was organised based on with an associated or integrated set or a pillar of science. The assumption is that there are sufficient similarities between science and technology that models developed in science studies may usefully be applied in technology studies (Giere, 1993; Layton, 1993). Similarly, De Vries (1996) noted that some traditional subjects, like industrial arts or crafts, emerge in science education to demonstrate how scientific knowledge is applied to technological products. Given the arguments so far, it is reasonable to assume that technology and science can be mutualistic, because together they can provide for each other with what they need to achieve science education and technology education goals. Technology education here refers to a subject commonly associated with secondary school in which students develop ideas and make sense of the experience of technology. More detail on technology education is presented in section 2.6.

2.4: Theoretical orientation of this study

This section introduces the theoretical orientation of this study. Literally speaking, theoretical orientation refers to the testing of hypotheses that have been advanced in previous research based on theory rather than experience or practice (Cambridge dictionary, 2019). However, for the purpose of this study, theoretical orientation is related to what learning theories say about how we learn. The learning process or approach has been very influential in developing our understanding about learning. Gibbs (1994) and Hodge and Ollis (2014) noted that theories provide a foundation for education practice, for example in relation to conceptual understanding and the importance of a useful context (in the case of this study, how conceptual understanding can be applied to develop a curriculum for learning and teaching technology). According to Phanphech et al. (2019), conceptual understanding is an important goal in learning in general but is particularly relevant in science education, because such understanding is required to make sense of phenomena. Similarly, Cope and Kalantzis (2015) noted that students learn ways in which concepts they are learning about connect or are connected in order to help them relate their experiences. According to Cope and Kalantzis (2015), for learning to occur, teaching and learning choices need to be made explicit, pathways planned and performance clearly tracked. McCarthy and Anderson (2000) contended that the teacher is expected to get students actively involved in the classroom, because active learning transforms students from passive listeners to active participants and helps students understand the subject through inquiry. Eraikhuemen and Ogumogu (2014), meanwhile, argued that if teachers are to help students learn conceptually, the teacher themselves must have a proper conceptual understanding of the subject. They claimed that students’ weak knowledge in physics in Nigerian schools was connected to the students’ misconceptions about the subject. Kola (2017) also noted that students’ poor knowledge was associated with a poor conceptual understanding of physics. Similarly, Vosniadou (2007) suggested that the relationship between facts, skills and conceptual understanding is one that needs to be developed if we want our students to be able to apply their skills and knowledge to different contexts. Vosniadou (2007) went on to argue that students should possess conceptual understanding, as opposed to merely memorising facts, in order to understand scientific concepts from the various disciplines, as they cannot rely on memorisation.

Learning theories have received considerable attention in educational research, and researchers (Gibbs, 1994; Cotton, 1995; Hansen, 1997; Doolittle and Camp, 1999; Fosnot and Perry, 2005; Baviskar et al., 2009; Ebert, 2009; Pšunder and Hederih, 2010; Hodge and Ollis, 2014) agree that they help us make more informed decisions around the design, development and delivery of learning. For example, Gibbs (1994) discussed how theories of learning may help to understand how people learn, by emphasising the importance of individual qualities, attributes and abilities in the learning process, and Hodge and Ollis (2014) claimed that theories of learning give teachers new ways to understand learning and new techniques and strategies to apply in teaching situations. According to Barnes (1994), these views probably represent the most commonly used theory for teaching and learning, perhaps because it offers a clear indication of what should be taught and how achievement should be assessed.

However, Marton (1988) has argued that the context in which learning takes place is also important, as teaching and learning are dependent on it. This means that learners' needs and perceptions of the context they are in also impact what happens in learning. This could include, for example, the use of classroom activities (lectures, theory lessons, textbooks) or practicals as exercises. If the goal of education is the production of artisans, then the practicals given within that educational system would be directed towards the conveyance and attainment of the specific subskills needed by that artisan (Kirschner, 1992).

Ebert (2009) claimed that constructivism and behaviourism theories are two of the prominent educational theories of learning that form the basis of much of what happens in the technology classroom. From this perspective, some studies (such as Hansen, 1997; Fosnot and Perry, 2005; Baviskar et al., 2009; Jones et al., 2013) have focused on constructivism learning theory, while other researchers (Cotton, 1995; Doolittle and Camp, 1999; Pšunder and Hederih, 2010) have focused on behaviourism learning theory, with the aim of understanding the knowledge assumed by each theory and how the theory influences the teaching and learning of technology.

These studies may provide insights that are useful for this study's investigation of students' experiences of technology. Therefore, the rest of this section will focus on the discussion of constructivism and behaviourism to better understand whether this study could benefit from them.

Constructivism learning theory

Koohang et al. (2009) defined constructivism learning theory as the "active construction of new knowledge based on a learner's prior experience" (p. 98). This means that learning is based on the idea that knowledge is constructed by the learner. Other researchers (such as Hansen, 1997; Fosnot and Perry, 2005; Baviskar et al., 2009; Jones et al., 2013) have often associated constructivism with how people might acquire knowledge and learn. In the literature reviewed for this study, constructivism has sometimes been linked to educational research (Ertmer and Newby, 1993; Taber, 2008; 2011; Metsärinne and Kallio, 2014; Mogashoa, 2014; Bada, 2015). Indeed, according to Fosnot and Perry (2005), constructivism in education sees learning as the result of learners reflecting on their actions, modelling and constructing explanations through interacting with their physical and social world.

Two major types of constructivism are common in the classroom: (1) cognitive or individual constructivism, where ideas are constructed by the individual; and (2) social constructivism, where ideas are constructed through interaction with the teacher and fellow students (Fosnot and Perry, 2005; Powell and Kalina, 2009). Each type of constructivism is based on different epistemological assumptions. For example, *cognitive constructivists* consider knowledge to be a cognitive entity constructed when the learner forms connections between new concepts and those that comprise an existing framework of prior knowledge (Jones et al., 2013). For example, using a strategy of cognitive learning, the teacher would explain the similarities and differences between mobile communication and radio or television broadcasting so that connections could be established to the new concepts (Mani, 2017). In this sense, students would be able to construct their own knowledge using knowledge they already had (Mogashoa, 2014). *Social constructivist* perspectives, on the other hand, consider both the individual and the social context within which the learning occurs (Doolittle and Camp, 1999). Social constructivism, unlike cognitive constructivism, emphasises the social nature of knowledge, and the belief that knowledge is the result of social interaction and language usage and thus is a shared, rather than an individual, experience (Prawatt and Floden, 1994). Mani (2017) suggested that from the perspective of social constructivists, learning occurs through observation, imitation and modelling as part of an individual's participation in a social and cultural environment, such as a workplace or the teaching and learning environment.

Baviskar et al. (2009) outlined four critical conditions necessary for learning under the social constructivist perspective: (a) eliciting prior knowledge; (b) creating cognitive dissonance; (c) application of the knowledge with feedback; and (d) reflection on learning. By this, a relationship between the student and their social context or an interaction with their teacher and other students throughout the learning is considered as knowledge that is socially constructed and learning that is a social process (Westbrook, 2013). From this perspective, the teacher's role is essential for knowledge construction, because teachers contribute to the construction of knowledge through their teaching methods. This is consistent with the view of Schreurs and Dumbraveanu (2014), who suggested that the learning process should be designed by the teacher. A similar line of reasoning was put forward by Jones et al. (2013), who stated that teachers' knowledge pertaining to technology is crucial for developing students' knowledge and practice, because they will be able to formulate relevant problems and questions and will link the resources and questions to the knowledge they had. Several influential perspectives consistent with this point of view can be seen in the work of Hein (1991) and Tobin and Tippins (1993). Hein (1991) stated that constructivism refers to the notion that learners construct knowledge through hands-on learning, with opportunities to experiment and manipulate the objects of the world. For example, Mezirow (1990) noted that it can serve as a tool for critical reflection, which guides subsequent understanding or meaning-making of a situation or context to critically assess the justification of new knowledge. The point from the social constructivist approach above is that social constructivism emphasises collaborative processes in the construction of knowledge (Loynes and Gijbels, 2008). Therefore, in this way, the learning process is not limited to students, but includes teachers as facilitators and learning activities in which learners apply what they learn to construct new knowledge.

According to Doolittle and Camp (1999), constructivist principles are fundamental requirements of teaching and learning technology in the 21st century in that they provide some insights into theoretical considerations. Students construct knowledge and skills as they become exposed to new experiences and ideas in the course of everyday life, therefore, curricula and courses should take account of the fact that students need relevant learning activities. Mogashoa (2014) noted that the constructivist model of learning assumes that learners play an active role in the personal creation of knowledge, and argued that teachers, as facilitators of learning, should guide learners to discover for themselves as they interact with the learning process. Similarly, Taber (2011) argued that approaches that support learners in the creation of new knowledge are important, for example in activities leading to alternative conceptions and application of knowledge to perform scientific inquiry (Yager, 1991; Brooks and Brooks, 1993; Zahorik, 1995; Hansen, 1997). Yager (1991).

Behaviourism

The behaviourism theory of learning is most widely attributed to the American psychologist and behaviourist scholar Skinner (1953), who postulated that learning occurs through a process of events happening at the same time (Kivunja, 2014). However, Cotton (1995) posited that behaviourism is a learning theory that is relatively unconcerned with processes that are internal to the individual; instead, it is more concerned with the reaction to a particular stimulus, such as associating reinforcement to shape a learner's behaviour and learning (Westbrook et al., 2013), where pleasant experiences are positive reinforcers and a learner establishes connections between stimuli and responses. For example, in order to encourage a better learning strategy, students need to see the direct consequence of engaging with behaviourism perspectives (Desforges, 1995). On the other hand, unpleasant experiences are negative reinforcers if a learner does not receive any reinforcement – for example, when an unwanted behaviour is stopped to increase their attention and learning.

Within the context of teaching and learning technology, Doolittle and Camp (1999) argued that doctrine linked to behaviourism assumes that a learner is essentially passive, where learning consists of the formation of links between specific stimuli and responses through the application of rewards or knowledge copying from one mind to another (Taber, 2011). Pedagogic approaches using this perspective may result in practices such as demonstration, rote learning, memorisation, copying and teacher-controlled learning, where the teacher is the sole authority figure and his or her duty is to pour knowledge into the students, with little student choice or interaction (Westbrook et al., 2013).

The influence of prior knowledge

Another issue associated generally with the constructivist learning theory is the influence of prior knowledge. Baviskar et al. (2009) argued that eliciting prior knowledge from others is an essential component of constructivism; for example, creating cognitive dissonance, application of new knowledge with feedback and reflection on learning is the influence of prior knowledge and is manifested through the activities with which learners are engaged. This knowledge includes students' self-knowledge of their own capabilities, their perceptions of the learning tasks, the social environment and interest potentials (MacPhail et al., 2003). Similarly, Tsai (2000) noted that "learners' prior knowledge influences how new knowledge is constructed" (p. 194) and argued that prior knowledge is constructed as an interplay between learners' understanding of a phenomenon and school experiences. In contrast, Singh and Athavale (2008) claimed that in behaviourism, skills demonstrated do not represent knowledge constructed by the students, because behaviourism involves the transmission of knowledge from the knowing expert (teacher) to the student, whereby skills and knowledge are imposed externally on the students. The authors contended that behaviourism learning theory has little relevance to the realities of teaching and learning technology in the 21st century. However, behaviourism might actually be relevant in some schools/parts of the world. Given the differing views of the constructivist and behaviourist proponents, more research is needed in this area in order to arrive at more conclusive evidence.

Motivation for learning

Existing studies (Ryan and Patrick, 2001; Ainley, 2006; Autio, 2011) that have explored how students learn also recognised the critical role that motivation to learn plays in the construction of knowledge and the processes of learning. For example, Ryan and Patrick (2001) argued that when students feel a sense of relatedness or belonging, they are motivated to learn and perform well in school. Similarly, Ainley (2006) posited that student emotions relate directly to social factors such as relationships with peers and teachers, which facilitate a desire and motivation to learn. For example, learners are most likely to be motivated to learn if the teacher creates a context that enables the students to engage with classroom activities (Delialioglu, 2012). If the students do not have scope for self-discovery, they are less likely to ask questions or discover transferable concepts (Cakir, 2008). Similarly, according to Castledine and Chambers (2011), in learning how to solve a real-life problem by discussing the issue, searching for the required knowledge and methods, discussing it with the teacher and presenting a solution, students can build new concepts and enhance or correct existing ones to successfully solve problems in real-life situations. It seems, therefore, that if students are motivated to learn technology, that encourages them to be actively involved – for example, thinking about how technology works, forming a worldview in which they can take part in creating technology, and being able to make connections between their learning of technology in the classroom and their everyday experiences of technology. This view aligns with the work of Saeed and Zyngier (2012), who stated that students are motivated and by knowing that what they are learning has clear meaning and relatively immediate value to the student.

The arguments above suggest that both theories of learning share a few key features – for example, learning processes assume learners are involved and individual learners' perspective is unique. However, constructivists believe that the learner constructs knowledge rather than passively absorbing it (Brooks and Brooks, 1993). Therefore, from the perspective of constructivists, learners should be challenged with tasks that refer to skills and knowledge regarding technology in order to help them create meaning from such tasks (Barlex, 2004). The classroom experience should be an invitation that allows their everyday experience of technology to come together and enables them to construct new knowledge, with the aim of capturing their motivation and building on previous successes to enhance their learning (Tunnicliffe and Reiss, 2000). This is in line with David (2005), who stated that to fully engage and challenge the learner, the learning environment should allow the learner to be able to function, and, according to Mani (2017), it should reflect workplace and industry requirements, ensuring that learning meets the diverse needs of enterprises and the broader labour market. From this perspective, teachers should be able to identify and describe the learning outcomes for the curriculum, and construct and implement the curriculum to prepare students to participate in rapidly changing technologies (McCormick, 2006). Therefore, teachers' ability to reflect on their practice and employ appropriate teaching strategies and methods is also important (Williams, 2000; Delialioglu, 2012). Another key feature that both theories of learning recognise is that motivation is crucial to the learning process. While behaviourist approaches are mainly concerned with shaping behaviour through reinforcements (Gibbs, 1994), behaviourists believe motivation is important for both students and teachers in developing learning processes (Doolittle and Camp, 1999; Pšunder and Hederih, 2010) and can be used to create effective teaching methods, such as praise from the teacher (Gibbs, 1994). Similarly, Ainley (2006) and Mani (2017) claimed that the constructivist learning theory aspect of learner motivation improves with small group activities in the class. Not taking into consideration the views highlighted above can impact students' learning.

2.5: Towards conceptualising technology

In section 2.3, the researcher explored the term 'technology' and argued for the need to unpack the diverse views of the meaning of technology that may impact our understanding of technology. To better explain the unusual scope of these diverse views, the researcher explored some existing conceptualisations made by a range of authors in the field of technology. In the context of this study, conceptualisation refers to clarifying ideas or concepts about technology with words and examples and arriving at a precise verbal definition (Soanes and Hawker, 2008), with the aim of devising a concept of technology that will assist in the development of a technology curriculum and in the teaching and learning of technology. This section begins by examining two approaches: the social aspect of technology and the philosophy of technology. The aim of examining both approaches was to demonstrate that there is an alternative approach (the social construction of technology approach) that was discussed in the literature (Pinch and Bijker, 1992; Klein and Kleinman, 2002) but was rejected because it seemed to be limited in scope and may not have helped the researcher to better understand the topic under investigation and to answer the research questions.

The social construction of technology (SCOT) approach

The social construction of technology (SCOT) approach is one way in which we could attempt to conceptualise technology. This method originates from a social context but is often formulated in physical or concrete terms. SCOT frequently takes a descriptive theory as its basis (Pinch and Bijker, 1992). For example, Pinch and Bijker (1992) argued that descriptive theories make general attempts to address the relationship between technology and society. Pinch and Bijker (1992) further elaborated that in the SCOT approach, technological development follows scientific discoveries, as inventors and engineers apply science. Subsequently, this influences the meaning assigned to technology when the social group come to a consensus. Each participating group has a unique view of how technology is created or should be made, based on its interpretation of the problem requiring a solution. Pinch and Bijker (1992) illustrated this by stating that bicycles are a more convenient mode of transportation for some people, while representing a technical nuisance to others. However, Klein and Kleinman (2002) and Jasanoff (2004) critiqued this approach. Klein and Kleinman (2002) argued that the SCOT conceptual framework of technology made "only limited contributions to illustrating [that] the influence of social structures can influence the development of technology" (p. 28). They contended that it emphasises the social group and neglects the design, development and transformation of technology. For example, they noted that sociocultural and political concepts of a social group shape how people regard or interpret technology (Klein and Kleinman, 2002). Jasanoff (2004) argued that the SCOT approach goes too far in emphasising the social aspects of technology and the ways we are constrained by it. Similarly, De Vries (2005) argued that the social construction of technology is a means of reflection, in which the focus is on the relationship between technology and its social context. Moreover, the view of technology as a subset of science has been replaced by one in which science and technology are two distinct fields (Skolimowski, 1972; Gardner, 1994; Stokes, 1997; Feenberg, 2006; Dugger, 2007; Norström, 2011), which have diverse methods of viewing the world and different knowledge and skills (De Vries, 2005). Considering the arguments for and against SCOT, it may not be adequate in relation to education, because the scope seems limited. If students are to acquire a broad knowledge of technology that has a direct impact on their understanding of technology, a major task will be the creation of curricular content that has a wide scope for conceptualising technology in a way that helps them develop ideas and understanding and demonstrate their ability to apply that knowledge in hands-on tasks such as problem-solving activities. For example, a person designing the interior of a house has to solve many problems, such as how to make it functional in an appropriate way, how to make it attractive, how to make it comfortable and how to achieve all this on a given budget. The designer needs to ask: ‘Whom am I designing for?’ An interior for one client may be very different to one designed for another client.

The philosophy of technology approach

A review of the literature yields a range of technology philosophers (including Ihde, 1979, 1990; Borgmann, 1984, 1992; Mitcham, 1994; Feenberg, 1995, 1999; Pitt, 2000; Vincenti, 1990; Hickman, 2001; Baird, 2004; De Vries, 2005). These authors emphasise philosophy as an essential framework for conceptualising technology. They believe that an understanding of technology stretches beyond the social aspects of the subject and is central to analysing different perspectives of the nature of technology. For example, De Vries (2005) suggested that a part of cultivating a philosophical understanding of technology is the development of the distinction between the social aspects and conceptual knowledge (as explained in the subsequent sections, where the social context and conceptual knowledge are explored). For example, Koski et al. (2011) noted that in learning about technology, the learner in the social context (e.g. a musical context) is confronted with objects such as guitars, other musical instruments and mobile phones. Through the conceptual knowledge obtained, explanations and relevant abstract concepts (e.g. concepts from technical and engineering sciences) are explored. Thus, each domain enriches and inspires learning in the other domain. With this obtained knowledge, learners can choose a better approach to explore the objects further and find alternatives and improvements. For example, De Vries (2005) argued that products have a dual nature (a physical and a functional nature), which can be linked to practical and concrete explanations. In this sense, technology philosophy provides a conceptual basis from which to reflect on the things we take for granted. For example, a teacher may challenge students to list abstract concepts that were central to prior activities, which will be helpful in explaining a concrete object or real-life problem. By this method, students can be challenged to move beyond usefulness in the narrow sense to focus on the nature of knowledge. For educational purposes, De Vries (2005) claimed that technology could stimulate students to develop ideas that make sense of technology as it is practised. It should be noted that this study's focus is on students' conceptualisation of technology through their experiences. The remainder of this section reviews the literature that considers what technology means from a philosophical perspective, consistent with De Vries (2005).

De Vries's perspective

One of the challenges facing teaching and learning is the need to develop an adequate conceptualisation of technology and the criteria for knowledge so that we can understand technology, and how it should be taught and learnt (De Vries, 2005). Thus, the researcher provides a framework for conceptualising technology in accordance with De Vries (2005). This section reviews the literature that conceptualises what technology means from a philosophical perspective. Consequently, the researcher's attempts to describe technology as can be seen in related practices that have often been underemphasised in the context of understanding technology.

The framework is organised around four key components: technological artefacts, technological knowledge, technological processes and technology as part of human existence. Figure 2.2 presents a visual representation of interrelated integral concepts which contributed to a clearer understanding of the meaning of 'technology'. The pragmatic argument presented by this conceptualisation of technology is that these four components are necessary, but not sufficient to conceptualise technology individually. The framework is a philosophical reflection based on adequate descriptions of technological practices, which can be a fruitful source of inspiration for those involved in the development of technology education, thereby contributing to knowledge in technology education. The section concludes by offering a definition of technology that draws from the researcher's proposed model for the conception of technology derived from De Vries (2005).

The nature of De Vries's (2005) model of conceptualising technology

De Vries (2005) did not offer a description or definition of the term technology, stating that "it is useful to make a remark about my use of the terms 'technology' and 'engineering'. For those who are looking for a definition: there are thousands out there to choose from and I do not think I can come up with one that beats them all" (p. 11). In conceptualising technology, De Vries (2005) considered four distinct concepts (dimensions) of technology, each with its own knowledge. A variety of issues may be included within each of these four distinct concepts, but each concept is hypothesised to be developmentally and conceptually distinct. The first of these concepts views technology as a technological artefact and explains how technological artefacts can be recognised in the context of their “dual nature” (p. 18). The second relates to technical knowledge as an inherent component of technological artefacts. The third pertains to technological processes, which are those that help evaluate the design processes of technological artefacts. Finally, the fourth dimension describes technology as a characteristic of human nature, concerned with all aspects of the design and making of products but driven by the way human beings appreciate technology or humans that are involved in this activity. The remainder of this section describes each dimension in detail.

Technology as technological artefacts

De Vries (2005) suggested that we can regard technology as a set of objects or products arising from technological activities (designing and making). De Vries (2005) argued that technological artefacts can be conceptualised in terms of their dual natures (a physical nature and a functional nature). The difficulty emerging from this argument is that individuals seem to construe technology to mean physical (tangible) objects. By implication, this suggests that technology is tangible, which does not take into account the many intangible elements of technology, such as modern technology software programmes. This suggests that it is inappropriate in the present context to conceptualise technology in terms of physical objects. However, it is important to acknowledge that technology cannot be regarded merely as the outcomes of design projects. It is necessary to consider if they have anything in common in terms of description (shape, colour, weight) or constituting materials (combustible, non-combustible, wood, acrylic) which characterise the physical properties. whereas the functional properties are how we relate to the technological artefact. (De Vries (2005). According to De

Vries (2005), the functional nature is not fundamental to recognising an artefact. Rather, the issues are relational and subject to the wishes of the users or designers. Therefore, the boundaries exist only at the limits of human imagination. De Vries (2005) contended that there are several options of physical nature for any desired functional nature. The key notion here is that the definition of technology has broadened. An example to illustrate this point is as follows. A designer designs a mug for holding liquids for people to drink, which can be described as the "proper function", because that is what the designer had in mind (p. 22). However, users could also use it to prevent papers from flying away. In this context, the mug has been ascribed an 'accidental' function that may or may not happen. Based on the argument above, both designers and users have beliefs about technological artefacts. The concept of beliefs relates closely to the concept of knowledge given that belief is an internal thought that most people accept as knowledge (Greco, 2003). Similarly, De Vries (2005) revealed that understanding the dual nature of technological artefacts is genuine knowledge, even when restricted to artefacts. Given this focus, the dimension of technology as technological artefacts and the dimension of technology as technological knowledge are related. The following subsection examines technology as technological knowledge in more detail.

Technology as technological knowledge

To understand De Vries's (2005) conception of technology as technological knowledge, we will discuss the two types of knowledge explored. De Vries (2005) identified two main types of knowledge that are relevant to this study: "knowing-that" and "knowing-how" (p. 31) De Vries (2005) described the first type, knowing-that knowledge, as that form of knowledge that can be expressed in "propositions" (p. 31). De Vries (2005) described a proposition as "the content of a statement about something" (p. 30). In other words, a proposition tells us about something in a statement that may be true or false; that is, it need not express a fact. A proposition can be an assertion that expresses an opinion considered regarding its likely success or difficulty. De Vries (2005) considered the statement "Today it rains" (p.30) but also "Tomorrow it will rain" (p.30) as a proposition, and argued that the same can be said for whatever falls under the definition of knowing-that knowledge, because knowing-that knowledge as understood here is expressed by a proposition (or propositional knowledge), for which the "justified true belief" (p. 30) account could fit. For this study, the concept of justified true belief will not be discussed in detail. Rather, let us restrict ourselves to what De Vries (2005) described as a "short description of knowledge" (p. 30). For example, imagine asking someone to write down in a sequence of sentences on a computer and store them on a universal serial bus (USB) flash drive. USB is a type of computer port which can be used to connect equipment to a computer. An example of a USB is the interface used to upload pictures from a digital camera to a computer. It is very likely that if this instruction was given to a young child for the first time, s/he could do it even though it may require a few sentences. Even if the child was successful in the task, there is no suggestion that s/he would be able to solve a design problem associated with technological artefacts because s/he may not have acquired the relevant type of knowledge.

De Vries (2005) referred to the second type of knowledge as knowing-how, which represents that form of "knowledge that cannot be expressed in propositions" (p. 32). For example, knowing-how knowledge is associated typically with practical and mental skills, and determines quality. De Vries (2005) gave the example of a carpenter who says that s/he knows how to hammer a nail straight into a piece of wood. In De Vries's (2005) view, which is consistent with Ryle (1945), that type of knowing is not proposition-based. Even if the carpenter is asked to write in a sequence of sentences how to hammer a nail straight into a piece of wood, they may not make themselves understood as intended. This type of knowledge, which is difficult to write in a sequence, is also referred to by Polanyi (1983) as tacit knowledge. For Eraut (2000), "if a situation demands rapid action or is too complex to be fully analysed, tacit knowledge is the only available solution" (p. 118). Tacit knowledge is a non-linguistic, non-numerical form of knowledge that is highly personal and context specific and deeply rooted in individual experiences, ideas, values and emotions (Nonaka, 1994; Gourlay, 2002). The significance of this concept for this study is that it reveals that technology also comprises knowledge that can be used to analyse skills. This perspective on tacit knowledge supports the view that technological knowledge can be acquired through reflecting on doing compared with listening to a teacher or watching demonstrations. Thus, technology is dynamic, which suggests that it involves activities or processes. This is discussed in the following subsection.

Technology as technological processes

Technological processes are also applied to conceptualise technology. De Vries (2005) argued that the technological knowledge applied to the designing, making, appreciating and assessing processes contains knowledge that provides a useful mechanism for discussing technological processes in which analysis, synthesis and evaluation could easily be found irrespective of whatever is being designed. This argument suggests that technological knowledge covers a broad spectrum of technological experiences, such as technological problem-solving, which is often directed broadly towards activity surrounding the development and maintenance of technological artefacts. This raises the following questions. What is the character of technological knowledge applied to the designing, making, appreciating and assessing processes? What type of criteria can be used to classify and structure technological problem-solving? De Vries (2005) suggested that one approach to illustrate this is by referring to the idea of designers' and users' beliefs about technological artefacts, which were discussed earlier in relation to technology as technological artefacts. The designer's idea is closely related to human intentions (directed towards something or someone). The designer is responsible for any modification when and if necessary. To stimulate the proper use of the artefact, the designer ensures the artefact has an appearance that reflects what it is intended to be used for. Once the artefact is completed and handed over, the user must decide what to do with it. De Vries (2005) argued that one way of conceptualising technology as technological processes is the way designers solve design problems. De Vries (2005) explained that designers combine procedural (strategic) and conceptual (or declarative) knowledge in solving design problems. De Vries (2005) suggested that this is 'not to be confused' with "knowing-that and knowing-how" (p. 59). To execute a design plan (insights into users' preferences about the use of technological artefacts), "designers have to refer to conceptual knowledge" (p. 60), which clarifies the design goals through a list of requirements to analyse the problem. This could involve, for example, taking cognisance of the criteria from both the designer's and the user's perspective to understand the concepts involved, to which solution paths can be formalised into a structured rule. De Vries (2005) described this as technological knowledge of rules (prescriptive knowledge), which often seems to be "acceptance-like" (p. 35) for practical reasoning, particularly because this type of technological knowledge has to do with rules. Consider the following example: a plan to produce an artefact for opening, closing or locking both interior and exterior doors. The designer may explore a range of shapes, including levers, knobs and pull bars, which all serve as handles. However, the designer chooses the parts that are most appropriate for the design. For example, the designer may consider ease of operation and the level of security required for each door. Moreover, this may include whether multiple handles, which should match the material, style and colour, will fit with the surrounding décor based on the designer's experience and people's aesthetic preferences. Therefore, the designer has a basic image of the product in his or her mind based on the prescriptive knowledge and context. Conversely, the designer may decide that the rules make no sense and reject them.

In contrast, De Vries (2005) believed that procedural knowledge is "the knowledge of the sequence of action" (p. 35). In other words, it concerns how designers solve design problems and the knowledge involved. Furthermore, "procedural knowledge at least partially can be expressed in propositions, and this happens when design procedures are prescribed in design handbooks" (p. 59). This suggests that not only is knowledge exercised in the performance of some tasks, but the demands of the tasks may be unpredictable to a degree, and the required knowledge and skills are not necessarily set by prior instruction (propositional knowledge) on the problem. This could sometimes pose an additional challenge that may have implications for the design process. However, De Vries (2005) noted that "a description of the type of design problem would have to be made before coming up with a prescription for the problem of solving it" (p. 50) – an indication that conceptual knowledge and procedural knowledge could be combined to solve design problems. Furthermore, more than one solution is proposed before the optimal one is found. For example, flowchart presentations can be used in which there is scope for backwards and forwards movement. Other options may include emphasising the decision points in the design process for each variety of solutions listed, before each combination of partial solutions is considered an optimal solution to the overall problem. This suggests that making decisions about an appropriate procedure to adopt in problem-solving is important. For example, De Vries (2005) considered taking into account "a variety of aspects such as functionality, safety, effects on the natural environment, costs, maintenance, patents, user-friendliness, company strategies and policies, and so on" (p. 52). From the argument above, De Vries's (2005) concept of technology as technological processes reminds us that in solving a design problem, it is always necessary to combine conceptual and procedural knowledge. By implication, this can be knowledge of the physical nature, the functional nature and processes (sequence of actions). It also demonstrates that problem-solving is an essential process in the construction of knowledge, which can be achieved by making an adequate decision about choice of procedure and concept formation to rationalise a solution in technological processes.

Technology as a part of human existence

De Vries (2005) conceptualised technology as a part of human existence because it expresses that aspect of human character that makes us technological beings by "emphasising the non-neutrality of technology" (p. 68), whereby the value aspects of technological developments – ethics and aesthetics – play a vital role. Similarly, Stables (1997) highlighted the intrinsically value-laden aspect of technology, arguing that it is always driven by the diverse needs, wants and aspirations of individuals or groups of people, which some may see as good and others as bad. For example, cars are good for getting to places, but bad for the environment because of gas emissions. Also, De Vries (2005) argued that this aspect of conceptualising technology differs from technology as artefacts, knowledge and processes. This is because it draws primarily from cultural philosophy (the main aim of which is value judgement) rather than analytical philosophy (the main aim of which is to conceptualise – to define and understand concepts properly). It considers the moral problems or dilemmas regarding the way we interact with artefacts and how a balanced argument can influence informed decisions. Consider dealing with the issue of risks, such as deciding on technological developments where ethical codes play a prominent role. For example, what types of ethical responsibilities do technological innovators have for the technologies they design? De Vries (2005) argued that the use of professional ethical codes, which serve as guidelines, suggest possible directions in which technology develops, where the choice is always based on either conscious or unconscious values. For example, Hickman (2001) and Feenberg (2006) described two differing views of technology as a part of human nature. Hickman (2001) approached this aspect of the concept of technology from the perspective of the effect devices have on our experience of reality. Hickman (2001) contended that what is done in technology should be determined not by previous knowledge or ideologies, but by what is successful in practice. Hickman (2001) used the example of television to argue that some television programmes can be useless and are bad for social relationships; conversely, educational programmes can have a strong engaging effect. Furthermore, Feenberg (2006) viewed technology as a threat to humankind, because it embodies in the design some danger that can cause human suffering but independent of the product and its creator. For example, medical technology provides benefits to patients, but also yields significant risks that can threaten patient safety – for example, life-saving radiation therapy can have devastating consequences if errors occur. Thus, for Hickman, the essence of technology as a part of human nature is a side effect of our experience of inquiry into our tools and techniques. However, for Feenberg (2006), the essence of technology as a part of human nature depends on social variables associated with technology and the consequences that users experience thereafter. The significance of this concept for this study is that it suggests that a link exists between humanity and technology, each shaping and affecting the other.

Definition of the term 'technology' for this study

This study's definition of technology may not be absolute, but drawing on all the arguments above, the term 'technology' is intended to be understood broadly and refers to a multidimensional phenomenon determined by the interplay of four fundamental dimensions: technological artefacts, technological knowledge, technological processes and the human desire to improve our lives. Given the inherent limitations of a written definition of technology, and consequently the limitations of technology as a school subject, the researcher thinks that a model is likely more worthwhile in demonstrating these interacting factors, because it highlights what is required to understand technology, particularly in the 21st century. One way to think of how the model works is to consider that what each of the dimensions holds is varied and unique characteristics. However, on an individual basis, each one is an insufficient condition to conceptualise technology. Therefore, to obtain a better understanding of technology, it is appropriate to consider all four dimensions. It is possible that some attributes could vary widely, but others are fixed. An example of such a situation can be found, I think, in the development of cars. A car colour may vary, but a vehicle without an engine or with only two wheels would not satisfy the conditions of a car. The four dimensions mentioned here are not meant to suggest four independent components of technology that ought to be taught separately. In technology, as a curriculum subject, they should all run together.

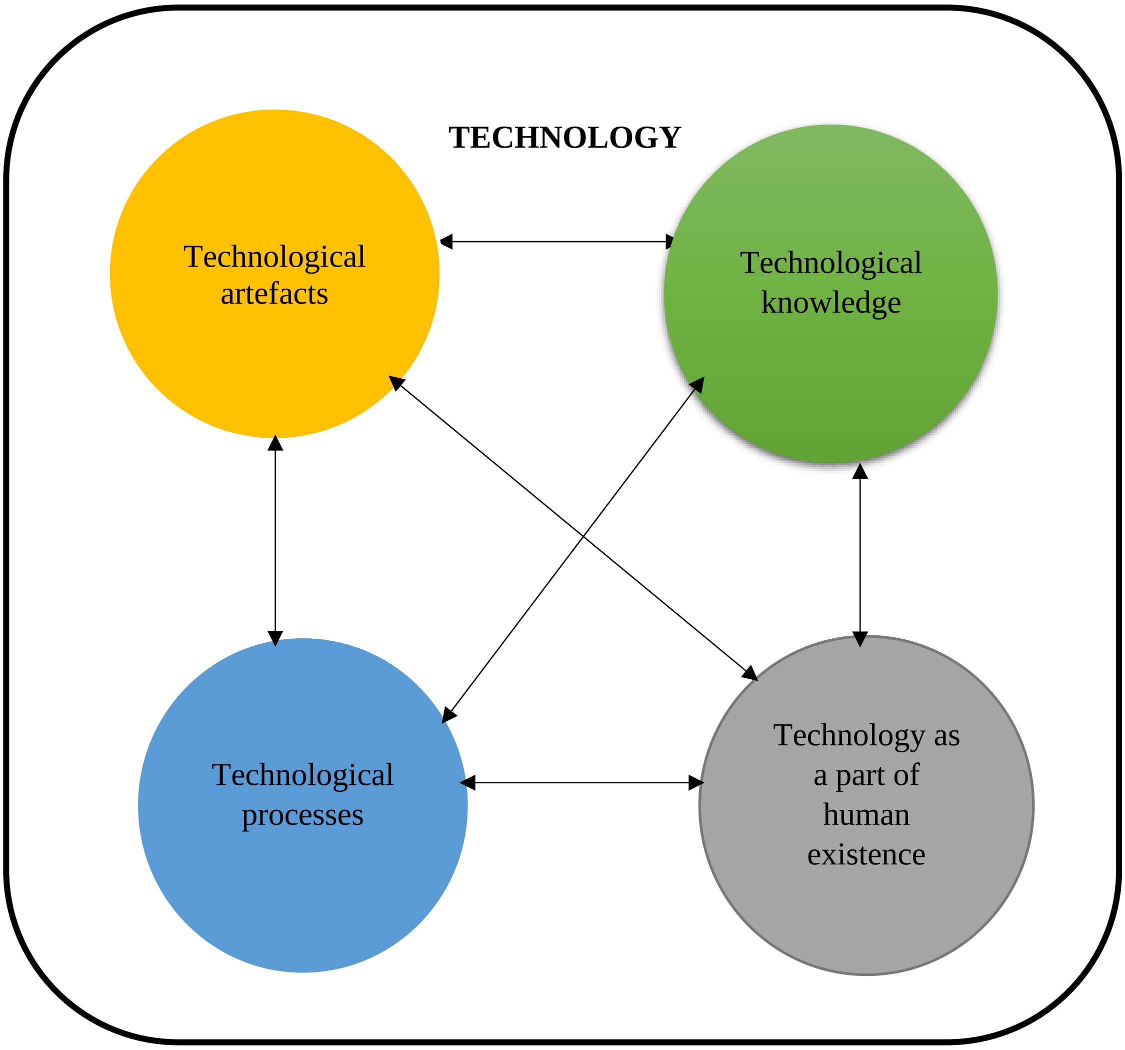


Figure 2.2 Proposed model of a conceptual framework of technology desgned after De Vries (2005).

The conceptual framework for this study

Although De Vries's model was explained previously in detail, the researcher feels it is important to provide a summary of the model, so the reader can see where and how the researcher's model (Figure 2.2) draws from it. Of interest to this study's researcher is the way De Vries discusses the relevance of the four key components – namely, technological artefacts, technological knowledge, technological processes and technology as a part of human existence. As a frame of reference for this study, the researcher has adapted De Vries's four dimensions, which might encompass the individual dimensions as shown in Figure 2.2. The definitions of each of these concepts have been presented previously in this chapter (see "The nature of De Vries's (2005) model of conceptualising technology", page 47). Thus, for the researcher, *technology is the interrelatedness of a set of integral concepts, namely, technological artefacts, technological knowledge, technological processes and technology as a part of human existence to meet human needs and wants.* Interrelatedness here means each integral concept or dimension impacts on the others. Therefore, the arrow between each integral concept goes both ways. The extent to which these integral concepts are interrelated may only be determined by their connection in ordinary thought (Martin and Billman, 1994). In a similar vein, there may be points of intersection or overlap between the dimensions in the sense that one provides attributes that stimulate or facilitate change in another.

From a pedagogy perspective, each dimension is insufficient to describe how technology might be characterised or understood or help students make connections between the classroom and the real-world context, thereby providing opportunities for them to develop mastery in those areas. It is important to mention that the model is not intended to recognise any order. The order in which an individual or group of individuals chooses to work through the dimensions depends on their experience of technology or on the situation or event. This suggests that within the framework, the connection with individual dimensions is interchangeable albeit under one conceptual umbrella, which falls within the broad definition of technology. Therefore, this model is significant in that it recognises that each dimension is considered a necessary condition by which technology is defined.

The relationship between De Vries's model and the researcher's model

As we can see in this adapted model, each of De Vries's (2005) four concepts – technological artefacts, technological knowledge, technological processes and technology as a part of human existence – is maintained. Also, in the proposed model, the relationships among the dimensions are not represented in a 'linear or reductionist' manner but are interrelated to show how the integral concepts can shape each other, thus providing a powerful visual metaphor for understanding technology. De Vries (2005) did not offer any definition for the term technology or emphasise the interaction between these dimensions and the meaning of technology as an entity. However, the dimensions' interrelatedness is considered important to this study, and therefore the model has been adapted, as shown in Figure 2.2. The interconnecting arrows suggest that the meaning of technology encompasses the four distinct dimensions as interrelated concepts. Thus, if a condition(s) in any dimension is overlooked, the other dimensions could be affected. Moreover, a change within one dimension will affect some, if not all, decisions made by the others. For example, a change in how things work in reality, where values play a vital role (as a part of the human nature dimension), could influence design styles (technological processes dimension) and knowledge employed that appears to differ from scientific knowledge (technological knowledge dimension). Thus, the researcher's model proposes that the term 'technology' encompasses the four distinct dimensions of technology (Figure 2.2). Also, the researcher proposes that in an educational situation, learning technology should involve a sense of linking all the dimensions. In this way, the structure of teaching and learning can move between the four dimensions, thereby making the knowledge cohesive and providing more accessible opportunities that enhance students' strengths and reduces their weaknesses in relation to understanding technology.

Table 2.1 Summary of De Vries's (2005) model of conceptualising technology

Key conceptual dimensions of technology	**Brief description of key concepts of the dimension and its educational implications**
Technological artefacts	Concepts include physical aspects of artefacts (which we take to include shape, surface characteristics and all sorts of mechanical properties), but mere physical aspects may not be sufficient in relation to technological artefacts since they have no place for artefacts' functional features. Therefore, students' attention would need to be drawn to the functional aspects of artefacts as well. Implications for education: Students can gain a deeper understanding of technological artefacts by exploring the artefacts in such a way that their physical nature fits their functional nature.
Technological knowledge	Concepts include two types of knowledge: knowing-that, which can be expressed in propositions, because we have belief about it; and knowing-how, which refers to knowledge that cannot be expressed in propositions because part of it is usually associated with mental skills, such as thinking skills, that are used to do things like solve problems, make decisions or create new ideas. Implications for education: Part of technological knowledge needs hands-on experience for learning. Therefore, it is learnt in a different way from just reading about it or seeing it being done. Thus, understanding gained by actually doing something could be distinguished from learning about something from a book.
Technological processes	Concepts include methods of designing and making things, and appreciation and assessment of those things, irrespective of what is being designed. These

	require knowledge of design criteria regarding the technological artefact and its plan for use. Implications for education: As in the world of real design, students can be expected to reflect on all sorts of methods for designing, making, using and assessing products, such as coming up with different solutions for the design problems. Thus, it might be helpful to make students aware of design processes in which knowledge about the process of designing as well as knowledge of the content matter are both used and developed.
Technology as a part of human existence	Concepts include aspects that show the human character of technology, in which values (ethical and aesthetical) play a prominent role. Implications for education: Using role play and discussion groups, students can be stimulated to reflect on ways to express the aesthetical or ethical values to develop their opinions in clearer terms that make sense. This could include, for example, reaching a conclusion that fits one's interests on a specific occasion, such as feelings of responsibility towards the safety of the future user of something or the environment. The idea is to enable ethically informed decision-making about technology compared to a range of alternatives, such that it may help to avoid the dilemma that we find in moral problems when choosing between two or more conflicting values.

For people who may be interested in understanding the nature of technology from Figure 2.2 the rationale behind Table 2.1 is to summarise the values and attributes to teaching and learning technology as a curriculum subject was derived after De Vries (2005) based on this study' conceptual framework which consequently informed the researcher' s motivation for choosing De Vries's (2005).

2.6: Conceptualising technology education

There is little consensus regarding what technology education means, because, as De Vries (2005) noted, technology education policies are often rooted in rationales surrounding the development of school curricula. De Vries (2005) argued that “a first strategy towards reconceptualising technology in the learners’ minds is to adapt the content of the curriculum” (p. 116). Thus, for the purpose of this study, ‘technology education’ refers to the efforts by schools to teach fewer theoretical aspects and more practical aspects of technology, which are likely to generate among students some knowledge, skills and dispositions that might prepare them to think critically and become problem-solvers and innovators of what De Vries (2005) described as the “intuitional technological concepts” – namely, technological artefacts, technological knowledge, technological processes and technology as a part of human existence (p. 110). According to De Vries (2005), when the curriculum does not reflect these concepts, learners focus solely on the making process, as they assume that the design exists already, and thus they will never recognise the importance of the design process in technology. De Vries (2005) claimed that an awareness of the philosophy of technology can impact on teaching and learning of technology and could provide useful information for technology curriculum designers. In addition, De Vries (2005) argued that technology education has generally been dichotomous and related to either the liberal arts or vocational training. Pavlova (2009) argued that technology education is an essential component in achieving the goals of vocational training, although the rationale for technology education was developed within a philosophy strongly opposed to the aims and objectives of vocational education, in which activity is integral due to the need of that field to prepare students for a specific vocation. For Williams (2012), technology education is “the responsive philosophical change to social phenomena” (p. 12). Williams (2012) argued that “what is needed is educators who understand technology through its approach for examining concepts and activities in the technological world” (p. 11). This includes the practical dimension: an integration between technological knowledge and technological activities, which can help provide the basis for an alternative model of teaching and learning about technology as a unique subject (Vincenti, 1990; ITEA, 2000; Feenberg, 2006; Williams, 2012; Norström, 2011). One way of achieving this is for the modern curriculum to address real-world learning experiences, by enabling students to use knowledge learnt in school in everyday practice, or to use everyday knowledge in school (Wicklein, 1997). Gardner and Hill (1999) emphasised helping learners to become technologically capable to identify human needs for which technological solutions, design and make appropriate products (physical products or organisational systems) are possible and to evaluate their quality and their potential societal and environmental effects. Similarly, Purkovic (2018) noted that the learning of technology, which usually begins with insights into and experimentation with objects of technology – that is, recognising their physical and functional characteristics – holds the potential for students to learn in the context of designing and making artefacts and to gain insights into how technology shapes and influences people, culture and society.

So, as we can see in this section, technology education is arguably characterised as more of an activity than a body of content. Therefore, it is reasonable that the presentation to students must be centred around designing and making that inform the activity and the impact of its use (Barlex, 2007), and the process of learning must allow the students to have opportunities to think, reflect and develop ideas in a practical context (Williams, 2000).

Technology as a curriculum subject

Technology is a curriculum subject in Nigeria, as in other countries, including New Zealand (Reid, 2000; Jones, 2003), Australia (Rasinen, 2003; Williams, 2006) the USA (ITEA, 2000) and England (Barlex, 2007). In the context of this study, the term ‘curriculum’ refers to a curriculum for education. This can encompass the aims and content of what is to be taught (planned curriculum), what is implemented (enacted curriculum), what is experienced by the students (received curriculum), and learning that can occur that is not overtly included in the planning (hidden curriculum) (Kelly, 2009). Thus, technology as a curriculum subject here is based on an educational rationale comprising a series of planned topics, each of which provides students with direct experience to solve individual and societal problems. According to Raizen et al. (1995), one of the guiding principles of technology as a curriculum subject is the ability to enable students to develop a basic understanding of fundamental technology concepts and skills. Similarly, Kimbell (1997) noted that technology as a curriculum subject could help students be innovators, as they will develop the capacity not only to identify things that need improving or creating in the world, but also to design and make something that will bring about the desired improvement. Thus, a lack or a limited amount of curriculum materials for technology education, which includes, for example, information about approaches to instruction, could impact student learning about technology (Jarvis and Rennie, 1998; Lewis, 1999). The next section discusses the highlights of four different instructional approaches that seem relevant to technology education.

Traditions of instructional approaches to technology education

De Vries (2011) noted that teaching of technology has changed substantially. De Vries (2011) argued that all school subjects go through changes, which are often caused by changes in the social context of education, and further claimed that some practical issues related to teaching about technology, in accordance with the ideas in contemporary philosophy of technology, need to be taken into consideration when teaching for a proper conceptualisation of technology. Compton and Compton (2013) claimed that the technology curriculum in New Zealand moved away from behaviourist theories of learning towards constructivist theories, which resulted in a strong direction for the development of technology programmes. However, Raizen et al. (1995) noted that the choice of instructional approach is a challenge. They suggested that it is not appropriate to elevate one type of instructional approach above others, because different schools will need to find solutions that are acceptable to local needs and requirements, and therefore approaches are likely to differ. According to Lewis (2000), the answers to such a challenge depend on circumstance but are developed through an evaluation of the choices available. The researcher will now examine this perspective and its implications for appropriate instructional approach needs for teaching technology subjects. It is reasonable to gain insights into some of the instructional strategies that are available so that we can reflect on the different approaches and make an informed choice about which option to use in a given situation at a specific time. Thus, in this study, the researcher examined instructional approaches that have been adopted across the curriculum.

One of the approaches in the literature is the ‘problem-solving approach’. Todd (1999), Jonassen (2000), Williams (2000) and Koch and Sanders (2011) believed that the problem-solving approach promotes student awareness of their learning skills and makes them reflect on what they have learnt through practical activities. The problem-solving approach refers to solving problems that arise throughout any process in order to proceed (McCormick, 1996) and involves a process of repeated evaluations and improvements (Yu et al., 2015). Indeed, Castledine and Chambers (2011) noted that students’ problem-solving strategies could help them reflect on how to build strategies. Therefore, different schools are likely to need to find solutions that are appropriate to their local needs and requirements. Lewis (2000) believed that most countries pushed away from industrial arts to technology, and argued that the conditions for children in developing countries differ from those that prevail in developed countries. For example, the social technologies that have evolved in developed countries provide good institutional models, while less developed countries must create particular conditions within which favourable technology will materialise. Similarly, Vandeleur (2010) argued that most teachers in South Africa face challenges in implementing indigenous technology and culture in their classrooms, asserting: “If the implementation of ‘indigenous technology and culture’ is going to be meaningful, then we need to consider the relevancy of the context to meet the needs of the learners in our technology classrooms” (p. 199).

The craft-based approach emphasises hands-on activity and general theoretical understanding of technologies, in which the goal is to teach students how to carry out standard operating procedures (Autio, 2016). Teachers who use this approach demonstrate various skills with gestures and oral explanation to communicate their skills (Koskinen et al., 2015). Typically, teachers have a trade background, and the course content tends to emphasise techniques such as technical drawing, metalwork and woodwork, which involve working with materials and are foundational to careers in skill trades (Raizen, 1995; Lewis, 2000). This involves creating things based on a prescribed design, with too much emphasis placed on psychomotor skills for students moving into a vocational craft or trade. In this sense, students tend to align with project ideas rather than how to solve problems (Flowers, 1998). From this perspective, Autio (2016) argued that craft-based approaches “do not prepare students to meet the challenges of modern technology and working life” (p. 75), claiming that students reproduce artefacts on their own without any sense of creativity and that learning is focused on how to replicate demonstrated skills. Similarly, Raizen et al. (1995) believed that the philosophy behind this approach was limited because it focused too strictly on the idea that education is linked with preparation for work, albeit with limited skills (De Vries, 2012).

In contrast to the two approaches above, the design approach assumes that students will be responsible for decision-making regarding the type of product required, what it will look like, how it will work and how it should be constructed (De Vries, 2012), and that they will understand when it is not possible to predict what will work with certainty because of the manifold qualitative variables involved (Williams, 2011). For example, students will progress through stages of concept development (developing an understanding of the design factors), construction of prototypes (construct a model) and evaluation (analyse the model). A blended approach, as the name suggests, means the integration of different approaches. It reflects a dependence on different approaches to form a rich and balanced tactic (De Vries, 2012) and would require an additional rationale and structure (Devlin et al., 2013) given that instructional strategies for technology education should be able to address learning about modern technology, which continues to advance and change (Mettas et al., 2007; De Vries, 2012). However, Bennett (2013) argued that students in different countries may not experience similar technology lessons given their national economic statuses, although they could identify similar problems that may influence their learning – for example, attempting to achieve the intended curriculum goals.

2.7: Technology education in Nigeria

Technology education has evolved in Nigeria, like other African countries after independence, due to a nationalistic desire to launch a change in the educational structure for the general good of the country (Adejumobi and Ivowi, 1990; Akinseinde, 2012). Historically, technology education dates to the era after the British colonised Nigeria, as previously mentioned. Some authors, such as Rwomire (1998) and Woolman (2001), have critiqued the colonial educational system for not paying attention to the education that was required to empower the traditional societies and for instead introducing a Eurocentric system, which focused on Europe and the needs of European people. Indeed, Umunadi (2013a) claimed that the colonial missionaries' technology education initiatives were aimed at achieving the vested interests of colonial masters. However, others, such as Akinseinde (2012) and Mamman et al. (2013), upheld the values of the colonial education system, arguing that the curriculum, though not as systematic as that of today, was effective because it fulfilled its intended purpose. For example, Akinseinde (2012) noted that British missionaries helped prepare their converts for practical work-related activities by providing them with vocational training. Similarly, Mamman et al.

(2013) noted that non-indigenous companies, like Shell BP (which became Shell-BP Petroleum Development Company of Nigeria in 1932) and the United Africa Company (which changed its name to United Africa Company Ltd in 1943), trained artisans among their employees, in order to develop the skills needed by the company at that particular time, but through "observation and imitation of their colonial master" (p. 47).

As demonstrated above, technology education has been taught in Nigeria since pre-independence but has undergone various reforms with the aim of meeting the challenges students would encounter in learning about technology. However, Opoola and Adeniyi (2013) noted that it is unlikely that curriculum reforms alone will make the difference in helping students to develop adequate skills to become technologically literate in line with government policy for technology education as described in its curriculum framework.

The basic technology education curriculum in Nigeria

There is a common nationally prescribed basic technology curriculum for all students throughout JS1–3, referred to as the basic technology curriculum (Federal Ministry of Education, 2007). This curriculum is based on nine themes: (1) you and technology, (2) safety, (3) materials and processing, (4) drawing practice, (5) tools and machines, (6) energy and power, (7) applied electricity and electronics, (8) building, and (9) maintenance. These themes represent the minimum content to be taught in schools in order to achieve the goals of technology education in Nigeria (Federal Ministry of Education, 2007), which include:

"(i) inculcation of technological literacy, that is basic understanding of, and capability in, technology;

(ii) exposure of students to the world of work to match their talents and interests for vocational choice, and

(iii) inculcation of positive attitudes towards work as a source of human identity, livelihood and power" (p. iv).

According to Alhasan and Tyabo (2013), technology education in Nigeria uses a technical and vocational education (TVE) curriculum. According to the national policy on education (FME, 2004), states that the goals of technical and vocational education shall be:

"(a) provide trained manpower in the applied sciences, technology and business particularly at craft, advanced craft and technical levels.

(b) provide the technical knowledge and vocational skills necessary for agricultural, commercial and economic development.

(c) give training and impact the necessary skills to individual who shall be self-reliant economically." (pp. 30–31)

As Ajibola (2008) and Udin et al. (2012) noted, the TVE curriculum activities showed students were trained using demonstration and sometimes in an abstract way, without engaging them in real-life practical work. For example, Olusola (2014) noted that TVE focuses on practical skills over theory in each trade during training. The aim is to enable the trainees to gain practical experience in their chosen vocation so as to be gainfully employed in the world of work, as reflected in the UNESCO and ILO (2002) technical and vocational education and training (TVET) programme aimed at producing semi-skilled and technical manpower necessary to sustain the national economy and substantially reduce unemployment. According to UNESCO and ILO (2002), TVET is

"a comprehensive term referring to those aspects of the educational process involving, in addition to general education, the study of technologies and related sciences, and the

> acquisition of practical skills, attitudes, understanding and knowledge relating to occupations in various sectors of economic and social life" (p. 2).

Raizen et al. (1995) noted that TVE can lead to the acquisition of specific skills but is limited because it emphasises a craft or industrial practice background. Although the official policy reforms of the Nigerian educational system were intended to modify TVE subjects, the current aims in relation to technology, according to the Federal Government of Nigeria (2007), are:

> "(a) introduction into world of technology and appreciation of technology towards interest arousal and choice of a vocation at the end of Junior Secondary School and training. professionalism later in life;
>
> (b) acquiring technical skills
>
> (c) exposing students to career awareness by exploring usable options in the world of work;
>
> (d) enabling youths to have an intelligent understanding of the increasing complexity of technology" (p. 30).

Recognising the perspective of the Federal Ministry of Education (2007), as above, Odili et al. (2011) argued that much work is required to facilitate the effective implementation of the curriculum. They noted that a significant gap between teachers' knowledge of the curriculum objectives and their ability to present learning in a way that would achieve the curriculum goals was a common occurrence in the Warri South Local Government Area (WSLGA) of Delta State and that this impacted on their capacity to implement the curriculum. As a result, teachers in WSLGA (and, by extension, Nigeria) are not being prepared or trained adequately, which is likely to impact teaching and student learning. Similarly, Odu (2013) noted that the absence of adequate facilities to foster effective implementation of the curriculum for basic technology still poses a challenge to secondary education in Cross River in Nigeria. Similarly, Okenjom et al. (2016) recommended that

> "adequate instructional materials should be provided for the teaching of basic technology in junior secondary schools in Cross River State, in-service or on the job training should be given to teachers in this subject area for professional growth, well-equipped laboratories and technology workshop should be provided for practical work and teachers should make the course content attractive by involving students in practical classes to enhance better understanding" (p. 129).

2.8: Development of technology education internationally

As a review of all literature would be beyond the scope of this study, a brief review of established programmes of technology education in various countries is presented here to help put technology education developments in Nigeria in context, given that different perspectives could provide insights into what students should know and the extent technology curricula are likely to enhance students' knowledge and skills. The researcher decided to focus on two countries – the United Kingdom and the United States – because they both influenced the development of the education system in Nigeria. As previously discussed, (see section 2.2), the British colonised Nigeria when technology education was not a core subject; rather, technology education was occupationally specific hands-on training in the form of craft and trade studies. Some authors citing the legacy of British colonisation of Nigeria contend that prior to the 1990s, technology education was viewed primarily as training in manual and technical skills for preparation for jobs (Akubue and Pytlik, 1990; Ajeyalemi and Baiyelo, 1990). However, post-independence, Nigeria decided to adopt the American education system (Nwagwu, 1998). Thus, it is assumed that some characteristics of the current national curriculum are consistent with what is obtainable in the US educational system. For example, in the US, schooling resides at the state level. Similarly, both junior and secondary schooling in Nigeria resides at the state level. It is important to state that no claim is being made that UK and US traditions reflect the full range of views regarding technology education internationally. Rather, the rationale for examining these two countries is to gain insights into the curriculum justification for technology education. To this end, technology education in both countries is discussed below.

Technology education in the United Kingdom (UK)

Design and Technology (DT), used in the UK to refer to technology, was added to the National Curriculum in England and Wales as a distinct curriculum subject in 1988 (Owen-Jackson, 2007), developed by the National Curriculum working group (DES/WO, 1988). The purpose of the DT curriculum is to enable students to achieve competence by engaging in a broad range of activities with a blend of different approaches (De Vries, 2012), with the common requirement being to develop skills in designing and making and to facilitate pupils' ability to participate in future technological advances, and to learn to think in a creative manner to improve quality of life (Rasinen, 2003). Harris and Wilson (2003) stated that DT in the UK:

- "Is a deliberately, interdisciplinary subject.
- Combines both design and technology but is broader than both.
- Encourages pupils to develop the capacity and value judgements to operate effectively and creatively in the made world
- Focuses on designing and making activities, and developing technological capability for all pupils
- Involves the use of cognitive modelling.
- Combines knowledge and motivation to enable pupils to intervene in the world to improve it" (p. 4).

Down (1986) noted that craft training and skills development emerged from the craft areas of woodwork and metalwork, which were the most common justification cited for the purpose of DT in the UK. Similarly, Barlex (2007) restated the distinctive model of teaching and learning that involves learners taking a task from inception to completion, which also prepares students to meet the skills challenges that need to be addressed. This is an important part of learning and helps students to develop creative thinking, critical thinking, analytical thinking and problem-solving skills, which they need to participate in technological society (Linton and Rutland, 1998; Twyford and Järvinen, 2000), and it is vital to success in sustainable development within students (Barlex, 2007).

Technology education in the United States of America (US)

The US has a long history of technical training through which students gain in-depth preparation for the world of work. The study of technology as a formal school course began in the last half of the 1800s as manual arts education (Dugger, 2013). In the late 1980s and 1990s, industrial arts moved towards teaching technological content, such as manufacturing, construction, energy and power, transportation, and communication. However, despite decades of advocacy for the transformation of industrial arts (which is an educational programme limited to woodwork, metalwork and technical drawing or using a variety of hand, power or machine tools) into technology, efforts of professionals like ITEA and National Association of Industrial Technology have spawn lively discourse and critical debate on such topics as what technology should be taught (De Miranda and Folkstead, 2009). The rationale was that every citizen should be technologically literate and thereby able to use, manage and understand technology (De Miranda and Folkstead, 2009).

From a professional desire to have a broader content for teaching and learning in the future, the *Standards for Technological Literacy: Content for the study of technology (STL),* developed by ITEA (2000), were produced. The goal was to create standards built around a cognitive base as well as involving activities for grades K–12 (ages 5–18). One of the purposes was to establish technology as a core subject in the curriculum; educators in the states and localities could use the content found in the standards to develop a curriculum (Dugger, 2013). These standards did not prescribe the curriculum to be achieved as an STL outcome but were motivated by the need to promote the development of technological literacy for all citizens. Therefore, the US focused on promoting technological literacy (discussed in detail in a later section), which relies on a broad range of concerns associated with technology education.

Lessons from technology education in the UK and the US

The discussion above highlights that just as the goal of technology education in Nigeria is the technological literacy of students, there is also evidence that students' technological literacy is one of the primary goals of education in most curricula worldwide, including New Zealand and Australia (Nia and De Vries, 2016). For example, New Zealand introduced technology education as a separate subject in 1995, with an enhanced curriculum in 2007, with the aim of developing the technological literacy of all students (Jones and De Vries, 2009).

Also, we can see from the examination of the development of technology education in the UK and the US that an important part of learning for students is to develop creative thinking, critical thinking, analytic thinking and problem-solving skills, which they need to participate in technological society.

To conclude, from the information above, it is evident that there is a general trend towards emphasising technology education and technological literacy. Of relevance to this study is that the technology education curriculum document in Nigeria shares a similar vision to those of the UK and the US. Today, the UK and the US are considered to be examples of countries that have been able to transform their economy into a modern technology-driven economy with a relatively low unemployment rate. The situation in Nigeria is different in the sense that the unemployment rate is high, and even graduates cannot get employment (see Chapter 1.1). The next section discusses technological literacy for the purposes of this current study, clarifying the meaning of this term, given that it is often 'implied' when technology education curricula are discussed in the literature (Gagel, 1997; FME, 2007; ITEA, 2000; Keirl, 2006). For example, a study by Gu et al. (2019) showed that technological literacy is often misinterpreted as being equivalent to scientific literacy or digital literacy by the Chinese public.

2.9: Technological literacy

Technological literacy – sometimes referred to as technological literacy education (Waks, 2006) – is viewed commonly as a general understanding of technology, which may not be comprehensive, but must be developed sufficiently for a person to function effectively in a technology-dependent society where rapid change is the norm (Pearson and Young, 2002). For example the choices of the intellectual skills and abilities, and the contexts in which technological activity takes place are most obvious aspects of technological literacy (De Vores, 1986). Therefore, it could be argued that how well we are prepared to make those choices depends largely on how individuals understand the meaning of technological literacy, based on what technology means to the person (Lewis and Gagel, 1992). Similarly, Borgmann (2006), in the foreword to *Defining Technological Literacy: Towards an Epistemological Framework*, suggests that there is a "need for a penetrating understanding of contemporary life" (p. ix). The accomplishment of this could be found in our reflection on the theories of technology. For example, as discussed previously, many theorists took a dichotomous view, focusing on either the social impact of technology (SCOT approach) or the characteristics of technology itself (philosophy of technology approach). However, to ensure the inculcation of technological literacy in schools (including which skills technological literacy might involve and how students learn about those skills), the development of the curriculum for technology teacher education and the implementation from a policy perspective, Lewis and Gagel (1992) contended that the curriculum will need to be concerned predominantly with education rather than technology alone. Therefore, for the purposes of this study, the researcher will attempt to examine some definitions of technological literacy to gain insights into the essential knowledge, skills and understanding and the overall sense in relation to the school curriculum.

Dakers et al. (2007) described technological literacy as technology education that must engage with:

> “the development of informed attitudes about the impact that existing and emerging technologies will have upon their cultural development, as well as the potential and actual consequences these technologies will have upon the environment, both locally and globally. This is known variously as ‘technological literacy’ or ‘technological capability’” (p. 7).

As we can see from the definition above, it is unclear if Dakers et al. (2007) combined two concepts (technological literacy and technological capability) into one idea, indicating that a relationship exists between individual concepts in that they speak of the significant potential of what needs to be learnt about technology, or they are just saying that the two terms are used to mean the same thing. Petrina (2000) referred to the term ‘technological literacy’ as a counterpart of technological capability, which “is simply the potential for efficient practical, quality work in design” (p. 181). However, Jones (1997) argued that technological capability was carrying out problem-solving activities in a variety of contexts. All three meanings – namely, a counterpart of technological capability; the potential for efficient, practical, quality work in design; and carrying out problem-solving activities in a variety of contexts – resonate with the work of Pearson and Young (2002), who defined technological literacy as having three major dimensions:

- "knowledge – both factual and conceptual understandings of technology;
- capabilities – how well a person can use technology – problem solving;
- critical thinking and decision making – one's approach to a technological issue" (pp. 36–37).

Also, the requirement to think critically and make decisions regarding technology not only seems to resonate with the ITEA definition of technological literacy, but links back to the nature of technology, as demonstrated below. Technological literacy, according to ITEA (2000), refers to "the ability to use, manage, understand and assess technology" (p. 242). Therefore, the ability to use technology can be considered to be an integral part of technological literacy but is insufficient to understand technological literacy, because little is known about the ability to manage, understand and assess technology. From this perspective, technological literacy involves not only knowledge of the functional use of technology, but also an awareness of people's ability to use, manage and understand it. In other words, to be considered a technologically literate citizen, a person should understand what technology is, how it works, how it shapes society and what factors influence technological development. This suggests that technological literacy involves more than knowing how to use technological artefacts such as computers or a mobile phone. Furthermore, ITEA (2000) argued that technological literacy would include detailed knowledge of individual technologies that have become part of our everyday life at home, at work or in our community. Moreover, it is concerned with the processes that created these artefacts or the awareness of the various implications for society that arise from the existence of these technologies based on initiative and resourceful thinking. Furthermore, technological literacy is often misinterpreted as being alike in meaning to scientific literacy or digital literacy (Gu et al., 2019). Indeed, Gu et al.'s study (2019) suggested that because the development of technology is rapid and follows current trends, the content of technological literacy should be up to date and explicit rather than currently acknowledged.

As can be noted from the point above, technological literacy may not be referring explicitly and exclusively to technology, but could mean people's ability to understand different individual technologies and relate to how technology can be used to achieve objectives with effectiveness and efficiency. It also seems unlikely to conceive of technological literacy without an emphasis on technology (Gaskell, 1982; Lewis and Gagel, 1992). For example, technological literacy would be meaningless as a practical tool without focusing on key concepts of technology (Bugliarello, 1990), factual and conceptual understandings of technology, how well a person can use technology, and critical thinking and decision-making (Pearson and Young, 2002). Thus, the technology curriculum would most likely consider including those activities associated with identifying problems, gathering information from a variety of sources using a variety of techniques, exploring ideas, modelling and testing, evaluating, and other activities being taught (Kimbell et al., 1991; Petrina, 2000), which affect what and how students learn, and what and how teachers teach, for a holistic and ethical interpretation of technological literacy (Keirl, 2006).

2.10: Students' perceptions of technology and technology education

Students' perceptions of technology and technology education have been the focus of some studies in technology education, which have explored how students make the connection between their experiences of technology and technology in the classroom. While the number of studies focusing on this issue is limited, those available (Raat and De Vries, 1987; Burns, 1992; Boser et al., 1998; Bame et al., 1993; Van Rensburg et al., 1999; Becker and Maunsaiyat, 2002; Volk et al., 2003; Khunyakari et al., 2009) focused on quantitative concepts, such as understanding students' interpretations of technology, using questionnaires or surveys as data collection instruments. For example, Raat and De Vries (1987) investigated the views of 2,631 students (1,246 boys and 1,385 girls) aged between 13 and 14 years old in secondary schools in the Netherlands, aiming to determine their attitudes towards technology and their understanding of technological concepts. Data were collected using the Pupils' Attitudes Towards Technology (PATT) questionnaire, which consisted of 78 questions using a five-point Likert scale format. In the concept-of-technology part of the questionnaire, the results revealed that the dominant themes were technological artefacts, such as bikes, cars, domestic appliances and computers. Raat and De Vries (1987) concluded that students' conception of technology is "almost entirely restricted to equipment and machines" (p. 164). Moreover, the results showed that students think of technology as a broad and important subject. However, their conception of technology seems not to go beyond things that help them achieve specific goals – for example, using a bike or car for transportation – which implies that students think about technology based on how it supports their needs and preferences.

DiGironimo (2011) investigated 20 students' opinions of technology. The sample criterion was that students are experienced in using various types of technology, including the internet. The survey questions were coded using a conceptual framework of technology. The findings suggested that all the students in the study demonstrated at least a partial understanding of the nature of technology. For example, none of the students linked technology to technological processes (making) or to how humans are involved in the use and development of technology. Also, the results showed that exactly half of the students tended to associate technology with technological artefacts (objects), and several of the students mentioned newer artefacts, such as computers, handheld gaming devices, video games and mobile phones. Four students out of 20 students' responses were linked to the straightforward role of technology in society, such as technology used for fun or for school-related and work-related things. Based on the analyses presented, DiGironimo (2011) concluded that students' perceptions of technology are influenced by what they see rather than the logic surrounding elements, such as how an artefact was made. Similarly, Khunyakari et al. (2009) investigated 644 middle school students' (class 8 students whose average age was 13 years) perceptions of and attitudes towards technology. The study focused on the associations they make with objects, activities, knowledge and consequences of technology. This age group marks the end of middle school, by which time students have been exposed to technology through school subjects, which in the authors' view include skills of drawing and crafts, which they can reflect on in meaningful ways. The sample consisted primarily of students in co-educational schools. The criteria for the sample selected were influenced by the socio-economic setting (rural and urban), media of formal learning in the state, and gender. From the findings that emerged, the authors concluded that students not only saw technology as an important component in fulfilling their future career plans, but also associated positive attributes and consequences, such as working faster, with technology, although, in their view, negative attributes of technology included polluting the environment. Furthermore, the results showed that students tended to consider electronics as high technology, while household activities were rated low technology or seen as not involving technology. These findings, according to the authors, suggest that students tend to understand technology based on its uses and consequences – an indication of a lack of understanding of the nature of technology beyond its use. This is a result of students having an insufficient conceptual link to the inherent messages of thoughts and actions to provoke how to examine technology critically. From this perspective, one part of understanding the difference between external reality technology and the conceptual perspective of it involves the ability to differentiate what is seen in the real world from what is known, whereby the ideological interests focus on what is intended rather than appearance (Armitage and Allen, 2015). Similar results could be found in a few studies that have identified strong links pertaining to students' perceptions of technology and their school experiences. For example, Akpan et al. (2012)

examined 2,500 JS 3 (13- to 14-year-old) students from a population of 48,302 JS 3 students in the state public schools in Akwa Ibom State, Nigeria, in the 2008/2009 academic year. The aim was to understand how students' comprehension of the concept of technology influenced their achievement in technology education. The study was quantitative, and data was collected using a survey. Akpan et al. (2012) concluded that "effective teaching would lead to students' understanding of the role and concept of technology and stimulate students' commitment to the pursuit of engineering and technology" (p. 47). This suggests that it is not only what students learn in technology that is important, but also how the subject is enacted in the classroom. Similarly, Collier-Reed (2009) investigated 15 learners at three schools in Cape Town, South Africa, to understand the different ways in which learners conceive of technology in South Africa. Collier-Reed (2009) adopted a phenomenographic study method. Although phenomenography is qualitative, it aims to describe the different ways in which people experience a phenomenon (in this case technology) rather than focus on the richness of individual experiences (Marton, 1988). Data was collected during interviews from photographs taken with a disposable camera. Collier-Reed (2009) concluded that students conceive of technology in varied ways, although not all of these are useful in the context of their technology education; therefore, "engaging with learners around technology learning outcomes, a teacher needs to dedicate time to explicitly develop in learners a fuller, or more complex, understanding of what the nature of technology is" (p. 81). This suggests that when a teacher presents a limited view of technology, the learners are likely to find it difficult to develop more than an overview of the subject.

To conclude this section, it is important to state that this study differs from most other reported studies in two ways. First, most other studies, as described above, adopt a quantitative approach. The quantitative approach is concerned with the collection and analysis of data in numeric form (Atieno, 2009), with the aim of providing 'facts', and might not be suited to interpretation because the result is not likely to represent the ‘whole story’ due to limited information (Cohen et al., 2009). For example, it may not be able to explain why respondents made the choice they did. Thus, this study provides evidence of students’ understanding of technology using their ideas in their own words to gain a richer understanding of the students’ experiences. Secondly, a previous study by DiGironimo (2011) focused on developing a conceptual framework for the nature of technology using data collected from an exploratory survey; this study provides a conceptual framework for conceptualising technology, but with data collected through interviews from students in their own words and lesson observations, which will provide a more in-depth look at how students perceive technology and their experiences inside and outside school. The next section presents the research questions that this study attempts to answer.

2.11: Research questions

This study aimed to gain insights into students’ experiences of technology in their technology education. Given that students are the focus of this study, a key concern, as outlined in the literature review, is the need to understand how they make sense of technology education from how they are taught in schools. As we saw, the literature review argued that it is vital for Nigeria’s economic future that it develops people with knowledge and skills that are fit for purpose and meet the challenges of a fast-changing technological world. Consequently, the following two key research questions were formulated:

RQ 1: How do students conceptualise technology in their everyday lives outside of school?

This first question aims to explore the conceptualisations of technology that students have in common. In the context of this study, the term ‘conceptualise’ refers to the individual students’ interpretation of their personal experience of technology in terms of what technology means for them in their everyday lives. Using the definition of Greene and Hill (2005), experience here refers to the “state of being consciously affected by an event” (p. 4). By this token, experience comprises both the activity in which the student engages and the meaning that s/he makes of that activity. Thus, it could be argued that without access to the content of students' experience of technology, we have an incomplete account of how students understand and make meaning of technology in their everyday lives. Therefore, a key aspect of this question focuses on their experiences of technology rather than on the students themselves. Conversely, Lewis (1991) noted that some meanings seem to emphasise technology's essence in our minds, rather than its physical form, while others attempt to describe its manifestations. Similarly, Watson (1998) reminded us that "making meaning of one's experiences often conveys both cognitive and affective qualities" (p. 1,025). Thus, it could be hypothesised that individuals' experiences of technology are unique, because individual students are unique and have different life experiences with technology. Moreover, previous studies have shown that technology has a variety of meanings to students (de Klerk Wolters, 1989; Jarvis and Rennie, 1998). This variety of meanings could provide an insight into the conceptual challenges that influence students' understanding of technology. Therefore, this question attempts to gain insights into the variety of meanings of technology, the meaning students ascribe to their everyday lives and how they construct meanings of their own experience of technology. Thus, the purpose of this question extends to the search for the qualitative differences in the collective experience of technology; it does not aim to capture the individual's understanding per se, which can be a lens through which to reflect their experiences. Questions such as how students talk about technology outside of school using an artefact (a mobile phone) or any gadget that they have used as a stimulus object, and how they would describe what technology means to them in their everyday lives, were explored in one-to-one interviews with students. The rationale for providing the students with a mobile phone or other device as a stimulus material was based on previous studies (Jones, 1997; Watson, 1998; Twyford and Järvinen, 2000; Davis et al., 2002; De Vries, 2005). These researchers found, from referring to certain objects, that a modern communication device was often the most common way to describe technology.

RQ 2: In what ways and to what extent, if any, does student experience of technology align with learning about technology in the classroom?

The second question examines the role that everyday-life meanings of technology play in learning about technology in the classroom. It considers the possible consequences of differences in the meanings given to technology through students' everyday experience of it and through learning about it in the classroom. Thus, the researcher is interested in the understanding (making meaning) of technology education by students, and how it helps to shape the values they hold about technology. How are they consonant? How are they dissonant? If aligned, possibilities and capabilities afforded by the experiences will help to influence how perceptions about learning and understanding ultimately become operational in any teaching and learning situation (Brown, 2009). However, if the meaning provided for them does not resonate with their everyday experiences of technology that they bring to the classroom, this might create dissonance (Lindblom-Ylanne and Lonka, 1999). Such dissonance, it might be hypothesised, would affect how students approach learning about technology (Cano, 2005) or lead students to reject the meanings around technology taught in school. It would also increase the likelihood that the subject is not valued or is seen as a less important subject at school (Männikkö-Barbutiu, 2011). The researcher in this study gathered data to answer this research question through lesson observations and interviews (student group interview), which were corroborated by individual teacher interviews. The researcher observed some technology lessons. Questions pertaining to what students do in the classroom or workshop were explored using a group interview with students and lesson observations. Teacher one-to-one interviews were also employed. Although teachers were not the focus of this study, their perspectives were considered necessary to corroborate the students' viewpoints. For example, teachers were asked to talk about a typical technology lesson, how they felt it went and if they thought the students got what they wanted in the lesson.

The answers to these questions will enable the researcher, in the final chapter of this thesis, to reflect on the learning experience that students have based on their descriptions of their experiences with technology.

Chapter 3: Methodology

3.1: Introduction

The purpose of this chapter is to discuss the methodology used in this study to explore students' conceptualisations and experiences of technology. The term 'methodology' refers to the choices we make, in planning and executing a research study, about cases to study, methods of data gathering and forms of data analysis (Silverman, 2006). Thus, in this study, the term encompasses the rationale that explains and justifies the research methods that the researcher employed to address the research questions. An outline of the chapter sections is presented below.

The first section discusses the philosophical perspective set out to guide this study. The second section explains the choice of a case study approach and gives an overview of the methodological considerations in relation to the research design and data analysis that underpinned this study. The third section presents the research design that has been used to investigate the students' experiences of technology within the scope of this study. The fourth section presents a summary of the pilot study, and the fifth provides an overview of the data analysis techniques employed. The ethical considerations are presented in the sixth section. Finally, the seventh section discusses both the trustworthiness of the study and the ethical considerations.

3.2: The underlying philosophy of this study

The underlying philosophical assumption of a study can be a positivist paradigm or an interpretivist paradigm, depending on what the study wants to achieve (Cohen et al., 2009). Hudson and Ozanne (1988) noted that through an interpretivist paradigm, the researcher is able to gain a deep understanding and interpretation of the experiences of the participants under study. This paradigm places a strong emphasis on understanding the world through first-hand experience, truthful reporting and quotations of actual conversation from insiders' perspectives (Merriam, 1998). On the other hand, the purpose of research that follows a positivist paradigm is scientific explanation, which is described by Strevens (2011) as being a deductive derivation of the occurrence of the event to be explained from a set of true propositions, requiring the same resources and giving a similar kind of satisfaction. The phenomenon must be studied using objective methods (Tubey et al., 2015). This means that positivist researchers, unlike interpretivist researchers, aim to be scientific, use observations and measurements to explain something we see in the natural world, and tend to interpret and look for correlations in an objective way (Cohen et al., 2009; Tubey et al., 2015). Through this orientation, knowledge is gained (Pring, 2002). Thus, positivists are interested in explaining human behaviour by looking for facts that are external to the individual, based on scientific evidence, such as experiments and statistics, to reveal the true nature of how society operates. This means that knowledge is obtained from experiments and statistics.

Given that technology education in Nigeria is new and needs more than previously believed facts, this study aimed to understand technology education from the students' experiences in their own words. From this perspective, the interpretivist paradigm was the most appropriate philosophical paradigm on which to ground this study, because it emphasises the ability of an individual to construct meaning that will be studied contextually and holistically (Mack, 2010).

Walsham (1993) argued that in the interpretive tradition, there are no correct or incorrect theories. Instead, they should be judged according to how interesting they are to the researcher as well as those involved in the same areas. Similarly, Deetz (1996) noted that the interpretivist paradigm attempts to understand phenomena through the meanings that people assign to them because it places emphasis on conducting research among humans, instead of conducting research on objects (Saunders et al., 2009). Therefore, the interpretivist paradigm was deemed the most suitable for this research due to its potential to help the researcher understand the participants' interpretations of technology, which would allow the researcher and the research participants to engage in the construction of the meaning of technology (Denzin and Lincoln, 1994).

Typical research designs in the interpretivist paradigm include qualitative approaches such as interviews and observations (Cohen et al., 2009; Kawulich, 2012), which involve the researcher and participants constructing a new reality together from the research process (Thanh and Thanh, 2015). In the positivist paradigm, on the other hand, many of the statistics are themselves socially constructed (Cohen et al., 2009). From the perspective of the interpretivist paradigm, the researcher in this study was able to use the qualitative-inquiry method to engage the participants to get rich and in-depth information about their experiences of technology through a case study approach, which is discussed in the next section. Further details on this qualitative-inquiry researcher interaction will be explained later, in the data collection section. Data analysis is often associated with identifying themes, patterns and relationships (Cohen et al., 2009). A detailed explanation of how this process was conducted is provided in the analysis and findings section (Chapter 4).

The positivist paradigm was considered because positivist and interpretivist paradigms are two important paradigms used in social sciences research (Pring, 2002). However, the positivist paradigm was unsuitable for this study because this research is not concerned with a single and objective reality consistent with the tenets of the positivist paradigm (Cohen et al., 2009; Kawulich, 2012), as positivists belief that knowledge can be gained only from observable phenomena (Pring, 2002) that are ultimately accessible to the human mind and can be perceived objectively, whereby we could all have the same interpretation of what is true, what is right, what is false and what is wrong (Yarusso, 1992). Furthermore, positivists usually use a quantitative approach for the design of a research study, such as a survey or questionnaire (Cohen et al., 2009), and they adopt statistical and mathematical techniques to uncover a single and objective reality, which suggests that data analysis could be restricted because of the lack of details (Carson et al., 2001). For example, responses may be imposed on the respondents based on the selection made by the researcher (Kivunja and Kuyini, 2017). These limitations served as the rationale for the researcher to eliminate the positivist paradigm for this study.

3.3: Case study approach

This study uses a case study approach as a method of data collection because the researcher needed a small number of schools to look at in order to allow him to go into depth in understanding students' experiences of technology (Creswell, 2014), and he was interested in obtaining a diverse range of students' perceptions of technology both inside and outside school. In addition, Denscombe (2007) noted that the case study approach allows the researcher to use a variety of sources, a variety of types of data and a variety of research methods as part of the investigation and helps to avoid the time and costs of travel to multiple research sites. In this study, the case study approach was justified, as it attempted to understand the students' experiences of technology in the belief that it may lead to a better understanding of multiple cases in its real-life context (Stake, 1995; Merriam, 1998; Yazan, 2015), which can result in a rich, thick description of a phenomenon (Cohen et al., 2009) with a consequent generalisation to a wider population (Robson, 2002).

Although the case study approach has been chosen for this research, it is important to know the limitations of using this method. For example, although a rich, thick description and analysis is desired, Yin (2014) asserted that case study research may not be considered as generalisable in some cases. However, while Creswell (2014) suggested that rich, thick description would allow readers to make decisions about transferability to another research context, other critics, such as Merriam (2009), hold that case studies lack robustness as a research method. Similarly, Diamond (1996) believed that case studies are limited by the researcher's subjectivity or are seen as less rigorous than the quantitative approach. In addition, Flyvbjerg (2006) argued that the case study method apparently allows more room for arbitrary judgements than other methods, meaning that the study becomes doubtful. Taken together, these criticisms suggest that the case study approach may not guarantee the rich, thick description and analysis the researcher sought, because the data gathering and analysis processes may be threatened (Best and Kahn, 2006). However, Eisenhardt (1989) proposed three remedies to counteract this constraint: using multiple sources of evidence, establishing a chain of evidence and having a draft case study report reviewed by key informants. Also, Best and Kahn (2006) proposed that this can be controlled by careful formulation of questions and a pilot test of the interview schedule. In terms of analysis, a framework reflecting the themes in the case study can be developed and evidence gathered within relevant themes and analysed in order to achieve a description of the case study that can be corroborated from multiple sources of evidence (Rowley, 2002).

Considering the strengths and weaknesses associated with a case study approach as a method of qualitative data collection, as understood from the characteristics discussed above, the adoption of a case study approach was seen as important, because this study seeks out meaning and understanding directly from the students about their experiences of technology and aims to uncover new ideas they might have. This is preferable to, for example, an attitude scale such as a questionnaire, where there is less scope for the respondent to supply answers that reflect their true feelings on a topic. In Chapter 2 we saw examples of previous studies on students' perceptions of technology that have relied on measurement devices such as the Pupils' Attitudes Towards Technology (PATT) questionnaire as the key tool of data collection (Raat and De Vries, 1987; Boser et al., 1998). Hoepfl (1997) mentioned that extensive research has been carried out relating to students' perceptions of technology, but only a limited number of studies have used qualitative methods, suggesting that technology educators "engage in research that probes for deeper understanding rather than examining surface features" (p. 47). Surface features, as the name implies, mean it is a good start but would not be sufficient to help students to understand things in depth. Consequently, in order to address this 'limited' number of studies, a case study approach, aimed at making sense of students' experiences, was seen as important, since a quantitative approach cannot reveal the 'whole story' (Hoepfl, 1997; Ponelis, 2015). Therefore, this study has the potential to contribute to qualitative studies in relation to advancing the body of knowledge in this field (technology education) (Merriam, 2009).

While recognising that this study is guided by the tenets of interpretivism, the researcher introduced some aspects of hermeneutic phenomenology in the study's data collection strategy (Padilla-Diaz, 2015), because the researcher was interested in sense-making and interpreting meanings and essences derived from experiencing the phenomenon. The strategy is consistent with Moustakas (1994) and Langenbach (1995), who claimed that it enables true meaning to be reached as it appears through beliefs, intents, desires, emotions, knowledge and perspectives that are different from one's own. For this reason, it was adopted in this study as an attempt to understand the intentions of the participants. It is important to highlight that adopting some aspects of a phenomenological approach does not mean this study is a phenomenological research. Therefore, a discussion of the various branches of phenomenology is beyond the scope of this study, but the relevant philosophical hermeneutics interviewing techniques are discussed later in this chapter (see section 3.5.2).

3.4: Research design

Research design refers to the plan for conducting a study, including the data collection procedures and ethical considerations during all phases of the research process (Creswell, 2003). Gerson and Horowitz (2002) noted that there is no definite right or wrong approach to any research, but researchers have to use an approach that is able to offer them relevant answers to their research questions. Additionally, research design is also based on the nature of the research paradigm being used in a study (Creswell, 2014). For Draper (2004), research design is concerned with the practical arrangements of getting an answer to the research question. Thus, in this study, the research design includes the research location and participants, how the sample was identified and recruited, the data collection process, an overview of data analysis, and ethical considerations.

The primary research question of this study asks how students conceptualise technology through their experiences of technology inside and outside school, with the aim of gaining an in-depth understanding of technology. Therefore, the researcher aims to understand what technology means to them. The research adopted lesson observation and individual and group interviews with students (Greene and Hill, 2005), with the aim of capturing rich and wide-ranging accounts of the students' experiences of technology.

Given that this study aimed to gain a better understanding of the students' experiences of technology, the researcher was required to listen more, talk less and ask questions that could help him to address the research questions (Westcott and Littleton, 2005). This view is supported by Miles and Huberman (1994), who suggested that the researcher should aim to collect rich data about experiences that the participants wish to share. This requires the researcher to be immersed in the issue of sample size.

3.4.1: School sample size issue

The researcher was aware that the sample for the study needed to be as large as possible, and yet in order that the study could be resourced, particularly in terms of time, two schools were chosen. However, the researcher's decision to use two schools was somewhat unintentional. Initially, the researcher wanted to work with three schools, which were the only ones within a reasonable commuting distance on public transport for the researcher. However, two schools agreed to participate and were recruited for the study. It was considered that understanding them would lead to a better understanding of, and perhaps better theorising about, a still larger collection of cases (Stake, 2006), and, as noted previously, it was felt that a richness of data could give each case additional depth (Cohen et al., 2009). Another significant element in this decision was how periods of extended travel would affect the costs of potential expenses, which, according to Kvale (1996), are frequently overlooked during the research design stage.

School selection

School selection was based on convenience sampling (Etikan et al., 2016), because the schools were within a reasonable commuting distance on public transport for the researcher. Both schools were within 30 kilometres of each other and easily accessible by the researcher using public transport. This sampling technique is consistent with Khunyakari et al. (2009) and Robinson (2014), where samples were selected because of their convenient accessibility and proximity to the researcher. In this study, the process of selection involved requesting permission from the Ministry of Education of Delta State to gain access to secondary schools to conduct research in education, because the location of this study was the Delta State region of Nigeria (Appendices A, B1 and C1). Access was granted following the submission of a letter in which the researcher explained the nature and purpose of the research, in addition to clarifying the ethical considerations followed throughout the study (Appendices B2 and C2).

Sample school characteristics

To preserve anonymity, the two schools will be referred to henceforth as Ekete and Nwanne. Using such coding allows the researcher to form a simple system in which it is relatively easy to identify the school a student attends or a teacher works in. Both Ekete and Nwanne are co-educational schools and operate the basic technology curriculum for upper basic education (JS1–3) (Federal Government of Nigeria, 2008). The National Policy on Education suggests a maximum technology class size of 40 students in JS. Teaching is based on a syllabus and detailed teacher's guides produced by the curriculum development centre of the Nigerian Educational Research and Development Council (NERDC). However, teachers are encouraged to enrich the contents with relevant materials and information from their environment, adapting the curriculum to the students' needs and aspirations.

Ekete is, by Nigerian standards, a large (n = 900) comprehensive secondary school that was established in October 1983. It is located in an urban area with approximately 363,000 inhabitants (Okali et al., 2001). In Ekete, class sizes range from 36 to 40 students and there are 14 classes in JS years 1–3 (JS1 n = 5 classes, JS2 n = 5 classes and JS3 n = 4 classes). Each class is allocated two lessons (a total of 70 minutes) of technology subjects per week.

Nwanne is a small (n = 194) secondary school established in 1963 and based in a rural area with approximately 4,000 inhabitants (Okali et al., 2001). Class sizes range from 15 to 20 students and there are nine classes in JS1–3 (JS1 n = 3 classes, JS2 n = 3 classes and JS3 n = 3 classes). Each class is allocated 70 minutes in total of technology lessons per week. An overview of Ekete and Nwanne is presented below (Table 3.1).

Table 3. 1 Summary of sample school characteristics

School	Location/type	Size 2013/2014	Age range (years)		Time allocated to technology lesson per class / no. teachers
Ekete	Urban/co-educational	900	11–17		
		JS1–3 538	11–14		2 lessons (70 mins) per week
		SS1–3 362	15–17		4 technology teachers
Nwanne	Rural/co-educational	194	11–17		
		JS1–3 110	11–14		2 lessons (70 mins) per week
		SS1–3 84	15–17		1 technology teacher

3.4.2: Student sample size issue

Eight students per school were recruited for this study because the principals in each of the recruited schools restricted the number of students the researcher could work with to eight, because they did not want to overly disrupt the normal life of the year group. One principal had only wanted to allow five students, and the other principal wanted to allow six students. However, the researcher, with the support of the heads of the technology education departments, persuaded the principals to increase this to eight. Had the researcher had more money and more time available for data collection, he would have gone into more schools, which would have meant working with more students and teachers. Therefore, the small sample size adopted in this study was because that was as strong a sample as could reasonably be achieved in the circumstances because of the constraints explained above (the number of students being restricted by the principals of the participating schools); however, the information gained provided an informed picture of students' perceptions of technology.

Using a small sample size might have weaknesses, as some authors (Yin, 1994; Stake, 2006) have claimed. However, Sandelowski (1995) argued that deciding on an adequate sample size in qualitative research "is a matter of fitting the sampling strategy to the purpose of and method chosen for a particular study" (p. 182). Sandelowski (1995) further suggested that sample size should be determined by the intended research analysis. In this study, the research was concerned with getting rich and detailed accounts of students' experiences of technology. Therefore, the small sample size adopted in this study had the potential to adequately answer the research questions the researcher sought to answer. It was considered that a minimum of two interviews (individual and group) was appropriate for this study, with a range of perspectives likely given the strategic split. The researcher relied on the conviction that what was of interest to the researcher and this study was detailed accounts of the meanings which students give to their experience and conceptual understanding of technology; their apparent ability to make connections between their experiences of technology inside and outside of the classroom; how they talk about technology; what happens in learning technology; their participation in learning; what the students learnt; student motivation; what teachers do in the classroom; and what teachers actually did in teaching technology. This involved eliciting the thoughts and intentions of the teachers and students to gain a wide range of accounts of their experiences, which might help explain how students learn technology. The student sample size for this study therefore had the potential to address the research questions that this study aimed to answer.

Student selection

A purposive sampling technique was used to select 16 students in order to address the research questions (Miles and Huberman, 1994; Marshall and Marshall, 1996; Gentles et al., 2015), which is above the minimum recommended number for qualitative study (Dworkin, 2012). The student sample comprises eight students (four males and four females) from each school, because the principal in each of the recruited schools had restricted the number of students. The students are aged between 12 and 14 years, which is the age when organised formal technology education is introduced to most students at JS level (Opoola and Adeniyi, 2013; Igbokwe, 2015). The selection of this age group was consistent with Hill (2005), who suggested that children in this age group can make judgements and thus can meaningfully participate.

The criteria that governed student selection were the following:

(1) The research questions the researcher sought to address, as suggested by Marshall and Marshall (1996), who argued that in purposeful sampling, researchers should actively select "the most productive sample to answer the research question" (p. 523).

(2) Those willing to provide the information, as willingness is an important factor in sharing knowledge or experience (Palys, 2018). This criterion relates to the researcher's desire to explore the knowledge and understanding that shapes students' perceptions of technology. This approach is consistent with Gentles et al. (2015), who stated that "the logic and power of purposeful sampling lie in selecting information-rich cases for in-depth study. Information-rich cases are those from which one can learn a great deal about issues of central importance to the purpose of the inquiry" (p. 1,778).

The researcher was aware that accessing information from students aged between 12 and 14 years would be problematic (Hill, 2005). However, the researcher made clear that students had the option not to be involved in the study, and informed consent was obtained from the students and their parents or guardians before they participated. The selection began with two students, a male and a female, from each of the JS1, JS2 and JS3 class groups (Table 3.2). As the researcher had not met previously with the students, the teachers were best placed to choose the participants. Students were selected by the class teachers on the basis that they were willing to participate, gave their informed consent and had parental approval. The researcher ensured that the teacher was aware that a student might be keen to participate initially but might subsequently want to withdraw. Therefore, it was important that their parents gave their consent, in line with Hill (2005), who suggested that researchers reach an agreement with parents or guardians about their children taking part. Once the two students from each year group were selected, in order to make the number up to the required eight, it was decided to use a random sampling technique to select another two (a male and a female) from any class of JS1–3 to ensure an equal gender split. For example, in Ekete, the male was in JS1 and aged 11–12 years, and the female was in JS2 and aged 12–13 years. A similar process was adopted for Nwanne, and the two students selected were a male aged 12–13 years in JS1 and a female aged 12–13 years in JS2 (see Table 3.2 below).

Table 3.2 Summary of number of student participants and selection procedure

Students at Ekete (Male=M, Female=F) (Class, gender, age range (years old), sampling technique, total number of students from each class)			Students at Nwanne (Male=M, Female=F) (Class, gender, age range (years old) sampling technique, total number of students from each class)		
JS1 1 x M (12–13) 1 x F (12–13) [Purposive sampling]	JS2 1 x M (12–13) 1 x F (12–13) [Purposive sampling]	JS3 1 x M (13–14) 1 x F (13–14) [Purposive sampling]	JS1 1 x M (12–13) 1 x F (12–13) [Purposive sampling]	JS2 1 x M (12–13) 1 x F (12–13) [Purposive sampling]	JS3 1 x M (13–14) 1 x F (13–14) [Purposive sampling]

1 x M (11–12) [Random sampling]	1 x F (12–13) [Random sampling]		1 x M (12–13) [Random sampling]	1 x F (12–13) [Random sampling]	
Total: 3 = 2 x M, 1 x F	3 = 1 x M, 2 x F	2 = 1 x M, 1 x F	3 = 2 x M, 1 x F	3 = 1 x M, 2 x F	2 = 1 x M, 1 x F
Total students recruited = 16					

The researcher was constrained by the number of students allowed to participate in the study. However, once the researcher was satisfied that the students were within a similar age bracket (12- to 14-year-olds) and technology education was compulsory for them in JS1–3, it was felt that eight students was sufficient to conduct the research interviews, since the aim was to get rich, thick accounts of their experience of technology. In addition, the related strength of this sample size is that the researcher believes the number of participants will facilitate the researcher’s close association with the students and enhance in-depth inquiry in naturalistic settings. Pseudonyms are used to ensure confidentiality. Each student is referred to first with either ‘E’ for Ekete or ‘N’ for Nwanne, followed by a letter of the alphabet that represents their name, and finally JS1, JS2 or JS3, which refers to their class group in school. A summary of the students’ selection procedure is presented in Table 3.2 above.

Several debates surround the appropriate sample size for qualitative research. For example, Mason (2010) argued that an adequate point would be reaching the point of saturation – at which the data collection process no longer offers any new or relevant data. For Bowen (2008), the saturation point in qualitative research refers to when there is enough data to ensure the research questions can be answered. Furthermore, it could be argued that adhering to the saturation point can be influenced by some factors beyond the researcher’s control – for example, ensuring in-depth examination of concepts or ideas that are potentially critical for emergent findings (Marshall et al., 2013). Marshall et al. (2013) explained: “While qualitative methodologists are unlikely to agree on exact sample sizes needed for qualitative studies, they generally agree that a number of factors can affect the number of interviews needed to achieve saturation” (p. 10). In contrast, Dworkin (2012) suggested that anywhere from 5 to 50 participants, based on interviews, helps to penetrate social life beyond appearance and manifest meanings in any qualitative research, while Crouch and McKenzie (2006) proposed that fewer than 20 participants in a qualitative study helps a researcher build and maintain a close relationship, thereby improving the open and free exchange of information. The researcher adopted these lines of argument as the basis for this study’s sample-size consideration.

3.4.3: Teacher sample strategy

It is believed by authors (Birch and Ladd, 1998; Wubbels and Brekelmans, 2005; Darling-Hammond, 2006) that the nature and quality of teacher interactions with students can be significant for student learning. This made the researcher think about gaining insights into what teachers were doing to engage students in the learning process. Consequently, it was decided to recruit teachers for this study to gain their perspectives, which could help to throw light on students’ accounts of their experiences in the classroom.

The teachers who participated in this study were selected opportunistically (Patton, 1990), though there was an element of purposive sampling, since the researcher ensured that they taught technology as a curriculum subject in their school. The researcher met these teachers for the first time in the participating schools and explained the purpose of their involvement in the study if they decided to participate. Thereafter, they agreed to participate in the study by returning their signed consent forms. When this study was conducted in May 2014, there were no female technology teachers in the schools. There were four technology teachers at Ekete and just one at Nwanne. Both school and teacher names are pseudonyms to preserve anonymity. The teachers' pseudonyms are preceded by a letter that represents the school they work in – that is, 'E' represents Ekete and 'N' represents Nwanne. The following is a brief summary of their qualifications and teaching experience. EJohn holds a B.Sc./Ed. degree in science and education and has approximately 16 years' experience of teaching technology. He teaches metalwork and technical drawing across JS1–3 classes. EOkpaku has a B.Sc. in Engineering and worked as an engineer for 10 years before entering the teaching profession. EOkpaku has approximately five years' teaching experience and teaches applied electricity and electronics across JS1–3 classes. EOgodo holds a B.Sc./Ed. degree, has approximately three years' teaching experience and teaches woodwork across JS1–3 classes. NAndrew has a B.Sc. in Engineering and five years' teaching experience. NAndrew is in charge of all activities in the technology education department and teaches all technology subjects (metalwork, woodwork, technical drawing, applied electricity and electronics) across all classes in JS1–3.

3.5: Data collection design

Data collection in research is important and researchers are responsible for selecting the most appropriate tool for their specific study (Dawson, 2002; Wilkinson and Birmingham, 2003; Almalki, 2016). The rationale for selecting the data collection method used in this study rather than alternatives was born out of the intention to generate in-depth knowledge about students' experiences of technology that would help to answer the research questions. In order to select the most appropriate tools for data collection in this study, the researcher examined the three most common data collection methods, namely, quantitative, qualitative and mixed methods (Barbour, 1999; Johnson and Onwuegbuzie, 2004; Flanagan, 2013). Based on their strengths/limitations, the qualitative data collection method was adopted, because qualitative data provides opportunities to understand any phenomenon in its context and in detail (Cardon, 2000; Creswell and Creswell, 2017).

The selection of data collection methods for this study – lesson observations and interviews – was guided by the research questions (detail is presented in sections 3.5.1 and 3.5.2). One technique the researcher initially thought about using alongside lesson observations and interviews was videotaping, to provide a basis for reflection (Liang, 2015; Walker and Boyer, 2018) or to reawaken memories of what happened in the classroom. This could have helped the researcher to explain the research questions – for example, when something may have been conducted in silence that was of interest (Jewitt, 2012). However, the literature on the use of videos for gathering research data states quite clearly that it requires time to introduce it because of issues of reliability, it can be costly (Quinn et al., 2002; Tessier, 2012), it requires specific informed consent (Otrel-Cass et al., 2010) and it requires software to analyse the data (Asan and Montage, 2014). Also, analysis can tend to focus on short segments of video or lead to overly descriptive and weak analysis (Jewitt, 2012) and therefore has the potential to exclude an enormous amount of information. Therefore, simply making a video does not guarantee easy access to understanding expression of feelings or ideas and hence meaning (Otrel-Cass et al., 2010). Rather, the use of video adds greater complexity to the research process (Chan, 2013). Consequently, the researcher, in consultation with his supervisors and after evaluating both the advantages and challenges, including the legal and confidentiality processes, technical aspects, the time needed to familiarise himself with the video camera's various settings and data analysis issues, felt that videotaping was not a desirable choice. Table 3.3 provides an overview of the data collection design and specific data collection methods. As can be seen in Table 3.3, the data set is collected as part of the data collection design. The data collection process in both schools was of approximately eight weeks' duration in total – four weeks in each school, with visits lasting a maximum of two hours.

Table 3.3 Overview of data collection design

Research question	RQ rationale	Data set and source	Data set rationale
RQ1: How do students conceptualise technology in their everyday lives outside of school?	To gain insights into how students talk about technology in their everyday lives outside school	Student one-to-one interviews	To get ideas about their thought process when they conceptualise technology: how they reflect on their experiences of technology using their personal accounts of their experience of technology, which they might have taken for granted, or those things that are common in their daily life and can help the researcher to understand how concepts of technology are framed when they talk about their experience of technology
RQ2: In what ways and to what extent, if any, does students' experience of technology align with their learning about technology in the classroom?	To gain insights into what technology means to students given their experiences of technology in the classroom	1. Lesson observations 2. Student-group interviews 3. Teacher one-to-one interviews	1. To get a sense of what teaching and learning technology look like, which the researcher might explore during teacher one-to-one interviews and group interviews with students 2. To gain a wide range of students' accounts of their experiences in school classrooms 3. To gain insights into understanding how teachers view their technology lessons

Although it would have been possible to use quantitative data, Atieno (2009) claimed that all quantitative data is limited in nature, as it looks only at one small portion of a reality that cannot be split without losing the importance of the whole phenomenon, and data analysis is most likely restricted by the lack of details, as responses are imposed on the respondents based on the selection made by the researcher. For example, to understand how students develop a sense of technology from the teaching approach taken by their class teacher, a survey that includes fixed responses, such as a simple ‘yes’ or ‘no’, might not provide data that enables a detailed level of discussion, because we may not know how different respondents were interpreting the data.

Similarly, the reason that the researcher did not use a mixed-methods data collection approach was because the study is grounded in an interpretive paradigm that was designed to explore, in as much detail as possible, a smaller number of instances or examples that are seen as being relevant to the study’s research questions and to uncover information that is probably not accessible when the potential response to a question is predetermined (Atieno, 2009). For example, a survey question might ask: What do you understand by the term technology? Tick all options that apply from the following list. If ‘Other’, please state what this is. Since the researcher does not want to miss out any options that s/he had not thought about or that are not in the literature, the researcher in such study might include an open question, labelled ‘Other’ (Couper, 1997; Cohen et al., 2009). This means respondents can write anything in the space provided. Data analysis might show that respondents had entered information that the researcher (who designed the survey) may not have thought about, because such responses may not have been anticipated when creating the survey. Hence, in this study qualitative data was preferred in order to gain greater insights into the meaning of the data, including the participants’ intentions and the reasons they gave for their interpretations.

3.5.1: Lesson observations

This study involved the observation of a technology lesson for each of the four teachers. The purpose was to help the researcher to capture a sense of students' engagement in teaching and learning, which the researcher might explore during the interviews with teachers and students. The rationale was to be able to better describe what technology education looks like. This could include the activities (if any) in which students were involved and the settings (classroom or laboratory) in which these activities took place. To achieve this, the basic technology curriculum (FME, 2007) was used to gain insights into the topics taught, since the curriculum represents the students' guide to learning in technology. The researcher observed six routine lessons of 70 minutes' duration across three classes (JS1–3) in both schools (Table 3.4). For every lesson, field notes were made as soon as possible after the observed lesson to ensure as accurate a record as possible was made (Ostrower, 1998). During the lesson observations, the researcher adopted the role of a non-participant observer (Ostrower, 1998), given that the reason for observing the class was to gain insights into the activities through which students learn technology in the classroom and not to take an active part in teaching and learning. Throughout all the lesson observations, the researcher remained at the back of the class to try to preserve the normal classroom situation as much as possible (Singleton Jr et al., 1993) and took notes about what students were doing to have a first-hand view of the event or situation in the classroom.

3.5.2: Interviews

Interviews can be a great way to elicit rich, detailed first-person accounts of experiences and phenomena under investigation (Rowley, 2012; Seidman, 2013). Rowley (2012) noted that the main advantages of interviews as a method of data collection are that the research objectives centre on understanding experiences, opinions, attitudes, values and processes to obtain detailed information. Additionally, Seidman (2013) noted that interviewing provides access to the context of participants' behaviour and thereby provides a way for researchers to understand the meaning of that behaviour. Based on the advantages interviews provide, it was decided to use interviews for data collection in this study because of their ability to get details of the students' experiences of technology and the meaning the students make of the experience. To achieve this, it was decided to use semi-structured interviews with follow-up questions rather than focus group interviews, because it was assumed that focus groups might not yield a wide range of views and might give less detailed data. A semi-structured interview, on the other hand, would give more depth and detail with the same number of individuals, because responses from participants may vary (Cohen et al., 2009). Discussion in the interviews was recorded for purposes of transcription later. All 16 students and four technology teachers took part in the interview sessions. The interview period was about eight weeks in total, with four weeks in each school, and activities during each visit lasted no more than two hours (Table 3.4).

Table 3.4 Summary of schedule of lesson observations and interviews

<table>
<tr><th rowspan="3">Week</th><th rowspan="3">Ekete = E
Nwanne = N</th><th rowspan="3">No. of lesson observations</th><th colspan="3">No. of interviews</th></tr>
<tr><td colspan="2">Student</td><td rowspan="2">Teacher
(One-to-one)</td></tr>
<tr><td>One-to-one</td><td>Groups</td></tr>
<tr><td>1</td><td>E</td><td>1</td><td>3</td><td rowspan="3"></td><td>1</td></tr>
<tr><td>2</td><td>E</td><td>1</td><td>3</td><td>1</td></tr>
<tr><td>3</td><td>E</td><td>1</td><td>2</td><td>1</td></tr>
<tr><td>4</td><td>E</td><td colspan="2"></td><td>2</td><td rowspan="3"></td></tr>
<tr><td>5</td><td>N</td><td>1</td><td>3</td><td rowspan="3"></td></tr>
<tr><td>6</td><td>N</td><td>1</td><td>3</td></tr>
<tr><td>7</td><td>N</td><td>1</td><td>2</td><td>1</td></tr>
<tr><td>8</td><td>N</td><td colspan="2"></td><td>2</td><td></td></tr>
</table>

Student one-to-one interviews

The researcher conducted 16 one-to-one semi-structured interviews with students, each lasting approximately 15–25 minutes, with the aim of eliciting information directly from students in relation to their use of technology. The student one-to-one interview was concerned with gaining a better understanding of students' experiences of technology in their everyday lives. The researcher wanted to find out how their experiences had impacted the ways they talk about technology and why, wherein the goal of the researcher was understanding meaning and making sense of the experience. Thus, topics were explored according to the insight they may offer the conversation. A conversational technique related to what Vandermause and Fleming (2011) referred to as a "philosophical hermeneutic interview" (p. 369) was adopted to elicit a description of the respective topics. As Vandermause and Fleming (2011) further elaborated, this type of interview

> "is distinctively different from other forms of interviews, where representation of events in a journalistic fashion is sought. The hermeneutic interview, by contrast, relates to a phenomenon that has to mean in itself, may be variously interpreted, and elicits understanding by its very nature as a description of significance" (p. 372).

Similarly, Kafle (2013) noted that hermeneutic phenomenology is focused on subjective experiences of individuals and groups, assuming that it is the human mind that actively gives meaning and that description itself is an interpretive process people use to tell stories of their experiences. Therefore, the phenomenological hermeneutic interview technique was employed in this study to encourage the student to reflect on situations and think about contexts that they could grasp easily and that they might not normally be mindful of or otherwise consider. Also, the interview situation would not only provide flexibility in discussing what particular instances come to mind and the reasons for the use of words in a particular context, but would also allow information to be gained about a student's understanding in situations where the student is unsure how to describe an instance of the concept under consideration. If these views are accepted, then it would appear desirable to investigate students' understanding of basic concepts of technology for a number of reasons. Firstly, a student may not understand the concept in the way it is intended in the communication; alternatively, the student may understand the intended concept, but the particular context may evoke a different interpretation of the concept. A variety of such instances would then give some indication of the understanding and type of understanding a student is likely to have when reading a textbook or listening to a lesson where the word/concept is used. For example, the word 'pen' may evoke the concept of 'a small enclosure' or a 'fountain pen', rather than 'a writing instrument that uses ink'. Apart from the problems of a student not understanding a concept, this means that these additional problems can create hidden learning difficulties. Secondly, there is the student's actual domain of understanding of a particular concept in situations where the concept is explicitly specified by a given formal statement or definition, for example via a teacher or textbook, which is accepted by the student as a definition that he understands. In this case, the student would probably be influenced by their perception of what the researcher required, rather than by their own conceptual understanding. Thus, the focus of attention shifts from external manifestations to an 'experience', to an 'interior' perspective.

The possibility of eliciting crucial information (emotions, conceptions) in interviews through stimulus material has already been valued and employed by previous researchers (Jones, 1997; Twyford and Järvinen, 2000; Davis et al., 2002; De Vries, 2005), who noted that the stimulus material is not the focus of the interview; it is a useful resource which serves as a springboard for thinking. This is analogous to a role-play task where students would likely play out solving technological problems. If the role play becomes all about having fun, with insufficient deeper questioning, then even though the lesson may be memorable, the learning point might fizzle away. Drawing on this line of thought, the researcher provided students with a mobile phone as a chosen example/stimulus on the basis that previous studies (Jones, 1997; Twyford and Järvinen, 2000; Davis et al., 2002; De Vries, 2005) showed that referring to an object, often a modern communication device, is the most common way of describing technology. If the topic of research concerns an object of interest to the interviewee, what is evoked in a student's mind through the researcher's deep questioning can often serve as a door opener. This is not usually considered irritating or confrontational by the student respondent, so it rarely forces the student into a defensive or artificial position. This contrasts with a situation in which an interview is just verbal and without stimuli.

All student one-to-one interviews took place in the technology workshop of the respective school with the teachers' permission. The only available periods for student interviews were during their lunch breaks (between 11.05am and 11.35am). Students seemed content to spend their lunchtimes being interviewed. Students appeared relaxed during the interview sessions. The researcher took the position of active listener while acknowledging that the participant is the expert on the topic being discussed (Magnusson and Marecek, 2015).

Student one-to-one interview protocol design rationale

The rationale for the design of student one-to-one interview protocol was to ensure the interview questions were able to elicit rich and in-depth information about students' knowledge and experiences of technology as it appears in their consciousness (Moustakas, 1994). Consciousness here literally refers to what comes out of their mind that makes the experience of technology unique for them. Thus, in designing the student one-to-one interview protocol (Table 3.5), the researcher was guided by using aspects of a phenomenological approach to search for meanings and essences of experience through first-person accounts in informal and formal conversations and interviews consistent with the philosophy of phenomenology. Moustakas (1994) noted that phenomenologists attempt to look at things openly and assume that meaning is created when the object as it appears in our consciousness mingles with the object of nature: "what appears in the consciousness is an absolute reality while what appears in the world is a product of learning" (p. 27). Thus, the phenomenologist sees truth as a relation between different types of appearance (Moran, 2001). For example, the meaning of an object could be revealed by the person's motivation to make extraordinary efforts to better understand the phenomenon, using the meaning of the object as a learning strategy. Therefore, in this study, the rationale for the design adopted for the interview protocols is to discover the students' underlying subjective experiences of technology as it appears in their consciousness. This could include, for example, their intentionality and specific connections between something they did and the resulting consequences, so the two become their experience of technology. In this case, intentionality suggests that whenever there is consciousness, it is always an awareness of something. In other words, consciousness cannot be empty. This meaning assigned to the term 'intentionality' differs from that used in everyday life; for example, you intend to go to America on holiday next summer. Rather, the intentionality referred to in the design of the student interview protocols concerns the consciousness of something, the way things manifest that may take on different shapes and forms. They could be mental, objective, logical or emotional (Moran, 2001). For example, imagine something happened accidentally or by chance because it was not intended, and that yielded the ability to think differently but with the consciousness of that thing in play. During an interview session with a student in this study, he initially said he did not have a mobile phone. However, he went on to speak about his experience of a mobile, because he accidentally found his mum's rejected mobile phone, replaced the battery and started to use it. Two key features (consciousness and intentionality) arguably form the background to that brief story. Firstly, the student was not looking for a mobile phone but got one by chance (object intention here is exemplified by a physical object, in this instance a mobile phone). Secondly, the student reflected on the object intention based on his consciousness, which could be exemplified by thoughts and feelings. Thus, intentionality and consciousness arguably are related. Therefore, from the examples above, it could be argued that his unique experience of technology could be linked to his belief that if he fixes the mobile phone, then he can keep it for his personal use at his convenience.

Table 3.5 presents the interview protocol, with a few semi-structured questions that defined the areas explored but also allowed for divergence and/or follow-up questioning (Gill et al., 2008), which provided opportunities for the researcher to ask the participants for clarification when viewpoints seemed unclear or to probe any emerging issues (Bishop, 1997; Merriam, 1998). In some instances, the researcher followed up with a second and third question when necessary. For example, when a participant talked about using their mobile phone or a blender, the researcher explored with them what they did exactly. The researcher injected additional questions only to clarify the needed information, such as how did you do it? How would you describe what that means for you? How would you describe your feelings? (Gillham, 2005; Dawson, 2002).

Table 3.5 Student one-to-one interview protocol

1. Please may I know if you have a mobile phone?
2. Please can you tell me what you do with your mobile phone?

   Prompt: Do you enjoy it (or not)?

   Prompt: Please can you describe what you did exactly?

   Prompt: What was it like?

   Prompt: What did you feel when doing it?
3. If they said they did not have a mobile phone, then they were asked:
4. Is there any other gadget that you use at home that you would like to tell me about? I mean something like a computer. If they said yes, then they were asked:
5. Please tell me what you do with the computer? Follow-up probes included:

   Prompt: What stands out for you about the computer?

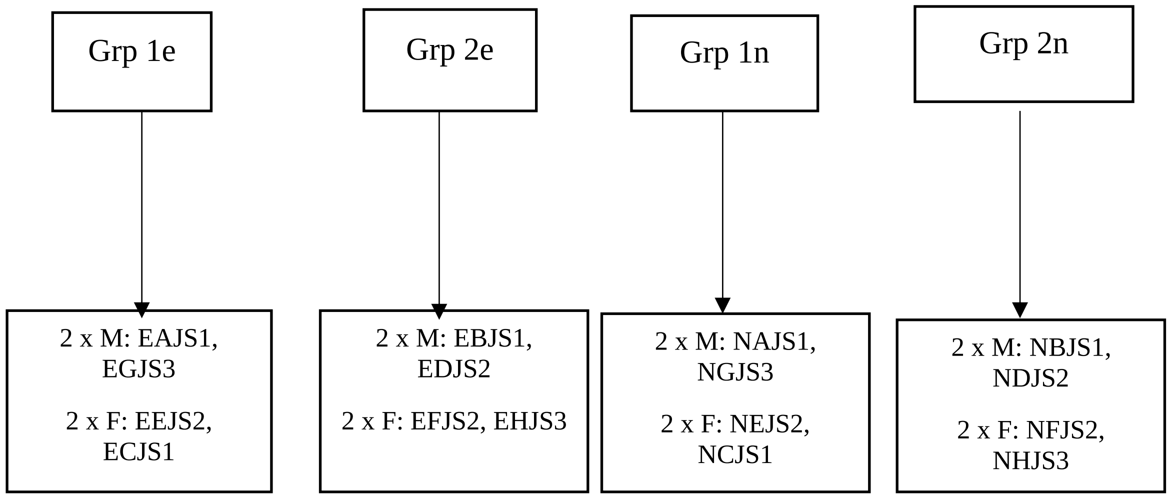
   Prompt: Please can you tell me about that? The final question was:
6. Is there anything else you remembered that you want to say?

Student group interviews

In this study, group interviewing was used with the aim of generating a wider range of data (Cohen et al., 2009). Also, the researcher wanted to learn from the students' reported experiences how technology lessons were enacted in their school and how the students achieved a sense of understanding. Although, initially, the researcher was worried about the small group size, he found that in some ways the small groups worked better due to time constraints and the amount of information that participants wanted to talk about. Morgan (1997) pointed out that small groups work best when the researcher wants to give participants more time to talk. Peek (2009) believed that a small group allows for more free-flowing conversations and also facilitates analyses that examine differences in perspective between groups. In light of those viewpoints, two groups of students were interviewed, each comprising four students – two males and two females per group (Table 3.6). The size of the group also facilitated discussion, as this seemed to embolden the participants to make statements that they may not have disclosed in an individual situation or in the presence of their teachers. The researcher invited all 16 students who were individually interviewed to participate in the group interview session, because they all learn technology in the classroom, and the researcher had the opportunity to observe their technology lessons at different visits to each of the schools. Group names were Grp 1e, Grp 2e, Grp 1n and Grp 2n. The number '1' or '2' differentiates the two groups in each school, and the letter 'n' or 'e' represents the school.

Each interview lasted 15–25 minutes and was held in the school technology workshop. Before commencing the interview, the researcher told each group of students about the nature of the interview, with the aim of making the students relaxed as well as giving the group the opportunity to ask the researcher questions, although none were asked. The researcher explained to each of the student groups that the group interview was different from the individual interview that they had earlier, given the likelihood that they might be talking about technology rather than their technology lesson. The group interview questions (Table 3.7) were semi-structured, because the researcher was trying to gain a wide range of descriptions from students' experiences. The researcher read the question, and by a show of hands, the researcher gave the participants the opportunity to address the researcher and the group about his or her views about the question asked. The researcher ensured every student was able to speak on every question the researcher asked to give everyone an opportunity to recount their experience of their technology lessons. If a participant varied in his or her choice of words – for example, talking about technology rather than technology lessons – the researcher pointed that out and explored that variation with the participant. Towards the end of the interview, the researcher encouraged the participants to bring up topics or questions of their own. The rationale for this was to empower them to talk about anything that related to their technology lessons that the researcher may not have asked.

Table 3.6 Student group interview arrangement



Student group interviews protocol design rationale

The protocol for the student group interviews was structured in the manner presented in Table 3.7 because the researcher wanted to gain insights into students' learning experiences, which may have influenced their perceptions of technology. This contrasted with the student one-to-one interviews, in which questions were focused on students' individual everyday experiences of technology. Therefore, the purpose of the student group interview protocol was to guide the researcher to ask questions focused on technology lessons. This was consistent with van Manen's (1997) view that the role of the researcher in a hermeneutic interview is to keep the interviewee focused on the topic being investigated.

Table 3.7 Student group interview protocol

1. Please can you tell me a bit about your technology lessons?

2. How do you feel about the lessons?
3. What did you enjoy or not enjoy about that experience?
4. Please tell me how you felt about that?
5. Please can you tell me what you enjoy or don’t enjoy about the lessons?
6. What do you find interesting about the lessons?
7. How do you think the lessons will be useful to you – now or in the future?

   Prompt: Why? / Why not?
8. How do your technology lessons relate to your everyday life?

   Prompt: Please can you tell me about any lessons where this happened?
9. Please feel free to tell me anything else you want to tell me about your technology lessons.

Teacher one-to-one interviews

The researcher conducted interviews with four teachers about what and how they think about their technology classes. Teachers were flexible with the time of interview sessions. In both schools, teachers were interviewed in their offices. Each teacher was interviewed for about 30 minutes regarding their teaching of technology immediately after the researcher observed the teacher’s lesson. Incidentally, this study was not designed to investigate teachers’ practices directly through lesson observations, or to assess their confidence in teaching technology given that teachers are experts in their subjects. The interview questions were formulated to focus on teachers’ thoughts about their lessons. It was also not the intention to report their behaviour to the school administrators. During the interview, the researcher pointed out to the teachers that he involved them as co-participants in the research, where observations are shared and the reasons for certain observed behaviours or activities are discussed (Given, 2008). Therefore, the purpose of involving the teachers in this study was to get them to discuss their technology lessons, in order to provide insights into how their typical technology lessons looked. The researcher did not request the teachers' views regarding the meaning or understanding of technology as a subject. Rather, the questions focused on teachers' thoughts about their lessons. Table 3.8 presents the protocol for the one-to-one teacher interviews.

Teacher one-to-one interview protocol design rationale

The design rationale for the teacher one-to-one interview protocol was to gain insights into understanding how they viewed their technology lessons. This was important, because when analysing data collected from the student group interviews, which focused on their understanding of what they do in the classroom, the teacher data could serve to corroborate their testimony.

Table 3.8 Teacher one-to-one interview protocol

1. How do you feel your lesson went?

   Prompt: Was that how you hoped it would go?

   Prompt: Did it go as you wanted?

2. Would you say this lesson was typical of your lessons?
3. Can you tell me about your thinking behind doing it this way?
4. Did the students get out of the lesson what you wanted them to learn?
5. Anything else you would like to tell me about teaching technology?

3.6: Pilot study

Van Teijlingen and Hundley (2001) described a pilot study as a mini version of a full-scale study that is intended to ensure that methods or ideas work in practice. Seidman (2013) suggested that researchers test their research design to gauge their ability to conduct studies and to come to terms with practicalities. Pilot studies therefore offer an opportunity for the researcher to test a research protocol such as a data collection method (Kim, 2010). A pilot study is valuable as it helps to assess whether the resources and environment for the study are feasible, because, as LaGasse (2013) reported, equipment failures can result in data loss. Therefore, assessing the resources can assist with future planning. Drawing on LaGasse (2013), the researcher decided to pilot the interview protocols designed for this study and also the audio recording device before they were used in the main study. The pilot study lasted two weeks.

Since the objective of the pilot study was to test the interview protocols and audio-recording device, it was felt appropriate to use one lesson observation, three one-to-one interviews, one group interview (comprising the same students as were involved in the one-to-one interviews) and one teacher interview (Lancaster et al., 2004; LaGasse, 2013). The lesson observation was intended to assess the researcher's observation techniques, while the aim of the interviews with the students and the teacher was to check whether they would understand the interview questions. In addition, the interviews tested the functionality and any potential practical constraints of the audiotape recorders (main recorder and back-up recorder). The technique adopted for the selection of the sample for the pilot study involved convenience sampling and purposive sampling (Etikan et al., 2016). The school was chosen for this pilot study based on the convenience sampling technique. Since the purpose of the pilot study was to test the interview questions and resources, it was convenient to use a readily available school which the researcher had already contacted and gained approval from. The selection of students was based on purposive sampling, because they were selected explicitly to encompass instances in which the phenomenon under study are likely to be found. The researcher began the process of negotiating what he would refer to as 'an interim consent' with the principal of one of the selected schools, Ekete, which was also used for the main study. This was followed by a similar arrangement with the head of the technology education department, in which the researcher outlined the broad aims and scope of the research. Through the interim consent, the researcher made a commitment that the participant's agreement was understood to be that they were only agreeing to take part in the pilot study. The researcher asked the head of the technology education department to recommend three students for the pilot study: one each from JS1, JS2 and JS3, comprising at least one male and one female in the interests of gender equality, who were within the age range of 12–14 years. The pilot study student group comprised two males, one from JS1 and the other from JS3, and one female, from JS2. All students who participated in the pilot were given a consent form which they returned with parental approval. The purpose of the interviews was explained to the students, and it was explained that participation was voluntary and that those selected for the pilot study would not participate in the main study. It was felt that failure to let them know that they would not participate in the main study after taking part in the pilot study would amount to concealing the real intention of the researcher. Once initial provisional consent was established, the researcher attempted to build a rapport with the participants by clarifying their right to withdraw at any time, and by encouraging them to speak out if they felt uncomfortable with the questions. Before piloting the interview questions, the researcher ensured the participants read and consented to the ethics requirements for the study. Nevertheless, the researcher ensured the pilot study participants were not treated any differently from those in the main study.

The selection of the teacher for this pilot study was based on convenience sampling, because the teacher was willing to participate in the study. Once the teacher had given his informed consent, the researcher observed his lesson, which lasted for 70 minutes, and then interviewed him immediately after the lesson. The interviews with students took place in the technology workshop during their lunch breaks, while the teacher interview was held in the teacher's office. The interviews lasted about 20 minutes each. At the end of each interview, a member check was made by giving the students and the teacher their transcripts of the interview data to go through, which the researcher received feedback on (Lagasse, 2013; Seidman, 2013).

In conclusion, considering that the students offered their lunch break as the only time available to them to participate in the pilot study, it was decided that the time (15–20 minutes) was reasonable, as this was above the recommendation for student interviewing by Cohen et al. (2009). The students and teacher responded spontaneously and did not ask any questions. It was clear from their feedback that they had no difficulty understanding the questions. Their understanding proved to be satisfactory. Throughout the pilot study, no observations or corrections were made regarding the wording contained within the interview questions. The pilot study also revealed that the audio tape recorders were effective, and while they picked up some background sounds, the clarity was sufficient to enable the researcher to transcribe the material unproblematically.

3.7: Data analysis overview

An aspect of a qualitative case study is the process of making meaning out of the data and interpreting what people have said and what the researcher has seen and read. The data analysis described in this study involved looking at what the participants said about their experiences of technology that was relevant to the research questions. Thus, the analytical procedure involved the researcher interpreting the meaning of what the participants said after the interviews. This entailed reading and rereading the transcripts to determine potential points of analytic interest, and then using key descriptive phrases to code the data set. The analysis proceeded through grouping like codes into larger themes based on the relationships among them. As a final step, the process involved engaging in detailed analysis of the data in each theme to refine categories, followed by a final refinement of the analysis that established the significance of the findings. To allow the researcher to examine the unit of analysis within the school, a two-stage analysis (within-case analysis and cross-case analysis) was adopted (Wells et al., 1995).

In the within-case analysis, Ekete and Nwanne were analysed separately as individual cases. In the cross-case analysis, findings from Ekete and Nwanne were compared, and similarities between the two schools were drawn across both cases. All interviews were transcribed by the researcher in a process that involved playing the audio tape data several times and incrementally transcribing the recording. The transcribed data material was imported into NVivo 12 software as a document source. Using the NVivo software facilitated coding in that coding stripes were made visible in the margins of documents so that the researcher could see, at a glance, which codes had been used and where (Bazeley and Jackson, 2013).

3.8: Research ethics

Ethical considerations are important in every research method involving human subjects (BERA, 2011). For example, concerning research that involves listening to children (Hill, 2005) noted that ethical considerations in researching children's experiences is different from or similar to researching with adults, and has implications for obtaining consent.

Given that this study is aimed at students, it has been important not only focus to consider what the research was about but also obtaining consents from the students. The researcher ensured the ethical guidance provided by the British Educational Research Association (BERA) (2011) and the University of Leeds Ethics Committee was adhered to at all times. As this study was focused on exploring student experiences, the main ethical concerns of this study involved:

1. Obtaining Disclosure and Barring Service (DBS) clearance. The researcher applied for and received a satisfactory disclosure check in relation to conducting research with children (enhanced certificate number: 001425810470).
2. Authorisation from the Education Social Sciences and Law, Environment and Leeds University Business School (AREA) Faculty Research Ethics Committee. Authorisation for the research was granted by the Faculty Ethics Committee of the University of Leeds, confirming a favourable ethical opinion relating to the study (ethics reference: AREA 13-048).
3. Permission and approval from the Ministry of Education in Nigeria and the principals of the participating schools. The researcher requested and was granted permission to carry out a research study on technology education in Delta State (Appendices B2 and C2).
4. Participants' rights. A written information letter and consent forms were given to participants who were willing to take part in the study so that their parents' or guardian's approval could be obtained. The researcher ensured that all participants and their parents or guardian gave their consent before taking part in the research. Consequently, where parents or guardians did not provide consent, the student was not eligible to participate in the study.
5. Anonymity and confidentiality of students and their families, schools, and teachers. Given that this study was not seeking to be judgemental or critical, but aimed to gain insight into students' experiences of technology, the research access to raw data was restricted to the researcher and his supervisors. All data collected was stored on the university's servers.
6. Confidentiality was respected, and so pseudonyms were used for all the participants and schools in this study, including tapes of interviews, transcripts and any other

information deemed necessary to protect the anonymity of the participants and schools. Data will be disposed of sensitively and securely once it is no longer required.

3.9: Trustworthiness issues

Trustworthiness can be used to evaluate qualitative inquiry (Shenton, 2004; Baxter and Jack, 2008). According to Lietz et al. (2006), trustworthiness does not just naturally occur but instead needs to be rigorous and explicit, such as established procedures that can assess the quality of work. Strategies to ensure the rigour of this study were member-checking, a dependability audit trail, thick description and inter-rater reliability. Practical examples of these strategies underpin the attempt to demonstrate the trustworthiness in this study. The researcher employed Guba's (1981) four criteria for assessing the trustworthiness of naturalistic inquiries, namely, "credibility, transferability, dependability and confirmability" (p. 80). The hope is that these will help the readers examine the evidence provided by the researcher. The applicability of these four criteria within this study is discussed below.

3.9.1: Credibility

The credibility of findings and interpretations of the various sources from which data were drawn in qualitative research is important in assessing trustworthiness (Guba, 1981; Lietz et al., 2006). This can be demonstrated through the process of member-checking, in which the researcher allows participants to read the transcription of their interviews to ensure that they have been accurately recorded and are therefore credible (Houghton et al., 2012). In this study, member-checking was conducted following transcription, so that participants could acknowledge and respond to their own words. The researcher gave participants the transcripts of their interview for verification, which they provided feedback on, indicating that shared discussions of the interview transcripts had been achieved. This strategy is recommended by Sandelowski (1993), Altheide and Johnson (1994), Koch (1994) and Stake (2006).

3.9.2: Transferability

Guba (1981) highlighted that a researcher should be able to demonstrate how the samples were selected and how they met the sampling criteria to establish any degree of transferability. The aim is to provide the information necessary to link to what seems appropriate both in the setting and in relation to the understandings the researcher hopes to generate by creating what Houghton et al. (2012) called "thick description" (p. 5). In this study, the different data sources used, such as the interviews (16 individual student interviews, four student group interviews and four one-to-one interviews with teachers) and the six lesson observations, not only helped to develop rich and thick descriptions of students' experiences of technology but also gave an element of trustworthiness to the findings that emerged.

3.9.3: Dependability

In this study, dependability is seen as an important issue. Guba (1981) noted that the way in which data is collected and decisions are made throughout the research process should be well reported in case others wish to replicate a study's methods in a different context. In this study, the researcher presented a detailed account of the rationale for the sample size of two schools with eight students per school, and the design of the student interview protocol. While this gives readers an idea of what the data is like, it also provides the reader with a basis to evaluate why the sampling was as strong as could reasonably have been achieved in the circumstances. On those grounds, the reader is given the opportunity to judge the trustworthiness of the interpretation presented in Chapter 4 (Horsburgh, 2003).

3.9.4: Confirmability

Guba (1981) suggested that to establish confirmability, a researcher should be able to "provide documentation for every claim from at least two sources" (p. 87) so that the accuracy of the data is evident (Houghton et al., 2012). Confirmability demonstrates that findings emerge from the data rather than the characteristics and preferences of the researcher (Shenton, 2004) or the researcher's preconceptions (Mack, 2010). This was achieved in this study by using the technique of inter-rater reliability (Armstrong et al., 1997). The process involved the researcher asking two PhD students to check whether the identified themes had been sufficiently represented in the original coding to ensure that no interview data had been omitted. Rather than come up with a list of themes, the consensus was reached through discussion between the two PhD students, who at this point constantly referred to the original transcripts. In this way, the shared experiences of students were highlighted, as well as unique occurrences. By this approach, it was not the standpoint of the researcher that created or interfered with the trustworthiness of the findings; rather, it was the findings derived from the data that were used that seemed to make the difference. This process is detailed in Chapter 4.

Chapter 4: Data analysis and findings

4.1: Introduction

The primary aim of this study is to answer the following two research questions:

> **1)** ***How do students conceptualise technology in their everyday lives outside of school?***
>
> **2)** ***In what ways and to what extent, if any, do students' experiences of technology align with their learning about technology in the classroom?***

Both research questions guided the analysis of the collected data. While searching for the most appropriate method of analysing the data collected in this study, the researcher considered Kvale (1996), who noted that:

> "there are no standard methods, no *via regia*, to arrive at essential meanings and deeper implications of what is said in an interview … The search for techniques of analysis may be a quest for a technological fix to the researcher's task of analysing and constructing meaning" (p. 180). (italics in original).

Drawing on Kvale's (1996) perspective and given that this study aims to explore and examine students' perceptions of technology and experiences of technology education, several components of data analysis were considered due to their close association and usefulness in addressing the research questions. For example, it was crucial to decide which data coding techniques would be used and how the data would be analysed in order to address the research questions. Consequently, the researcher considered Strauss and Corbin (1990), whose chapter on open coding provided the idea for the method used to code the transcripts in this study. Also considered were Braun et al. (2014), who explained how to develop themes using inductive thematic analysis techniques as integral elements of sense-making procedures. The analysis relies on data sets from the one-to-one interviews with students, the student group interviews, the one-to-one interviews with teachers and lesson observation file notes. The interviews were transcribed, and read repeatedly, for the purpose of getting to know them as a collective. Different interesting aspects were found in the transcripts. Since the aim of the study was to understand students' experiences of technology, this was the focus of the continuing analysis.

This study's analysis revealed evidence of the 'disconnect' between students' experiences of technology and their perspectives on technology, demonstrated in the two key points identified and described briefly below. The first relates to RQ1, which demonstrated that from the analysis of student one-to-one interview transcripts, there is evidence of a 'limited knowledge' of technology. The findings related to RQ1 revealed that outside the classroom, the students' dominant conceptualisation of technology can be summed up as technological artefacts such as mobile phones, personal computers, electric cookers, cars and refrigerators, either in terms of their function associated with their successful performance or their effect on society. In the literature review chapter, we saw that the term 'technology' has varied meanings. For example, Schatzberg (2006) reminded us that the term is viewed readily as both knowledge and making artefacts, and is fully consistent with its 19th-century meanings. In the same vein, De Vries (2005) noted that knowledge and artefacts in relation to technology are distinguishable and argued that they are integral aspects of conceptualising technology. Looking at Schatzberg's (2006) and De Vries's (2005) views suggests that students' experiences of technology are narrow. The interpretation can be better described in terms of a limited or lack of conceptual understanding of technology, which was reflected in their limited knowledge of technology when focusing on concepts of technology construed most generally to explain the characteristics of technology as identified in the literature (Ihde, 1979, 1990; Borgmann, 1984; 1992; Mitcham, 1994; Feenberg, 1995, 1999; Pitt, 2000; Vincenti, 1990; Hickman, 2001; Baird, 2004; De Vries, 2005). For example, De Vries (2005) gave prominence to four concepts:

technological artefacts, technological knowledge, technological processes and technology as a part of human existence.

The second point concerns findings pertaining to RQ2, which indicated that the students' experiences of technology 'do not align' with their learning experiences of technology in the classroom. Students organised their knowledge around their experiences of construction of angles and shapes, and projects that related directly to their interest and enthusiasm in the subject. Within the findings, there is evidence that revealed that the teaching and learning processes by which students learn about perspectives on technology are limited. This finding has demonstrated the potential required to make what students learn in the technology classroom connect with or be relevant to real-world knowledge, which is also underpinned in other subject areas. For example, from the perspectives of research on students' experiences of school science, Teo (2008) claimed that the disconnectedness that students experience between their school learning and their real-world experience could deprive them of the opportunity to make connections between their everyday and world knowledge experience – that is, the chance to think, reflect and develop ideas, and then to test their ideas within a practical context. The remaining sections of this chapter will introduce the data analysis procedures adopted for this study and provide an explanation of the detailed analysis.

4.2: Data analysis process

This study was designed to better understand how students interpret what technology means for them inside and outside of school. Therefore, the challenge for this part of the study was to analyse and interpret the data collected from the participants' accounts of their experience to answer the research questions, and not to prove or disprove a theoretical standpoint. Vaismoradi et al. (2013) noted that there are two types of approaches that can be used to conduct analysis of qualitative data (sometimes referred to as techniques, procedures or methods): qualitative content analysis and thematic analysis. Moreover, Vaismoradi et al.

(2013) argued that the boundaries between them in data analysis remain unclear. On the one hand, both are similar in that they share the aim of analytically examining narrative from life stories: for example, becoming familiar with the data and breaking the text into relatively small units is commonplace. On the other hand, they differ, as content analysis is used when the aim of the study is to validate or conceptually extend an existing theory or theoretical framework (Mayring, 2000), whereas thematic analysis involves identifying, analysing and reporting patterns (themes) within data. It minimally organises and describes the data set in (rich) detail (Braun et al., 2014). The process of thematic analysis can occur in two primary ways: inductively or deductively (Patton, 1990). Inductive analysis refers to the process of coding the data without trying to fit it into a pre-existing coding frame or the researcher's analytic preconceptions. In this sense, this form of thematic analysis is data-driven. In contrast, the deductive approach tends to be driven by the researcher's theoretical or analytic interest in the area. In this sense, the researcher is not seeking anything beyond the statements made by participants. Thus, this form of thematic analysis tends to provide a less rich description of the data overall. However, both techniques are discussed briefly below to establish the rationale behind the data analysis technique adopted in this study.

Choosing a data analysis process for this study

In order to find some way or ways to discover out what the researcher considered to be essential meaning in the interview transcripts, this study adopted the thematic analysis technique, because the researcher was looking for a technique that focused closely on the research questions and could be used to analyse both implicit and explicit meaning in the participants' own words or phrases. Therefore, the researcher noted the views of Vaismoradi et al. (2013), who suggested that the thematic analysis technique is flexible and can provide a rich and detailed yet complex account of data, and Braun et al. (2014), who stated that the process allows for searching for and identifying meaning within a data set. Moreover, they argued that by employing this technique, the trends and links in the data set can be viewed from different perspectives. Indeed, Vaismoradi et al. (2013) claimed that thematic analysis incorporates both manifest (explicit) and latent (implicit) aspects. Moreover, they argued that analysis of latent content is an inseparable part of the manifest analysis approach and helps with identifying and achieving a distinctive description of a phenomenon within a data set.

In this study, the researcher was able to draw on this perspective to focus on both implicit and explicit meanings to make sense of students' ideas regarding their perceptions of technology. For example, some students substituted words in place of the term technology. They did not understand that gadgets relate to technology in that gadgets are innovations of technology even when discussing technology and gadgets in the same way. To some extent, this was considered significant, as it represents a departure from focusing on the numbers recorded in quantitative analysis. Within this perspective, the researcher could view what students thought, felt or did in certain situations or at a certain point in time, which is an essential part of interpretation.

The process of thematic analysis involved grouping the data into themes that would help answer the research question(s) (Guest, 2012; Braun et al., 2014). Indeed, Maguire and Delahunt (2017) claimed that thematic analysis can be used with numerous types of qualitative data and with many goals in mind, because it offers a clear and usable framework. For example, it can provide basic insights into how words are used. However, Hsieh and Shannon (2005) noted that the findings from this approach could be limited due to inattention to the broader meanings present in the data.

On examining the content analysis technique, it became apparent that the final analysis would not be suitable for this study. According to Vaismoradi et al. (2013), content analysis is related to reporting the results within which the context of data is obvious – for example, to describe the characteristics of the document's content by examining who says what, to whom and with what effect. Therefore, it would be helpful to draw on a number of experiences from a range of sources relating to the content being analysed. Indeed, as noted by Cohen et al. (2009), one major challenge of this type of analysis is that it analyses only what is present rather than what is missing or unsaid. Moreover, they argue that researchers who employ content analysis often disregard the context that produced the text, as well as the status following the production of the text. Therefore, there is a tendency to allow for incomplete understanding of the context, thus failing to identify the level of depth of the respondents' accounts. This can result in findings that don't illuminate key issues for researchers, because they may not allow for determining any deeper meaning or explanation for the emerging data patterns. Thus, for the purpose of this study, the content analysis technique was rejected, as it was unlikely to yield nuanced and rich descriptions of the experiences of students' perceptions of technology.

In order to make an informed choice regarding the particular type of thematic analysis to adopt, the researcher considered the views of Braun et al. (2014) pertaining to deductive and inductive thematic analysis, as explained previously. Deductive analysis is driven by the researchers' theoretical or analytic interest and may provide a more detailed analysis of some aspect of the data but tends to produce a less rich description of the overall data (Braun et al., 2014). According to Boyatzis (1998), the process is descriptive because analysis is limited to the preconceived frames before the commencement of data collection. Furthermore, Vaismoradi et al. (2013) argued that using a predetermined thematic framework can lead to a loss of analysis flexibility, which can lead to bias and limit the interpretation of the data. In contrast, the themes may be inductive, in which case themes emerged naturally from the data as the study was conducted. A tendency to adopt the inductive approach suggests that once themes have been identified, it is useful to group the data into thematic groups and begin analysing the meaning of the themes before linking them back to the research question(s).

Focus of data analysis in this study

Based on the understanding of inductive analysis and deductive analysis as highlighted above, this study adopted the inductive thematic analysis strategy for the following reasons. Firstly, a deductive thematic analysis approach, which could have been an alternative, was rejected because the analysis process is less descriptive and limited to a preconceived framework. If the deductive approach had been adopted, this study's findings would have been limited due to a lack of rich and detailed interpretations. Investigating students' experiences requires telling stories of individual students' experiences; therefore, rich and detailed interpretation might be helpful to obtain individual students' stories of their lives. Such a situation, with different facets of looking at students' experiences, suggests that it would have been difficult to adopt deductive analysis. Secondly, inductive thematic analysis seems to fit the purpose of this study, which is that the researcher wanted to understand the ways in which students make meaning out of their experiences of technology while retaining a focus on the context in which those experiences occur. Since technology education in Nigeria is new, the researcher is interested in more than the previously believed facts found in quantitative studies for which there are no strong orienting hypotheses, predictions or theories. Thirdly, the interpretive nature of the inductive analysis technique (Thomas, 2006) satisfactorily fits this study's focus. The epistemological underpinning of this study has elements of the interpretivist paradigm assumption, which is rooted in the idea that our knowledge of reality is gained through personal experience, whereby the researcher and the participants create meaning (Denzin and Lincoln, 1994). In this case, the researcher attempts to get important themes and build up connections between the research aim and themes to answer the research questions. If the researcher does not engage directly with the primary source of data, it could be difficult to understand meaning created by the participants. Thus, it is reasonable to adopt an inductive thematic analysis technique as it is best suited to answering this study's research questions.

As Mack (2010) noted, the inductive thematic analysis technique is data-driven and flexible for data analysis. Braun et al. (2014) emphasised that the inductive thematic analysis technique also allows the researcher to understand the world as it is from a subjective point of view and seeks an explanation within the frame of reference of the participant by making explicit that analysis is constructed by both parties. Therefore, in an inductive thematic analysis process, it is not possible for the researchers to free themselves from their epistemological responsibilities. From this perspective, using the thematic analysis technique potentially fits well with the aim and philosophical paradigm (interpretivist) that are foregrounded in this study. In other words, both the thematic analysis process and the interpretivist paradigm are based largely on what the researcher wants to find out or the motivations of those being studied. Moreover, this process enables the researcher to interpret elements of the study from the gathered data (Braun et al., 2014; Thanh and Thanh, 2015), rather than making a judgement on the validity of their thoughts and feelings. For example, in this study, the decision was made to focus on students' perspectives of their experiences of technology, including those that the students might interpret differently, and the factors motivating their intentions.

In light of the above arguments, the researcher took encouragement from Ely et al. (1991) to engage with the analysis process. According to Ely et al. (1991),

> "To analyse is to find some way or ways to tease out what we consider to be essential meaning in the raw data; to reduce and reorganize and combine so that the readers

> share the researcher's findings in the most economical, interesting fashion. The product of analysis is a creation that speaks to the heart of what was learnt" (p. 40).

Drawing on the above quotation, it was not necessary to rely on a conceptual framework to determine themes in this study. Moreover, as a part of the flexibility and adaptability of thematic analysis, which allows the researcher to choose from a variety of approaches (Braun et al., 2014), the researcher was able to determine themes inductively without trying to fit the analysis into a pre-existing framework or any predetermined theory. Details of this are presented in the subsequent sections of this chapter.

4.2.1: Inter-rater reliability

To assess how the entire data set was coded and analysed through the eyes of someone else, the researcher adopted the concept of inter-rater reliability (Armstrong et al., 1997), which emphasises defining codes clearly and in mutually exclusive ways. However, Armstrong et al. (1997) noted that the way in which inter-rater reliability is used in qualitative research is less clear should researchers be expected to identify the same codes or themes in a transcript or produce different accounts – for example, considering variation in the language used and the ways they packaged the coding frameworks. However, Armstrong et al. (1997) also argued that it is an important method for addressing whether or not the same codes or themes in a transcript are in close agreement.

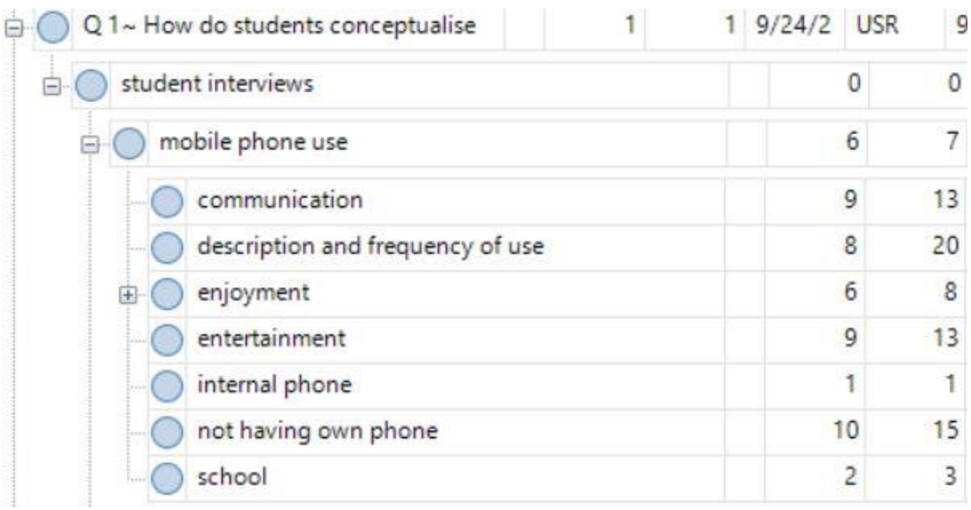
Influenced by Armstrong et al.'s (1997) argument outlined above and the methods of Barbour (2001), Hruschka et al. (2004), Hallgren (2012) and Campbell et al. (2013), the researcher considered the possibility of using a second researcher to code the data as a means of addressing the robustness of the coding process and the codes developed. After reviewing all the transcripts, finding independent researchers who were both knowledgeable and willing to dedicate themselves to coding semi-structured interview data proved extremely difficult. Due to both time and cost constraints (Barbour, 2001), it seemed sensible to invite two other PhD colleagues to look at a few of the same transcripts if the coding process led to the identification of themes and in the same piles of similar meaning (Cooper et al., 2009). The use of one or two independent coders is supported by the literature (Barbour, 2001; Cooper et al., 2009; Campbell et al., 2013; Belotto, 2018). Consequently, a meeting was held, in which the feedback indicated that it was difficult to understand the coding scheme due to a large number of codes, and it was suggested that it should be modified. At this point, the researcher decided to reread Saldaña (2013) to enhance his knowledge of coding techniques, which helped make the decision to adopt Strauss and Corbin’s (1990) open coding method. This enabled the researcher to understand how to break down the text and develop codes, before being able to implement the analytical process described in section 4.3. During the review of the feedback, the codes and themes were reviewed and sorted again by cutting and pasting them to the related research questions. In another meeting with the same two PhD colleagues, they agreed that the coding scheme this time around made sense and that the final themes all pointed to the same related concepts and were identified in the interview data. This method successfully addressed some of the challenges where participants provided lengthy and complex responses or digressed (jumped from one thought to another and went off topic here and there). Further details will be presented later in this chapter.

4.2.2: Computer-assisted qualitative data analysis software: using NVivo software in this study

Computer-assisted qualitative data analysis software (CAQDAS) programs are established tools for qualitative research (Woods et al., 2016). However, each software program is unique and may not fit with the purpose of the qualitative study (L. Richards, 2002). Cope (2014) noted many advantages of using computer-assisted software, pointing to features such as researchers saving time tracking changes and systematic analysis, which allows them to focus on analytical techniques and identifying meaning and emerging themes using their intellect, rather than having to spend time on manual tasks. Cope (2014) argued that in this manner, scientific rigour is enhanced, and an audit trail is created. In addition, with the ability to code multiple categories, the researcher is able to study relationships and gain depth in analysis (Cope, 2014). While there is no one particular software package that is best to facilitate qualitative management (L. Richards, 2002), there are criteria upon which to make a judgement, such as examining the form of analysis that can (or cannot) be executed by CAQDAS and the researcher's experience (Cope, 2014). For example, a researcher who had previously coded interview transcripts by highlighting relevant sections on paper copies must adjust to coding electronic versions of transcripts (Woods et al., 2016). All of the points highlighted above about CAQDAS were considered by the researcher in this study before committing to its usage for the purpose of this study.

In this study, the researcher used NVivo 12 software (originally called NUD*IST), a qualitative data analysis (QDA) computer software package produced by QSR International and designed for deep levels of analysis on small or large volumes of data (T. Richards, 2002). NVivo 12 software assisted with the first analytical step by being able to track the data that loses the narrative flow back to the original source through coding sources at the node. This is achieved by enabling the researcher to link a preliminary set of codes established prior to analysis based on the research questions. This approach therefore helped the researcher to easily and quickly access or trace all relevant data for the purpose of the main data analysis process. However, as the analysis proceeded, the preliminary structure needed to be modified as a hierarchy of nodes became evident. An example of the hierarchical nodes structure that was the result of the data analysis is presented in Figure 4.1. This structure recognises the fact that the phenomena under study here are interconnected.

Figure 4.1 Example of node hierarchies



Q 1~ How do students conceptualise	1	1	9/24/2	USR	9
student interviews		0	0		
mobile phone use		6	7		
communication		9	13		
description and frequency of use		8	20		
enjoyment		6	8		
entertainment		9	13		
internal phone		1	1		
not having own phone		10	15		
school		2	3		

4.3: RQ1 analytical procedures

This section elaborates on how the data set collected for research question RQ1 was analysed using Braun et al.'s (2014) six-step thematic process. Recall that RQ1 is:

How do students conceptualise technology in their everyday lives outside of school?

The purpose of RQ1 is to gain an understanding of underlying reasons, opinions and motivations in relation to how students talk about their perceptions of technology outside school. The researcher attempted to understand and interpret the students' experiences of technology based on their beliefs and intentions. Students were free to talk about their experiences without constraints, minimising the impact of the researcher's prior knowledge, assumptions and expectations. As such, the data that occur in the students' statements as they appeared in the transcripts of the interviews will be used to gain a clear understanding of the participants' thoughts and to convey their experience (Vaismoradi et al., 2013). The researcher analysed the data for each individual, including 16 one-to-one interviews conducted with students across two schools (Ekete and Nwanne). A summary of the analysis revealed the emergence of five themes: 1) communication; 2) entertainment; 3) familiarity with the use of certain types of items; 4) completing schoolwork; and 5) aversion towards technology. The analytical process is discussed in detail below.

4.3.1: Student one-to-one interview data analysis

Analytical step 1: Familiarisation with data

The first step of data analysis involved reading and rereading the interview transcriptions to find potential points of analytical interest. Thus, in this study, the process of identifying a theme began by transcribing the audio tapes to become familiar with the data. All interviews were transcribed by the researcher in a process that involved playing the audio tape data several times and making incremental transcriptions of the audio recording. The transcribed data material – which consisted of over 25,000 words from all the interviews – was imported into NVivo 11. Thus, the first analytical step was a two-part process. The first part was to transcribe the data into a written form and the second part was to import that into NVivo 11 software as a document source, which made all transcripts easily and quickly accessible and traceable.

Analytical step 2: Initial coding

In the second step, codes were assigned to data in the form of extracts from the interview transcripts. A code was assigned each time the researcher noted something interesting in the statement. Braun et al. (2014) suggested that the researcher must decide whether to code for a single word, such as ‘technology’, as this is related to this study, or for sets of words or phrases – for example, where a student says, “sometimes I use it [my mobile phone] to call my friends”. Reflecting on this, the researcher recognised the need to find a way into the data that would provide him with a meaningful point from which to examine every statement for very specific elements. However, this could have a significant bearing on the research questions. Given the main purpose of this study – to explore students’ perceptions of technology in relation to their experience of technology inside and outside school – the researcher decided to organise the data into meaningful groups using the data comprising the word *"technology"* without a prompt as a way of narrowing the focus of attention (see Table 4.2). The justification for this approach was that the researcher asked all students a similar question, which was to talk about their experience of a mobile phone or any gadget that they had used, and that most students identify mobile phones or gadgets as technology (Twyford and Järvinen, 2000; DiGironimo, 2011).

Table 4.1 Examples of extracts from individual interview transcripts

Number	**Student**	**Examples of student's description of what a gadget or device they have used means to them based on their experience (as long as they say the word 'technology')**
1	EAJS1	I use a desktop computer for doing homework, reading, browsing the internet, sending emails and typing documents with Microsoft Word. It is technology, because without the aid of *technology*, we cannot get all these gadgets to use. Also, technology is the act of making things for use.
2	NFJS2	[I] use my mobile phone to surf [browse] the internet, play games, send text messages. I think the things that happen inside the mobile phone are developing more scientific knowledge through *technology*. Without *technology*, the world will be meaningless. Like *technology* has brought cars, many machines to work with.
3	NHJS3	[I use a] mobile phone and internet to check for meaning because it is faster than using the dictionary. I think a mobile phone is *technology* because it is like a laptop and helps a lot of people. Because when you see a lot of students in the university, they say they need a laptop to browse and answer a lot of questions. So, if you have a mobile phone [then] you do not need a laptop. To me, this *technology* is a way of making things easier for people.

4	NAJS1	Using a car to travel because it is faster than trekking. Using a lawnmower to trim grass is faster than using a cutlass. Using a refrigerator to store our food so it does not go bad. Prefer an electric iron to [char]coal iron because, for the charcoal iron, you need hot coal from firewood. Television helps us to know what is happening in the world. Without it, you cannot know what is happening in the world. They are like *technology* because without technology life will not be easy. They help us in our day-to-day activities.
5	ECJS1	Using a mobile phone for communicating with friends and family members, like parents. I know that a mobile phone is an example of technology. So, the phone is connected to technology. When the television is on, you discover that it makes it easy to see what is going on. I think it is the work of *technology* because, even though you don't know how the person came inside, it makes it easy to see things and hear sound from the speaker. So, technology is an application of science; it makes work easier, saves energy faster and saves time.
6	NGJS3	We have another gadget in my house, which is a television. It is one of technology. When I am calling on my mobile phone, I always imagine how am I here and somebody in a far place can hear me as if he is close to me? So, I think *technology* is like life is to human beings.

7	EEJS2	I love the car so much because where we live is very far and so rain fell today. If not for the car, we would have been beaten by the rain to come to school. If not for the car, we would not be in the school right now because where we live is very far. So, I would say that the car is a good *technology* because the car has helped us so much. Right from when I was small [a younger child], the car has been helping us. All these are *technology* because now without the air conditioners the whole place in the house will be hot. If not for the TV, we won't know what is going on in the world and if not for the solar system, when the light goes off, we won't have electricity to use and things in the fridge can go bad quickly. Also, we use the solar system to power everything in our house easily and that is why I say *technology* helps us to do everything.

Table 4.1 (theme numbers 1–7) presents examples taken from students who used the word technology during their interviews. Of interest here is the fact that the researcher avoided using the word technology during one-to-one interviews. This was to observe whether and how their stories spontaneously incorporated the word *technology*, because students may not have considered: (1) the perceived lack of understanding regarding the nature of technology; and (2) issues regarding their experience. The researcher felt that approaching the analysis in this way would help sort the data into meaningful groups, which is consistent with Miles and Huberman (1994), who suggested focusing on important things. Therefore, this criterion for selection was intended not to attribute greater overall explanatory value to themes on a quantitative basis, but rather to focus attention on the themes that would help answer the research question. These two focuses, which were whether and how their stories spontaneously incorporated the word *technology* and the most salient constructs in their statements, were identified and shaped into a finite set of codes.

Moreover, in Table 4.1, the seven students made unsolicited use of the word technology when referring to their experiences of devices or gadgets. Although their experiences are diverse, the researcher identified consistency between their use of the word technology and their statements, driven primarily by convenience and importance in meeting their needs. For example, students stated that technology creates devices to enhance human lives by developing more scientific knowledge (NFJS2); technology is an act of making things to use (EAJS1); television is technology (NGJS3); and technology saves energy and is faster and saves time (ECJS1). Knowing that the word ‘technology’ appeared in only seven students’ statements would not be sufficient for interpretation, regardless of its validity (Braun et al., 2014). Nevertheless, it provided the starting point that helped the researcher critically investigate the remaining nine students (Table 4.2, numbers 8–16 below).

Table 4.2 Students who did not use the word technology

8	EBJS1	Watching television and listening to news to know what is happening around you and in the world, educational programmes and watching movies. Television is to acquire skills and knowledge for everyday life. For example, if you want to become a musician you can watch music videos, so you can use it to improve yourself. I use the computer or mobile phone and the internet to do my homework. Cars make life easier for us: like when it rains, and it helps you to come to school early and not using public transport because it is a waste of your time.
9	NBJS1	Repaired and started using Mum's mobile phone to make calls, send text messages and play games. Also, my parents use their mobile phone to call me when they travel. Using a mobile phone makes life comfortable and easier for humans like us.
10	EFJS2	Used computer to draw shapes. Computer use is a manmade or natural way of using things. Also talked about how he is fascinated about rockets travelling into space.
11	EDJS2	Using the computer to type software [Mavis] Beacon while playing word games at the same time helps me achieve my goals, like learning how to type. It is something that saves time and energy and is easy to use.
12	NDJS2	A computer, stabiliser, television, blender, gas cooker, electric cooker, VCD. All these gadgets are important to me because they assist in the

		house and ease boredom. Our television, I use it every day. I watch news, films, movies and sometimes cartoons. And that is why I like television. If there was no television, there would be nothing to entertain us when we are bored.
13	NEJS2	Electric kettle, television, electric bulb, electric blender, electric iron, charcoal iron, hand-grinding stone, DVD player. These things are good because they help us a lot at home. Some use electricity, like the electric kettle, they don't give us stress. Others, like the hand-grinding stone, can cause stress. Though it still helps when there is no electricity.
14	NCJS1	[A] mobile phone [is] a gadget for communicating and playing games. Using a bicycle instead of trekking. It is all about making life easier.
15	EHJS3	Small electronic gadgets used to do things that we do not know about. Use a mobile phone to gain access to the internet to do a school assignment.
16	EGJS3	Computer, mobile phone and browsing the internet using various search engines, for example, Google and Opera. Serves to entertain oneself or overcome boredom.

The remaining nine students (Table 4.2, theme numbers 8–16) did not use the word technology but had very similar experiences to those students who did mention 'technology'. The researcher found that these students also expressed their connection with devices and gadgets as something that saves time and energy and is easy to use. Moreover, they mentioned making life comfortable and easier for human beings. The difference was the absence of the word 'technology' from their conversation. However, they exhibited similar characteristics found in the other seven students who did use the word technology.

Analytical step 3: Searching for themes

In the third analytic step, on rereading the transcripts, the researcher felt that if the students were saying the same thing but using different words, it would be unfair to be too restrictive. Moreover, it would be unlikely to yield greater insight and rich information pertaining to the participants' experiences of technology. For example, they did not understand that gadgets relate to technology in that they are innovations of technology even when discussing both in the same way. While they do not have an implicit understanding of gadgets, some students substituted words in place of the term technology. Noting these exceptions, the researcher could see similar, but less exaggerated, instances in other transcripts. Thus, the researcher decided that the language used by the participant should be considered and analysed in order to recognise the language barrier. By adopting this approach, all data would be treated equally and considered worthy of analysis regardless of their adequacy. This is because students may be unsure about using technological perspective language to articulate their ideas. Moreover, there may be some other clues and cues to the underlying ideas, which might be pertinent to the researcher's questions. Consequently, the researcher decided that all the discarded data should be reinstated so as not to limit the analysis solely to those who use the word technology.

Initially, small units of data were used as the basis from which to develop an analysis. The researcher began looking at the list of descriptive codes and their associated extracts to collate the codes into potential themes. Codes that shared similar traits were then subsumed under an overarching theme. For example, several rereads focused on how students talked about a combination of elements that were either non-electrically or electrically operated; these were subsumed under 'artefacts'. In the context of this study, an artefact refers to objects modified by a human being to make them suitable for serving a certain purpose (De Vries, 2005). Thus, henceforth, the term 'artefacts' will be used interchangeably with 'objects' or 'things' (Table

4.3 below). All students talked about technology in terms of the gadgets, machines and household items they used in everyday life. Based on the data collected and to ensure nothing was taken for granted, the researcher realised that students spoke at length about making life comfortable and easier. For example, all students mentioned specific types of artefacts, such as computers, devices, systems and machinery. The data collected revealed that students referred frequently to how they used gadgets and devices to achieve their goals. The researcher found this to be relevant in all the transcripts. Although this was something the researcher had not explored initially, the information that emerged was useful, because it supported the need to consider all data during the analysis process.

Table 4.3 List of ideas mentioned by students in their statements

Transcript number	Pseudonym	Ideas students talked about in their interviews
1	EAJS1	Computer, internet, tape recorder, television
2	EBJS1	Computer, gadgets, internet, mobile phone, television
3	ECJS1	Laptop, iPad, television, remote control, cars, machines, mobile phone
4	EDJS2	Camera, iPhone, modem, laptop
5	EEJS2	Desktop computer, printer, television, gadgets, printer, mobile phone
6	EFJS2	Computer, DVD player, solar system, air conditioner, internet
7	EGJS3	Gadgets, scanner, computer, printer, laptop, mobile phone
8	EHJS3	Gas cooker, washing machine, electric cooker, electric iron, microwave, CD player, mobile phone
9	NAJS1	Gas cooker, television, bicycle, DVD player, refrigerator, lawn mower, cutlass

10	NBJS1	Electric iron, electric kettle, [char]coal iron, mobile phone
11	NCJS1	iPod, laptop, mobile phone, gadgets, television
12	NDJS2	Blender, computer, electric cooker, stabiliser, television, DVD player, gadgets
13	NEJS2	Electric kettle, television, electric iron, DVD player, grinding stone, electric blender, charcoal iron
14	NFJS2	Gas cooker, blender, mobile phone
15	NGJS3	Television, gadgets, mobile phone, computer
16	NHJS3	Television, electric kettle, electric iron, coal iron
Note: Each student is referred to as a letter (A to H) preceded by E or N, which represents the school, and followed by JS1, JS2 or JS3, which refers to the class level in school.		

Analytical step 4: Reviewing themes

The fourth step involved reviewing and refining the themes identified following the third analytical step. In this step, the researcher returned to the original text. All data extracted that fitted into each theme were reread to ensure that the data formed a coherent pattern to guarantee that the themes accurately reflected what was evident in the extract. To achieve this, the students' statements were reviewed for each transcript. An attempt was made to make clear why the key summary points were grouped in the way they are in Table 4.4 below. For example, the researcher classified the mobile phone as a means of communicating with friends and family as 'communicating people'. Once a clear idea of the various themes and how they fitted together emerged, the analysis moved on to step five.

Table 4.4 Summary of example of extracts and themes across both schools

Theme number	**Example of extracts**	**Themes**
1	"I enjoy using it to communicate with my parents when they are not around, I will call them anytime" (ECJS1). "My parents use it to call me often when they travel" (NBJS1).	Communication
2	"You can use it [mobile phone] to play games to entertain yourself" (EGJS3). "I like television, if not television, there will be nothing to entertain us when we are bored" (NDJS2).	Entertainment

3	"A washing machine is an example of technology because it is faster than washing with our hands" (EHJS3). "Our electric cooker is faster than the stove. If you give the stove the time to boil water, the electric cooker is faster than the stove. However, if there is no light [electricity] it won't work" (NAJS1).	Familiarity with use of certain types of items
4	"If I am given an assignment at school, and I know that I would need the computer, like I am told to go online and get research on something, that is when I would need the computer" (EEJS2). "When our aunty [physical education class teacher] told us that we should go and research and check the world's best player, how he scored his first goal, the date he scored his first goal." However, NHJS3 told her sister to check for her because at this time she had not got a mobile phone, but she used her sister's phone and "everything was there" (NHJS3).	Completing schoolwork
5	"Like on the internet, you see many things that you are not meant to watch like pornographic movies. And if you are a good person you will not go to that site on the internet; you will only go to the good sites" (EBJS1).	Aversion towards technology

Analytical step 5: Defining and naming themes

During step five, these themes were named to capture the essence of what each theme is about and what aspect of the data each theme captures. Since these decisions were subjective, the researcher also used direct quotes from participants to support the rationale for each theme. A descriptive approach was used to describe each theme in a couple of sentences so that it fitted into the broader overall story in relation to the research questions. For example, ‘communication’ refers to activities aimed at communicating with people; ‘entertainment’ refers to activities that aimed at diverting, engaging or giving pleasure and delight; ‘familiarity with use of certain types of items’ refers to activities by which students tend to develop a preference for things merely because they are familiar with them; ‘completing schoolwork’ refers to activities aimed at reinforcing the knowledge that students learn in the classroom; and ‘aversion towards technology’ refers to activities intended to cause the students to dislike technology (Table 4.4).

Analytical step 6: Producing the report

The sixth step involved a final refinement of the analysis to establish the significance of the findings. The aim of this last step was to return to the original research questions and the theoretical interests underpinning them and present the findings of the analysis grounded in the patterns that emerged in the exploration of the texts. As far as the researcher’s own position in relation to this study is concerned, the researcher possesses intimate knowledge and experience of the phenomenon being studied. Moreover, the researcher remains reflective on his own experience with the intention of gaining deep insight and understanding of the phenomenon by delving into the students’ experiences of technology. The following section presents the findings for RQ1.

4.3.1.1: Presentation of findings related to RQ1

This presentation of findings indicating how students conceptualise technology in their everyday lives outside of school is provided to answer the first research question. The findings are drawn from comments made during individual student interviews. This section includes a within-case analysis of the findings from Ekete and Nwanne and concludes by providing a summary of the data analysis and findings pertaining to the specific research question.

Findings related to how students conceptualised technology

As can be seen in Table 4.4 above, five themes emerged during the data analysis, thereby indicating how students from Ekete conceptualise technology in their everyday lives outside of school, including the conceptualisation of mobile phones as devices that are used for communication, entertainment and completing schoolwork. Also, students conceptualise technology in terms of familiarity and aversion. Each theme will be discussed below in detail, with selected extracts taken from one-to-one interview transcripts for students in both Ekete and Nwanne.

1) Communication – Communication emerged as a theme during the individual student data analysis. Most students began by offering views regarding a mobile phone as a means of communicating with friends and family. For example, EGJS3 said: "Sometimes I use it [my mobile phone] to call my friends." For ECJS1, whose parents occasionally travelled, the mobile phone was a valuable means of keeping in touch. ECJS1 also indicated she does not usually use her mobile phone, except when her parents are not around: "I use my mobile phone when my parents are not around, so I have to call them, I will call them anytime." From these students' responses, it may be construed that the mobile phone is valuable because it represents a means of remaining in contact with parents and friends. The researcher interpreted ECJS1 as meaning that she does not often use her mobile phone. However, when the researcher asked her what else she thinks about mobile phones, she made statements that linked mobile phones to technology: "I use my mobile phone to do other things like play games. I know that a mobile phone is an example of technology for calling. So, the phone is connected to technology" (ECJS1). While communicating with parents when they are away may be seen as a more unnecessary use of the mobile phone, EGJS3 indicated that a mobile phone is "helpful in communicating". EDJS2 responded in similar terms, stating: "I use it to call my friends."

EFJS2 also talked about conceptualising the mobile phone primarily as a means of facilitating online communications, saying, “I use it for chatting with friends” and “When I want to call my friends when [I am] online.”

It is notable from these responses that when students use mobile phones, most appear to focus on the functional nature associated with technology and the ease of achieving their immediate needs. For example, when they were asked how they could use the experience to describe what mobile phones or gadgets mean for them, typical responses included “it makes things easier” (ECJS1). This reveals why students identify easily with the functional aspect rather than inherent characteristics, such as the design aspect. This is likely to make them reflect on, for example, the physical properties and the knowledge involved in the design of the artefacts.

At Nwanne, five students (NBJS1, NGJS3, NCJS1, NFJS2 and NHJS3) conceptualised the mobile phone primarily as a device that facilitates communication. For these students, the mobile phone is a means of maintaining contact with people who are physically absent, rather than being used for socialising with those who may be contactable through alternative methods. NBJS1, for example, said of the mobile phone: “My parents use it to call me often when they travel.” However, when asked how distant a person would have to be before he would use the device to contact them, this student answered: “Let me see, in a neighbouring town.” Asked if he would ever use his mobile phone to send a text message to a person who was sitting at the table next to his in class, he said, “It’s not necessary.” Notable in this last response is the student’s sense that his use of his mobile phone should be for a “necessary” rather than a frivolous purpose. Limiting the device’s use for purposes perceived as important suggests that NBJS1 conceptualised the device as significant, thus indicating his deep relationship with his mobile phone. The conceptualisation of technology that emerged from NGJS3 was similar to

NBJS1 in that NGJS3 conceptualised the mobile phone as a means of contacting physically distant people, saying, “I used it to call my friends at my other school when I left.” For NCJS1, the mobile phone is an easier means of contacting their parents if they feel unwell. “When I’m in the school and not feeling fine, I call him, and I tell him that I’m not feeling fine, rather than to take transport to go to Warri to meet him.”

For NFJS2 and NHJS3, who also conceptualised the mobile phone as a means of contacting parents and friends, the text message was their preferred mode of communication. When NFJS2 was asked whether there was any reason for her preferred mode of communication, her response emphasised the ease of sending: “I just type the message, and I choose whom I want to send it to, my best friend, my mum, my dad and our other relatives. Message sent, done” (NFJS2). NHJS3 limited her mobile phone usage to purposes she considered important. She explained that this limitation was due to the cost of using the device. Indeed, the lower cost of text messages was the reason for preferring that mode of communication to voice calls. “Like messages, they don’t take much credit like calls. So, when I want to minimise my spending of credits, I just send messages” (NHJS3). These findings further support the findings in Ekete regarding how students conceptualise mobile phones as focusing on the functional nature of technology and indicate that students identify this aspect of technology based on their association with functional attributes, rather than other elements that could help describe the characteristics of the technology.

2) Entertainment – Students talked about their mobile phone as an entertainment device, stating, for example: “I use it to download music and to play word games” (EDJS2). For EGJS3, the mobile phone was conceptualised as an entertainment device. When the reasons behind the associations between mobile phones and entertainment were explored, it was revealed as a means of overcoming boredom: "When you are bored, you can play some games on your mobile phone to entertain yourself." Again, these responses suggest that students sometimes tend to conceptualise mobile phone technology primarily as a distraction, which causes a change of one's state of mind in relation to leisure and socialisation.

Nwanne students (NBJS1, NDJS2 and NHJS3) conceptualised the mobile phone as a medium for socialisation, as well as a source of diversion when they are alone. Thus, mobile phone technology provides an alternative to whether the student wished to interact with another person or be independently occupied. NBJS1 described how playing a game on a phone with his brother had led to solitary gaming: "When [my brother] played, because he got higher points than me, so I left that game, and started playing another game that he does not like, but on my own" (NBJS1). When asked what else he would like to say about his experience with television, NDJS2, who has no mobile phone, replied: "I like television, because if not television, there will be nothing to entertain us when we are bored." NHJS3 described how she used her mother's iPod as a form of simulated companionship because "you will be chatting with a robot". The responses above suggest that students can express their ideas of technology by navigating alternative purposes.

3) Familiarity with use of certain types of items – Students in this study also outlined their familiarity with the use of certain types of artefacts associated with the artefacts' versatility. For example, ECJS1 emphasised his conceptualisation of his mobile phone as highly adaptable (e.g. "you can search anything you want"). Moreover, he viewed the device as combining the utility of an academic aid, the fun of an entertainment device and the importance of a link to national and world events (via online news organs) in one accessible format. EGJS3 described how he used his phone to browse the internet: "Sometimes I use it to browse all the Nigerian newspapers online. Sometimes I use it to browse for some videos or some games. Sometimes I even use it to browse about some subjects that I do not understand in school."

To discover whether the student was familiar with using certain types of technology functionality, the researcher asked the student to express their thoughts on certain types of technology based on their personal experience. Subsequently, the students offered further insights into their conceptualisation of the items (e.g. mobile phone, computers). Some went on to describe the procedures they employed in using the technology, while others discussed how it helps them accomplish their task. For example, EGJS3 further explained:

> "First of all, in every mobile phone, they have a browsing centre. Like a Nokia phone, Nokia phone has a browsing centre. From that browsing centre search for Google. From that Google, you can search anything you want in any aspects, news, games or anything at all."

EDJS2 also gave a response emphasising his conceptualisation of easy-to-use mobile phone technology. In describing the text messaging feature of mobile phones, he stated: "When you finish typing you just press 'send', and it will go to whomever you want it to go to." Moreover, EFJS2 gave responses emphasising versatility and empowerment in the conceptualisation of mobile phone technology as a facilitator of social interaction:

> "Like there is some 2go status [emoticons] as in pictures of faces whether you are sad, angry, crying or happy … By going to symbols. You take a symbol whether you are happy, the face smiling. Or the face laughing or your face crying or sad. That is how we express our feelings … [To express when I am happy] I click on the happy face."

Other responses include "I know a mobile phone is connected to technology. That is all I know about mobile phones" (ECJS1) and "A washing machine is an example of technology because it is faster than washing with our hands” (EHJS3).

From the responses above, we can observe that familiarity with technology can help students do anything they want with ease. However, regarding the pattern of usage, four students discussed items that related to transportation, refrigerators or electric cookers. Nevertheless, it was unclear whether the students were intuitive or innovative. EBJS1 was asked his opinion of cars, since he had been travelling in his dad’s vehicle:

> “I feel happy [when I am in my dad’s car on the way to school]. I feel happy because I will not be trekking and now that it’s raining season, like, rain like when it comes to school early and the rain will not trap us at home because we are using a car” (EBJS1).

A similar response from another student was:

> “I love the car so much because where we live is very far and so whenever it rains, like today, if not for the car, we would have been wet and late to school. So, I would say that the car is a good source of technology because the car has helped us so much right from when I was small, the car has been helping us” (EEJS2).

The responses above reveal that students may find it easy to discuss their feelings about artefacts, but they seldom articulate how artefacts work or are designed. However, the responses also provide a sensible and coherent understanding of how students view technology but have a limited understanding of technology in relation to the role of artefacts.

ECJS1 also thought technology made work easier: “It saves energy and is fast. It saves time. That is how I will describe the technology” (ECJS1, individual interview).

Indeed, EHJS3 perceived technology as artefacts that enable people to accomplish efficiently tasks that would otherwise be difficult or impossible: “In case you want to listen to music you can always operate it at any time because National Electricity Power Authority (NEPA) light is not always constant and you can use your battery if it is fully charged. That is why it is great using electronics like technology" (EHJS3).

Four Nwanne students (NAJS1, NBJS1, NCJS1 and NEJS2) demonstrated their familiarity with certain types of artefacts. For example, NAJS1 spoke about an electric cooker, emphasising the device's dependence on a supply of electricity, but stating that it was faster than the [kerosene] stove: "Our electric cooker is faster than the stove … But if there is no light [electricity] it won't work." NBJS1 described the procedure for using an electric blender to blend beans [seeds]: "As the bean seeds are very hard, you turn the switch to the highest point so that it can blend very well." However, NEJS2 described her family blender as magic: "We use it for grinding maybe tomatoes and pepper." When asked what she thought about the blender, she enthusiastically stated: "I feel like it is magic, because [my mother] just puts the tomatoes in, [and after a] few minutes it is ready for use, and I am happy" (NEJS2).

Other responses regarding familiarity with the item included: "The electric kettle is almost the same as the electric iron … But the electric iron they don't put water [in] but electric kettle they put water [in]". This participant (NAJS1) went on to talk about lawn mowers as technology because they were made for us to use rather than using a cutlass. On further questioning regarding whether a cutlass is technology, his response was that a "cutlass is still a technology, because we use metal and iron to form [a] cutlass, but [it] is not as fast as the [lawn] mower".

The respective findings from Nwanne and Ekete relating to the first research question revealed that students from both schools indicated that they conceptualised technology outside of school regarding the function and usefulness of artefacts, such as mobile phones, personal computers, electric cookers, cars and refrigerators. For example, mobile phones were conceptualised as versatile devices (due to their variety of functions) that facilitated communication with absent persons, as well as offering solitary entertainment and independent learning. Personal computers were associated with entertainment and schoolwork and were seen as versatile and easy-to-use means of expanding a student's range of reference (via online searches) and simplifying mechanical tasks, such as writing and calculating. Televisions were regarded by students in both schools as sources of information (via the news), as well as sources of comfort and emotional stimulation. All the electronic devices mentioned by students (e.g. mobile phones, televisions, CD players and personal computers) were perceived in both schools as ways to alleviate boredom and loneliness.

4) Completing schoolwork – Seven students (EAJS1, EBJS1, EDJS2, EEJS2, EFJS2, EGJS3 and EHJS3) conceptualised technology, in part, as a means of completing homework or other educational activities outside of school. Students gave open-ended responses to how they feel about the choice of technology that helped them complete their homework. The device associated most closely with education was the personal computer. Although the students did not do this, they were sufficiently familiar to be able to use it as an artefact. EAJS1 conceptualised personal computing technology as a useful source of assistance with the mechanical tasks (e.g. writing and calculating) associated with schoolwork: "For school, [I have used the computer to type out my homework], and maybe if you have a printer, you can use it for printing it out." Furthermore, students talked about their personal computer as a source of learning: "The computer helps me to achieve my goals, like learning how to type" (EDJS2). EDJS2's response was notable for its characterisation of aspects of a task that typically would be considered a chore (learning to type) and the description of the computer as helpful ("helps me to achieve my goals"). Furthermore, EEJS2 discussed her use of the computer as an educational aid. However, she also described a somewhat technical-sounding conceptualisation of the personal computer and its functions, before characterising the educational use of the device as enjoyable:

> The computer is an electrical component which we use to receive data, retrieve data and store data. And so, with the computer, if you plug a modem into it you can browse with it, and these are all the result of technology. you can browse with it … And I enjoy it because it is an educational aid" (EEJS2).

EFJS2 appeared to conceptualise personal computing technology as a means of facilitating creative self-actualisation:

> "I mainly use it for drawing because there is a drawing place that is concentrated with shapes. So, you choose the kind of shape you want and determine the size. Like, I normally draw the sky or paint it with blue then there's a cloud shape. In that place, I put it there with a circle shape as a sun and the moon" (EFJS2).

EGJS3 described the laptop and associated devices (printer and scanner) as academic aids: "I have a laptop. I use the laptop for some school activities. If they say, I should print something, like I also have a printer, also [a] scanner. I use the scanner to scan things that I see outside." Furthermore, EGJS3 conceptualised web browsers on personal computers as a method of obtaining important information about national affairs that could be passed on to friends. Thus, the personal computer was conceptualised as a means of facilitating a form of civic self-education, something of which he appears to be proud:

> "Like all the gadgets, one day I was browsing and just saw a picture of the bomb activities. So, I clicked it and I read through and [that] is how I [came to] know about Boko Haram. So, when I came to school, [I] told my classmates. Some of them don't even know about Boko Haram activities. So, I explained to them … I am very glad that

people are learning from me. They were thanking me for those things" (EGJS3).

EHJS3 further conceptualised the personal computer primarily as an educational aid. Her descriptions of the complex ways in which the computers, to which she had access, were shared hints at the importance she and her peers place on these devices:

> "Actually, I don't use my textbooks. I just open my laptop which my brother and I share and go there easy sometimes if they give us an assignment on the computer. For me not to be late for submitting my assignment, I go to my computer and do whatever I want to type and submit" (EHJS3).

As in the responses related to mobile phone technology, students discussing personal computer technology appeared to conceptualise the technology primarily regarding its uses (e.g. writing, drawing, scanning, calculating, and preserving documents) and as a way to keep themselves entertained and informed.

Four students (ECJS1, EAJS1, EBJS1 and EEJS2) talked about television as technology that helps in gaining information, which might relate directly to their education. When EBJS1 was asked what television meant to him, he described his experience as a source through which we acquire knowledge:

> "If not for the television, we would not have known what is happening around us. Like people that want to become a musician, you can watch music videos, so you can use that knowledge to improve yourself. Like if you are watching where a woman is learning how to cook, you will like to listen to what they are saying and see what they are doing so you can acquire your knowledge of cooking" (EBJS1).

However, when ECJS1 was asked a similar question, remarkably, he spontaneously associated televisions and CD players with technology that works mysteriously:

> "I think televisions are an example of technology, because television, when you put it on, somebody is inside the television and you are watching. You will imagine how this person came inside. I think it is the work of technology. That is why televisions are an example of technology … I think the CD player is an example of technology because if you put the CD in to watch, it will just be showing words on your television screen" (ECJS1, individual interview).

Similar comments included: "I think television is technology, because without technology we can't get gadgets like television to make people enjoy themselves" (EAJS1). However, EEJS2 described television as a source not only of information, but also of technology. This appeared to be a contradictory statement, so the researcher asked her to clarify what she meant by "source of technology". She replied: "Television is a kind of technology because it is a source of information … If not for the TV, we won't know what is going on outside the world and in the country" (EEJS2). The news of the Chibok girls who were kidnapped in Nigeria, which went viral and of which the researcher was aware, was cited by the same student to elaborate what she wanted to communicate: "Like, I got to know through the television that the Chibok girls were kidnapped. So, it is a source of information which tells us what is going on even in places that are far from us" (EEJS2).

As can be noted from the responses above, students can demonstrate an understanding of ideas applied to education. They seem to focus exclusively on technology in education. However, some of these students often contradicted themselves, demonstrating incomplete conceptions of some necessary dimensions.

At Nwanne, students were asked what would happen if they did not use a mobile phone to aid their schoolwork. For NHJS3, "When our aunty [physical education class teacher] told us that we should go and research and check the world's best player, how he scored his first goal, the date he scored his first goal." However, NHJS3 told her sister to check for her because she did not have a mobile phone at the time. Rather, she used her sister's phone and "everything was there". Similarly, NFJS2 did not know how to use a laptop when they were asked "to go to the internet for stories and other things". Consequently, her dad showed her "how to use it". NCJS1 spoke of using the television to master the alphabet, while NDJS2 spoke of using children's computer programs to search for the definitions of unfamiliar words heard on the news. NCJS1 and NDJS2 spoke of using recreational technology to learn: "If you are a kid, you can buy some [DVD] cassettes to learn how to sing ABCD." For NDJS2, "Because anytime I am listening to the news, I only see [unfamiliar words], and I don't know the meaning. That is why I went to the computer and found the meaning, that is why also I like using the computer."

5) Aversion towards technology – When students were asked if they wished to discuss any other factors pertaining to their experience of technology, two students expressed an aversion towards technology. Views conveyed in their statements included the notion of an unreliable national electricity supply, which impedes the progress of completing tasks, and some aspects of what people can suddenly encounter on the internet. From the perspective of the first student:

> "Like now, if you don't have UPS, which is the uninterrupted power supply, maybe NEPA takes light and [if you] have not saved what you are doing, then it will be lost. So that's one of the disadvantages of computers" (EAJS1).

The second student offered an insight into some students' potentially negative conceptualisation of technology by mentioning unfiltered access to inappropriate content: "Like on the internet, you see many things that you are not meant to watch like pornographic movies. And, if you are a good person you will not go to that site on the internet; you will only go to the good sites" (EBJS1).

The students' views demonstrate that although technology can be positive, it is evident that students can develop an understanding, and be wary, of the dangers associated with technology. These views were based on experiences with these technologies, thereby helping them recognise that such a notion is reflected in the characteristics of the technology.

4.3.2: Summary of RQ1 data analysis and findings

The rationale for RQ1 was to gain an understanding of underlying reasons, opinions and motivations in relation to how students conceptualise technology outside the classroom. The researcher employed qualitative methods to explore students' perspectives on technology through multiple realities they had experienced. A semi-structured interview protocol was employed as the most suitable technique to elicit students' responses in relation to their individual perceptions of technology. Based on the analysis of students' statements from Ekete and Nwanne related to the first research question, a high degree of similarity was exhibited in relation to the context they provided and the objects exemplified. Students from both schools indicated that they conceptualised technology outside of school in terms of artefacts, such as mobile phones, personal computers, electric cookers, cars and refrigerators, and in terms of functions associated with their successful performance. For example, mobile phones were conceptualised as versatile devices (due to their variety of functions) that facilitated communication with absent persons, alongside offering solitary entertainment and independent learning. Personal computers were associated with entertainment and schoolwork and were regarded as versatile and easy to use as a means of expanding a student's range of reference (via online searches) and simplifying mechanical tasks, such as writing and calculating. Televisions were perceived by students in both schools as sources of information (via the news), in addition to sources of comfort and emotional stimulation. All the electronic devices students discussed (e.g. mobile phones, televisions, CD players and personal computers) were regarded in both schools as a means of alleviating boredom and loneliness. Furthermore, the overarching theme (technological artefacts) that emerged after the analysis matched in part with the conceptual framework of technology that was proposed for this study, which is built around De Vries's (2005) concepts of technology, namely, technological artefacts, technological knowledge, technological processes and technology as a part of human existence (see 2.5.2.3). From this, we can infer that students appear to associate technology with the perceived importance of the artefact to them individually, particularly in terms of it meeting their needs. Moreover, we also saw that for a few students, technology is not merely about modern artefacts, such as computers, as reflected in most previous studies (Raat and De Vries, 1985; Boser et al., 1998; Rose et al., 2004). Nevertheless, the analysis demonstrates that objects such as cutlasses (NAJS1), charcoal irons and grinding stones (NEJS2) are considered technology. This is remarkable, because it reveals that students also perceive technology in terms of 'medieval' [researcher's emphasis] artefacts, which may or may not be the case for most adults.

The analysed data and findings for RQ1 suggest that the aspects of technology experience demonstrated by students in this study revealed the relevance of their conceptualisation of technology. Moreover, knowing what kinds of concepts are in students' minds has potential benefits when we aim to develop strategies to support a student's ability to understand technology. Indeed, Kober (2015) suggested that students connect knowledge most effectively in the classroom, where they negotiate understanding through interaction and varied approaches.

4.4: RQ2 analytical procedures

This section focuses on how the data set collected for RQ2 was analysed using Braun et al.'s (2014) six-stage thematic analysis process to answer:

> ***RQ2: In what ways and to what extent, if any, does student experience of technology align with learning about technology in the classroom?***

For the purpose of the question above, the term *align* refers to the demonstration of connections students make between their experiences of technology inside and outside of the classroom. Therefore, connection here embraces both the relevance of lesson activity and a task beyond the instructional contexts. This connection can be construed as existing in a bi-directional way, in which knowledge can be demonstrated from both directions but be complementary in that one can complete or enhance the qualities of the other. One connection can be between actual objects, events, experiences outside school and situations that effectively address concepts of technology they know about. The other connection can be between what is taught in class and the relevance or applicability it has beyond the classroom and examinations, which can be construed as bringing what is inside the school textbooks or classroom out into the real world. Therefore, the focus of the analysis assumes that technology in the classroom provides students with opportunities to make connections between world knowledge and experience, whereby they are encouraged to construct their own ideas and deploy them practically with a sense of reality regarding everyday life, for example in design and making activities anywhere and everywhere.

By adopting the focus of analysis perspective outlined above, the researcher was able to analyse whether student experiences in the classroom and what they learn align or do not align in relation to perspectives on technology that have been described in the literature. For the purposes of this analysis, the researcher adopted the notion of technological literacy consistent with ITEA (2000) and De Vries (2005) to understand how students develop their own understanding of technology. For example, ITEA (2000) emphasised advancing technological literacy through study of technology. In the same vein, De Vries (2005) emphasised that existing curricula consider the philosophical insights to stimulating teaching about technology, as they should also be seen as what should be taught and learnt to acquire technological literacy.

Consequently, the data analysed in relation to RQ2 focused primarily on the students' and teachers' interpretations of technology lessons and activities they had experienced and, more crucially, the extent of student engagement and instructional strategies. Therefore, the primary data sets for RQ2 comprised four student group interviews (two each at Ekete and Nwanne). The researcher felt it was important to also consider teachers' views in order to better understand what students do in technology classrooms. Thus, teacher one-to-one interviews and lesson observations formed part of the data sets to corroborate what students were doing in technology lessons. Moreover, the researcher assumed that technology teachers are in positions whereby they could use their subject knowledge and instructional strategies to influence students' learning processes in a varied and inspiring manner – for example, helping students to connect aspects of concepts of technology to the real-world context.

The analysis process involved coding to classify characteristics associated with the student group data set and the research questions, alongside what occurs in technology lessons from the teachers' perspectives. For example, six themes emerged from the data gathered from the student group interviews: 1) acquisition of knowledge through new experience; 2) construction of different angles and shapes; 3) emotions; 4) connections with skills learnt; 5) practical work; and 6) boredom. Meanwhile, the analysis of the data from the teacher one-to-one interviews revealed a consensus among teachers that a major challenge in relation to the teaching of technology lessons is the lack of resources to teach the subject as intended. This was corroborated by the analysis of the lesson observations. The analytical procedures for each data set will be discussed next.

4.4.1: Student group interviews data analysis

Analytical step 1: Familiarisation with data

The first step of data analysis followed the same process as that for RQ1 except for importing the data into NVivo. Instead, the researcher coded all of the data manually using highlighters, coloured pens and Post-it notes for the transcripts, thereby enabling him to know exactly which sheet held which statement.

Analytic step 2: Initial coding

In the context of this study, initial coding refers to the process of attaching a label to a data segment (Yin, 1994). For this study, this was applied to identify an idea expressed directly in the transcripts that was relevant to the research question. This process involved reading the transcripts several times and organising the data into small chunks of meaning that were relevant to the research question. The researcher felt that it would be reasonable to begin coding by using specific responses that could capture interesting statements such as students' perceptions of technology lessons. This was achieved as the researcher attempted to break down and understand the text and develop code notes that appeared to contain valuable data, which was consistent with Strauss and Corbin's (1990) open coding. In this instance, each segment of the data extracts that was relevant was coded to prevent the researcher from being constrained or inhibited from effectively generating codes.

Analytical step 3: Searching for themes

In this step, the differences between the interviews were examined critically to ensure their relevance to the research question and the researcher's interest. Thus, coded aspects were analysed for all potential themes that captured something important about the data in relation to RQ2 – that is, any pattern in responses that the researcher might count as important data in answering the research question. Students' statements were scrutinised for issues that could be used to organise a concept for a theme. For example, potential themes used in this analysis process included the following: "The reason why I said technology lessons are fascinating is because the teacher when they teach us, they will explain to us why it is like this and why it is like that"; "I enjoy my technology lesson very well because it gives me more ideas about life … I feel happy because I am knowing more things. So, I can go and tell people who do not know" (student group interview). This process led to the development and refinement of themes, which capture students' perceptions of technology lessons in their own words (see Table 4.5 below).

Table 4.5 Key themes resulting from responses from the student group interviews regarding what technology in the classroom means for them

Theme number	Example of extracts	Themes
1	"It gives us the knowledge to see things and look [at] things that [we] have not heard about before"; "Technology subject is very important for us as individuals because without technology lessons we can't know how to build cars, build houses and all other things"	Acquisition of knowledge
2	"Like the construction of angles, like our teacher if he is doing it, we used to wonder how he will do it and the line will be very straight"; "What I have been taught in our technology lesson is how to create angles, construct angles, construct shapes, bisect lines. Like the last time, we were taught how to construct the square"; "How to construct different types of angles like 90°, 180°, 360°, all the degrees we have in a circle, even in triangles and other shapes"	Construction
3	"The reason why I said technology lessons are fascinating is because the teacher when they teach us, they will explain to us why it is like this and why it is like that"; "I enjoy my technology lesson very well because it gives me more ideas about life … I feel happy because I am knowing more things. So, I can go and tell people who do not know"	Emotions
4	"I feel that my technology lessons in school can help us on how to build knowledge"; "all these things that have been taught in school, when we leave school we can still remember them, and if we decide to read technology in the university it can also help us to have larger knowledge than those who didn't learn anything from technology from their foundation"; "If you are a graduate and you don't have work, you can	Connections with skills learnt

	become a carpenter and just learning about those things. Like constructing of lines in case you want to become an engineer”	
5	“I feel that my technology lessons in school can help us on how to build knowledge. Like our teacher taught us how to make a spanner”; “We did [a] car project with slippers”	Practical work
6	“The lesson makes us know something about technology but sometimes it is boring”; “And assignments, he gives us bulk of assignments. If he wants to give us assignments, he will ask us to copy from the textbook, like he will give us like 20 pages. At least if he [teacher] wants to give assignments for us to copy, he should summarise it very well for us”	Boredom

Analytical step 4: Reviewing themes

This step involved undertaking a critical review of the themes. Themes were revisited for emergent meaning of the data as a whole rather than the line-by-line method of reading the entire transcripts used previously. The researcher had to create tentative labels for chunks of data. For example, repetitions of ideas and themes – such as construction, construction of shapes and angles, bisecting a parallelogram, construction and creating things, and construction of all the degrees in a circle – were searched and drawn together where substantial overlaps were identified.

Analytical step 5: Defining and naming themes

Step five enhanced the refinement of the themes. This involved reconciling their independent codes and generating words to describe the themes. The researcher identified different themes that expressed similar concepts and could therefore be unified. For example, the theme ‘construction’ emerged in the following manner. A selection of similar utterances was identified – for example, “Like the construction of angles, like our teacher if he is doing it, we used to wonder how he will do it and the line will be very straight”; “What I have been taught in our technology lesson is how to create angles, construct angles, construct shapes, bisect lines. Like the last time, we were taught how to construct the square”; and “How to construct different types of angles like 90°, 180°, 360°, all the degrees we have in a circle even in triangles and other shapes”. These different extracts could be listed under the theme of ‘construction’ because the main idea they seemed to be conveying related to the construction of something. By adopting this technique, the researcher was able to identify six distinctive key themes, as presented in the table above. Similarly, the theme of ‘practical work’ refers to experience linked to students’ own practice. This involved problem-solving and knowledge construction, whereby they engaged in different practical activities during which they made decisions that would help them improve the quality of the choices they make. Other themes included ‘emotions’, which refers to some expressions that seem to explain why students are interested in technology as a subject; ‘boredom’, which refers to the uncomfortable feelings students have had to endure as part of their school experience of technology; and, finally, ‘acquisition of knowledge through new experience’, which refers to the opportunity to learn something new.

Analytical step 6: Producing the report

In this sixth and final step, the researcher attempted to draw attention to any connection between the themes and multiple examples provided by the students. At this point, it is important to note that the ideas related to these themes represent the researcher’s interpretation of the students’ comments on their experience of technology lessons. Therefore, they are subject to the interpretation of others. Consequently, the reader can make his or her own judgements in relation to the interpretation presented.

4.4.1.1: Presentation of findings related to student group interviews

As can be seen in Table 4.5 above, the analysis suggests that students' knowledge and understanding of technology appeared to be confined to what they had acquired through their experience of technology in the classroom. However, it also demonstrated limited conceptual understanding related to technology. This section illustrates specific events at Ekete and Nwanne using extracts from the student group interview transcripts to demonstrate how the students talked about technology in the classroom. This section also compares the findings gathered from Ekete and Nwanne.

How students talked about technology in the classroom at Ekete and Nwanne

There were indications that students at Ekete and Nwanne demonstrated some degree of knowledge acquisition based on what they are taught in school. They claimed this might not have been beneficial were it not for the experience they had in their technology lesson. However, the evidence suggests that they had weak or brief explanations to account for the concepts they used, which is indicative of either a limited or a lack of conceptual understanding in their learning. Although students think they have sufficient technology lessons because they can make something, the evidence suggests that they lack understanding of why an action is being taken. For example, the analysis revealed that students rarely connect between what they are being taught and their own individual experience. They also stated that their teachers' strategy in the classroom was inspiring. In technology activities, most students seemed to enjoy technology as a subject. This was demonstrated by how they took practical work seriously. There is evidence that teachers made students take control of their project work, which suggests that students were responsible for constructing the technology concepts by themselves. However, the evidence points towards this having more to do with the teacher's attitude to the student and less to do with the conceptual understanding of their actions. The findings are discussed in detail below using the themes that characterised the experiences of students in technology lessons.

1) Acquisition of knowledge through new experience

This theme refers to what students seemingly consider an opportunity to learn something new and in different contexts. Thus, in this theme, the findings suggest that not only have the students gained new experience, but they have also learnt about different areas of technology education that provide opportunities to reflect on technology as a subject. An example is provided below:

> "Like my technology class what I like best is metalwork, because it teaches us about metals, other things such as how to bend metals, how to be a good first aider and how to treat a dying person. Like in elect/elect [applied electricity and electronics] they teach us about use of computers. The input unit and the output units, how to access computers. And in technical drawing, they teach us how to bisect lines" (Student R4, Group 1e).

The students' narratives also emphasised the importance of their technology lessons to them, as demonstrated by two other students below.

> "Technology subject is very important for us as individuals because without technology lessons we can't know how to build cars, build houses and all other things. For example, without woodwork we would not be able to know how to make chairs, benches and other things. Also, we learn about Vernier [callipers] in woodwork, also in metalwork we learn about aluminium and some other things. Like in our technical drawing we learn about parallelogram, rhombus and other shapes and how to construct them" (Student R2, Group 1e).

> "My technology lesson means a lot to me because it exposes me to various technological terms like technical drawing. It teaches us and gives us the knowledge of how to construct. It gives us the knowledge to see things and look [at] things that [we] have not heard about before. It helps us, for example the way technology exposes humans to things like [the] internet and some other things" (Student R3, Group 2e).

Moreover, the students reflected on their opportunities to apply what they have been taught in school to the world outside school. Thus, they were mindful that technology would likely play some role in their future. The evidence indicated that making connections independently between concepts taught in class and experience at home was part of the new experience.

> "My technology lesson in school helps me a lot outside because it gives me the chance to see all those things that have been taught in school … before I came into this school, I don't know much things about the computer, but when they started teaching us elect/elect, something about the computer, I started knowing more and more about computers. It also increases my knowledge of things like, for example, how to operate my phone" (Student R3, Group 2e).

> "Like in elect/elect, when our teacher taught us about atoms. I didn't really understand at first, but when I got home, I was watching a programme which shows how to know about technology on the TV. Then I said let me just watch it. As I was watching it, they said that before it could take a rocket to launch out of earth, it needs a lot of fuel. And when that fuel is finished, the rocket has its own atom insider and when tiny particles of sunlight hit it, then [it produces] its own energy to make it move very fast" (Student R2, Group 1e).

The extracts presented above highlight that the students found technology relevant not only as a subject, but also for future use because of its anticipated usefulness. However, inclusion of ideas about science, as illustrated by Student R2, Group 1e, suggests that students have difficulties distinguishing between science and technology. Furthermore, it suggests that students sometimes draw from science lessons to express their understanding of technology lessons. It could be argued that the way in which this experience was presented reflected the student's use of language, as the student departed significantly from what the researcher had in mind. A question that comes to mind at this point is the significance of language in technology education: to underscore that how a story is told carries as much import as what is told.

Evidence that supports the acquisition of new experience was also highlighted, but through interaction from the perspective of a roadside carpenter within the student's local environment:

> "It [technology lesson] gives us more intelligence. To know more things about technology, like what he said about the planing of [a] table. Normally I have not seen it before, but the way he [teacher] explained it, it looks like I have seen it before … Our teacher, he explained it in the right way … Because after he explained it, the roadside carpenter I saw was planing tables. So, I know that he was correct" (Student R2, Group 2n).

The evidence was consistent with another student group response in which a student talked about taking the technology lesson seriously to accumulate knowledge with a strong desire to know how to create things:

> "Technology lessons make me believe in myself that in the future I can become a technological person, a person who knows a lot of things about technology. And it also makes me believe that these people that create cars and create computers, phones or electrical appliances, they were once like me in school, in technology class, sitting

> down, learning. So, if they can accumulate knowledge and they can create all these things, I can do that too, if I take my technology lesson seriously. So, technology lessons have made me feel like I can be like all these people creating cars, computers, phones, and one day I can be like them" (Student R2, Group 1n).

Here, the student demonstrates awareness that someone can be a technological person. The researcher thinks the student is referring to become someone 'versed' in technology.

From the evidence found in this theme, it is clear that students learning technology have expectations in some areas, which require the development of new skills and an understanding of concepts related to technology, including vocabulary. Therefore, we can infer that students have positive attitudes towards the subject because it is novel; consequently, they are optimistic about the opportunity to learn technology at school.

2) Construction

Construction refers to the constructional techniques discussed frequently by students. For example, when the researcher reflected on one of the themes, "knowledge", he said to students: "You said technology lessons help you to build knowledge. Can you describe one of those experiences where you think this has happened for you?" The students' responses included:

> "Like the construction of angles, like our teacher if he is doing it, we used to wonder how he will do it and the line will be very straight. So, we are just wondering about it. So, he will tell us to go and do it by ourselves. And when we do it, we find out that there is no magic. That is just by our acquiring of skills and the way we perform when we are doing our [technology] education" (Student R4, Group 2n).

Furthermore, the student below talks about learning how to use the skills acquired when they learn about construction, which they might need elsewhere.

> "For example, there was a project on construction of [a] motor. During that construction, we know how to make also the motor and all those kinds of things. How to construct electrical things in the lab [workshop], even in the class too we construct things like cars, lights, different types of things so that we can use them for our technology experience in the class. So, my own understanding of technology lesson is that it helps us in so many ways like construction of things" (Student R1, Group 1n).

The extracts above outline how students reflected on how they apply 'knowing-how knowledge' (their implicit knowledge), as opposed to 'knowing-that knowledge' (which is often explicit), in constructional techniques. For example, during the car project activities, they explained that they knew how to make motors and all kinds of things. However, it was surprising for them, because it was considered magic until they had to use it for their car project. From the perspective of this theme, it could be argued that students seem unaware that technological concepts are interrelated, such as connections with technological artefacts (in this case, a car) and technological knowledge (constructional techniques in a technology lesson). This is further elaborated in the following extract:

> "In construction, I never knew how to construct before, so when our teacher taught us how to construct, I thought I would not be able to construct, because it was so hard for me to understand. So, when he gave us an assignment and told us to look to the textbooks for examples to understand it, so as I was going through in the house, I found out that it was very simple, it was not that hard. So, I succeeded in carrying out the construction, and since then any time he gives us construction work I was able to do it without stress or thinking that I will not be able to do it" (Student R2, Group 1n).

However, the examples below reveal that students were fascinated with construction. Thus, it is not clear whether they understood why they were being taught constructional techniques. This is evident in the following extracts:

> "What I have been taught in our technology lesson is how to create angles, construct angles, construct shapes, bisect lines. Like the last time, we were taught how to construct the square. Normally when I want to draw a square and really say I draw the four lines equal but the way our teacher taught us how to construct the square, now I can be proud to construct a square" (Student R1, Group 1e).

> "Before I don't know how to bisect a parallelogram, but now I can, and I enjoy it" (Student R4, Group 1e).

Again, the extract below outlines explicitly how they learn to construct different types of angles:

> "We learn how to do some metalwork in our technology lessons. How to construct different types of angles like 90°, 180°, 360°, all the degrees we have in a circle even in triangles and other shapes" (Student R1, Group 1n).

In summary, the experience of students in relation to this theme underpins the importance of creating a learning experience that students can associate with technology. As can be observed, the findings in this theme suggest how student experiences of technology in the classroom can influence the formation of technology concepts that may be relevant to other areas of learning.

3) Emotions

This theme refers to some expressions that explain how students feel about technology as a school subject. Strong, emotive words, including 'fascinating', 'revived', 'enjoy' and 'happy', were used by students when they described their experiences of technology in the classroom. For example, two students who talked about the instructional approach taken by the teacher stated that:

> "The reason why I said technology lessons are fascinating is because the teacher when they teach us, they will explain to us why it is like this and why it is like that" (Student R2, Group 1e).

> "With what our teachers teach us in technology in all the four subjects that are under technology, I will say I enjoy them, especially our technical drawing. I like the way our technical drawing teacher digs deep into the topic and teaches us very well. Even those who hate to participate in things in class, once our teacher is through teaching us, even people that don't like the subject come to like it. And one thing I would like to say is that our teacher appreciates everybody's effort" (Student R1, Group 1e).

Although the students are somewhat unclear, there is a connection between their emotions and the instructional strategies employed by the teacher to help students become independent, strategic learners. For example, as we can see in the extract above, Student R1, Group 1e, enjoys the subject because the teacher "digs deep into the topic". This suggests that for students, their teacher's pedagogic strategies are important in understanding what is being taught.

Other students talked about similar experiences. For example, in the following two extracts, the students seemed inspired by technology as a subject because they felt that their teachers used techniques that helped them to understand the lesson, although this was not explained clearly in the extracts. For example, a student felt their technology teacher was revivifying: "In my technology lesson, I feel revived … When teacher is teaching us" (Student R1, Group 2e).

Meanwhile, another student derived interest not only from the subject, but also from trusting what the teacher told them about the topic they learnt:

> "I would like to talk about metalwork. Metalwork is an interesting subject for me. Like now, our teacher tells us how we can use metals … to make wires because it has a high level of ductility and can be stretched. And because it is a good conductor of electricity and heat. What I have to say is that is true because at times if we don't take care in the house, we can get shocked or electrocuted by electricity in the house and that is because it is a good conductor of electricity and heat too" (Student R3, Group 1e).

Moreover, students reflected on their personal feelings regarding technology without making an explicit connection to the instructional approach:

> "I enjoy my technology lesson very well because it gives me more ideas about life … I feel happy because I am knowing more things. So, I can go and tell people who do not know" (Student R3, Group 2e).

Further evidence suggests that students appeared interested in technology lessons due to their relevance to their aspirations. Examples included:

> "My technology lesson is nice, most especially the metalwork. It teaches us most especially about metals and non-metals" (Student R4, Group 2e).

> "Technology lessons make me believe in myself that in the future I can become a technological person, a person who knows a lot of things about technology. And it also makes me believe that these people that create cars and create computers, phones or electrical appliances, they were once like me in school, in technology class, sitting

> down, learning. So, if they can accumulate knowledge and they can create all these things, I can do that too, if I take my technology lesson seriously. So, technology lessons have made me feel like I can be like all these people creating cars, computers, phones, and one day I can be like them" (Student R2, Group 2n).

The evidence presented above hints at a connection between student interest in the subject and a thirst for knowledge. At this point, it could be argued that such a connection (for example, something motivating and capable of raising interest in the subject) should be encouraged in teaching and learning, since it is likely to contribute to the development of knowledge.

4) Connections with skills learnt

This theme involves students connecting the skills they have learnt with their future significance. It is related closely to themes such as acquisition of knowledge through experience and construction, which were discussed previously. This is because it was apparent that students were able to make links between how the skills, they learnt may be helpful in a different context and result in knowledge construction, which may be useful to them in the future:

> "I feel that my technology lessons in school can help us on how to build knowledge. Like our teacher taught us how to make a spanner. Also, all these things that have been taught in school, when we leave school, we can still remember them, and if we decide to read technology in the university it can also help us to have larger knowledge than those who didn't learn anything from technology from their foundation" (Student R2, Group 1n).

> "If you are a graduate and you don't have work, you can become a carpenter and just learning about those things. Like constructing of lines in case you want to become an engineer" (Student R2, Group 2e).

As can be seen in the statements above, the evidence suggests that if technology lessons are structured to build skills and instil beliefs, students will remember them and will likely apply those skills to real-life situations. Students appeared to be aware of the need for 'large knowledge', which can be interpreted as adequate knowledge not only to enhance their knowledge, but also to better organise the student experience. From these findings, it is evident that thinking through something can help students formulate knowledge and that there is an intimate connection between knowing and doing.

5) Practical work

This theme refers to experiences linked to students' own achievements, such as problem-solving and knowledge construction, which they engaged in during different practical activities. Indeed, students make decisions that will help them improve the quality of their choices. This theme was identified when the researcher posed the following question to students: Can you tell me about something you did, like a project, in your technology lesson?

> "We did a car project with slippers. We used old slippers to construct a car" (Student R2, Group 2n).

> "About the car that he was talking about, before we cut the sides of the car we first drew the car [and] calculated the length and sizes before we started cutting the shape to form the car. And again, we also needed some motor to make the tyres move. And if you want the tyres to move, you have to connect something flexible to hold the two tyres.

> So, when you turn on the car, the two tyres will be able to respond to the motor. That is how we made our car" (Student R3, Group 1n).

The researcher asked specifically about a project that they might have undertaken to highlight an experience of learning technology. The reason for this was to gain insights into details of their practical activities; up to this point, none of the students had said anything to suggest any practical application. In this context, 'practical' refers to a project or idea capable of being put into effect. Although it could be argued that the researcher asked a somewhat leading question, the responses were surprising. The students' responses indicated that they think intelligently and imaginatively. Students not only explored different skills, including technical drawing (drawing the car to size) and materials (making tyres), but also talked about the decisions they made in the process of undertaking the project, such as: "And if you want the tyres to move, you have to connect something flexible to hold the two tyres. So, when you turn on the car, the two tyres will be able to respond to the motor" (Student R2, Group 2n).

When the researcher asked if there was anything else they would like to tell him about their technology lesson, statements made by two students reflected their experience of another project. Again, the evidence was similar but contextualised differently in that this time the focus was on electricity technology:

> "I want to talk about the electricity technology in our class. We constructed a light, a standing light which was given to us as a project by our teacher. We measured the height of the pole to use before we can make the standing light" (Student R4, Group 2n).

> "Yes sir, the electrical bulb. We look for wasted bulbs. All those ones that are spoilt, Christmas lights or all those white bulbs, we look for a microphone battery with a high

> wattage, preferably new ones, then look for CD plates, then you put a hole inside, fix the bulb inside, you put wire, measure your plank, you nail the plank together with the cassette with the disk. Then you join all the wire[s] to two wires, negative and positive, then put it inside the battery and light will begin to light" (Student R3, Group 2n).

It was not clear what the project title was, but this was later clarified:

> Researcher: *What do you call that project? I mean, what is the name of that thing that you produced?*
>
> Chorus: A lamp.
>
> Researcher: *Do you mean a lamp project?*
>
> Chorus: Yes.

Overall, the responses from students revealed their ability to identify the project in unison and talk about how they used local materials to create a lamp that demonstrates some elements of knowing-how knowledge. They could therefore explain the relationship between the design and construction processes. For example, they made decisions about the materials required in the project and production and evaluation; they knew that there was a relationship between the battery, the flashlight bulbs and the wires; and they knew why the light was illuminated. This theme therefore implies that a problem-solving activity can be used as a teachable component of the curriculum that enables students to gain distinctive knowledge, such as how to work with materials and processes of industry.

6) Boredom

This theme refers to negative feelings expressed by students regarding their experience of technology lessons. An example is illustrated below:

> "The lesson makes us know something about technology but sometimes it is boring" (Student R2, Group 2e).

Evidence indicated that students think that a part of the boredom is aroused when they have to copy from the textbook. Some of the students' comments included:

> "I just feel like work/constructing something, but our teacher's notes are very long. They are too long. And it is hard to read it. And assignments, he gives us bulk of assignments. If he wants to give us assignments, he will ask us to copy from the textbook, like he will give us like 20 pages." (Student R2, Group 2n).

This was further emphasised when one of the students in the group said:

> "At least if he [teacher] wants to give assignments, if we want to copy, he should summarise it very well for us. I hate that part about technology lessons" (Student R3, Group 2n).

Therefore, the researcher delved deeper and said: "Feel free to say how you feel. I am not here to tell your teachers about what you told me." Surprisingly, all four students in the group said:

> "I don't enjoy writing" (chorus).

Recognising that one of the teacher's roles is to help students accomplish tasks or meet their goals (Becker, 2001), the evidence above indicates that students recognised assignments as a part of their learning. However, the way in which this is conveyed to them is unlikely to help the student work at home without teacher supervision, including greater student learning outcomes (Grodner and Rupp, 2013), or promote excitement and engagement (Buijs and Admiraal, 2012). Rather, it could lead to frustration and a lack of motivation and interest in the subject (Buijs and Admiraal, 2012). Thus, it could be argued that the process of giving homework assignments is viewed as 'bulky' and 'hard'. As the students' statements above suggest, this could mean that students consider it an improper technique, which could mean that potential opportunities to promote excitement and engagement are lost. This finding further highlights the need for teachers to adopt adequate instructional techniques that will motivate students in learning technology. In the next section, the data gathered from one-to-one interviews conducted with teachers will be analysed to understand their classroom routine.

4.4.2: Teacher one-to-one interview data analysis

Four teachers were observed and individually interviewed immediately after their lessons to accurately represent and interpret their views about what they do in the technology classroom. They were asked about the rationale behind the strategies they adopt and the extent to which they influence student learning. The interviewees were: EJohn, with approximately 16 years' experience of teaching technology; EOkpaku, who has 10 years' experience; EOgodo, with three years' experience; and NAndrew, who has been teaching for five years. The letters 'E' and 'N' represent the names of the schools, and the teachers have been given pseudonyms to safeguard their anonymity.

Process of analysis

The researcher began the analysis process by familiarising himself with the data as he had done with the student and teacher interviews, as previously discussed in sections 4.3 and 4.4. This was consistent with Braun et al. (2014). The researcher read the transcripts many times to familiarise himself with the content. The researcher aimed to retain some flexibility at this stage in order to get out of the transcripts what he considered relevant to answer the research question. For example, it was important at this point to reflect on the technology education curriculum. The Federal Ministry of Education (FME) constructs what a government-appointed panel of experts consider an appropriate technology education curriculum for secondary schools, which is subsequently handed over to the various schools for implementation. Although the degree to which individual schools are expected to comply with such officially prescribed curricula may vary, FME (2007) suggested that teachers adapt the curriculum to their needs and aspirations in line with the government declaration of the nine-year basic education curriculum. The rationale is also underpinned by McCormick (1996), who noted that the teacher's role is to help students acquire the appropriate knowledge, skills and understanding of technology. Fox-Turnbull and Shape (2011) claimed that learning in the 21st century requires educators to include the development of critical thinking and problem-solving skills, in order to equip students for an era of accelerated technological progress characterised by new innovations whose rapid application and diffusion have caused an abrupt change in society. Moreover, new curricular guidelines can be interpreted differently by teachers influenced by the specific beliefs they hold (Donnelly, 1992), which can create difficulties for both teachers and students (Gibson, 2009). Indeed, Wooff et al. (2015) concluded that teachers of the subject and those in the wider design and technology community have significant work to do in terms of educating students about the wider implications of the subject and its potential impact on their futures.

Drawing on the perspectives of Wooff et al. (2015), there was a clear need to use Braun et al.'s (2014) inductive thematic approach to analyse the data set for the teacher interviews, given that the aim was to analyse and represent individual views as accurately as possible, which required identifying the main ideas that occur in their responses in relation to what they actually do. Braun et al.'s (2014) thematic analysis technique has been discussed in previous sections of this chapter; therefore, the researcher felt it was not necessary to discuss the whole process again. Instead, he presents a summary of the emergent themes, before interpreting them and outlining the findings from them.

Table 4.6 Overview of interview guiding questions, including examples of extracts and themes

Theme number	Interview question	Examples of extracts	Theme
1	How do you feel your lesson went?	"Well, I hope it went well … you could see at the end of the lesson I gave the class two assignments. One is the classroom exercise, the other is a take-home exercise" (EJohn); "I feel the lesson went well because from the evaluation I get from the students, which is the feedback, it shows me that the lesson went well" (EOkpaku); "Erm … you know we base our teaching on exams … I think it was very OK" (EOgodo); "Well, the lesson went well as to the availability of the things we have. So, to me it went well" (NAndrew).	Beliefs about lesson delivered
2	Would you say the students got out of the lesson what you wanted them to?	"Erm … not really, because of what I said, time, considering the time after preparing your lesson plan, examples that one would give to substantiate the point, one might not finish writing that within the time frame" (EOgodo). "… they [school] want to use one person to be doing the job of three persons. Ordinarily, in terms of technology like this, or science subjects, we have the lab technician, who is supposed to be purely fully a technician that works on	Constraints

		the lab. So that is one of the major constraints … sometimes, when you tell the school that you are short of staff, they will say you are there" (NAndrew).	
3	Was that how you hoped the lesson would go?	"… because technology is a practical subject and each concept acts as the foundation to the next one, I give them exercises to make sure that they really understand the particular concept that you introduced before you go to the next one. Because up to 70 per cent that showed their class work got them right. However, there are still some that need some assistance. So, I believe that approach has been working for me and I do not have any reason to change drastically" (EJohn). "No, that s not how I hoped it would to go, but that is the extent that we can go, because when you are teaching theory it is just a matter of explaining. You describe the object but that practical when the workshop is there, the students will do it. There might be some ways you might explain some certain things practically from a theoretical way of viewing it" (NAndrew). "Yes, I think because the strategies I adopt to impart my knowledge go a long way [towards] telling me that the students are getting it. … the behavioural moral objective which takes cognisance of the main point in the lesson … The	Disposition to teaching style

		question that I put to the students as an evaluation and the students' participation in the class are some of the yardsticks that actually let me know whether the students actually get what I want or not" (EOkpaku).	
4	What are the things you think would make you vary the way you present your lesson?	"The only thing that I would say is that you know in the design of the curriculum for this course, we need to have what I will call the practical materials on the ground and not we just go to the class, demonstrate, then you come back [and] you try to do one or two designs" (EOkpaku). "You know we talked about metalwork and that metalwork is supposed to be demonstrating the practical to the students. In the class, you see that we are trying to tell them how to visit other places where we can find these materials like the workshop, which is owned by people who are doing it outside for their daily job, whereas it is supposed to occur in the school … The aspect of the practical is not there. But it has been our system here because there is lack of technical know-how on how to handle this subject technology" (NAndrew). "… in some of the new schemes that we have now, there are strange things which [are] in some of the books that I have consulted, so you [I] cannot do it.	Pedagogic challenges of teaching technology education

		… At this level, they may not get it right, because it is more of a practical course, in the sense that they need to go to the site to see it done by somebody and get to know them. But the problem that we have here is that the school is so tight [lack of funds] [that it's not able] to sponsor an excursion and see how it is done" (EOgodo). "… teaching technology is a big challenge in a developing country like Nigeria in that we don't have the necessary materials and equipment as it is supposed to be" (EJohn).	

As we can see above, there are four main themes: 1) beliefs about the lesson delivered, which refers to links made between the lesson delivered and the duty of helping students to learn; 2) constraints, which refers to limitations arising from school schedules; 3) disposition to teaching style, which refers to teachers' strategies on the topic to be taught; and 4) pedagogic challenges of teaching technology education, which refers to feelings related to meeting or exceeding expectations that go along with the teaching and learning. These will be discussed in detail during the presentation of findings below.

4.4.2.1: Presentation of findings related to teacher one-to-one interviews

1) Beliefs about the lesson delivered

This theme was key to understanding the link between the lesson delivered and the duty of helping the student to learn. For example, we saw from all teachers that although the lessons could have been better, they felt the lessons went well generally, as outlined in Table 4.5 above. The evidence associated with this theme further demonstrated that teachers believe students are yet to understand technology as a subject. For example, EJohn said, "Because technology is somehow a relatively new subject for secondary school students in Nigeria, in that it is not something that they started very early in primary school. So, because of that you have to apply all sorts of methods to make them interested in it." There is also evidence that teachers teach to exams, as another teacher, EOgodo, stated that "We base our teaching on exams" when asked, "How do you feel your lesson went?"

2) Constraints

This theme refers to some limitations arising from school schedules, which were constraining the teachers' lessons. For example, EOgodo's statement revealed that in certain situations, the technology lesson period requires more than the 70 minutes scheduled in their school: "Considering the time after preparing your lesson plan, examples that one would give to substantiate the point, one might not finish writing that within the time frame" (EOgodo). Similarly, EJohn said: "I have to sacrifice some of my time to assist them. So that those that I could not see their work in the classroom, they can come back to me in my office in their free time." The story is no different at Nwanne. The researcher asked NAndrew: "As the only technology teacher in this school, can you tell me how you manage with the different lessons, for the different classes?" His reply is presented below:

> "… they [school] want to use one person to be doing the job of three persons. Ordinarily, in terms of technology like this, or science subjects, we have the lab technician, who is supposed to be purely fully a technician that works on the lab. So that is one of the major constraints … sometimes, when you tell the school that you are short of staff, they will say you are there."

3) Disposition to teaching style

This theme refers to teachers' strategies on the topic to be taught. Given that all teachers claimed their lesson went well, the researcher asked teachers: "Was that how you hoped the lesson would go?" This was particularly important for the study, because the researcher was interested in their decision-making about teaching technology, in terms of whether it is conceptually or morality related. Consequently, EOkpaku described how he knows whether the students take what he wants from the lesson:

> "The question that I put to the students as an evaluation and the students' participation in the class are some of the yardsticks that actually let me know whether the students actually get what I want or not."

EOkpaku further elaborated:

> "Apart from the explanation you give in the class to elaborate or explain or to describe to the students what you want to communicate to them, there are certain facts that you cannot do without, which is the main point, the behavioural moral objective which takes cognisance of the main point in the lesson."

Conversely, EJohn said:

> "… nothing good comes easy. And you know that when you compare technology concepts with ordinary average subjects we do in Nigeria, it demands a lot from students before they can actually grab the concept of technology … It is not like some draw flower, like literature and others, telling stories, bible knowledge they are used to telling stories, which students will just follow easily without too much task in their brain. But in the case of technology, you have to develop the skill and their mental ability. So, I try to commit extra efforts to help them."

As we can see from these two teachers' statements, there is evidence to suggest that the way they teach technology as a subject can be linked to what they want the students to take away from the lesson.

4) Challenges of teaching technology education

This term refers to how teachers describe their feelings in relation to challenges they have to confront in order to meet the expectations demanded of them by their work. Indeed, there was a consensus among teachers that a lack of resources presented a major hindrance to the teaching of technology. Below are some extracts taken from their related individual comments:

> "They know what a microphone is. But if I have a transmitter standing with an aerial and I say let's transmit today and we transmit it will make the lesson interesting and the students cannot forget the item he used in the course of teaching that lesson" (EOkpaku).

> "… new schemes that we have now, there are strange things which in some of the books that I have consulted, because it is more of a practical course, in the sense that they need to go to the site to see it done by somebody and get to know them. But the problem that

> we have here is that the school is so tight [lack of funds] [that it’s not able] to sponsor an excursion and see how it is done” (EOgodo).

> “… we don’t have the necessary materials and equipment as it is supposed to be” (EJohn).

> “In the class, you see that we are trying to tell them how to visit other places where we can find these materials, like the workshop, which is owned by people who are doing it outside for their daily job, whereas it is supposed to occur in the school … The aspect of the practical is not there” (NAndrew).

4.4.3: Lesson observations data analysis

Further to the analysis of the one-to-one interviews conducted with teachers, analysis of lesson observations and field notes revealed that teachers do not incorporate practical work into classroom practice. At this juncture, it is important to mention that the data-capturing method for lesson observations consisted of taking informal field notes. Therefore, the purpose of lesson observations data analysis is to provide a context for what is going on in technology classrooms in order to make decisions when something may be considered significant to the research question. This enabled the researcher to recall what had been seen and heard without having to infer why and how something happened, in addition to providing the opportunity to better understand how technology lessons are taught in Nigerian schools – for example, the process of learning that is employed to foster an understanding of technology; the extent to which activities, talk and tasks are linked to get students to recognise their value and meaning beyond the instructional context; and the need to give students explicit access to strategies that will enable them to construct and process their own ideas.

Process of analysis

Analysing lesson observations and field notes was not a straightforward process. For example, the coding part of Braun et al.'s (2014) six-step process was considered unnecessary. This was because the researcher made notes about what he saw and heard during the lesson observation within a few hours of the observation. He felt he might forget most of it if it wasn't written down somewhere, which would have affected the issues he wanted to better understand in relation to the research question. Therefore, rather than transcribing them, as for the interviews, field notes were analysed as collected, as they provided an accurate account of what was observed and the observation process.

4.4.3.1: Presentation of findings related to lesson observations

The findings focused on the interactions between teachers and students. During lesson observations, it was possible to differentiate between most of the students' approaches to learning; they were simply sitting, listening or watching the teacher write on the chalkboard, and the lesson moved on. In this analysis, the researcher is not claiming that he knows what was going on inside the students' heads. However, he noticed that when the teacher described something in a way that was funny, and when they explained an idea or made a comparison, the students listened intensely. The students did not ask any questions. Most students did not have textbooks for the different technology subjects. Therefore, they relied on the teacher's notes, often written for them on the chalkboard. During each observation, the teacher carefully explained the lesson's objectives. During the interview, the teachers explained what was stated in the curriculum and how they supported student learning processes (Table 4.7).

Table 4.7 Overview of analysis of lessons observed drawn from field notes

Field note number	**Class group / Topic or actual classroom practice / period (time)**	**Reflection on student activities**	**Related teachers' extracts drawn from teacher one-to-one- interview transcripts**
1	JS1 / Construction of parallelogram / 70 mins Teacher-led lesson: a) The teacher demonstrated on the chalkboard how to bisect and divide lines, measure angles, and bisect and construct angles.	Students listened to the teacher talk and copied notes as directed by the teacher. This was a technical drawing period. When the teacher finished drawing on the chalkboard, they asked the students to carry out a task on their own based on the dimensions provided. The students' work was assessed, and those who were unable to complete it had to hand in their work the following day.	"We improvised like those things you saw us using to teach the students. The classroom drawing instruments we have to fabricate them in our woodwork workshop and metalwork workshop. We could have needed other things like an overhead projector and all that, which we don't have because the school budget is tight. These are the things that make us have a little bit of difficulty in teaching our lesson in the way and manner it is supposed to be. Because some of these teaching aids that are supposed to help us reach out and make students understand more are not there. We have to make more extra effort by way of explanation,

			improvisation and giving extra time and all that" (EJohn).
2	JS2 / Transmission of electric power at high frequency / 70 mins Teacher-led lesson: a) The teacher explained the meaning and principles of transmission at low and high frequencies. b) The teacher explained types of frequencies. c) The teacher's list of types of frequencies included Amplitude	Students listened to the teacher talk and copied notes as directed by the teacher. The students exclusively listened to the terminologies, such as modulation, electromagnetic waves, carrier waves and different frequency bandwidths. The researcher cannot claim to know what the students were thinking or why they were not asking questions, but their expressions suggested that they were not getting on with the lesson.	"Take for instance, now we are talking about transmission of electricity at high frequency, which should do with radio communication and TV communication. Now assuming we could have enough time to visit any of these radio houses, DRTV [Delta Radio Television] for example, go there with your students and they go around, ask questions if possible, let they themselves air something. So, it is not just about going to class and telling them that a microphone, erm … They know what a microphone is. But if I have a transmitter standing with an aerial and I say let's transmit today and we transmit, it will make the lesson interesting and the students cannot forget the item he used in

	Modulation (AM), Middle Wave (MW), Short Wave (SW) and Frequency Modulation (FM) bands (this is for the radio frequencies). For the television bands, we have Ultra High Frequency (UHF), Very High Frequency (VHF) and Super High Frequency (SHF) channels. d) He described how the microphone converts the information or message (voice signal) as a form of sound waves into a vibrating electrical signal; the transmitter modulates the carrier waves and sends out the electromagnetic waves received from the transmitter. The receiver demodulates (separates) the carrier waves, amplifies the message signals to the loudspeaker and		the course of teaching that lesson" (EOkpaku).

	converts the message signals into sound and electrical energy.		
3	JS3 / Marking out the wood for a frame / 70 mins Teacher-led lesson: a) The teacher described and demonstrated setting and marking-out tools: try-square, pair of compasses, sliding bevel, metre square. b) The teacher asked students to visit local carpenter workshops, at their convenience, to see the practical aspect.	Students listened to the teacher talk and copied notes as directed by the teacher. This lesson was intended to engage students with methods of marking out on a piece of wood, so the class was held in the school workshop. Surprisingly, the teacher was sketching on the chalkboard while also demonstrating the procedures on the chalkboard as the students watched. The researcher observed that two students were not drawing or writing. An informal discussion with the two students indicated that they were bored and would have preferred to be practically engaged.	"You remember that my subject is practical oriented. And anything practical you are doing in less than three hours is not a practical. A practical should allow at least three hours. And as you can see, I am the only person taking the practical aspect of it and taking the theoretical aspect of it too, because in carpentry and joinery, ideally, you are supposed to have an instructor and the lab attendant. Then after I have taught them on the chalkboard, then they would go and exercise with the lab man, but we don't have a lab man" (EOgodo).

4	JS3 / Joining wood / 70 mins Teacher-led lesson: a) The teacher named, classified and stated uses of common woodwork joints. b) The teacher demonstrated freehand sketching of common woodwork joints. c) The teacher demonstrated mortise and tenon, butt, dovetail, and lap joints.	Students listened to the teacher talk and copied notes as directed by the teacher. The teacher wanted the students to talk about wood joints from their textbooks but there was a problem. Only two students had the official textbook and could not interpret their understanding from the textbook and the other students laughed at them.	"I really want the students to know every-thing, both the theory and the practical … Ordinarily we are supposed to go to the workshop and demonstrate different aspects of how to mortise wood and how to curve the wood and different types of wood joint, and they have to do it, so that when they see the carpenter doing it outside, they would be able to know that this is what I was taught. But in the class, they just only understand that there is one thing they call a joint" (NAndrew).
5	JS1 / Metalwork and hand tool / 70 mins	Students listened to the teacher talk and used most of the time to copy notes. The students were often engaged trying to draw the marking-out tools as well as	"Like the class we just finished now. You know we talked about metalwork and that metalwork is supposed to be demonstrating the practical to the students

	Teacher-led lesson: a) The teacher explained types of metalwork machines and their functions. b) The teacher demonstrated the centre lathe and its operation using his drawing on the chalkboard. c) The teacher emphasised safe operation and sense of tidiness and safety in the workshop.	they could. In a class of 18 students, only two had drawing instruments, but they were content to share them with classmates. So, the class was disorderly, because the students were moving from the seats to either collect or return the drawing instruments to their rightful owners.	… But if we have it in the school, they will do it in my presence and I will monitor and correct whatever errors they must do … But since the cutting tools are not there, the metals are not there, if we want to do something, I will just tell them to go to the market and buy it" (NAndrew).
6	JS2 / Woodwork machines and portable power tools / 70 mins	Students listened to the teacher talk and copied notes as directed by the teacher. This was another period the students just	"I teach them woodwork now and maybe if the school will teach them how to saw, they may not saw it very straight. But

	Teacher-led lesson: a) The teacher explained portable power tools and their uses. b) The teacher demonstrated safe use of the machines. c) The teacher listed safe workshop behaviours.	listened while the teacher went on reading from his textbook. At the end of the period, the students were given sections of the textbook to copy from. Also, they were told that if they wanted to see any of those tools, they should visit factories that make furniture around their locations.	when they go to the factory, they see the finished work of how the machine is sawing it and very neat and how they sandpaper it and how they spray it. If they see a finished work like that, they will now have the idea that it is OK. This is the machined type and the one we did in school was using hand tools. So that is what we are doing now, the machine can still do it. With that idea, you will be building their orientation that there is more than one way to do the same thing. If they are not exposed to that refined [machine] product and they see one from the factory, they will think that the local way [using a hand tool] is the only way to produce the thing" (NAndrew).

Table 4.7 reveals that, to a large extent, teachers lack adequate material to teach in the way they intend or to motivate the students to undertake a task or activity. Thus, it could be inferred that a 'disconnect' exists between what students in technology lessons are actually doing and what they are 'supposed' to be doing. For example, in a technical drawing lesson, the teacher demonstrated how to bisect and divide lines, measure angles, and construct angles, "because some of these teaching aids [overhead projector and drawing instruments] that are supposed to help us reach out and make students understand more are not there" (EJohn). We can see similar evidence in other lesson observations – for instance, in JS3, the joining wood lesson, in which the teacher named, classified and stated uses of common woodwork joints, using some freehand sketching on the chalkboard to demonstrate mortise and tenon, butt, dovetail, and lap joints. During the interview, the teacher spontaneously recalled what had happened in the lesson to express his feelings about what is actually happening in his school:

> "Ordinarily we are supposed to go to the workshop and demonstrate different aspects of how to mortise wood and how to curve the wood and different types of wood joints, and they have to do it, so that when they see the carpenter doing it outside, they would be able to know that this is what I was taught. But from the class, they just only understand that there is one thing they call a joint. But to the extent at which the joint go, they won't know" (NAndrew).

In terms of what happens in the classroom, the statements from teachers reveal that they are concerned that they are not able to make students put what they have learnt into practice given the circumstances in their schools.

4.4.4: Summary of RQ2 data analysis and findings

RQ2: In what ways and to what extent, if any, does student experience of technology align with learning about technology in the classroom? As previously explained, in the context of this study, the term 'align' refers to the demonstration of a connection students make between their perceptions of technology and their relation to experiences of technology in the classroom. Therefore, in this section, the researcher attempts to use the findings from the student group interviews, the teacher one-to-one interviews and the lesson observations, because they relate to students' learning about technology in the classroom. These findings bring to the fore several issues.

Findings related to student group data revealed that students at Ekete and Nwanne demonstrated that their school technology is about construction of different angles and bisection of lines and angles. This might indicate that students do not seek the underlying concept. It is the researcher's understanding that students tended to associate their reasoning with usage of physical things. Reflecting De Vries's (2005) perspectives on technology, the basic idea is that physical objects (concept of technological artefacts) are interrelated with other concepts (technological knowledge, technological processes and technology as a part of human existence) to form an entity (technology), as previously explained in Chapter 2. As we saw in the analysis, the students gave weak or brief explanations to account for the concepts they used, which suggests that a limited understanding of the concepts of technology in the context of real-world applications (everyday; existing or occurring in reality) may have negatively impacted their interpretation of technology.

In addition, based on the findings related to teacher one-to-one data and lesson observation data analysis, there is evidence to suggest that what teachers were doing could be related to what students do in technology lessons and, by implication, how they talk about their experience of technology in the classroom. Therefore, in relation to RQ2, this analysis has shown that students' experiences of technology in the classroom reflect what they do and that they are 'disconnected' from technology outside the classroom – in other words, in a real-world scenario. They are not clear about what the term 'technology' means and are unable to formulate an analytical definition of technology (see Chapters 2.4 and 2.5). The term 'analytical' is used here in its classical sense, as it is defined in the book *Teaching about Technology: An Introduction to the Philosophy of Technology for Non-philosophers* (De Vries, 2005). In this book, the main aim of analytical philosophy of technology relates to characterising technology itself and how technological concepts can be defined and understood. Mitcham (1994) used the term 'engineering philosophy of technology' (for analytical philosophy of technology), arguing that it is helpful in developing appropriate concepts and ideas to understand both the practice of designing and creating artefacts (in a wide sense, including artificial processes and systems) and the nature of the things created.

There is evidence of students having to rely on teachers, who have indicated their willingness to support the students' learning processes but are constrained by the lack of adequate resources to meet the challenges of providing students with opportunities to make connections between what they teach about technology and its applicability outside the classroom. Therefore, it is reasonable to assume that the students' experiences of technology do not align with perspectives on technology (most concepts of the nature of technology in the real world), given that there is evidence that students have made little or insufficient connections between the realities of technology and what they learn in the classroom.

In the model for conceptualising technology proposed in the literature review chapter, we saw that each integral concept of technology – technology as technological artefacts, technology as technological knowledge, technology as technological processes and technology as a part of human existence – represents technology but is insufficient in itself to understand what technology means. However, the findings related to students' experiences of technology education, based on the data sets from the student group interviews, teacher one-to-one interviews and lesson observations, suggest that technology education in students' interpretation implies technical drawing, metalwork, woodwork, applied electricity and electronic subjects, construction of different angles and shapes, and joints. When students were involved in projects in which everyday knowledge was used intuitively – for example, during the car project activities and the standing lamp project – most students barely gave an explicit explanation for what they were doing. Thus, it remains unclear whether students can link technology education with their knowledge of concepts of technology. However, there were a few instances where teachers attempted to link the technology lesson to the context of everyday experience of technology in the interview. A case in point is the example quoted earlier: "They know what a microphone is. But if I have a transmitter standing with an aerial and I say let's transmit today and we transmit, it will make the lesson interesting and the students cannot forget the item I used in the course of teaching that lesson" (EOkpaku). The teacher seemed frustrated that he could not deliver the lesson as intended, in that he wanted the students to attempt the practical aspect with him in the class; however, he could not implement it practically due to a lack of adequate resources. Therefore, it seems appropriate to consider how to encourage the students to develop and construct new knowledge that is dedicated to understanding technology, as well as considering how to support the technology teachers. Details of this notion will be discussed in the next chapter (Chapter 5: Discussion and conclusions).

Chapter 5: Discussion and conclusions

5.1: Introduction

In this chapter, the researcher considers the findings in relation to the two research questions of this study: 'How do students conceptualise technology in their everyday lives outside of school?' (RQ1) and 'In what ways and to what extent, if any, does students' experience of technology align with their learning about technology in the classroom?' (RQ2). It is important to understand that the background to this study is the rising rate of unemployment and poverty in Nigeria (Oshewolo, 2010; Okonjo-Iweala, 2012; Asaju et al., 2014; Olateru-Olagbegi, 2016). In addition, some of the literature (Uwaifo and Uwaifo, 2009; Adeoye and Olabiyi, 2011) suggests that a key issue is to ensure the technology education curriculum provides adequate knowledge and requisite employable skills to students. Considering these perspectives, the current study's analysis and findings consider the perceptions of technology students hold (that is, the way they interpret and understand technology in everyday life and in the classroom) to gain insights into how they learn technology which might be useful for understanding how they can best develop employable skills for the present and future. To achieve this, the study design focuses on exploring data that can help answer the aforementioned research questions.

As previously discussed in Chapter 2, technology education research is a relatively new field of activity. However, as the primary focus of this research is to understand the technology education process, it cannot be considered in isolation from the practice of teaching and learning and the students involved. In their book *Making Sense of Secondary Science: Research into Children's Ideas*, Driver et al. (1994) noted that it is important for students to know how scientific ideas are developed and evaluated so that they can appreciate the significance of sharing and revising ideas and gain confidence in trying and testing ideas. This current study has done something similar (see Chapters 3 and 4) by directly observing technology education classroom practice and gathering data from the teachers and students in their own words with respect to their perceptions of technology. This has provided detailed description of how students perceive technology and technology education based on their experiences.

Although generalisation of findings is always a ‘tricky’ issue in qualitative studies (Magnusson and Marecek, 2015), it is important to mention here that the sample used in this study was relatively small – two schools, and eight students per school – which might have limitations in relation to generalisation. Therefore, the researcher suggests that it is important to bear in mind this limitation when generalising the findings in this study to a larger population.

Thus, in this final chapter, the researcher discusses in detail the findings and their originality in the context of the existing literature. The chapter also outlines some of this study’s limitations, implications for future research, and policy and practice derived from this study, before offering some concluding thoughts.

5.2: Summarising the findings and their originality in the context of the existing literature

This section reviews some of the issues that arise from this study’s findings pertaining to each of the research questions (RQ1 and RQ2). In Chapter 4, the researcher analysed the data collected for this study and summarised the findings to RQ1 and RQ2, which can be found in sections 4.3.2 and 4.4.4 respectively. With respect to the RQ1 data analysed, the themes produced were “communication”, “entertainment”, “completing schoolwork”, “familiarity with use of certain types of items” and “aversion towards technology”. In relation to RQ2, the themes that emerged were “acquisition of knowledge”, “construction”, “emotions”, “connections with skills learnt”, “practical work” and “boredom”. Overall, the findings in this study suggest a rethink of conceptualisation of technology is needed in the context of both inside and outside the classroom. These findings also have potentially far-reaching consequences for any future attempts to make technology education more relevant to students learning about technology, particularly in terms of shaping and managing students' practical experiences in order that they may maximise their potential, develop their skills, improve their performance and achieve their personal and professional goals.

Based on this study's findings, the researcher argued that students' conceptions of technology are limited when judged against existing views of technology in the literature. Indeed, this study found that students appeared to associate technology with the perceived importance of the artefact to them individually, particularly in terms of it meeting their needs.

This study's findings differ from some of those in research by Firat (2017), who found that an artefact had to be powered by electricity to be regarded as technology and that a non-electrical thing could not be considered to be technology. The current study, on the contrary, found that some things that are not operated by electricity were recognised as technology. For example, one student described a cutlass as technology, stating that "a cutlass is still a technology, because we use metal and iron to form a cutlass, but it is not as fast as an electric [lawn] mower".

Reflecting on the available studies carried out on students' perceptions of technology, as discussed in greater detail in Chapter 2, the work of DiGironimo (2011) concluded that students' perceptions of technology are influenced by what they see rather than the logic surrounding elements. The findings in this current study differ. As evident in the example given above, the student not only described a cutlass as technology, but also talked about the reasoning surrounding the process of making a cutlass and its function.

In light of the findings for RQ1 and RQ2 and given the contexts of students' conceptualisations of technology and learning about technology as a subject, the researcher identified five central features that characterise the findings presented in Chapter 4: variety in students' talk; technology and technological literacy; learning strategy and teaching strategy; and student engagement. These features will be discussed in turn below and will also be used as the focus for this study's discussion and conclusions chapter.

Variety in students' talk

One of the main findings of this study was that technology is often conceptualised in terms of technology as artefacts in a variety of ways. Some experiences were explicitly explained, but most were not. It was noted that all the students were enthusiastic about technology, but they seemed unaware of basic concepts of technology. In Chapter 4, a summary of the findings related to RQ1 was discussed. The findings indicate that students from both schools conceptualised technology outside of school in terms of artefacts, such as mobile phones, personal computers, electric cookers, cars and refrigerators, and in terms of functions associated with usefulness and usability (see Chapter 4, section 4.3.2, for details). The diverse ways students talked about technology was surprising. For example, one unanticipated finding was that the students regarded charcoal irons and hand-grinding stones as technology. Indeed, some students made extensive use of narratives of personal experiences of technology outside school. As this study showed in Chapter 4, while seven students used the word 'technology' when referring to their experiences of devices or gadgets, their statements reflected similar experiences to those students who did not mention 'technology'. The researcher found that these students also described devices and gadgets as things that saved them time and energy and were easy to use, which reflects views expressed in the existing literature on students' perceptions of technology (see Chapter 2). The examples show that what technology means to students revolved around their emerging needs. The findings related to RQ1 in this study revealed that students recognised televisions, electric mowers, charcoal irons and cutlasses as examples of technology. These examples suggest that when it comes to understanding technology in general, context matters. As the researcher discusses later, this potentially has significant practical implications, because, as seen in this study, the primary pedagogical approach was theoretical, and students listened to the teacher talk for most of the lesson.

Also, this study's findings are consistent with those of Khunyakari et al. (2009), who helped highlight insights about students' ideas of technology among Indian middle school students. The study conducted by Khunyakari et al. (2009) revealed that students recognised electric/electronic objects as technological artefacts, but kitchen equipment and making *rangoli* (decorative patterns on house floors) were not regarded as technology. The study stressed the need to incorporate some ideas when developing activities such that technology education could foster a comprehensive and broader understanding of what constitutes technology. In this current study, it was revealed that all the students who participated in the study also talked about familiar technological objects (artefacts). The question that arises from these similar findings (Khunyakari et al. (2009) and this current study) is why it is that when students are asked to talk about technology, they gravitate towards technological artefacts.

In another study conducted by DiGironimo (2011), which aimed at developing a conceptual framework for the nature of technology, students were asked explicitly: 'What, in your opinion, is technology?' Exactly half of the student responses referred to objects, general and specific, and most students tended to characterise the nature of technology as technological artefacts used for fun and for school-related and work-related factors. This suggested that the students recognised, at some level, that technology is made for a purpose and, in its use, fulfils a need. DiGironimo (2011) concluded that students tended to understand technology based on its uses and consequences but noted that the source of this tendency to define technology in such a way seemed to be that they rarely develop a practical, intuitive feel (rational process) for how technology works.

Firat (2017) aimed at determining student recognition of and reasoning about technology and technological artefacts, and found that students mostly considered that being powered by electricity was essential for anything to be regarded as technology and that a non-electrical thing could not be considered to be technology. The justification given by students for their reasoning about technology was that if an object is operated by electricity or involves use of an electric current, then it is considered to be technology, but things that do not involve use of electricity cannot be regarded as technology. This suggests that the students in Firat's (2017) study considered technology and electricity to be synonymous. In this sense, it is possible that another aspect of this finding that Firat (2017) may have overlooked is that the students lacked the capacity to make sense of alternative ways of thinking or make useful distinctions (for example, because they were unaware of alternative ways to conceptualise technology). This further highlights the necessity to encourage students to explore objects using critical thinking skills.

In summary, given the examples of technology that students talked about, it is possible to say that in most studies, students were capable of associating technology with technological artefacts. However, it would be useful for students to perceive technology beyond technological artefacts and to see it as a whole entity involving technological knowledge, technological processes and technology as a part of human existence (De Vries, 2005).

This study showed that technology in the classroom is providing students with new experiences. In Chapter 4, a student in group 2e described technology in the classroom as follows:

> "It [technology lesson] teaches us and gives us the knowledge of how to construct. It gives us the knowledge to see things and look [at] things that [we] have not heard about

> before. It helps us, for example the way technology exposes humans to things like [the] internet and some other things."

Technology education in students' interpretation is lessons taught in the four main technology subjects in school, namely, technical drawing, metalwork, woodwork, and applied electricity and electronics. Although evidence from this current study indicates that students seem to recognise that technology education involves making artefacts, they seldom link what they do in the design process with design thinking (methods and processes that designer use), which would basically consist of technological processes in which analysis, synthesis and evaluation which could easily be recognised irrespective of whatever is being designed (De Vries, 2005) (see *Technology as technological processes* in Chapter 2, section 2.5). When asked whether they would like to talk about their classroom experience of practical work, the students gave responses that suggest that they had no difficulty in understanding what they want to achieve. As Chapter 4 showed, when students talked about their car-making project, they talked about use of materials, such as "old slippers". Some students could see that it was logical to cut the sides of the car, but they needed to draw the car on the piece of material and calculate the length and the size before cutting the shape to form the car. Other students appeared to be concerned about the ability of the tyres to respond to the motor. Therefore, personal motivation appears to be a significant factor in practical activities, such as in making their technology projects realisable. As we can see, this study showed that students apparently were unable to link or were unaware of design-related concepts of technology in the project they undertook. None of the students mentioned the word 'design' or 'process' even when what they were doing encompassed the concept of technological processes (De Vries, 2005). In order to be effective in solving problems, key skills such as critical thinking skills, creative skills, and design and making skills are potentially crucial components to consider (De Vries and Tamir, 1997; De Vries, 2005). Reflecting on this perspective, it could be argued that in this current study, the findings indicate that disconnects exist between practical learning experiences in school and students' application of knowledge in everyday-life situations. This suggests that students need to be provided with opportunities that enable them to understand concepts of technology. This finding is consistent with Jarvis (1996), who studied children's perceptions of technology in the classroom using writing and drawing activities and a picture quiz. Jarvis (1996) found that children lacked the ability to link ideas of designing and making. In light of this finding, it is possible that students are unaware of design-process-related concepts. For DiGironimo (2011), who investigated students' conceptions of the nature of technology, the students sampled possessed some naïve understandings of the nature of technology: "it is possible that either the students in the study have not had these technological experiences in school or, when it was taught, it was not linked explicitly to technology" (p. 1,348). Considering what the perspectives have revealed in the discussion related to variety in students' talk, it is reasonable to assume that developing learners' conceptual abilities to understand technology might be beneficial to them in learning about technology.

Technology and technological literacy

As previously mentioned in Chapter 2, one key purpose of technology education in Nigeria is to contribute to the achievement of the national education goals, which include the inculcation of technological literacy (FME, 2007). FME (2007) further elaborated that all students should be provided with opportunities to gain a "basic understanding of technology" (p. iv). It could be argued that what is meant here by 'basic understanding of technology' is not merely that technology is associated with computers and electronics, as reflected in the Gallup studies (Pearson, 2002). The findings in this study demonstrated that although all the students the researcher spoke to expressed an interest in technology and technology lessons, when they talked about technology in their everyday lives, a significant portion mentioned technological artefacts for completing schoolwork and communicating with family and friends. This finding demonstrates that the students are focused more on tangible things, such as computers and television, which fit firmly in the technology-as-technological-artefacts dimension, and they think less about other related aspects, such as technological literacy, which relates to the knowledge dimension – in this case, knowledge of ways to use, manage, understand and assess technology as a whole entity (ITEA, 2000; De Vries, 2005). This finding is significant, because existing studies conducted by Gaskell (1982) and Lewis and Gagel (1992) argued that it is unlikely for anyone to conceive of technological literacy without being able to demonstrate that understanding of technology concepts and its application to solve problems. In that respect, it could be argued that technology education and technological literacy are linked. This suggests that when technology education is delivered effectively, it helps students acquire technological literacy (De Vries, 2005), because the aim of technology education is often to develop the technological literacy of all students (Jones and De Vries, 2009). Its purpose is not only to prepare people for technology-related employment, but also to educate students for their whole lives so that they can cope with changes by manipulating ideas using different techniques (De Vries, 2005). Bame et al. (1993) noted that students show more interest in learning technology if they feel technology impacts their lives. They argued that if one of the educational goals of technology education is technological literacy, then students exhibiting a positive attitude towards technology would be more likely to attain technological literacy through technology education, because technology education plays a crucial role in advancing students towards attaining technological literacy (Young et al., 2002; Dugger et al., 2003). Indeed, Dugger et al. (2003) argued that technology education is a source of developing knowledge and abilities towards attaining technological literacy. They advocated technology programmes that would be consistent with the standard for technological literacy (STL), which includes content, professional development, curricula, instruction, student assessment and the learning environment.

Considering the arguments above, technology as a school subject should be broadened in order to develop students' knowledge in a way that helps them understand the application of technology in real-world scenarios. The technology curriculum should include problem-solving, encouraging students to make connections between their personal experiences of technology inside and outside of school, and aspects that help them to gain technological literacy.

Learning strategy

The traditional focus of technology education has been on doing and making things (Williams, 2000) which are likely to generate knowledge, skills and positive learning dispositions required by the students (De Vries, 2005). In this current study, the findings indicated positive results in relation to the students' problem-solving skills. The learning strategy seems to the students a meaningful strategy to generate knowledge, which impacts their motivation when they are learning. For example, we can see in this study that students constructing a car from old slipper material are developing physical skills, in terms of fixing their prototype motor car parts; learning about shape and size; and, at the same time, developing a positive attitude towards technology. This finding is consistent with previous studies on students' perceptions towards technology (Raat et al., 1985; Burns, 1992; Boser et al., 1998; Becker and Maunsaiyat, 2002; Chikasanda et al., 2011). These studies found that students have generally positive attitudes towards technology; the studies advocated that students' perceptions of technology need to be accounted for when teaching technology, as they have a bearing on the students' learning. Similarly, Jones (1997) argued that dispositions and perceptions of technological phenomena and problems are significantly affected by students' conceptual knowledge of technology. Also, Chikasanda et al. (2011) argued that students' perceptions and dispositions regarding the concepts and nature of technology may not be sustained unless the students become independent thinkers and lifelong learners.

However, the findings in this study indicated that students do not seem to understand how the skills and concepts they learn are connected to reality or situations (Williams, 2000; Schumacher and Ifenthaler, 2018). The findings related to RQ2 indicate that technology education as seen by students implies technical drawing, metalwork, woodwork, and applied electricity and electronics.

Raizen et al. (1995) posited that learning is less efficient when formal knowledge is delivered in the abstract and when opportunities to situate it in realistic contexts are absent. In van Dijk's (2011) view, emphasis must be placed on providing rich context that makes abstract notions comprehensible. Van Dijk (2011) suggested that in the case of a design task, the main challenge seemed to be to find a design that would make all theoretical notions meaningful in the light of the task. Indeed, Purković (2018) suggested that instead of performing content-restricted topics, the teacher should be able to choose artefacts and realise activities, and the sense and meaning of these activities should be adjusted to the pupils' interests and needs, the level and purpose of education, and the needs of the community and society. As these views show, it could be argued that the form and focus of technology inside the classroom as demonstrated in this current study is different. This suggests that knowledge and understanding of technology among some of the students in this current study seemed to be limited to the technology subjects mentioned above. Other students preferred to talk about construction of angles and shapes and bisection of lines, because they recognised that they used the ideas from technical drawing lessons, such as construction of shapes, when they constructed a prototype motor car and a standing lamp as practical activities in school technology.

Boser et al. (1998) discussed the difficulty of enhancing conceptions of technology held by students, noting that students' concepts of technology may be difficult to enhance if only one instructional approach is adopted in teaching. Männikkö (2011) also noted that students could reject the meanings around technology taught in school if the subject is not valued, which would not lead to an increased interest in technology. This suggests that if we do not talk about the benefits of understanding concepts of technology, then we are likely to be unable to link experiences of technology inside and outside school (Lauda, 1988). It is also argued that the curriculum design could fail if the instructional strategies are inappropriate or inadequate or students are disheartened because they see no relationship between what they study in school and their outside lives (Jones et al., 1996).

The views above highlight the positive value of conceptual understanding, which is well established in the literature both within and outside technology education. For example, Jones and Carr (1992) noted the potential benefit of understanding how students think about technology and emphasised that their understanding of technology can influence their learning. Similarly, previous studies (Raizen et al., 1995; UNESCO and ILO, 2002; Autio, 2016) emphasised that students' experiences reflect technical and vocational education traditions in relation to hands-on instruction, whereby students are encouraged to make artefacts using simple tools. However, other studies (De Vries, 2005; Collier-Reed, 2009; Khunyakari et al., 2009; DiGironimo, 2011) noted that a hands-on instructional strategy focuses on practising a physical skill (demonstrating and explaining a new skill and giving the student the opportunity to practise), which allows students to experiment with trial and error and learn from their mistakes, but places little emphasis on incorporating a conceptual understanding of technology. Until now, according to DiGironimo (2011), the literature lacked a thorough conceptual framework for the nature of technology. Therefore, it is reasonable to assume that the conceptual framework for conceptualising technology proposed within this study would contribute to fill the gap in the literature (see section on conceptualising technology education in Chapter 2.6 for details).

Teaching strategy

The researcher felt it was reasonable to separate this section from the section above because it focuses on the way technology lessons are taught and what is taught in them. As previously explained in Chapter 4.4.4, in the analysis of teachers' interviews and lesson observations, the evidence indicated that the teaching used a teacher-centred approach, because the activity in the classroom was centred around the teacher (Pring, 2004; Moate and Cox, 2015). While the teacher talked, the students exclusively listened, and evidence indicated that students put all of their focus on the teacher and on copying from the chalkboard or textbook. According to Pring (2004), in the teacher-centred approach, the student may not immediately see the connections between what is being taught and what the teacher thinks would benefit the students or what the students want to learn. For example, students lack the ability to make connections between technology in the lesson and what technology means in the literature, such as understanding how technological concepts apply in the real world as opposed to in a situation that is simulated or in a textbook (De Vries, 2005). In the technology education curriculum, real-world examples help to improve student problem-solving skills by using concepts of technology and daily situations (De Vries, 2005). Examples of real-world situations in technology education curricula are demonstrated in McCormick et al. (1994) when students encounter different problems that require different approaches, according to the kind of task and the stage reached in its solution. The students need to be able to identify and apply different strategies to solve these problems. Concepts that are able to be practised or seen are more likely to be effective when they are related to the knowledge of a student's (work) experience (Nuthall, 2012), but they need to be explicitly taught in a way that can be transferred across multiple kinds of problems or contexts (McCormick et al., 1994).

As previously highlighted, in this current study, it was observed that the classroom was designed around the teacher writing on a chalkboard, and students were spending a majority of their time being quiet or taking notes (see Chapter 4: Data analysis and findings). Teachers were often more focused on classroom management concerns, such as ensuring that lessons ran smoothly, without disruptive behaviour from students. This may have compromised the delivery of instruction. De Vries (2005) noted that student learning and engagement with lessons when this type of approach is used are limited, and that technology education needs to incorporate teaching strategies such as problem-solving, case analysis and simulation to facilitate students' learning of the concepts of technology. As De Vries (2005) further elaborated:

> "The unexamined technology is not worth teaching. Wouldn't it be a poor situation if technology is taught without any kind of reflection, just as a collection of bits and pieces of knowledge and skills? Would not that easily result in a fairly random choice of what is taught and what is not taught? And would that really contribute to what future citizens need to live in a technological world?" (p. 8).

Considering the points above, the findings in this study reinforce views highlighted in previous studies (Kimbell et al., 1991; Petrina, 2000; ITEA, 2000; Collier-Reed, 2009; Khunyakari et al., 2009; DiGironimo, 2011) regarding the need to encourage students' learning about technology. For example, ITEA (2000) emphasised that an understanding of technology involves more than knowing how to use technological artefacts. As the findings related to RQ1 revealed, all students in this study conceptualised technology outside school in terms of technological artefacts. In examining teaching strategy, it is helpful to explore the ideas the students bring from outside school before they are introduced to topics in technology lessons. As we saw in Chapter 4, in one of the student group transcripts, a student talking about an experience of technical drawing practice said:

> “Like the construction of angles, like our teacher, if he is doing it, we used to wonder how he will do it and the line will be very straight … So, he will tell us to go and do it by ourselves. And when we do it, we find out that there is no magic. *That is just* by our acquiring of skills and *the way we perform when we are doing our [technology] education*” (Student R4, Group 2n).

From the student statement above, it could be argued that the teacher hardly includes a link between what they teach the students, such as in construction practice (technical drawing lessons), and realities (different ways in which students can communicate to show understanding that relates to technology). It could be further argued that this finding underscores the importance of teacher strategy in enriching the contents of lessons with relevant materials and information from their immediate environment (FME, 2007), including making connections between content and problem-solving. This finding raises the following question: to what extent do existing technology education curricula in Nigeria take into account the philosophical insights that have been documented in existing literature? It is possible that the answer is neither in this study nor in any existing study. For that reason, it could be argued that this current study has the potential to contribute to the curriculum, which should be focused not only on the content of the knowledge but also on adopting knowledge derived from philosophy of technology. Although philosophy of technology may not be popular because it is a relatively young discipline compared to, for example, philosophy of science (De Vries, 2005), it is nonetheless established in existing literature (De Vries, 2005; Collier-Reed, 2009; Khunyakari et al., 2009; DiGironimo, 2011; Svensson et al., 2012; Compton and Compton, 2013; Kruse, 2013).

Similarly, the findings related to RQ2 indicated that students’ experiences of technology in the classroom suggest that what they do and what they are taught is inadequate to understand technology outside – that is, in a real-world scenario. As we saw in Chapter 4, as previously discussed, the evidence indicated that students show positive attitudes towards technology education and are enthusiastic to learn the subject; however, technology in the classroom is about technical drawing practice (construction of angles, bisection of lines) and theoretical aspects of other technology subjects: applied electricity and electronics, metalwork (tools and machines), woodwork, and building. This finding is consistent with Uwaifo (2010), who argued that the technology education curriculum in Nigeria is too theoretical and loaded with intellectual content in pure science and mathematics at the expense of basic engineering and technology. It should, instead, provide a balance to ensure that students develop critical thinking skills that would enhance their attainment of the requisite employability skills (Okolocha, 2006). Therefore, what this study has found in relation to RQ2 is important, because it shows that what students are taught seems inadequate. Further review of the curriculum is required to accommodate potential new ideas needed for the development of students' critical thinking and employability skills, including problem-solving skills, which they may need to meet the challenges of technology in the 21st century (Young, 1993). Similarly, some studies (Kimbell et al., 1991; Petrina, 2000) noted that an instructional strategy that will benefit students' attainment of technological literacy must differ from the learning of basic skills and facts.

Student engagement

Student engagement as used here reflects how students experience a curriculum. It considers what students do and think relative to what their teacher intended them to do and think when they are learning or being taught (Trowler, 2010) to form individual understanding which can help them to improve their learning outcomes (Ashwin and McVitty, 2015). Reflecting on student engagement as explained above, the findings in this study indicate that when they are learning or being taught, students are spending a majority of their time writing, listening to the teacher's explanations and preparing assignments. Therefore, it is possible that students learning technology have been engaged in knowledge acquisition mostly through listening to the teacher conveying their own knowledge. During all the visits the researcher made to their schools, the students were passive in lessons when being taught. The teaching is best described as teacher led (Pring, 2004), because students were often quiet and busy taking notes; thus, it was aligned with behaviourism (Doolittle and Camp, 1999; Singh and Athavale, 2008; Taber, 2011). Nevertheless, evidence in this study suggests that students are sometimes challenged through school projects that involve practical assignments, which allow students to construct something for presentation. For example, students said that their teachers had given them projects to do as practice: they had constructed a prototype motor car and a lamp, both of which they found interesting. However, a previous study conducted by Mogashoa (2014) stated that "hands-on-experience may be necessary for learning, especially for children, but it is not sufficient, we need to provide activities that engage the mind as well as the hands – Dewey called this reflective activity" (p. 53). A similar discussion regarding practical work in science education was included in a study by Abrahams and Reiss (2012), who suggested that a hands-on minds-on approach produced better results. Indeed, Abrahams and Reiss (2012) noted that practical work was highly effective in enabling students to do what the teacher intended; they argued that practical work might be made more effective, in terms of developing students' conceptual understanding, if teachers adopted a more hands-on minds-on approach.

5.3: Revisiting the framework for conceptualising technology previously proposed in Chapter 2

In the data collection and analysis of this study, we saw how students conceptualised technology through their thoughts, actions and assumptions, and the different ways they expressed their understanding of technology. The findings revealed that their experience of what technology means outside school is different from their perceptions of technology in the classroom. The findings further revealed that there is a disconnect between their perceptions of technology and existing literature's perspectives on technology, in particular that technology comprises four fundamental concepts: technological artefacts, technological knowledge, technological processes and technology as a part of human existence (De Vries, 2005). Furthermore, their experiences of learning technology demonstrate that they seldom reflect all four key concepts of technology. Moreover, lessons are overtly taught by employing a teacher-led approach. The literature review highlighted the importance of paying attention to four distinct concepts of technology (De Vries, 2005). This study has already shown that connecting these concepts is potentially relevant to learning technology. In other words, the existence of the four distinct concepts has to be assumed in all cases of technology. Each concept of technology has its own description with its own set of attributes and can contribute to teaching and learning technology in unique ways: each can reflect technology through activities that are firmly related, thus enabling an understanding of specific technologies and technology in society. Thus, each concept is a learning point regarding the overarching concept of technology.

Table 5.1 below highlights the need for the proposed conceptual framework for conceptualising technology to be considered, while recognising that students' perceptions of technology, as indicated in this study, are based on technological artefacts derived from social aspects and pertaining to tangible things, and not on the attributes (characteristics) of technology (De Vries, 2005), such as the distinguishable features: colour, shape, weight and size.

This study first examined the conceptions of technology which students hold both from everyday experiences of technology and in the classroom, including ideas about solving technological problems. Table 5.1 was conceived based on the evidence from the analysed data and existing literature on students' perceptions of technology and worldviews about technology. In this light, Table 5.1 proposes the ways in which the experiences interact and could be applied, irrespective of specific technology and technology in our society, to develop learning activities that could be of relevance to enhance students’ skills.

Thus Table 5.1 represents a model for thinking and developing technological ideas further that are likely to support students’ learning about technology. The table comprises three key sets of information: (1) the proposed conceptual framework of technology derived from De Vries’s (2005) description of the nature of technology (see Chapter 2); (2) interviews with individuals and groups of students; and (3) De Vries’s philosophy of technology education. The three sets of information have been put together here because it helps to link them for discussion about developing technological ideas further that would support students’ learning about technology by (a) highlighting aspects of technology education where students have difficulties and (b) suggesting ways of addressing these.

DiGironimo (2011) noted that few studies have focused on developing a conceptual framework for the nature of technology and that most of the attempts have come from the philosophers of technology. Table 5.1 is adopted from existing literature on the philosophy of technology. However, it is important to recognise that this model (Table 5.1) includes not only key concepts of technology as described in the literature, but also methods that link concepts to one another and potential for improving technology education – in other words, for teaching purposes, to help students who are learning about technology as a subject to orient themselves when they are just beginning and beyond.

Table 5.1 Mapping the proposed conceptual framework of technology with reflection on students' experiences of technology and a proposal for improving technology education

Proposed conceptual framework: characteristics or concepts of technology from existing literature based on a range of philosophical inquiries related to technology	**Reflection on students' everyday and school experiences of technology (data from student interviews)**	**Consideration for a proposal for improving technology education**
Technological artefacts: comprise physical and functional characteristics; exemplified in terms of tangible and intangible objects, but also physical properties (colour, shape, etc.) and functional properties (how we relate to an object; uses and purpose) (De Vries, 2005; Collier-Reed, 2009; Khunyakari et al., 2009; DiGironimo, 2011; Svensson et al., 2012).	Students talked about technology in functional terms such as purpose and use associated with the specific technology. In addition, students' talk about technology in technology lessons seemed connected to how they understand technology. Apparent shortcoming: Students seldom reflected on the physical properties of the artefacts.	Students should consider reflective thinking on both the physical and functional properties of artefacts, and the relationship between the physical and functional nature of the artefacts can be used to judge, for example, the design ideas to meet given needs or opportunities (Crompton et al., 2016). Consideration for education: Students can gain a deeper understanding of technological artefacts by exploring the artefacts in such a way that their physical nature fits their functional nature. For example,

		Bungum (2006) noted that teachers' view of what students could learn from technology teaching often includes technical aspects of artefacts; hence, the teacher may add a link to emphasise the physical characteristics, such as shape, colour, size, texture, materials used and functional characteristics, such as ways that technology is changing time we spend on doing things and ease of achieving them, which would give a clear set of expectations that the artefact could be evaluated against (Spendlove, 2008). Also, Purkovic (2018) noted that the learning of technology, which usually begins with insights into and experimentation with objects of technology – that is, recognising their physical and functional characteristics – holds the potential for students to learn in the context of designing and making artefacts and to gain insights into how technology shapes and influences people, culture and society.

Technological knowledge: comprises knowing-that and knowing-how; knowing-that is exemplified in terms of norms that help us to distinguish between knowledge expressed in proposition, and knowing-how is associated with practical skills (tacit knowledge), such as how the design of artefacts was conceived (De Vries, 2005).	Students reflected on knowing-that knowledge, for example knowledge that relates to statements of fact, such as knowledge concerned with the use of artefacts (electric and non-electric operated). Apparent shortcomings: Students rarely gave explicit explanations about practical reasoning, such as trial-and-error attempts to arrive at reasonable decisions and actions, and how the knowledge was learnt.	Students should think critically on how an artefact works, and what makes it work – typically associated with practical and critical thinking skills rather than reliant on prior instruction either from a textbook or a teacher. Consideration for education: Concepts include technological knowledge as a distinct kind of knowledge that gives new insights into the analysis of a technological task (Barak and Maymon, 1998). Therefore, students should learn not only what a certain device is, but also what the device could be like and how it is constructed. Through this approach, students can learn to develop ideas not only about how things are, but also about how they can be improved (Kruse, 2013; De Vries, 2005).

Technological processes: involves design and making of artefacts; constituent elements in design plans and user plans; making, appreciation and assessing activities such as critical evaluation of an artefact and its plan for use (De Vries, 2005).	Student experiences were strongly reflected in what sequence of steps their project work followed and producing what they made. Apparent shortcomings: Students tend to look broadly at producing something such as their school project and generally do not pay attention to the design process.	Centred on activities – designing, making and modification – resulting from critical evaluation of designing and making with the users of the products in mind. Consideration for education: Spendlove (2008) noted that students can get fixated on one design and find it very difficult to change direction; they often fearfully stagnate and stick with the tried-and-trusted ideas. To break this cycle, students could be encouraged through the use of concepts of technological processes to reflect on numerous methods of designing, making, using and assessing products, such as devising different solutions for the design problems, and risk-taking in anticipation of 'effective surprise' (Brown and Brown, 2010). Students would then have confidence in design processes, in which knowledge of the process of designing as well as knowledge of the content matter are

		both used and developed in ways that are consistent with finding solutions to identified needs or problems (Williams, 2000; De Vries, 2005).
Technology as a part of human existence: considers how technology shapes human nature, such as aspects of human characteristics in which values (ethics and aesthetics) play a vital role, and examines moral issues, such as whether it is permissible to use technology when there are dangers inherent in that technology (De Vries, 2005).	Students reflected on the negative side effects that contribute to a social problem, such as spending a lot of time watching movies on television or a computer that is connected to the internet. On the positive side, students reflected on how computers and the internet help them with their schoolwork. Apparent shortcomings: Students do not seem to recognise that value and aesthetics play a role in characterising technology.	Should constitute a means of looking at how the world should be and how people should conduct themselves based on values and norms that prescribe what is good and why we should strive for it. Consideration for education: Students can be stimulated to reflect on ways of dealing with values in designing and making, such as values they have chosen to hold about technology. An example could be asking students to justify the extent to which the products they surround themselves with bring them joy. A debate to unravel this question could help students develop their critical thinking in relation to technology. Therefore,

		this concept can help in solving social problems that involve technology by investigating which value issues apply and which are threatened, and assessing solutions based on their expected consequences in relation to the realisation of desired values (De Vries, 2005; Khunyakari et al., 2009; Vandeleur, 2010).

5.4: Contributions of Table 5.1 to existing knowledge

The contribution of Table 5.1 to existing knowledge is twofold: firstly, it can provide students with modes of thinking that are creative, which could enhance their strengths and reduce their weaknesses in understanding technology; and, secondly, it could be used to form a basis for a new technology curriculum in Nigeria by providing a practical framework for implementing technology in the classroom, including clarification on the concepts and activities of technology in the real world. These points are discussed in detail below.

The information in Table 5.1 reinforces the potential value of conceptual understanding of technology, because equipping students with concepts helps them to make sense of technology (Driver et al., 1994; Reddy et al., 2003). This view is well established in the literature, both within and outside technology education (De Vries, 2005; Collier-Reed, 2009; Khunyakari et al., 2009; DiGironimo, 2011; Svensson et al., 2012). Indeed, Kruse (2013) noted that highlighting philosophical underpinnings of technology, as in Table 5.1, provides a useful framework for helping students reflect on the meaning of technology.

Table 5.1 also provides a clear starting point to address difficulties or shortcomings that students encounter in learning about technology. Table 5.1 presents ideas in the right-hand column that teachers and students could benefit from. These suggestions could help teachers to understand areas where students are weak and need strengthening to develop their own ideas and realise them in the creative act of designing and making (De Vries, 2005; Dakers, 2006; McCormick, 2006; McGrann, 2008; Rutland and Barlex, 2008; Metsärinne and Kallio, 2014).

Finally, Table 5.1 has the potential to arouse curiosity about teaching and learning about technology. As can be seen, Table 5.1 provides an insight into what should be taught that could arouse students' curiosity to learn unfamiliar things, thereby helping them to develop a holistic understanding of technology and the implications for society and the environment that arise from the existence of these technologies. For example, teachers should provide a rich context that can enthuse students to engage in designing activities, because from the apparent shortcomings identified, it could be argued that students seemed to show an interest in making something, but only appeared to attempt what they were sure would be positive. They seemed to lack courage to test their knowledge about unfamiliar actions or processes. This is where trial and error play a role in their learning. Therefore, it could be argued that the learning experience becomes valuable only when it takes students on a journey that includes a varied array of concepts of technology (Spendlove, 2008). This would provide opportunities to teach concepts that are unique to technology, create contexts that make other aspects of the curriculum more meaningful to young people and engage students in thought processes that promote the development of critical thinking skills, such as problem-solving and clarifying concepts of technology using things the students can easily relate to their everyday lives.

It should be noted that Table 5.1 makes no claims as to completeness and is presented as another way of thinking about and understanding technology. Also, it is limited to the researcher's findings in this case and understanding of technology education.

5.5: Limitations of this study

This study had three significant limitations, small sample size, the accuracy of data collected and the presented conceptual framework, which are explained in turn below.

Small sample size

One of the weaknesses of this study was, on reflection, that there was a small sample, which reduces the generalisability of the findings (Ritchie and Lewis, 2014). However, the decision to use a small sample was made in consultation with the researcher's previous supervisor, and the idea was to get a very focused view based on the concept of phenomenology. With the previous supervisor, the researcher could not continue the initial research design and had different ideas about the concept of phenomenology, which might have impacted the reliability of the data collected. In retrospect, the researcher thinks that using six schools or conducting several interviews over multiple geographical areas might have enhanced the reliability of the data, but it would have increased the costs. As previously explained in Chapter 3, the sample size of students reflected the restricted number of students allowed by the principals of the participating schools. The researcher wanted to work with three schools, but because of the constraints, two schools agreed to participate and were recruited for the study. The study would have benefited from greater student numbers; however, there are some similarities between the schools in this study and other schools. For example, the findings of this study are most likely to resonate with teachers in another school in Nigeria, in the sense that all schools teach the National Curriculum as well as focusing on teaching technology as a subject. Moreover, the researcher spoke to all four technology teachers, who reflected on their lesson for the purpose of this study. It was noticed that the four teachers shared a common view about the insufficient time allocated to teaching technology in their school. They argued that teaching technology as a curriculum subject in any school involves teaching students practical work. To do this, teachers need more class periods on the school timetable. This would make a big difference to students' acquisition of skill and knowledge, because there would be enough time for the teacher to teach and the student to learn. From this perspective, it is more than likely that the same findings would have been found if this study had been conducted in other schools.

Accuracy of data collected

Data used in this study was collected using an audio recorder and transcribed by the researcher but may contain several potential sources of bias that should be observed as limitations. For example, a variety of question types were used to make questions relevant to the topic, which may be construed as leading questions (see Table 3.5: Student one-to-one interview protocol). The researcher would like to refer to the overarching question asked in this study, which is how do students conceptualise technology? Participants may have given answers that they felt were desired, although the researcher was careful to explain that it did not matter what students said as long as it was what they felt. This means it is possible that some of the students' answers may not have been accurate. Thus, the researcher, even with good intentions, would be limited in providing the full account of the participants' experiences. However, this study was based on mutual trust and open discussion, and the fact that there is no right answer encouraged dialogue.

Conceptual framework considerations

The conceptual framework presented in this study is based on philosophical exploration of technology (philosophy of technology after De Vries (2005)) and may contain some limitations, because the conceptual framework was designed to capture students' experiences of the core concepts and did not reflect intersections or overlaps among the concepts, which may have limited interpretations of students' experiences of technology. For example, the researcher decided to use an inductive thematic technique after Braun et al. (2014) in order to identify which ideas try to define the characteristics to the concept of technology (see "The conceptual framework for this study", p. 56). As a result, the analysis focused on identifying/verifying the essential attributes of a concept of technology in the framework, which did not bring into focus some aspects – for example, whether there were intersections between the different dimensions (see Figure 2.2, p.55). Much of the analysis focused on the four core dimensions namely technological artefacts, technological knowledge, technological processes and technology as a part of human existence in the proposed conceptual framework with the aim that the model would provide clarity to students' interpretations of technology based on their understanding of what technology means to them. As argued in section 4.3.2 (p.161), students at both schools talked about a wide range of technological artefacts outside of school, from statements that include mobile phones and personal computers through to electric cookers, cars and refrigerators, in terms of their functions and the goals that they achieve. As such, data analysed in relation to the conceptual framework did not draw on the inherent potential weaknesses in the design of the conceptual framework. The conceptual framework (see Figure 2.2 on p. 55), developed for the purpose of this study, aimed to find the implicit and explicit meanings of students' ideas regarding their perceptions of technology (see p.127) and their relevance for the technology education (see Table 5.1 on p.225).

If overlaps between the dimensions of the conceptual framework had been found in the data (between technological artefacts and technological knowledge, for instance, or technological knowledge and technological processes or technological knowledge and technology as a part of human existence) and drawn on in the analysis, it is likely that by interpreting such intersections, the findings may have been different. This means that this study is limited to some extent, because the conceptual framework is not as comprehensive as it could have been, and adjustments might need to be made to it to suitably take into account intersections or overlaps among the concepts. However, it could be argued that no single conceptual framework can be comprehensive enough to encompass all relevant views, as models will always be limited to some extent by the personal reality of their creators.

5.6: Implications for future research

Given that one of the goals of teaching technology is to achieve basic understanding of technology and technological literacy for all citizens (FME, 2007), a key starting point is to consider preparing students for understanding technology in real-world situations. In line with this thinking, the analysis in this study showed a number of possible ideas for further investigations, which are outlined in the next sections.

Conceptual understanding issues

In planning technology lessons, teachers need to be aware of a range of factors that will have a bearing on development, such as teaching and learning through practical experience and processes that allow children to construct their understanding of the world (Stables, 1997). In this current study, when students' interviews were analysed, it was revealed that students conceptualise technology in terms of technological artefacts. For example, all the electronic devices students discussed (e.g. mobile phones, televisions, CD players and personal computers) were regarded in both schools as a means of alleviating boredom and loneliness. A mobile phone was conceptualised as a versatile device (due to the variety of functions), which facilitated communication with absent persons, alongside offering solitary entertainment and independent learning. However, acquiring such a concept from exemplars alone may not be enough to infer the meaning of a 'complex' word like technology given that technology has varied definitions and meanings (see Chapter 2).

The students also need to be presented with different methods, such as being provided with definitions associated with concepts related to technology (De Vries, 2005). The implications that this has for curriculum development could be investigated – for example, to examine whether teachers clarify the concepts they use, perhaps by using the model of conceptions of technology proposed in this study. The findings from such a study might have implications for curriculum development materials.

Bennett and Maton (2010) argued that radical change in education is needed because traditional institutions do not meet the needs of a new generation of 'tech-savvy' learners. They claimed that young people are said to be different from all generations that have gone before because they think, behave and learn differently as a result of continuous, pervasive exposure to modern technology. Similarly, Kruse (2013) noted that people rarely discuss the complex and abstract character of the nature of technology ideas, and the resilience of misconceptions, because most people wrongly believe they have critically examined the technology they use. Therefore, examination into conceptualisation of the problem – how researchers might research the problem in such a way as to advance understanding in this area so as to better prepare students to be conscientious of technology's deep impact – is needed, because it is at this stage that the researcher should have a clear understanding of the words and terms used in the research in order that there are no conflicts arising later regarding their interpretation, and it might indicate whether the problem is worth researching (Nyonyintono, 2010; Sequeira, 2014). The results of this current study may be useful in such an investigation, for instance in the use of curriculum material with an emphasis on conceptual understanding.

The role of language in the whole issue of understanding technology

Technology encompasses a wide range of objects (both tangible and intangible) (see Chapter 2). The findings in this study showed that students had varied interpretations (explicit and implicit) of the word 'technology'. For example, some students substituted other words for the term 'technology'. This finding was unexpected, because, according to the Nigerian Educational Research and Development Council's basic education curriculum document (FME, 2007), students should have some experiences of school technology that support identification of the products of technology. However, the researcher could see similar, but not directly expressed, instances in other transcripts. Thus, the researcher decided that the language used by the participant should be considered and analysed in order to establish if there was a language barrier. Also, in this current study, the data analysed revealed that most students think of technology education as construction of angles, bisection of lines, and car and lamp projects.

This raises the following question: is it that the students use the same words, but mean different things, or are students unsure about what is ‘an acceptable’ word to articulate their ideas?

However, in this study, it was not possible to draw any conclusions about any differential effect of the role of language in understanding technology. Initially, understanding technology was taken to be independent of language skills. Consequently, the role of language was not considered, and therefore not explored. As a result, the findings highlighted the need for further studies on this issue and may form the basis of a useful investigation into the use of technological language with a wide range of students. In future, studies should be designed to determine what kind of language the learner engages in during learning about technology. For example, the links between understanding technology and development of language skills, if explored, may have considerable potential, because as the Piaget theory of learning indicates, the learning and retention of abstract concepts requires formal-operational reasoning and uses language as the key symbol by which to enter the concept into memory (Trebilco, 1987). An exploration of this linkage may require data to be gathered via quantitative or qualitative methods in order to obtain an optimum set of language students use when they talk about technology. Such studies should also explore the teacher’s knowledge and use of language skills to facilitate learning of new concepts or ideas to make sure that language is not a barrier to learning, because, as Fairbanks et al. (2010) noted, knowledge alone does not lead to the kinds of thoughtful teaching that teachers strive for. Therefore, this study may be useful as a means to supporting comprehension of words students use, clarifying meanings and helping interpretations.

Issues related to sample size

This study provides an insight into students’ perceptions of technology, but the data were obtained from a small sample, and more investigation is required to complete the picture – in other words, a larger sample that takes in schools from different geographical areas of Nigeria and more students. For example, a bigger study that employs a multi-site case study with, for example, 10 schools, and focuses on age, gender, socio-economic background or ethnicity, may help to get a picture of what technology education is like across all of Nigeria. Such a study should provide evidence for the development of technology curricula. The importance of a national survey was recognised by the researcher when some of the students who were interviewed for this study said they do not have mobile phones. Those students claimed that they could not afford one on their own, which suggests that to a certain extent, parental wealth might influence students' perceptions of technology.

This study used two schools; eight students (four males and four females) from each school were recruited. As a result of time and financial constraints attributed to the PhD, as well as the school restriction on the number of students, the sample was considered relatively small to be generalised to a larger population. From the evidence in this study, using everyday items such as mobile phones, lawn mowers and blenders could benefit students learning about technology concepts. Further research could examine the processes that promote mental engagement: everything that enters the mind and awareness – experience, perceptions, sensations, feelings, thoughts and ideas. The data collected during the research are analysed and turned into evidence, which may assist in the development of curricula for technology education.

Approaches to teaching and learning about technology

Although this study is exploratory and interpretative in nature, to some extent it signposts two learning theories (constructivism and behaviourism) discussed in Chapter 2. From the perspective of the constructivist learning theory, for example, the analysed data in this study showed that the process of knowledge construction was based on experience of technology practice in the classroom (see Chapter 4.4.1.1). Independent of the teacher, each student's subjective experience now has a special and unique meaning of technology in the classroom

(Boghossian, 2006). From the perspective of behaviourism, the analysed data showed that students were often busy copying notes and were led by the teacher; the teacher was the sole authority figure, and there was little student choice or interaction during the learning (Westbrook et al., 2013) (see Chapters 4.4.2 and 4.4.3).

From the evidence in this current study, all students were involved in practical activity (either a car project or a lamp project); however, it is difficult to attest that these activities were mainly due to the use of constructivism or behaviourism. This was because the researcher was only told by students what they did as practical activity in technology lessons, which was corroborated by their teachers. As a result, this study cannot claim that a constructivist or behaviourist approach – or indeed a mixed approach – is better, in terms of student learning in technology.

However, it would be helpful if further studies investigated student projects that require students to define concepts of technology in order to complete the activity – in other words, that allow students to actually experience or practise concepts and skills, as opposed to learning that is purely theoretical. Cakir (2008) noted that in order to learn a concept meaningfully, students must carry out cognitive processes that construct relationships between the elements of information in the concept and reality, arguing that students who have constructivist epistemological beliefs use meaningful strategies when learning. Therefore, more research-based information and evidence regarding real-world technology education activities is needed. Such studies may help researchers better understand how a learner’s epistemological beliefs shape their experiences in relation to learning.

5.7 Implications of this study for policy

The purpose of this study was to get insights into students’ experiences of technology and technology education. The findings in this study have a number of implications for policy which may be useful for policymakers or education authorities. For example, this study may provide those with responsibility for designing the technology curriculum with an opportunity to reflect on their current curriculum focus with regard to educating students for real-world situations.

As this study is descriptive rather than normative in nature, it might be helpful if the teachers’ perspectives presented in this study were taken into account in the further development and implementation of technology education curricula. The foundation for this proposal is underpinned in this study’s findings, which revealed that students were not actively involved during lessons (see section 4.4.3.1) and teachers were more interested in exam performance (see 4.4.2.1). This is particularly noticeable when looking at what teachers and students were doing in the classroom, where the primary pedagogical approach was theoretical, and students listened to the teacher talk for most of the class period. All four teachers who were interviewed for this study seemed frustrated that they could not deliver the lesson as intended due to a lack of adequate resources (see Chapter 4.4.4). All four teachers said that the greatest barriers to teaching technology were a lack of resources; a lack of an adequate workshop with equipment such as a computer, a projector and materials; and a lack of a workshop technician. This finding is consistent with Ogbu (2015), who noted that workshop facilities are not available for the teaching of basic electricity. This information may be useful for authorities responsible for funding resources for school technology education.

5.8: Implications of this study for practice

According to Owen-Jackson (2007), technology education develops in order to remain relevant, and teachers must constantly adapt and respond to change in a creative and innovative way. However, this current study found that what is advocated in the curriculum and what is done in the classroom do not necessarily align. There is evidence that all four teachers who participated in this study concentrated on theory, which was limited in real-world situations relating to technology (see Chapter 2.3 and Chapter 4.4.3). From this perspective, this study has implications for practice, which are presented below under two sections: implications for technology teachers, and implications for technology teacher education.

Implications for technology teachers

This study has found that some teachers seemed unaware of the disconnect between students' experiences of technology and reality (real-world technology, see Chapter 2). As such, if these findings were found to be generalisable across technology teachers nationally, it would imply the need for continuing professional development that relates to the teaching of technology as a curriculum subject. The aim would be to provide training about the nature of the disconnect between students' understanding of technology in the real world (the set of situations most humans have to deal with in reality, including real objects or things, as opposed to what is written in textbooks) and in the technology taught in the classroom. The purpose of the continuous professional development would be to help teachers support students to see the connection between the technology they are taught in the classroom and its relevance to their everyday life, rather than what they think they should be doing, such as focusing on exams, as was evident in Chapter 4: Data analysis and findings.

Another important aspect revealed in this study regards teachers' approaches to teaching – that is, their use of instructional strategies. Nigeria has only recently adopted technology education as a compulsory subject, and this study has shown that the instructional methods and strategies teachers adopt might have influenced how students talk about their experiences of technology. For example, the investigation into students' perception of technology has revealed that students demonstrate limited knowledge about technology, and one reason for this could be that the instructional strategies teachers adopt is limited. Jarvis (1996) suggested that it might be useful to give practising teachers resources and support through in-service training to develop and extend their knowledge and enable them to acquire new teaching strategies. The proposed conceptual framework of technology in this study might be useful, because it offers a broad scope of knowledge that students and teachers can explore. Therefore, encouraging teachers to consider the findings in this study might be useful, because it provides more opportunities they might want to use in their teaching, either as an alternative strategy or to reinforce current practice.

Implications for technology teacher education

Yip (1998) suggested that teacher education programmes should aim at equipping science teachers with what science educators have found out about students' misconceptions in science. Yip (1998) also argued that this knowledge helps the teacher to develop an awareness and understanding of the nature and sources of students' misconceptions, which is a first step in designing suitable instructional strategies. In agreement with Yip's (1998) view, the researcher in this study proposes that teachers' viewpoints in this study are relevant to the pre-service preparation of teachers in the field of technology. If teaching necessarily begins with a teacher's view of the nature of the subject, a teacher must possess an adequate knowledge of what he/she is attempting to communicate to students (Shulman, 1987; Owen-Jackson, 2007; Coe et al., 2014).

From the above perspectives, technology education teacher trainers may benefit from the findings in this current study by developing programmes that aim to help trainees articulate the potential contributions that they can make to both the development of technology as a subject and to students' development. In this context, learning activities should be both teacher-trainee initiated and inspired by expectations and requirements in the school curriculum. The purpose would be to see how such intervention could be developed to enhance the quality of training of teachers for the task of implementing a technology education curriculum.

Furthermore, this study's findings reveal that students talk about technology using implicit and explicit meanings, whereby what students meant was not explicitly stated and might be construed to mean something different. As previously explained, some students substituted words in place of the term 'technology'. They did not understand that gadgets relate to technology in that gadgets are innovations of technology, even when discussing technology and gadgets in the same way. Therefore, designing a teacher training programme that includes, for example, a conceptual understanding of technology may be useful, as it will make trainee learning experiences of technology rewarding and enable trainee teacher graduates to understand what these concepts may mean in the context of any particular debate or policy document.

5.9: Conclusions

This study explored students' perceptions of technology and technology education. While this is a small-scale study and limitations have been identified, it is anticipated that this research could form a useful point of reference in gaining insights into experiences of students' conceptualisations of technology and technology education in relation to learning technology as a school subject. The conclusions derive from findings that raise awareness of the problems students encounter in learning about technology, which require the attention of the school, teachers and policymakers. One key finding was that students lacked or showed weak conceptual thinking about technology. Indeed, students demonstrated a lack of or a weak ability to make connections between technology in the real world and in the classroom. Students' thinking should encompass an awareness of interpretation and use the knowledge and processes involved in the creation of artefacts, as well as in a variety of situations (ITEA, 2000). Consequently, this study has proposed a model of conceptualising technology, which could be developed to assist future research, policy and practice, and to widen the curriculum to help students learning about technology.

It was evident that individual students expressed their conceptions of technology in a variety of ways; there were degrees of similarity in their conceptions across the year groups (JS1–JS3). Technological artefacts such as computers and cars were the most frequently mentioned aspects of technology. Other technological artefacts were mentioned, such as a charcoal iron and grinding stone, suggesting that students had conceptions of technology that go beyond electrically operated artefacts like computers and electronic gadgets. Be that as it may, technological artefacts are relevant and integral aspects of technology, but are insufficient to describe what technology means. This study highlights that there are four distinct concepts of technology – technological artefacts, technological knowledge, technological processes and technology as a part of human existence – and these four distinct concepts could be unified and taught together, because they are interrelated and would provide insights into the holistic nature of technology; this would develop both the curriculum and learning experiences in technology education.

Given that the aim of this study was to understand what can be learnt from students' experience of technology, the findings that emerged and the implications for future research, policy and practice make the researcher believe that the two research questions have been answered, and the study has shed light on the field of technology education, in particular students' experiences of technology. In summary, this study highlights that there is a huge 'disconnect' between what students do in school, which is more 'theoretical', and how technology is viewed in reality. This study showed that all students seemed to have derived some understanding of technology education from construction of different angles and shapes. Indeed, construction of angles was a constant point of reference for many students in the group. The lack of connection between students' experiences of technology outside school and inside school suggests what Rossouw et al. (2011) described as a "lack of [a] realistic image of technology" (p. 409).

It is important to consider the nature of the classroom activity that takes place in the name of technology education, as there already exists a mismatch between rhetoric and practice in the subject, which has not been without its difficulties, such as lack of resources and teachers focusing more on students' performance in exams and less on how they learn. In this light, this study has found something that is interesting and of potential value to teachers and policymakers. The researcher suggests that schools and teachers have a responsibility to help explicitly draw students' attention towards the nature of technology, whereby students can become more thoughtful about the characteristics of technology. Schools should be able to encourage teachers to infuse the school curriculum with more project-based learning and exposure to real-world (practical, actual, everyday) problems. This also means that schools might need to consider technology education department infrastructural requirements and that resources (adequate infrastructure, materials for practical activity) need to be available, as well as incentives to encourage teachers. This will ensure that students can maximise their experience by exploring the conceptual understanding of technology, which could help develop their experiences during their lessons beyond the attainment of exam results and grades.

From a conceptual perspective, the findings in this study found that complete descriptions of what constitutes technology have been limited. Therefore, if we are educating students for the technological world, whereby they are encouraged to create the strongest-possible links between what they have been taught and the real problems faced by practitioners in the workplace, it would be helpful to start to encourage them to broaden their ideas about technology and apply conceptual thinking to solve problems.

Further, this study can be useful because of its implications for technology education. For example, the findings from this study might influence other developing countries to reconsider their technology education development programme, which may elicit broader implications for policies and practices such as curriculum planning, approaches to teaching and the organisation of school technology curricula.

Finally, this study's location is Nigeria, a developing country where technology education is new in schools and students may not be familiar with much of what is currently presented as modern technology, which makes it difficult for students to acquire knowledge beyond lessons that will give them academic subject context knowledge. This suggests that the way in which students reflect on technology in Nigeria may differ from the United Kingdom, where students might have more information linked to their experience of technology. Therefore, this study encourages knowledge of potential dimensions of technology, which could be of huge benefit to developing countries, including Nigeria, in their efforts to attain technological literacy for all their citizens.

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Appendix A: Authorisation letter from the Ministry of Education, Delta State

MINISTRY OF BASIC & SECONDARY EDUCATION
(HEADQUARTERS)
P.M.B. 5015
ASABA
DELTA STATE

Our Ref: DSME/SCH.4/80/AA/17 6th **January, 2014**

Mr. Godwin Ndukaego Osakwe,
48, Lindfield Road,
Stockport,
SK5 6SD

RE:REQUEST FOR ACCESSS TO RESEARCH STUDY ON TECHNOLOGY EDUCATION

I am directed to refer to your letter dated 25TH October, 2013 on the above subject matter and to convey the Ministry's approval to enable you carry out your research work in some selected secondary schools in Delta State.

2. You are to ensure the confidentiality of the information you may come across in the course of the study.

3. Accept the assurances of our highest regards, please.

E.O. Utebor
Director (Schools)
For: Honourable Commissioner

Appendix B1: Permission request to the Principal of [redacted]

School of Education

University of Leeds

38 University Road

Leeds

LS2 9JT

United Kingdom.

23 October 2013

The Principal

[redacted]

Delta State, Nigeria.

Dear Sir/ Madam,

Request for permission to include your school for education research

I am currently studying for a PhD degree in Education at the University of Leeds, researching into students' conceptualisations of technology in Nigerian secondary schools. I am asking for your permission to include your school in my research study to support the development of teaching and learning in technology education in Nigeria. I would like to work with your students and technology teachers, to understand their conception of technology and their experience of school technology lessons. As part of the requirement to advance with this study, your authorisation is a requirement of the University of Leeds ethics committee. I can assure you that I will respect the dignity of the school, students', and teachers', and data will be kept completely confidential. Pseudonyms will be given to provide anonymity, and data will be securely stored and only for the purposes of this study and any academic papers and presentations that might arise from it. I will ensure that the students' academic progress and teachers' professional practice are not compromised by taking part in this study. The study participants will be free to withdraw from or refuse to take part in the study at any time without inducement or adverse consequences. I will provide you with a copy of the summary of the report and will be happy to discuss the findings with you and your colleagues.

I will sincerely appreciate your response at a suitable time.

Yours faithfully,

Godwin Ndukaego Osakwe

Cc: Professor Geoff Hayward – Primary Supervisor

Dr Indira Banner – Second Supervisor

Appendix B2: Authorisation from Principal of [redacted]

[redacted]

Our Ref;BAHISCO/VOL 1/12/0053

Your Ref: Date: 29th October 2013

Godwin Ndukaego Osakvwe,
School of Education,
University of Leeds,
38 University Road,
LS29JT
United Kingdom

Sir,

Re- request for permission to include your school for education research

Reference to the above subject matter, i wish to inform you that your request is granted and you can contact us as the need arises. Also keep your promise of confidentiality.

Yours faithfully,

[redacted]

Principal

Appendix C1: Permission request to [redacted]

School of Education

University of Leeds

38 University Road

Leeds

LS2 9JT

United Kingdom.

23 October 2013

The Principal

[redacted]

Delta State, Nigeria.

Dear Sir/ Madam,

Request for permission to include your school for education research

I am currently studying for a PhD degree in Education at the University of Leeds, researching into students' conceptualisations of technology in Nigerian secondary schools. I am asking for your permission to include your school in my research study to support the development of teaching and learning in technology education in Nigeria.

I would like to work with your students and technology teachers, to understand their conception of technology and their experience of school technology lessons.

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I will sincerely appreciate your response at a suitable time.

Yours faithfully,

Godwin Ndukaego Osakwe

Cc: Professor Geoff Hayward – Primary Supervisor

Dr Indira Banner – Second Supervisor

Appendix C2: Authorisation letter from the [redacted]

[redacted]

DELTA STATE, NIGERIA.

Ref No.: THS / 5590 / 54

Date: November 6, 2013

Dear Sir,

Your request of October 23, 2013 to the school is hereby acknowledged. It is a well known fact that technology is the basis of scientific development and financial empowerment. We are delighted to know that one of our own is researching into students' conceptualization of technology in Nigerian schools.

This research, we hope, will bring to the fore the prospects and challenges of technological development thereby giving the individual and indeed the nation the opportunity of a holistic awareness of what it takes to be a technologically-based society. This will get all stakeholders better poised to take the challenges headlong so as to come up with a better positioning in the training for manpower skills and realization of an age long dream.

The school therefore is out to work together with you for a better society of tomorrow.

We look forward to further request from you.

Thank you.

Yours faithfully

[redacted]

[redacted]

PRINCIPAL