A fit-gap analysis of the National Certificate (Vocational)—Information Technology and Computer Science curriculum against the needs of the South African ICT industry

By

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DECLARATION

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ABSTRACT

The Information and Communication Technology (ICT) landscape is characterised by rapid innovation of digital technologies that are disrupting industries globally. These changes are so pervasive that it is now common cause that the industrial economy is transforming into a knowledge economy. This economic transformation led to the obsolescence of successive device models and production processes which render workers' previous skills, knowledge and competencies obsolete and out of date. Consequently, the gap between education and work requirements widens, posing enormous challenges for the education and training sector to produce graduates with relevant knowledge, skills and competencies. South Africa is no exception to these realities. Therefore, it is important to ask whether the country's education and training institutions provide appropriate educational programs and qualifications, which are relevant to the needs of the knowledge economy.

In 2007 the South African government introduced the National Certificate Vocational-Information Technology and Computer Science (NCV-IT) qualification at Technical and Vocational Education and Training (TVET) colleges to meet the skills demands of the 'modern' South African economy. The thesis considers this curriculum against the background of the ongoing technological advancements and digitization of the knowledge economy.

The purpose of the thesis is to determine the relevance of the current national NCV-IT curriculum to the knowledge and skills needs of the South African ICT industry. This is achieved by describing the curriculum against the background of international models and then by interviewing representatives from industry to ask about the skills they need from graduates and what they consider gaps in the education of recent graduates from TVET colleges that they've employed.

Using purposive sampling strategies, representatives from fifteen companies from the South African ICT industry were questioned using semi-structured interviews with open-ended answers. Their answers about their needs were compared with a description of the current national NCV-IT curriculum based on a document review.

The findings of the comparative analysis reveals a fit-gap between the current national NCV-IT curriculum and the South African ICT industry's knowledge and skills needs from entry level IT employees. The conclusion offers recommendations regarding the urgent need to review and update the current national NCV-IT curriculum in order to align it to the South African ICT industry's knowledge and skills needs.

OPSOMMING

Die Inligting- en Kommunkasietegnologie (IKT) landskap word gekenmerk deur versnelde innovasie van digitale tegnologie wat industrieë wêreldwyd ontwrig. Hierdie veranderinge is so ingrypend dat dit nou algemeen aanvaar word dat die industriële ekonomie besig is om in 'n kennis ekonomie te verander. Die ekonomiese transformasie lei tot die veroudering van opeenvolgende stelselmodelle en produksieprosesse wat die werkers se bestaande vaardighede, kennis, en bevoegdhede toenemend verplaas. Gevolglik word die gaping tussen die onderwys en opleiding van werkers en die uiteindelike werksvereistes al hoe groter. Hierdie realiteit bied enorme uitdagings vir die onderwys- en opleidingsektor om graduandi te lewer met toepaslike kennis en vaardighede. Suid-Afrika is in die verband geen uitsondering nie en dit is daarom belangrik om te vra tot watter mate die land se onderwys- en opleidingsinstansies toepaslike opleiding en kwalifikasies verskaf om aan die behoeftes van die kennis ekonomie te voldoen.

Die Suid-Afrikaanse regering het in 2007 die Nasionale Sertifikaat Beroeps-Inligtingstegnologie en Rekenaarwetenskap (NKV-IT) kwalifikasie by Tegniese en Beroepsonderwys en -opleiding (TVET) kolleges ingestel om aan die vaardigheidsbehoeftes van die 'moderne' Suid-Afrikaanse ekonomie aan te spreek. Die tesis ondersoek hierdie kurrikulum teen die agtergrond van die voortgesette tegnologiese vooruitgang en digitalisering van die kennis ekonomie.

Die doel van die tesis is om die relevansie van die huidige kurrikulum te bepaal in terme van die kennis- en vaardigheidsbehoeftes van die Suid Afrikaanse IT-industrie. Dit word gedoen deur die kurrikulum te beskryf en te vergelyk met internasionale modelle en dan in onderhoude met verteenwoordigers van die IT-industrie uit te vra oor die vaardighede wat hulle nodig ag by nuut gegradueerdes uit die TVET-kolleges wat hulle indiens geneem het.

Deur middel van 'n doelgerigte steekproefstrategie, is verteenwoordigers van 15 maatskappye in die Suid Afrikaanse IT-industrie uitgenooi om aan 'n semi-gestruktureerde onderhoud deel te neem. Hulle antwoorde oor die maatskappy se behoeftes is vergelyk met die beskrywing van die huidige NKV-IT kurrikulum gebaseer op 'n document-analise.

Daar is bevind dat daar wel 'n beduidende gaping is tussen die huidige nasionale NKV-IT kurrikulum en die behoeftes van plaaslike IT-maatskappye met betrekking tot intree-vlak IT-werknemers. Aanbevelings word ten slotte gemaak oor hoe om die NKV-IT kurrikulum te hersien ten einde dit in lyn te bring met die kennis en vaardighede wat die Suid Afrikaanse IT-industrie vereis.

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TABLE OF CONTENTS

List of Figures

List of Tables

Acronyms

ADSL	Asymmetric Digital Subscriber Line
DHET	Department of Higher Education and Training
DHA	Department of Home Affairs
DoL	Department of Labour
FET	Further Education and Training
FETI	Further Education and Training Institute
ICASS	Internal Continuous Assessment
ICT	Information and Communication Technology
ISAT	Integrated Summative Assessment
IT	Information and Technology
JCSE	Johannesburg Centre for Software Engineering
MICT	Media, Information and Communication Technologies
MVC	Model View Controller
NC (V)	National Certificate (Vocational)
NCV-IT	National Certificate Vocational- Information Technology & Computer Science
NIST	National Institute of Standards and Technology
NSDS III	National Skills Development Strategy III
NQF	National Qualifications Framework
OECD	Organisation for Economic Co-operation and Development
PAT	Practical Assessment Task
SETA	Sector Education Training Authority
TVET	Technical Vocational Education and Training
UI	User Interface
UIX	User Experience
UMALUSI	Quality Council for General and Further Education and Training Education
VET	Vocational Education and Training
VLAN	Virtual Local Area Network
VPN	Virtual Private Network
WEF	World Economic Forum

Chapter 1: Introduction

1.1 Introduction

This chapter introduces the following: background to the research problem, problem statement, research question and sub-questions, hypotheses, research aims, research objectives, significance of the study, delimitation of research, assumptions, definitions of key terminology and concludes with a brief overview of chapters comprising this research.

1.2 Background to the research problem

The 21st century has witnessed a dramatic increase in the production, adoption and use of technologies. Several industries are being transformed as novel products and services such as smart cars, autopilot, farmerless farms, automated medical diagnosis and prescription dispensing, 3D printing and online shopping enter the markets. Schwab (2015) posits that we are standing on the brink of a technological revolution that is and will continue to fundamentally change the way we work, learn, play and relate to each other. This revolution is referred to as the 4th industrial revolution (WEF, 2015, 2016; Schwab, 2015; Infosys, 2016). It is characterized by massive and complex digitization and high speed innovation based on combinations of technologies, which are blurring the lines between the physical, digital and biological spheres (Schwab, 2015). Whilst the previous industrial revolutions were industry or product specific; the 4th cuts across all industries.

The racing technological changes are disrupting every industry globally. The World Economic Forum (WEF, 2015) report on The Disruption of Unemployment states that these economic and technological disruptions lead to changes in the nature of work and occupations as business models change. This changes the skills that employers need and shortens the shelf life of employees' existing skill sets (WEF, 2016). Many traditional jobs and occupations are being transformed and previous skills, knowledge and competencies are rapidly becoming obsolete. As a result, education and work have drifted apart and will continue to do so (Allais, 2011) subsequently posing enormous challenges for the education and training sector, as it must produce graduates with relevant knowledge, skills and competencies. For this reason, the education sector needs to transform and adapt to these changes in order to keep in touch with industry and workplace needs of the 21st century (Houghton and Sheenan, 2000; McGrath *et al.*, 2010; Webb *et al.*, 2017).

According to Stiglitz (1999) and Newell *et al.* (2009), this Information and Communication Technology (ICT) driven technological revolution is transforming the industrial economy into the knowledge economy. The World Bank (2003:1) defines a knowledge-based economy as an economy that "relies primarily on the use of ideas rather than physical abilities and on the application of technology rather than the transformation of raw materials or the exploitation of cheap labour". Relatedly, Guruz (2011:6) posits that "a global economy is characterized by the increased importance of knowledge, both know-how and information and a well trained workforce that not only can apply know-how but also capable of analysis and decision making based on information".

From the preceding paragraph, it is clear that in order to participate in the global knowledge economy; graduates need to possess knowledge and skills that meet the requirements of the knowledge economy. It is more so for information technology graduates, as computer scientists and information technologists sustain the competitive edge of organizations and support innovation and development across all industries in a technology driven world (Webb *et al.*, 2017). Therefore, as the speed of change in the knowledge economy means that skills depreciate much more rapidly than before, there is need for information technology curriculum to keep pace with the current technological advances in order to meet employers' needs (World Bank, 2003).

South Africa and technology revolution

South Africa is no exception to the realities mentioned in the preceding sections, since according to Engineering News (2012) cited in the Media, Information and Communication Technologies Sector Education and Training Authority (MICT SETA) Sector Skills Plan report (2012:25)

> South Africa is the 20th largest consumer of IT products and services in the world. It is characterized by technology leadership, particularly in the field of electronic banking services. South African IT companies are world leaders in pre-payment, revenue management and fraud prevention systems and in the manufacture of set-top boxes, all exported successfully to the rest of the world.

Additionally, South Africa is home to several subsidiaries of international Information Technology (IT) companies who are world leaders in the field of ICT (MICT SETA, 2012), and the number keeps on increasing (JCSE, 2016). The presence of these companies means the country's ICT industry is moving at the same pace as that of developed countries (JCSE, 2016). Gartner, an international research group rates South Africa among the top thirty of software development countries globally (MICT SETA, 2012). Also, the last two decades have seen the country's ICT industry emerge as an ultramodern sector (Gillwald *et al.*, 2013) as well as the largest in Africa, with a Gross Domestic Product (GDP) of over R300 billion in 2013/14 (MICT SETA, 2015). Therefore, it is apparent that South Africa is an active participant and is among the leaders in the development, application and use of ICTs.

As mentioned earlier, information technology graduates need to possess relevant knowledge and skills required by employers and South Africa is no exception. It is therefore important that information technology courses and qualifications offered by the country's training institutions are in line with the needs of the local ICT industry. This therefore calls for a review of ICT courses such as the National Certificate (Vocational) (NC (V)) which is offered in South Africa.

National Certificate (Vocational)

In order to meet the skills demand of the 'modern' South African economy, in 2007, the government introduced a fully funded official curriculum; the National Certificate (Vocational) offered by Technical Vocational Education and Training (TVET) colleges, formerly Further Education and Training (FET) colleges (Department of Higher Education and Training (DHET), 2009; DHET, 2013). The NC (V) curriculum was introduced to reduce skills shortages in South Africa (National Skills Development Handbook 2010/11, 2011; DHET, 2011; Dzvapatsva *et al.*, 2014). The NC (V) programmes are offered across many academic disciplines including Information Technology. The qualification in Information Technology that one gets after completion is called National Certificate (Vocational) Information Technology and Computer Science (NCV-IT).

According to the DHET report on the Conduct of National Examinations 2009 "The NC (V) programmes are intended to respond directly to the priority skills demands of the modern South African economy by exposing students to high skills and knowledge" (DHET 2009:5). However, eleven years after the inception of the programmes and eight years after the first

NCV-IT graduation, the ICT industry in South Africa is still grappling with unprecedented levels of skills shortages (Lotriet *et al*., 2010; Mohlala *et al*., 2012; MICT SETA, 2012, 2015; South Africa, 2014a, 2014b, 2016; Kumar, 2017). Since 2007, the Department of Home Affairs (DHA) has been granting work permits to foreign nationals under scarce and critical skills categories in an attempt to reduce skills shortage (in the short term) within the ICT industry and other identified areas (South Africa, 2014a). Despite the above interventions (offering permits- perceived short term and introducing the NCV-IT course- perceived long term), more than a decade later, the department is still issuing these permits to information technology professionals; indicating a lack of local candidates with knowledge and skills required by the South African ICT labour market.

Therefore, the perceived long term intervention is failing to fulfil its mandate. The ICT skills gap continues to widen, yet on the other hand, the TVET sector through NC (V) programmes continues to produce graduates. Whilst this could be attributed to a number of factors such as a growing ICT industry, this study was triggered by DHET's White Paper for Post-school Education and Training conclusion that TVET graduates are not finding employment easily (DHET, 2013). The Further Education and Training Institute (FETI) (2012) and Kraak (2010) also make the same observation. Crucially, Kraak (2010) states that there is high unemployment rate of TVET graduates who hold qualifications in scarce skills areas such as information technology and sciences. Lotriet *et al*. (2010) also observes that employers are struggling to fill up ICT vacancies yet there are ICT graduates failing to secure employment. This is puzzling as according to South Africa (2006: 82) "the NC (V) at L4 on the National Qualifications Framework (NQF) enables students to acquire the necessary knowledge, practical skills, applied competence and understanding required for employment in a particular occupation or trade, or class of occupations or trades ..." Similarly, Oketch (2007:221) citing Tilak (2002) also agrees that "TVET produce 'specific human capital' which embodies the advantage of imbibing specific job-relevant skills that can make the worker more readily suitable for a given job …" This should also be applicable to NCV-IT, a vocational qualification.

Whilst failure to secure employment by NCV-IT graduates could be attributed to many other reasons, this study focuses on knowledge and skills imparted by the NCV-IT programme given the rapid technological changes and high speed innovation of the 4th industrial revolution. As mentioned earlier, South Africa is amongst the world leaders in ICTs and as such, technological advances are disrupting the country's ICT labour market. It is against this background that this study sets to investigate the relativeness of the current national NCV-IT curriculum to the ICT industry needs in the wake of the knowledge economy. In other words, the study seeks to ascertain any gaps between knowledge and skills imparted by the programme and the needs of the ICT industry.

Related to the above, Papier *et al*. (2012:22) noted that there is need for research "on the nature of knowledge required for uplifting the skills and knowledge base and the impact of these views on college curricula/offerings". They further note that "the relationship between labour training needs (as far as these may be ascertained) and FET college programmes/curricula" need to be researched (*ibid*). Allais (2011:17) also points out the need for research on "the kind of knowledge which is the basis of vocational qualifications and occupations". This involves looking at the relationship between vocational qualifications (knowledge and curriculum), and market. The National Skills Development Strategy III (NSDS III) published by DHET also notes that there is limited research on public FET colleges' programmes, strengths and weaknesses (DHET, 2011). Houghton and Sheenan (2000) also alluded to the importance of assessing knowledge and skills possessed by current and future employees to determine human capital needed in order to build economies. It is also against these gaps that this study is undertaken.

This study is also motivated by conclusions made by some researchers (Lotriet *et al*., 2010; Allais, 2011, 2012) that South Africa should look at how new forms of ICT training and education, that is; how programmes and curriculum are designed and implemented in order to effectively address industry needs and skills shortages. In other words, focus should be put on curriculum so as to bring the worlds of work and education close to each other. The WEF (2016) concurs that the ability to understand the current skills base, accurately forecasting, anticipating and preparing for future job contents and skills across all industries is increasingly becoming critical for businesses, labour, workers and individuals. Allais (2011) notes further that education should not only focus on short term employer needs but also on strengthening vocational education by building a strong curriculum based on clearly defined knowledge areas. These arguments align with the World Bank (2014) that pointed out that African tertiary education is not keeping pace with the continent's labour needs; and recommends that local graduates should have up to date skills and knowledge so as to address skills deficit in the continent's booming sectors such as extractive industries, ICT and agriculture. George (2006) also points out that in a knowledge-based economy, educational institutions should put more emphasis on programme content rather than institutional structure. In light of this, there is greater need to analyse the current NCV-IT curriculum in order to determine whether it is aligned to the South African ICT industry needs in the wake of the knowledge economy.

1.3 Problem Statement

The national NCV-IT curriculum purports to play a significant role in ensuring adequate ICT skills given the trend towards greater digitization of all sectors of the South African economy. Whether the curriculum is relevant and/or effective is not clear. An investigation into the relevance of the current national NCV-IT curriculum to the needs of the ICT industry in South Africa in terms of knowledge and skills in the wake of the knowledge economy is vital.

1.4 Research question

How relevant is the current national NCV-IT curriculum to the knowledge and skills needs of the ICT industry in South Africa?

In order to answer the main research question, the following sub-questions need to be answered:

a) What are the current skills and knowledge imparted by the NCV-IT curriculum?
b) What are the current knowledge and skills needs of the ICT industry in South Africa?
c) What are the identified gaps between NCV-IT curriculum and knowledge and skills needs of the ICT industry in South Africa?

An investigation around the above questions addressed the research problem.

1.5 Research aims

The aims of the research project were:

i. To ascertain the relevance of the NCV-IT curriculum to the ICT industry's knowledge and skills needs in South Africa.

ii. To determine the challenges militating against the NCV-IT curriculum from producing capable graduates who can 'fit' and participate in the ICT industry and the economy as a whole.

1.6 Research objectives

The objectives of the research were:

i. To identify current skills and knowledge imparted by the NCV-IT curriculum.
ii. To identify current knowledge and skills needs of the ICT industry in South Africa.
iii. To determine the existence or non-existence of knowledge and skills gaps between the NCV-IT curriculum and the ICT industry needs in South Africa.
iv. To draw conclusions about the relevance of the current national NCV-IT curriculum to the knowledge and skills needs of the ICT industry in South Africa.

1.7 Significance of the study

The study is significant in many ways. Firstly, to the researcher's knowledge, it is not known how relevant the current national NCV-IT curriculum is in terms of knowledge and skills needs of the ICT industry in South Africa, in the context of the knowledge economy. It is anticipated that this research will contribute to knowledge creation in this area. Secondly, this research will enlighten and help bridge the relevance gap between the knowledge and skills imparted by the NCV-IT qualification, with the needs of the ICT industry in the wake of the knowledge economy. Thirdly, it will enhance partnerships between government, training providers, curriculum developers and employers to better manage the impact of the 4th industrial revolution on knowledge, skills and education. Fourthly, it will intermediate knowledge (Information Technology) exchange between the TVET sector, government and businesses. Fifthly, the study may raise awareness levels among the readership on the value of NCV-IT qualification in line with the performance of the ICT sector in South Africa. Finally, there is need for close corporation between ICT training institutions, governments and organizations in order to build a 'true' 21st century curriculum (WEF, 2016). This study is a significant step towards that goal as employers' knowledge and skills needs in a knowledge-based economy can be mapped and incorporated in the NCV-IT curriculum.

1.8 Delimitation of research

According to Ogude *et al.* (2005), for higher education to respond to the needs of the knowledge economy in the South African context, curriculum must be responsive. They further state that curriculum must meet and respond to society's economic (labour market), institutional, cultural, disciplinary, pedagogical and learning expectations and needs. This study only considered economic responsiveness of the current national NCV-IT curriculum, in order to determine the relevance of knowledge and skills imparted by the curriculum, against the human resources needs of the ICT industry in South Africa in the wake of the knowledge economy. This is because the study was aimed at ascertaining why NCV-IT graduates are finding it difficult to secure employment yet on the other hand the ICT industry is experiencing massive skills shortages (both entry and high level). This helped to clearly understand the impact of the ICT driven knowledge economy on ICT jobs, knowledge and skills in the South African context. The other dimensions of curriculum responsiveness are concerned with individuals and institutions' identities and how the content is delivered. These have little or no impact on knowledge and skills required to complete a task or secure employment in the ICT industry.

The scope of this study was limited to knowledge and skills required by an NCV-IT graduate for entry level employment. In other words, focus was on what knowledge and skills are required in order for one to successfully complete his/her duties or tasks in a given entry level job or occupation in the ICT industry. Only entry level employment was considered because the highest level of the current NCV-IT qualification is Level 4 on the National Qualifications Framework. At NQF Level 4 one is not expected to get into high level employment (DHET, 2012). Also in general, vocational graduates are meant to perform at entry and intermediate levels of employment (Little *et al*., 2003; Oketch, 2007; DHET, 2009).

In this study, the scope of skills was limited to technical skills. This was because the main aim of this qualitative study was to ascertain gaps between the current national NCV-IT curriculum and the ICT industry's knowledge and skills needs, with a view of aligning the curriculum with the South African ICT industry's knowledge and skills requirements. Therefore, in terms of skills it was imperative to find what is it an entry level employee should be able to do using or operating a computer and other IT related technologies. Other skills such as communication, social and team work skills also known as soft skills were not considered. These skills are not domain-dependent that is, they are not subject-dependent, therefore, have little or no bearing on ICT industry skills requirements. Relatedly, ICT knowledge and skills are discipline specific, meaning they can only be developed through IT and computer science subjects. Therefore, the scope of the study was also limited to NCV-IT core vocational subjects, which are central to ICT knowledge and skills development. Fundamental and optional vocational subjects were not considered as they do not impart the knowledge and skills required in order to gain employment in an IT position.

1.9 Assumptions

This study involved conducting interviews with selected respondents. The researcher made an assumption that sample respondents were truthful in their answers to the researcher. It also assumes that the gaps that the respondents identified in the skill set of the recent graduates they hired were primarily the result of the NVC-IT curriculum and not the result of the respondents hiring weak graduates.

1.10 Definitions of key terminology

The following terms are important to this study as they relate to the study topic and are briefly explained below:

Curriculum: "refers to the knowledge and skills students are expected to learn…in a specific course or programme" (Glossary of education reform, 2017).

National NCV-IT curriculum: the national NCV-IT curriculum that is referred to in this study encompasses the syllabi for the nine core vocational subjects that form part of the Department of Higher Education and Training's NC (V) programme Level 2 - 4 in information technology and computer science (DHET, 2009).

Knowledge: In this study, knowledge refers to any one and/or a combination of the following knowledge dimensions as defined by Anderson and Krathwohl (2001).

> **Factual Knowledge** is knowledge that is basic to specific disciplines. This dimension refers to essential facts, terminology, details or elements students must know or be familiar with in order to understand a discipline or solve a problem in it.

Conceptual Knowledge is knowledge of classifications, principles, generalizations, theories, models, or structures pertinent to a particular disciplinary area.

Procedural Knowledge refers to information or knowledge that helps students to do something specific to a discipline, subject, or area of study. It also refers to methods of inquiry, very specific or finite skills, algorithms, techniques, and particular methodologies.

Metacognitive Knowledge is the awareness of one's own cognition and particular cognitive processes. It is strategic or reflective knowledge about how to go about solving problems, cognitive tasks, to include contextual and conditional knowledge and knowledge of self.

Skills: in this study refers to technical skills which "are defined as vocational theoretical knowledge acquired at school. For example, this might include: how to operate … a computer…" Mounier (2001:12); thereby allowing an employee "…to do a particular job as specified by the employer" (Winch and Clarke, 2003:240).

Entry level employment: "bottom-level employment in a firm which usually requires ordinary level of education, training, and experience qualifications. It gives a recruit the benefit of a gainful occupation, opportunity to learn and gain experience, and serves as a stepping-stone for higher-level jobs" (Business dictionary, 2017).

Knowledge economy: is an economy "where the production, diffusion and use of technology and information are key to its economic activity and sustainable growth" (OECD, 1999:7).

ICT industry: in this study includes all organizations and companies whose main activities are ICT oriented as well as those whose activities are not ICT but have large IT departments such as banks, universities and insurance companies (Adopted from MICT SETA, 2012).

1.11 Chapter overview

An overview of the five chapters of the dissertation is given below:

Chapter 1: Introduction

This introductory chapter provides a general background to the study, problem statement, research question and sub-questions, research aims and objectives, hypotheses, significance of the study, delimitation of research, assumptions, and definitions of key terminology and a brief overview of the chapters.

Chapter 2: Literature Review

This chapter gives a synthesis of scholarly materials about knowledge and skills imparted by NCV-IT curriculum against the needs of the ICT industry in South Africa in the wake of the knowledge economy. It also provides a comprehensive overview of vocational education and curriculum concepts.

Chapter 3: Research Design

Chapter 3 focuses on the research design, research method and methodology that were used in order to solve the research problem and eventually answer the research question. Sample size, validity and reliability, data analysis, instruments used for data collection as well as processes followed are discussed and outlined. Ethical considerations that were undertaken as well as limitations to the study are also discussed.

Chapter 4: Research Findings and Data Analysis

Chapter 4 reports on the findings of the study. This include findings from the analysis of the current NCV-IT curriculum as well as findings from interviews with employers in the ICT industry. A comparison of the two data sets is carried in order to answer the research question.

Chapter 5: Conclusions and Recommendations

This chapter draw conclusions of the research based on the empirical findings of this research as well as literature review. It also makes recommendations for immediate implementation as well as recommendations for future research.

Chapter 2: Literature Review

2.1 Introduction

This chapter provides a synthesis of scholarly literature about knowledge and skills imparted by the NCV-IT curriculum against the needs of the ICT industry in South Africa in the wake of the knowledge economy.

The first section explores literature relevant to this study in order to explain the concept of the knowledge economy and its implications on education, training and work in the context of South Africa. The changing nature of jobs and occupations as driven by racing technological changes is highlighted. This enabled the researcher to understand the nature of knowledge and skills that should be developed by educational institutions such as TVET colleges in their quest to meet the demands of the knowledge economy. This is followed by an exploration of VET and its role in South Africa. This study intended to ascertain the relevance of the current national NCV-IT curriculum to the needs of the ICT industry in South Africa in the wake of the knowledge economy. Therefore, the second section discusses VET, NC (V) and NCV-IT programmes to shed light on the role of TVET in relation to skills shortages in the ICT sector.

The last section explores the concept of a curriculum as it relates to VET and ICT programmes and qualifications. The ICT industry is characterised by rapid technological changes and this affects the relevance of knowledge, skills and competencies developed by a given curriculum like NCV-IT. It is vital to identify which knowledge is central to an ICT qualification. Therefore, lessons can be learned from analysing international computing curriculum models. This sheds light on how an 'ideal' ICT curriculum could be designed. The chapter concludes with a summary of the main points from the literature review.

2.2 Overview: South Africa and the knowledge economy

This section defines the knowledge economy, its implications on knowledge, skills, competencies and work. It further discusses these implications and their effect on ICT skills in the South African context.

2.2.1 Knowledge economy

Knowledge has played a key role in development throughout human history. But the 21st century has seen knowledge and innovation increasingly playing a critical role in economic growth, championing a new paradigm- knowledge economy (World Bank, 2007). The World Bank (2003:1) defines a knowledge-based economy as an economy that "relies primarily on the use of ideas rather than physical abilities and on the application of technology rather than the transformation of raw materials or the exploitation of cheap labor". In this economy, knowledge is the main resource for wealth and job creation (World Bank, 2007). That is, knowledge is the key factor of production and has become central to both economic and social development.

The concept of the knowledge economy is widely written (OECD, 1999; Houghton and Sheenan, 2000; Lengnick-Hall and Lengnick-Hall, 2003; World Bank, 2003; George, 2006; Roberts, 2009; Newell *et al.*, 2009; Guruz, 2011) and there is a shared view that, in this contemporary economy, knowledge is central to economic development and wealth creation. The World Bank (2007) concurs with this view and identifies knowledge as one of the four key pillars for knowledge economy attainment by nations. That is, for a country to develop economically, it needs an educated and skilled workforce for the creation, sharing and use of knowledge. This must be supported by a modern and dynamic information infrastructure (ICT), an effective innovation system and a supportive economic and institutional regime (*ibid*).

The shift from raw materials (resources) and labour as key factors of production to knowledge, has resulted in a knowledge revolution which is culminating in a technological revolution. This technology driven revolution is ubiquitous across all industries (WEF, 2015) and the computer has become a universal machine. Stiglitz (1999) and Newell *et al*. (2009) argue that this ICT driven technological revolution is transforming the industrial economy into the knowledge economy.

The racing technological changes bring with them massive disruptions to industries, economies and workplaces. The emergent contemporary workplace is characterised by new forms of working and work organisation. These include working from home, reduced life span of products and services as well as the knowledge used to develop them (Boisot, 1998), high level skills, the increasing importance of knowledge about customers, technologies and materials as well as the ability to rapidly respond to clients' needs (Newell *et al*., 2009). As a result, education and work have drifted apart and will continue to do so (Allais, 2011). These developments pose enormous challenges for the education and training sector, as it must impart students with high quality 'specialised' knowledge, skills and competencies that meet the demands of the knowledge economy. For poor quality, education has no place in the knowledge economy (World Bank, 2003).

Following the above, as centres of knowledge creation, translation and dissemination, education and training institutions need to develop knowledge and skills which are required by the ICT driven knowledge economy (George, 2006; World Bank, 2003; World Bank, 2007; Fullan & Scott, 2009). The World Bank (2003) urges education and training institutions to take cognisant of the above mentioned changing nature of jobs, occupations, the workplace and society to continue fulfilling their mandate. It identifies four key features of the knowledge economy that have implications on education. These are briefly described below:

- **Product cycles are shorter and the need for innovation greater**. As mentioned earlier, the pace of (technological and innovation) revolution shortens the economic life of products, services and processes as new and better products make the former obsolete even though physically, they might still be serving their purpose (Boisot, 1998). This puts pressure on organizations to produce new knowledge with greater frequency. This affects education and training institutions, as the knowledge and skills they impart on graduates need to keep pace with the innovation speed.

- **Knowledge is being developed and applied in new ways**. A highly educated and skilled labour force is needed to utilise the potential of innovation and new technologies. The information revolution supported by ICT has increased the pace, scale and capacity of change and innovation.

- **Trade is increasing worldwide, increasing competitive demands on producers**. This has resulted in a globalized economy (interdependence and integration of world economies through collaboration, outsourcing, crowdsourcing, innovation etc.) where changes in trade patterns call for education to produce a workforce in possession of skills and knowledge that meet these demands.
- **Small and medium-size enterprises in the service sector** have become increasingly important players, in terms of both economic growth and employment. In recent times the world has witnessed an increase in the number of leading and fast growing 'start-ups' especially in the technology sector (WEF, 2016). These entities thrive on innovation and creativity to stay ahead in an environment historically dominated by large enterprises (Capgemini Consulting, 2015). The need to create and innovate raises the level of knowledge and skills required. This in turn affects education and training institutions, as they need to produce graduates who can work in this new environment.

Therefore, the knowledge economy has brought with it new challenges, responsibilities and new relationships between education, training and work. Houghton and Sheenan (2000:9) concur with this view and state that the knowledge economy is characterized by "learning which involves both education and learning-by-doing, learning-by-using and learning-by-interacting". Therefore, there is need for education and training institutions to align their programmes and qualifications to meet the needs of the knowledge economy. The NCV-IT qualification is no exception. Hence, this study sought to ascertain the relevance of the current national NCV-IT qualification to the needs of the ICT industry in South Africa in the wake of the knowledge economy.

2.2.2 South Africa and the knowledge economy

Having defined the knowledge economy and its implications on education, it is imperative to move onto discussing the knowledge economy in the South African context. It is important because the aim of this study was to determine the relevance of NCV-IT curriculum to the needs of the South African ICT industry in the wake of the knowledge economy. The Organization for Economic Co-operation and Development (OECD) defines a country with a knowledge-based economy as one "where the production, diffusion and use of technology and information are key to its economic activity and sustainable growth" (OECD 1999:7). This is applicable to the South African context as stated by Rauner *et al*. (2012) that the South African economy is an advanced industrial economy. Relatedly, the National Skills Development Strategy III (NSDS III) published by DHET in 2011 state that the South African economy is increasingly becoming knowledge-based. Furthermore, Rauner *et al.* (2012) state that the economy has enjoyed considerable growth over the years. Lincoln (2014) pointed out that the growth is attributed to the enabling role played by the South African ICT industry, which is globally competitive.

Furthermore, South Africa is home to several subsidiaries of international IT companies who are world leaders in the field of ICT (MICT SETA, 2012), and the number keeps on increasing (JCSE, 2016). The presence of these companies means the country's ICT industry is moving at the same pace as that of developed countries and as such, the sector is experiencing the effects of the 4th industrial revolution (JCSE, 2016). The MICT SETA (2015) is also of the same view and posits that the country's ICT education and training programmes should be aligned to the needs of the knowledge economy. It further notes that many jobs in the sector are disappearing and at the same time, new jobs have emerged because of technology revolutionizing work.

Considering the issues raised in the previous paragraph, as well as knowledge economy implications on education mentioned in the previous section, it is clear that the South African education system is not immune to these and the NCV-IT programme is no exception. As mentioned in the previous chapter, NCV-IT graduates are failing to secure employment (DHET, 2013) while at the same time the ICT industry is grappling with skills shortage (JCSE, 2016). This scenario raises the question: What is the cause of this disjuncture? Could it be the case that the South African vocational education and training sector has failed to take note of the above implications of the knowledge economy on education and training? That is, could it be the case that the current NCV-IT curriculum develops knowledge and skills that are irrelevant in the ICT driven knowledge economy? The purpose of this study was to ascertain the relevance of knowledge and skills imparted by the NCV-IT qualification to the ICT industry needs in the wake of the knowledge economy. It is also important to give an account of the state of ICT skills in South Africa.

2.2.3 State of ICT skills in SA

The first South African National Master Scarce Skills List drawn up by the Department of Labour (DoL) in 2007 indicated a shortage of almost 40 000 ICT professionals (DoL, 2007). In 2015, almost ten years later, the number had increased to over 50 000 (MICT SETA, 2015). As mentioned in the previous chapter, since 2007, the DHA has been using this list to grant work permits to foreign nationals under scarce and critical skills categories to close the skills gap in the ICT industry (South Africa, 2014a). In a 2016 survey, the JCSE revealed that the percentage of local companies hiring foreign nationals went up from 12 % in 2014 to 26% in 2016 (JCSE, 2016), further indicating a worsening situation on the lack of local candidates with knowledge and skills required by the South African ICT labour market.

A survey conducted by the MICT SETA in 2012 reveals that 73% of South African CEOs are extremely concerned by ICT skills shortages (MICT SETA, 2012). In a separate but related survey, the Grant Thornton's International Business Report of 2014 reveals that 83% of South African businesses report a shortage of ICT skills (Kumar, 2017). Mohlala *et al*. (2012) also notes that the information technology industry in South Africa is faced with a dwindling pool of skilled and knowledgeable professionals. This has adverse effects on businesses as revealed in a 2016 survey by JCSE where 71% of local businesses indicated that skills shortage has a major effect on their operations and 29% were facing viability problems due to ICT skills shortages (JCSE, 2016). These revelations bring to light the need for aligning the country's information technology curriculum with the needs of the ICT industry.

However, these statistics (on ICT skills) have been criticised in some sections. JCSE (2016) is of the view that statistics collected by the MICT SETA might not be a true reflection of the current state of skills shortage due to government interference. That is, statistics may have been lowered so that it does not reflect badly on the government. Lotriet *et al*. (2010) notes that the current methods used to collect and define skills in ICT have limitations and therefore, the results might not be a true reflection of the current state.

According to JCSE (2016), the emergence of new technologies and business models worsens the current skills crisis. This has resulted in an increase in demand for new types of skills such as mobile technology, cyber security, application development, business intelligence/knowledge management and software as a service (MICT SETA, 2012; MICT SETA, 2015). Some of these skills did not exist ten years ago. This lays a huge question mark on the relevance of knowledge and skills imparted by the NCV-IT curriculum in relation to the current needs of industry, given the fact that the curriculum has not been changed since its inception in 2007. At the same time, NCV-IT graduates are finding it difficult to secure employment (DHET, 2013), despite government's assertion that NC (V) is the anecdote to the unification of the world of work and education as it involves both on the job training and theoretical learning (DHET, 2011).

This study sought to ascertain this disparity. That is, to investigate whether NCV-IT is delivering the kind of education that appropriately equips individuals with necessary knowledge and skills for employment in the ICT industry in the wake of the knowledge-based economy. Following the above, it is essential to turn to a review of vocational education and training.

2.3 Vocational Education and Training Overview

This section discusses vocational education and training and its role in South Africa. It further discusses NC (V) programmes and their role in economic development and skills shortage. It concludes by looking at the NCV-IT qualification.

2.3.1 Vocational education and training

According to the Organisation for Economic Co-operation and Development (OECD) (2010:26), "Vocational education and training (VET) includes education and training programmes designed for, and typically leading to, a particular job or type of job". Vocational education usually involves both practical (on the job) training and theoretical (classroom) learning (*ibid*). The European Centre for the Development of Vocational Training (Cedefop) states that the aim of VET is to "equip people with knowledge, know-how, skills and/or competences required by the labor market" (Cedefop, 2011:15). It further states that VET is and should be closely connected to the demands of the labour market (Cedefop, 2011).

The above definitions of vocational education are directly connected to its aims; which include producing 'job ready' graduates through programmes that link education to labour market requirements. VET is labour market oriented; making it relevant to industry needs (Cedefop, 2011). However, not everyone agrees with this view. Opponents of vocational education argue that it is inadequate and exclusive as it focuses on specific knowledge and skills for a particular field or trade, ignoring social knowledge (Gewer, 2010, OECD, 2010; Wheelahan, 2015), yet it is these social competencies that are required by the knowledge economy. They further argue that VET promotes social exclusion and creates societal inequality by intentionally marginalising social or theoretical knowledge. McGrath and Akoojee (2009) also argue that vocational education is neither academic (general education) nor occupational; further highlighting the restrictive nature and inadequacy of vocational education.

Critically, Oketch (2007) argues that TVET[1] is becoming less relevant in the contemporary knowledge led economy, as high specificity of low skills does not value the knowledge economy, which requires high level skills associated with general education. He argues that general education produces graduates with 'general skills and competences' allowing for greater flexibility and mobility within the labour market as well as educational progression. Pilz (2012) and the HRDC (2014) concur with this view and argue that vocational education is considered low or poor quality education and therefore less applicable in a knowledge based economy. Additionally, contrary to the widely accepted perception by proponents of VET that TVET helps to ease labour market problems, Oketch (2007) has the view that TVET does not create jobs neither does it alleviate poverty. In fact, in countries like Kenya, poverty and unemployment have continued to rise despite heavy investments in TVET (*ibid*).

Furthermore, the OECD (2001) argues that 'know-why', 'know-how' and 'know-who' kinds of knowledge rather than 'know-what' are the kind of knowledge required in the knowledge economy and are imparted through general education. General education adequately equips individuals with these kinds of knowledge and skills enabling them to adapt to the changing nature of work and occupations in the knowledge economy; making it relevant to a wide range of jobs (OECD, 2010). Cedefop (2011) further notes that general education opens up more chances in life than vocational education. By focusing on skills for work, VET is nothing but restrictive (McGrath, 2012) as it denies graduates the opportunity to fully participate in life. This then raises the question; Is vocational education suitable for the knowledge economy? More crucially, are vocationally oriented ICT qualifications relevant to the ICT industry in the South African context, given the lack of employability of NCV-IT graduates.

Furthermore, some researchers (Oketch, 2007; McGrath and Akoojee, 2009) argue that in many African countries, vocational education is meant for 'occupying' unemployed youth rather than equipping them with knowledge and skills for employment. Also, Pilz (2012) and Wheelahan (2015) states that in many countries, vocational education is considered inferior and is seen as the siding into which academically challenged learners can be pushed into. Wheelahan (2015) is critical of this practice and argues that it promotes social inequality. She suggests that instead of pushing academically challenged learners into vocational, the system should find a form of education that will include them.

However, despite the above concerns, many believe VET has a key role to play in developing young people and responding to the labour market needs of local, national and global economies (Oketch, 2007; DHET, 2009; Field *et al*., 2009; OECD, 2010; South Africa, 2011). They argue that vocational education and training is the panacea to skills shortages due to its close ties with industry. Vocationally trained graduates are equipped with specific skills that are required by employers and therefore they have high chances of securing employment (Lancee, 2016). Furthermore, proponents of VET argue that TVET skills are salient for economic development (Asian Development Bank, 2008; UNESCO, 2010; DHET, 2011; Powell, 2012). The Asian Development Bank (2008), further states that technical and vocational knowledge and skills are crucial for innovation, productivity and profitability, as well as for state productivity and wealth creation. It further notes that in the absence of relevant technical and vocational skills, business and national growth can be stunted.

[1] TVET is 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 life (UNESCO, 2010:5). The definition of VET is given above. However, in this study the two are used interchangeably, in line with the South African literature and government policies and documents.

Additionally, Psacharapoulos (1997) states that TVET provides entry and middle level skills as not everyone can be trained (through general education) for high level skills jobs. The OECD (2010) argues further that the current (labour market) landscape requires general tertiary education (high-level skills) to be complimented with well-skilled individuals with entry-level, mid-level, technical and professional skills that are normally delivered through vocational education. The Asian Development Bank (2008) concurs with this view and argues that, technological changes, workplace changes and economic openness, which characterise the contemporary economy, increase the need for technical and vocational skills. Oketch (2007) is also of the same view and posits that the present knowledge based economy has elevated the quality on knowledge and skills, thereby calling for the re-orientation of vocational education and training and general education to produce a good mix of knowledge and competencies among employees.

Furthermore, Oketch (2007) and Wheelahan (2015) state that VET offers an alternative route to those who are not successful in general education. They argue that without vocational education and training such learners will be doomed forever, as they can access neither employment nor tertiary education. This view sees vocational education as a mechanism for social inclusion and civic participation. The Asian Development Bank (2008:26) is also of the same view and states that "skills training is essential for promoting sustainable livelihoods where environments are fragile and informal economic activities often need suitable techniques and practices for resource management". In other words, VET equips graduates with education and training that allows them to live a fulfilled and meaningful life (Powell, 2012).

As stated in the previous paragraphs, VET is directly linked to a specific type of work, job, trade or occupation. Hence, it should be easy for TVET graduates to secure employment. However, as mentioned in Chapter 1, this is not the case for NCV-IT graduates in South Africa. This raises the question; could it be the case that the NCV-IT curriculum does not equip students with knowledge and skills that matches 'knowledge work', which characterises the ICT driven knowledge economy? In other words, is there a disjuncture or a misconfiguration between the contemporary workplace, which stamps the ICT industry and knowledge, and the skills imparted by the current NCV-IT curriculum? These were some of the areas the research sought to reflect on.

Given the above mixed views concerning TVET, it is imperative to clarify its role in the South African context to ascertain what knowledge and skills are required with respect to the economic requirements of the country (skills shortage and social development). The next section looks at the role of TVET in South Africa.

2.3.2 The role of TVET in South Africa

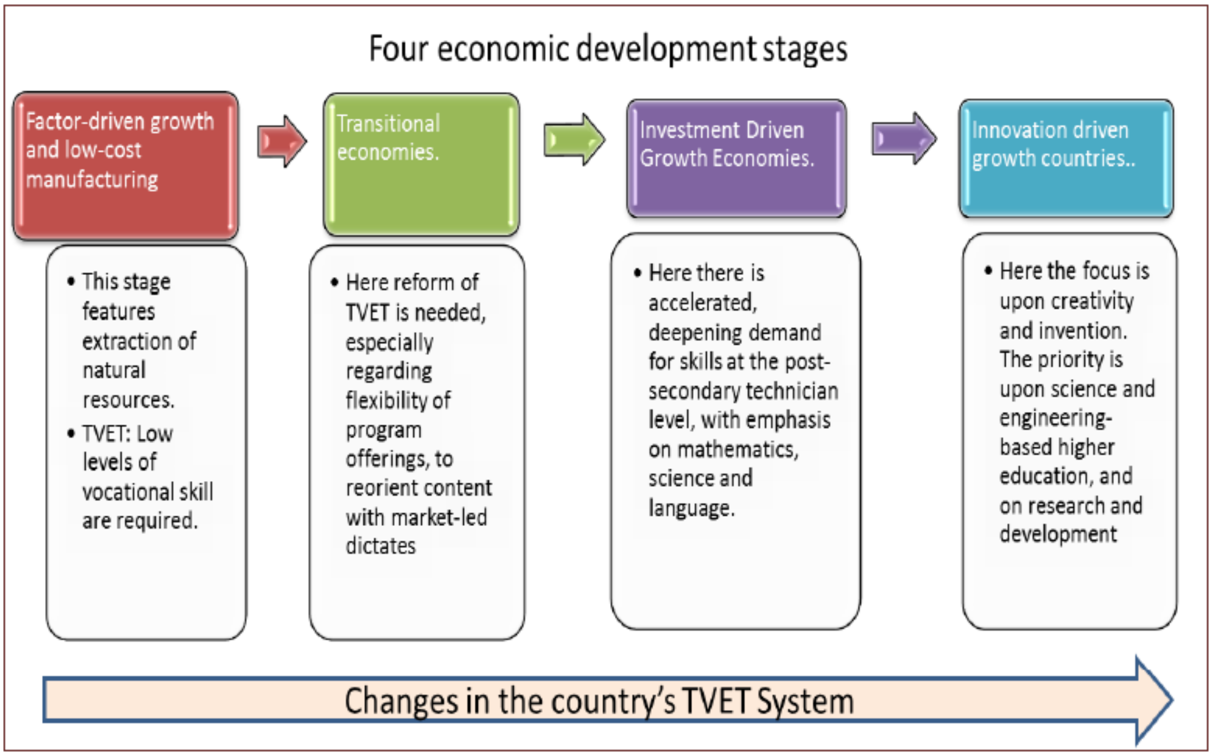
According to Lewis (2009) the role of VET is generally contested the world over. This is more so in developing countries (Bakari & Kemenade, 2013) and South Africa is no exception. However, various authors (McGrath & Akoojee, 2009; Gewer, 2010; DHET, 2012; McGrath, 2012; Powell & McGrath, 2014; HDRC, 2014) agree that even though the role of TVET in South Africa is broad and slightly contested, the sector is currently more aligned and sited within the economic development concept. That is, the role of TVET is to empower learners with vital knowledge, practical skills and vocational competences, which are essential for employment (South Africa, 2006b).

Furthermore, the HRDC (2014) observed that an analysis of government policies and documents reveal that the TVET sector is focused on skills development by building strong linkages with industry. These documents include the New Growth Path (2011), National Development Plan 2030 (2011), National Skills Development Strategy III (2011), the Green Paper on Post-School Education and Training (2012) and White Paper on Post-School Education and Training (2013). Crucially, according to the ministerial task team appointed for the review of the national policy regarding further education and training programmes, NC (V) is a characteristically job focused qualification (DHET, 2012).

However, it should be noted that the role of TVET is also to "… expand access to education and training opportunities and increasing equity…" (Green Paper for Post-School Education and Training, 2012: x). That is, TVET should perform a transformative and developmental role in addressing challenges of unemployment, inequality and poverty currently facing the South African society (HRDC, 2014). This entails a flexible and responsive TVET sector that is able to respond to the demands of industry, employers and society (Gewer, 2010). In other words, a dual purpose TVET sector responsible for equipping youth with necessary discipline knowledge and offering school leavers and unemployed people a chance to acquire qualifications (*ibid*). These (qualifications) will increase their likelihood of employment and higher education. Relatedly, McGrath (2012:624) citing Anderson (2009) argues that attempts of addressing poverty and inequality are under way within the economic development paradigm which take the view that "…training leads to productivity which, in turn, leads to economic growth (training for growth)". This leads Powell (2012) to conclude that the current purpose of TVET in South Africa is to respond to skills needs of the economy as well as responding to the social inequalities created by apartheid.

Important to this study was the skills development role of TVET, since one of the aims of this study was to ascertain the relevance of knowledge and skills imparted by the NCV-IT curriculum against the needs of the ICT industry needs. The question being asked is; Why TVET graduates are finding it difficult to secure employment, yet the role of TVET is knowledge and skills development for employment purposes. This raises questions on the relevance of knowledge and skills imparted by the TVET sector with respect to the needs of the country's economy. According to Lewis (2009), the role of TVET should be aligned with a country's stage of economic development. **Figure 2.1** illustrates a typology of TVET that correlates with the stage of economic development.

Figure 2. 1: Typology of TVET that correlates with the stage of economic development.



Source: HRDC (2014:17)

As illustrated in **Figure 2.1**, knowledge and skills imparted by TVET should be in line with the country's stage of economic development. Given the lack of employment by graduates, could there be a contrast between the role of TVET in South Africa and the developmental stage of the country's economy? This raises questions specific to this study such as; could the lack of employment of NCV-IT graduates be due to the misconfiguration of the curriculum with respect to the current stage of the economy? In other words, is the current NCV-IT curriculum relevant to the needs of the ICT industry in the wake of the knowledge economy? To the researcher's knowledge it is not known if such a research has been carried out, hence this study.

Having defined what is meant by vocational education and training and the role of TVET in South Africa, the next section discusses NC (V) programmes.

2.3.3 National Certificate (Vocational)

In 2007, the South African government introduced a new fully funded official curriculum, the National Certificate (Vocational) offered by TVET colleges (DHET, 2013). The NC (V) curriculum was introduced to deal with the quality and relevance shortcomings of the old curriculum (Gewer, 2010). This was done to reduce skills shortages in South Africa (Akoojee, 2009; National Skills Development Handbook 2010/11, 2011; DHET, 2011; Dzvapatsva *et al*., 2014).

The NC (V) programmes are offered across many academic disciplines including information technology. Students are awarded qualifications at Level 2, 3 and 4 on the National Qualifications Framework (NQF) in compliance with the national policy requirements set out in the policy document, National Certificate (Vocational): Qualifications at Levels 2 to 4 on the National Qualifications Framework (NQF) as promulgated in Government Gazette No. 28677 of 29 March 2006 (South Africa, 2006a).

According to the DHET report on the Conduct of National Examinations 2009, "The NC (V) programmes are intended to respond directly to the priority skills demands of the modern South African economy by exposing students to high skills and knowledge" (DHET, 2009:5). This means that the programmes are meant to impart learners with relevant knowledge and skills applicable in the workplace. According to DHET (2011, 2012), NC (V) programmes are the answer to the country's skills crisis. Relatedly, Ashton (2005) cited in Lewis (2009), taking cues from the success story of Asian TVET argues that, developing countries need low skills (gained through TVET) as a source of competitive advantage. That is, low skills are a spring board to thrust them into the next level of economic development. Referring to South Africa, he states that the country should adopt the low skills approach to alleviate unemployment among the previously disadvantaged groups and as a foundation for high skills jobs.

However, Magnus *et al*. (2013) perceive the programmes as not worthy, inflexible and not work-oriented. In other words, the programmes equip graduates with low level skills which are not relevant in the current economic developmental stage. They argue that they lead to 'unskilled' jobs.

Additionally, despite consultations with industry and labour, no meaningful contribution to curriculum development was made, as the two were sceptical about the design and effectiveness of the programmes (Akoojee, 2009; DHET, 2012; Mashongoane, 2015). However, despite poor participation by stakeholders in the development process, the Department of Education (DoE) went ahead with the roll out of the curriculum (DHET, 2012). This led the National Skills Development Handbook 2010/11 (2011) to contend that the introduction of NC (V) programmes by the South African government was a political move rather than an educational one. Akoojee (2009) concurs that the structure and content of NC (V) remains problematic. This brings into question the relevance of knowledge and skills imparted by the NC (V) qualification to the needs of the South African labour market. That is, are the skills and knowledge imparted aligned to the needs of South African employers?

Furthermore, the programmes have also been criticised for their lack of flexibility and access to higher education[2] (Papier *et al*., 2012). Gewer (2010) also, argues that the programmes are not inclusive as they neither carter for old learners nor offer part time study facilities. This means that many uncertified working people cannot enrol as classes are only available during the day. The programmes have also been criticised for not responding to their immediate future mandate of skills shortage; as the three-year duration is perceived a long time for a country that needs skills now (McGrath & Akoojee, 2009).

Furthermore, research reports (McGrath & Akoojee, 2009; Mashongoane, 2015) state that NC (V) programmes lack colleges' support as they are/were not familiar and confident with the new curriculum and preferred the old curriculum. This has undermined the responsiveness of the programmes to the labour market (Akoojee, 2009).

According to Pawson and Tilley (1997) cited by Bakari and Kemenade (2013:493), "when an evaluator tells us that a program is a success; s/he should be demonstrating what it is about the program which works for whom in what conditions". Given the mixed views mentioned

[2] In the early days and up to the period (2012-2013), institutions of higher learning were not accepting NC (V) Level 4 graduates in their academic programmes. However, of late most institutions have been accepting NC (V) Level 4 graduates.

earlier about NC (V) programmes, it is imperative to analyse the programmes on a qualification by qualification basis rather than painting all the qualifications with one broad brush. This study sought to ascertain the relevance of the current national NCV-IT curriculum to the knowledge and skills needs of the ICT industry in South Africa in the wake of the knowledge economy. According to the Asian Development Bank (2008:29), "The purpose of TVET is to provide relevant knowledge, skills, and competencies for employment and income generation". It was therefore important to ascertain knowledge and skills gaps between the current national NCV-IT curriculum and ICT industry needs. If a qualification does not lead to employment, then it is useless. To reflect on relevance, the following section looks at the NCV-IT qualification in relation to the needs of the ICT industry *vis-a-vis* skills shortages in South Africa.

2.3.4 National Certificate (Vocational) –Information Technology and Computer Science

It was mentioned in Chapter 1 that one of the significances of this study is that it will add knowledge to public TVET college programmes; specifically, to NCV-IT qualification as there is limited research in the programmes and qualification respectively. As a result of limited research, there is little literature that speaks specifically to the NCV-IT programme. Most of the available literature addresses the programmes as a whole, therefore the reader is informed that in the following sections where it says NC (V) it will also be referring and including NCV-IT.

As mentioned in the previous chapter, the NC (V) qualification in information technology is called National Certificate (Vocational) Information Technology and Computer Science (NCV-IT). Just like all NC (V) programmes, it is designed to meet the skills demands of the modern South African economy (DHET, 2009) by equipping students with the necessary knowledge, practical skills, competences and understanding required for entry level employment (Umalusi, 2013). In other words, the NCV-IT programme imparts knowledge and skills required for employment in the ICT industry in South Africa.

However, in the midst of the above promises and assurances about TVET and NC (V) programmes, the reality is; the ICT industry in South Africa is still inundated with skills shortages and at the same time NCV-IT graduates are struggling to get jobs. This makes many educators and employers ask how this is possible given that the NC (V) qualification is/was aimed at bringing education and training closer to the world of work (Akoojee, 2009; DHET, 2011). This reality reveals the limitations of the NCV-IT curriculum. Mashongoane (2015) states that the NC (V) qualification is not recognised by employers and lacks industry support. Doyle (2014) also states that some sections of ICT training institutions criticises NC (V) programmes and see them as a political move rather than solutions to the country's ICT skills problem. This follows government's rollout of the programmes despite limited participation of all the stakeholders (DHET, 2012). This raises questions such as; Does NCV-IT equip students with the right knowledge and skills? And does NCV-IT qualification address the ICT skills crisis as per mandate?

Umalusi (2006: 24) state that "ascertaining whether or not a learning programme prepares learners for the workplace is complicated, as 'the workplace' in fact, is extremely heterogeneous—different industries and companies have very different requirements". To the researcher's knowledge, it is not known if such a research for NCV-IT has been carried out. Hence, this study undertook to ascertain if NCV-IT prepares learners for the workplace. The study was set to investigate the disparity between NCV-IT curriculum and the ICT workplace. That is, the study sought to ascertain the gap between knowledge and skills imparted by current national NCV-IT curriculum and the ICT industry's human resources needs in South Africa, through determining current skills requirements of the ICT industry in the wake of the knowledge economy.

Having discussed literature on vocational education and training, the role of TVET in South Africa and the NCV-IT qualification, focus will shift to explore the concept of a curriculum in general, computing (IT) curriculum models and the current national NCV-IT curriculum.

2.4 Curriculum concepts

This section defines the concept of a curriculum within the context of this study. International models of ICT curricula are discussed to shed further light on how a modern ICT curriculum could be developed. The issue of rapid technological changes and their impact on curriculum change and review is also discussed.

2.4.1 Curriculum defined

According to the website, Glossary of education (2017), "curriculum refers to the lessons and academic content taught in a school or in a specific course or program… that is, knowledge and skills students are expected to learn…" This definition of a curriculum is in line with Young's (2013) argument that, 'specialized' knowledge, such as theoretical knowledge or key concepts in engineering, sciences or any other field should be central in curriculum. He states that school curriculum should focus on what is learned and taught. He laments the loss and continued loss of the central object (knowledge) by curriculum developers; as the focus shifts to competencies, learning outcomes and assessments (Deng, 2015). According to Hoadley (2015), loss of knowledge as the principal object in curriculum was dominant and is still visible in the post-apartheid South African school and vocational systems, where curriculum was/is focused on redressing the inequalities of the past. The main focus was/is on social inclusion, academic standards, evidence based practices and qualifications frameworks at the expense of knowledge.

As mentioned earlier, racing technological advances are disrupting every industry globally. These economic and technological disruptions lead to changes in the nature of work, jobs and occupations as business models change (WEF, 2015). These developments ask for immediate and increased attention to the identification and acquisition of the central object (knowledge) and skills and their subsequent incorporation in educational curricula. This calls for local, national and international education and training institutions to align their curricula in order to continuously produce graduates with relevant knowledge, skills and competencies required by employers in the wake of the knowledge economy.

According to Dede (2010) cited by Voogt and Roblin (2012), curriculum alignment is not only a matter of replacing current contents with those that are required by the knowledge economy, but also of re-defining and identifying what should be central in the curriculum. Proponents of knowledge as the primary object in curriculum argue that a curriculum which ostracise knowledge is incomplete and inadequate (Young, 2013; Scott, 2014; Deng, 2015). With this in mind, vocational education is deemed adequate as it equips students with specific (specialised) knowledge in a particular field or trade (Oketch, 2007; OECD, 2010; Cedefop, 2011). The World Bank 2003 report on lifelong learning agrees with this view and states that vocational courses are rich in knowledge as they focus deep on a specific subject (World Bank, 2003).

However, Wheelahan (2015) argues that vocational education curriculum is inadequate and is an apparatus for social exclusion as it focuses on experiential, applied and work-focused learning at the expense of theoretical knowledge needed for participation in arguments and disagreements in society and in work places. Citing Wheelahan and Moodie (2011), she notes that the curriculum is carefully fixated and imitates a thin conception of work, based on workplace tasks and roles, rather than occupations. She further states that vocational curriculum is mainly focused on skills needed for getting a job and securing employment instead of theoretical knowledge; yet it is these (social, communication, analytical, collaboration, critical thinking etc.) competencies that are necessary for participation in the knowledge economy (World Bank, 2003; Newell *et al*., 2009).

Furthermore, Gewer (2010) questions the adequacy of trade or 'specialised' knowledge imparted by a vocational curriculum, given the evolving skills demands of today's industries. He suggests that specialised knowledge should be complemented with theoretical knowledge. Lewis (2009) and the HRDC (2014), are of the same view and argue that VET curriculum should be designed for sustainable development and employment, that is, it should meet industries, individuals, communities and societies' needs and expectations. McGrath and Akoojee (2009) also agree with this notion and state further that in an unequal society like South Africa, vocational education curriculum should meet not only industry needs, but also political and social needs in order to address the imbalances of the past. Lewis (2009) avers that a vocational curriculum should not only focus on the core field or subject, but see the full purpose of a subject through connections or linkages. For example, electronics could be linked with mathematics and physics, wielding with chemistry etc. (*ibid*).

As previously stated, the ICT industry in South Africa is grappling with unprecedented levels of skills shortages (Lotriet *et al*., 2010; MICT SETA 2012, 2015; JCSE, 2016; South Africa, 2014a, 2014b, 2016) and on the other hand, NC (V) graduates are finding it difficult to secure employment (Kraak, 2010; FETI, 2012; DHET, 2013). Could this disparate be a result of the inadequacies of the NCV-IT curriculum? This study sought to determine the relevance of knowledge and skills imparted by the current national NCV-IT curriculum against the needs of the South African ICT industry in the wake of the knowledge economy. That is, to ascertain the adequacy or inadequacies of the NCV-IT curriculum. In other words, could the disparate be due to loss of knowledge (lack of key concepts of IT and computer science) or exclusion of theoretical (social) knowledge (knowledge which cannot be obtained at work, home or community) in the curriculum?

The above scenario raises questions about how a vocational curriculum like NCV-IT should be configured. That is, should it focus on skills for work or social knowledge or both? These questions are made more complicated by the on-going racing technological changes which are disrupting the political, social and economic status quo. This is affecting both technical and social knowledge. For example, consumers are becoming more aware of (some) products and their effects on the environment; that is, there are new patterns of consumer consumption. Such information is necessary for manufacturers, designers and resellers because it guides them on what consumers want and do not want. Therefore, product design and marketing require not only technical knowledge to produce a product, but also knowledge about consumers and the environment. For manufacturers, it has become important to know which knowledge is worth keeping since given the speed of innovation, hanging to old knowledge does not help. This therefore, raises the question; what knowledge and skills should be included in a modern vocational IT curriculum like NCV-IT. This study sought to determine the relevance of the NCV-IT curriculum to the needs of the ICT industry in South Africa in the wake of the knowledge economy. In light of this, it is important to look at how an 'ideal' computing (IT and computer science) curriculum should be configured. To help the researcher understand structure and content (core knowledge areas) of a modern ICT curriculum, a reflection on Scime's useful 2008 paper titled 'Globalized computing education: Europe and the United States' is given in the next section. The objective is to identify which knowledge and skills should be central to an IT curriculum from an international perspective.

2.4.2 Globalized computing education: Europe and the United States[3]

People from around the world with similar interests in computers and computing have come together to form professional associations such as Association for Computing Machinery (ACM), Association for Information Systems (AIS) and the Computer Society of the Institute of Electrical and Electronic Engineers (IEEE-CS) (ACM, 2005). According to Scime (2008: 49), "these professional organizations defined bodies of knowledge around the computer, which have been formalized and shaped as model curricula".

In his 2008 paper titled Globalized computing education: Europe and the United States, Scime (2008) analyses computing curriculum models from various organizations in Europe and the United States. The aim of the paper was to analyse computing curriculum models for the purpose of determining the possibility of ICT professionals' mobility. The following curriculum models were considered:

1. **ACM/IEEE-CS** model: developed by ACM, AIS and IEEE-CS.
2. Informatics Curriculum Framework 2000 (**ICF-2000**): a fundamental and broad-based set of curriculum themes that provide coverage of the informatics field. Developed by the International Federation for Information Processing (IFIP) in coordination with the United Nations Educational, Scientific and Cultural Organization (USESCO).
3. Career Space (**CSP**) model: guideline developed by Information and Communication Technology (ICT) companies to provide guidance on ICT skills needed in European industry.
4. The Italian Association of Computer Science University Professors (**GRIN**) model: developed by GRIN for both curriculum recommendations and an accreditation process for informatics in Italy.
5. **CDIO** model: developed by a consortium of engineering universities with input from industry as a framework for curricular planning and outcome-based assessment. The framework focuses on engineering education and computing.

Even though Scime's paper is focused on computing curriculum models at degree level, it is relevant to this study for three reasons. Firstly, in the South African context even though NC (V) is not a qualification pitched at university level, it (NC (V)) is considered post-school and is under the DHET, which is responsible for higher education and training. Secondly, curriculum models were developed by international bodies, meaning these models are highly credible. Finally, the NCV-IT curriculum was developed in order to prepare students for work in a modern South African economy; likewise, the models were developed to prepare students for work and employment. These models give an idea of how an 'ideal' computing curriculum should look like.

Table 2.1 provides a comparison of the areas/themes of study and study skills for each of the organizations developing computing curriculum models. Comparisons are necessary in determining key concepts (technical knowledge) and skills, which are common in the ICT field. In his comparison of the models, Scime (2008) found that science and mathematics,

[3] Since the scope and purpose of Scime's paper differs somewhat from the purpose and scope of this chapter, only the relevant aspects of the paper will be discussed.

hardware, software, and business, interpersonal, and social skills are common knowledge areas across all the models. Table 2.2 shows the minimum percent each model dedicates to these knowledge areas.

He further observed that the ICF-2000 and the GRIN models closely match the ACM/IEEE-CS model. The CSP differs in terms of terminology, however if one takes a closer look at the core technical knowledge, it covers similar disciplines as the ACM/IEEE-CS in areas such as; Computer Science / Software Engineering, Information Technology / Information Systems, IT networks/ IT and electrical engineering (information technology) / Computer Engineering.

However, one of the weaknesses of his comparison or analysis is that it focused on the subject name instead of subject core content. For example, under software development or engineering, the core knowledge area is programming, but he does not specify which programming language is used or which topics are covered by each model. The study would have been more relevant if the researcher had identified the core content of a subject or module. For example, programming mobile applications is not the same as programming general applications or programming smart devices. Therefore, one needs to learn specific programming skills and languages.

Also, Scime (2008) suggests that a curriculum review is performed after five years, but given the speed of technological changes and disruptions of the 4th industrial revolution, five years is far too long, given that the life span of IT qualification is two and half years, and rapidly decreasing according to the Gartner Group cited in Mohlala *et al*. (2012).

Table 2. 1: Comparison of computing curriculum models

ACM/IEEE-CS area	ICF-2000 themes	CSP skills	GRIN areas	CDIO syllabus
Algorithms	Algorithmic Potentials and limitations of Computing and related technologies		Algorithms	Core engineering Fundamental knowledge
Architecture	Representation of information Computer systems and architectures	Digital design	Computer architectures	Core engineering Fundamental knowledge
Business fundamentals	Broader perspectives and context			Enterprise and business context
Database			Database management Systems	Advanced engineering Fundamental knowledge
Hardware systems engineering		Digital signal Processing (DSP) applications Radio frequency (RF) engineering Product design		Conceiving and engineering systems
Human-computer interface/ interaction			Human-computer interaction	Advanced engineering Fundamental knowledge
Intelligent systems			Knowledge representation	Advanced engineering Fundamental knowledge
Interpersonal skills	Personal and interpersonal Skills			Teamwork communications
Mathematics				Knowledge of underlying sciences
Networks	Computer-based communication	Data communications engineering Communications network design	Network computing	Advanced engineering Fundamental knowledge

ACM/IEEE-CS area	ICF-2000 themes	CSP skills	GRIN areas	CDIO syllabus
Operating systems			Operating systems	Core engineering Fundamental knowledge
Programming	Formalism in information processing Software development	Software and applications development	Computer foundations Programming Computer languages	Core engineering Fundamental knowledge
Security Social and professional	Social and ethical implications			Professional skills and attributes
Software engineering (development)	Information modelling System design	Software architecture and Design Integration and test/ implementation and test engineering	Software engineering	External and societal context Engineering reasoning and problem solving Experimentation and knowledge discovery System thinking Personal skills and attributes Conceiving and engineering systems Designing Implementing
Software engineering (management)		IT business consultancy		
System administration		Systems specialist Technical support		operating
Web systems		Multimedia		

Source: Scime (2008:56)

Table 2. 2: Percentage content of knowledge areas for each model

	ACM/IEEE-CS[4]								
Area	CE	CS	IS	IT	SE	ICF-2000	CSP	GRIN	CDIO
Science/ mathematics	14	16	3	0	18	0	30	0-28	6
Hardware	58	20	16	10	0	11	30	5-25	0-78
Software	25	58	52	70	71	71	25	39-75	0-78
Business/interpersonal/social/ general education	3	6	29	20	11	18	15	0-28	16

Source: Scime (2008:59)

Furthermore, some of these models have been criticised. For example, Mulder and van Weert (2001) argue that the ACM/IEEE-CS is biased due to its American orientation. Therefore, it is not a universal representative. The CDIO framework has also been criticised due to its alignment to engineering education rather than Information Technology (Scime, 2008).

However, Scime (2008) concludes that these models can be adopted and used as they are, or customised to a nation's context and environment. There is a general concern by industry players that the current national NC (V) curriculum is not in line with industry requirements (Gewer, 2010; Mashongoane, 2015). This study sought to ascertain the relevance of the NCV-IT curriculum to the needs of the ICT industry in South Africa in the wake of the knowledge economy. Therefore, comparisons like these help interrogate the content and structure of NCV-IT in relation to international models.

The following section gives a brief overview of the current national NCV-IT curriculum.

2.4.3 NCV-IT Curriculum

The NCV-IT curriculum was introduced as a solution to addressing quality and relevance limitations in the then college curriculum (Gewer, 2010). It is focused on priority skills of the modern South African economy (*ibid*). A more detailed analysis and discussion of the NCV-IT curriculum is given in Chapter 4 (see 4.1.2).

However, despite this, the NC (V) qualification including NCV-IT has generally not been accepted and recognised by South African employers. That is, it lacks industry support despite consultation (Gewer, 2010; Mashongoane, 2015). According to Nhuta *et al.* (2015) and Walker *et al.* (2009), curriculum development should involve all relevant stakeholders and their roles clearly outlined. Stakeholders include curriculum designers, lecturers, subject experts, employers and students. The OECD (2010) agrees with this view and argues that students should be involved in curriculum development especially in vocational education as they are the best judges of their skills, abilities, preferences and interests. This is important because students feel emotionally and psychologically fulfilled after completion (achievement) of a qualification, even though they might not receive a job after completion. The OECD (2010) further states that vocational curriculum design should also be informed by supply constraints. In other words, curriculums should immediately respond to the rapidly changing demands of the workplace. As mentioned above, there was little input (on NCV-IT curriculum) from industry despite consultation. To the researcher's knowledge, there was neither student nor lecturer involvement in the development of the NCV-IT curriculum.

[4] The ACM/IEEE-CS model includes separate disciplines of computer engineering (CE), computer science (CS), software engineering (SE), information systems (IS), and information technology (IT).

Therefore, could the lack of involvement of all relevant stakeholders mean that the NCV-IT curriculum is not relevant or adequate?

Gewer (2010) further states that due to the general belief that the curriculum is not aligned to the skills needs of employers, five construction companies financed the rewriting of the NC (V) Civil Engineering and Construction curriculum. To the researcher's knowledge, no such exercise has been done for the NCV-IT curriculum; hence this study sought to ascertain if there were any knowledge and skills gaps between the curriculum and the ICT industry needs. Also, as mentioned earlier, the NCV-IT curriculum has not been changed or updated since its inception in 2007. This is despite recommendations by Gewer (2010) that NC (V) curriculum need to be reviewed after five years. Also, Scime (2008) recommends that a computing curriculum should be reviewed after five years. Therefore, could the lack of review or update of the NCV-IT curriculum mean that the curriculum is still relevant? With regard to the above, it is necessary to review the stagnant NCV-IT curriculum in relation to technological changes in the ICT industry and general curriculum practice.

2.4.4 Static NCV-IT curriculum

Recent studies note that previous industrial revolutions were moving at a slow pace and small scale so much so that the education sector managed to keep pace in providing and developing knowledge and new skills sets (Brynjolfsson and McAfee, 2012; Schwab, 2015; Infosys, 2016). However, given the accelerating pace and scale of the 4th industrial revolution, education and training institutions are faced with an insurmountable task of providing employers with required knowledge and skills. The on-going economic changes, brought by technological advances, are calling for major and speedy curriculum changes for many educational fields. Also, according to Abrahamson (1978), a curriculum should not be static but dynamic. Unfortunately, this is not the case for the national NCV-IT curriculum currently offered at public TVET colleges in South Africa as it has not been changed for the past eleven years. This is despite calls for a review of curricula in public TVET colleges in South Africa (McGrath *et al*., 2010). This raises the question; Does the continued offering of a curriculum developed more than ten years ago mean it is still relevant despite the above developments and concerns? There is need to determine the relevance of the curriculum given that many NC (V) graduates are failing to secure employment (DHET, 2013), hence this study.

Also, according to Scott and Fisch (n.d.) cited in The Future of Jobs report (WEF 2016: 20) "… nearly 50% of subject knowledge acquired during the first year of a four-year technical degree outdated by the time students graduate". As mentioned earlier, Information technology is one of the affected fields, with an estimated life span of two and half years, and rapidly decreasing (Mohlala *et al*., 2012). This raises another question; are NCV-IT students being equipped with yester years' knowledge and skills to apply in today and tomorrow's world of work? This study sought to answer this question by ascertaining the relevance of these skills and knowledge, that is, do they correspond or not to the needs of the ICT industry in South Africa in the wake of the knowledge economy.

The static NCV-IT curriculum is not only in contrast with general curriculum practices, as stated by Abrahamson (1978), but also with recent developments and practices pertaining to computer science curriculum in other parts of the world. Webb *et al*. (2017) emphasises the importance of computer science and/or information technology curriculum change in order to be aligned with on-going technological advances and industry needs. As a result, the last few years have seen the UK, Australia and Poland changing their computer science and/or information technology school curriculum in 2014, 2015 and 2015 respectively (Webb *et al*., 2017). The UK is also transforming its vocational and technical education in order to align it with industry needs (BBC, 2017). The World Bank (2014) also posits that the lack of curriculum re-orientation in Africa leads to lack of knowledge and skills hence lack of progress in the continent's booming industries like ICT and agriculture.

Furthermore, as previously stated in paragraph **2.2.1**, TVET has a key role to play in the knowledge economy. However, given the scenarios and realities that were highlighted about NCV-IT; questions such as; does TVET respond to the needs of the ICT industry are being asked? In addition, the World Bank (2003) asserts that the introduction of new technologies increases the demand for high level ICT skills and workers. Generally, VET graduates possess low level knowledge and skills suitable for entry level and middle level employment. Given the above assertions, does such knowledge (low level) have a place in the current ICT workplace? This raises another question, is it 'academically' feasible to offer a vocational qualification in IT given the rapid technological changes that brands the knowledge economy? It is therefore imperative to analyse the NCV-IT curriculum, in order to ascertain its relevance to the ICT industry and the South African economy at large.

2.5 Conclusion

In this chapter, the researcher explored the concepts of a knowledge economy, vocational education and training, NC (V) and curriculum as they relate to this study. In the first section, the researcher defined the knowledge economy and its implications on education and training and work. This was followed by the knowledge economy in the South African context and its effect on education, work and ICT skills.

The second section explored the concept of VET in the context of this study. A review of literature showed that the role of VET should be aligned to a country's economic development stage. Therefore, this raised questions about the role of TVET in South Africa with respect to the country's economic development stage. This led to an exploration of NC (V) programmes including NCV-IT, and their role in responding to the needs of the 'modern' South African economy and alleviating the skills shortage. Following this, the researcher explored the concept of a curriculum where it emerged that key theoretical concepts must be central to the curriculum. This has raised questions about which key concepts must be central to an IT and computer science curriculum. An analysis of international computing curriculum models showed software (programming), hardware (computer architecture and networking) and business as the most common knowledge areas. It also emerged that curriculum development process should involve all stakeholders such as students, lecturers, curriculum developers and industry.

Furthermore, ICT curricula should be reviewed frequently in order to keep pace with speeding technological changes which characterise the knowledge economy. Unfortunately, this is not the case with NCV-IT curriculum, as it has not been changed for the past eleven years.

Additionally, after going through several searches of scholarly materials, the researcher finds little or no literature on NCV-IT. This is similar to the findings of other researchers as mentioned earlier in this chapter and the previous chapter. Therefore, this study contributed to the body of knowledge in NCV-IT and the TVET sector in general.

Finally, a key question that remained unanswered by the literature was: is the current national NCV-IT curriculum relevant to the knowledge and skills needs of the ICT industry in South

Africa, given the greater digitization of the South African economy propelled by racing technological advances. Therefore, the next chapter focuses on the research design and methodology that was used to ascertain knowledge and skills gap between the NCV-IT curriculum and the needs of the ICT industry in South Africa in the wake of the knowledge economy.

Chapter 3: Research design

3.1 Introduction

The purpose of research is to find a solution to a particular problem. In other words, a researcher goes on a journey of developing new knowledge and finding answers to a problem in a particular field. However, knowledge cannot be accepted at face value alone. Researchers need to elaborate explicitly how they arrived/developed that knowledge, its nature and how the answers were created. If such steps are not taken "the whole research effort could produce a wrong or valueless result or be a waste of time." (Adams *et al*., 2007:22). This chapter discusses how the researcher planned, designed and executed this study.

Adams *et al*. (2007:81) defined research design as "the blueprint for fulfilling research objectives and answering research questions". According to Cohen *et al*. (2007), the purpose of the research determines the methodology and design of the research. The chapter starts by discussing and justifying the research method adopted for this study. It further discusses and justifies the sampling techniques used, data collection methods, data analysis, validity and reliability. The chapter concludes by discussing ethical consideration issues and research limitations.

3.2 Research method

A researcher can follow different research methods such as quantitative, qualitative and mixed methods also known as methodological triangulation. According to Struwig and Stead (2001:15), "Quantitative research is a form of conclusive research involving large representative samples and fairly structured data collection procedures. Qualitative research can be viewed as interdisciplinary, multi-paradigmatic, and multi-method". In this study, the researcher followed a qualitative research method. A number of factors motivated the adoption of a qualitative method.

Firstly, one of the aims of this research was to determine the relevance of knowledge and skills imparted by the current national NCV-IT curriculum to the knowledge and skills needs of the ICT industry in South Africa; in order to understand why NCV-IT graduates are finding it difficult to find employment in the ICT industry in South Africa. The study sought to understand the disparity between knowledge and skills imparted by the NCV-IT course and the needs of the ICT industry therefore, a qualitative method was suited as it helps the researcher to understand and construct meanings out of subjects (Henning, 2004). Similarly, various authors (Struwig and Stead, 2001; Saunders *et al*., 2007; Creswell, 2009) state that if the research is exploratory and/or interpretive, then a qualitative approach is suited for that research. In this study, the researcher explored the current national NCV-IT curriculum offered at public TVET colleges and therefore the qualitative approach was the best approach. In addition, Creswell states that if a research involves analysing documents, a qualitative method is the best approach. In this study, the researcher was analysing the current NCV-IT curriculum, therefore a qualitative approach was used.

Secondly, Creswell (2009:4) defines qualitative research as "a means for exploring and understanding the meaning individuals or groups ascribe to a social or human problem". This definition ties in with the objectives of this study. Among the objectives of this study was to identify knowledge and skills required by the ICT industry for entry level IT employees as well as those developed by the NCV-IT curriculum. In order to meet these objectives, it was imperative for the researcher to understand how individuals within the ICT industry (companies) create knowledge and skills, understand knowledge and skills, identify knowledge and skills as well as categorise and apply the knowledge and skills in their work environment in order to solve problems or achieve organizational goals. Therefore, qualitative research was the best suited approach for this study.

Thirdly, given the researcher's background in the ICT industry, NCV-IT and public TVET colleges, the researcher believed that there were multiple constructed realities. These realities were twofold. Firstly, knowledge and skills as perceived and constructed by individuals within various companies that form the ICT industry in South Africa. Secondly, knowledge and skills as perceived and constructed by NCV-IT curriculum designers and developers, as such a qualitative approach was best suited for this study because it helps the researcher develop a complex picture of the research problem through a holistic narrative (Creswell, 2009).

Additionally, it was mentioned in Chapter 1 that this research was motivated by lack of research in the NCV-IT field and the TVET sector in general. To the researcher's knowledge, the topic and the respective research problem addressed in this study had not been studied before. It is clear that the NCV-IT qualification needs to be understood, evaluated and new knowledge created and added to the domain. In such situations, Creswell (2009) recommends a qualitative approach. Therefore, a qualitative approach was suitable for this research.

Furthermore, Eisner (1985) states that, qualitative methods have many advantages including flexibility, openness and richness. As outlined above, one of the objectives of this study was to identify knowledge and skills needs of the ICT industry in South Africa. In order to identify these; a deeper understanding of the research question is required. In other words, one requires data or information which is rich, that is, in-depth information. Such data can be gathered through qualitative methods (Adams *et al*., 2007). However, qualitative methods have been criticized for being subjective, biased, time consuming and lacking generalizability (Ruddock, 1981). Despite the criticism, a quantitative approach could not be used in this study because the research question was neither confirmatory nor predictive (Struwig & Stead, 2001). A mixed method approach could not be used for similar reasons. Additionally, according to Fielding and Fielding (1986) the mixed method approach does not necessarily reduce bias, nor bring objectivity or increase the validity of a research. Therefore, there was little or no benefit in using it in this study.

3.3 Sampling

As previously defined, the ICT industry in this study included all organizations and companies whose main activities are ICT oriented as well as those whose activities are not ICT but have large IT departments such as universities, finance and insurance companies (Adopted from MICT SETA, 2012). It is apparent that the defined population was big and the researcher could not gather data from the entire population due to time and cost constraints. Therefore, a smaller group or sample of this population was used. Adams *et al*. (2007:88) defines "sampling as a process or technique of selecting a suitable sample for the purpose of determining parameters or characteristics of the whole population". Cohen *et al*. (2007) state that knowledge obtained from the selected group should be representative of the entire population.

However, sampling is not an easy task. Cohen *et al*. (2007) identify four key factors in sampling. These are discussed below:

i. **Sample size**. The researcher selected fifteen companies from the ICT industry. This sample was big enough to meet the objectives of the study; as there is no ideal sample size, rather the sample size depends on the type and goal of the study and the researcher's judgement (Adams *et al*., 2007; Cohen *et al*., 2007). In selecting fifteen companies, the researcher's judgement was guided by Guest *et al*. (2006) who note that a minimum of twelve interviews in a qualitative research is enough. In this case, the sample size was more than the minimum, therefore, it sufficed and to some extent it addressed sampling error. In addition, Cohen *et al*. (2007) state that in qualitative research; the sample size is usually small. Additionally, due to time constraints and costs associated with travelling, the researcher could not afford to administer interviews to a large pool of companies, as he was self-sponsored.

ii. **Representativeness of the sample.** To cover all aspects of knowledge and skills needs of the ICT industry (so as to meet the second objective), companies in different sectors or businesses were selected. The companies included three ICT companies, a government department, a metropolitan city, consultancy and auditing, finance, retail, gaming, health, insurance and two large South African institutions of higher learning. Table 3.1 below gives a detailed description of company profiles.

Table 3. 1: **Profiles of participating companies**

Company Identifier	Company profile/description	Respondent description	Number of years in ICT industry
Company 1	Higher education and training institution with a large IT department which offer ICT support services to the institution's various units and departments.	Senior Service Desk Technician/Analyst	8
Company 2	Financial and Insurance services sector. Products and services supplied both nationally and internationally.	Technical Lead/Architect	23
Company 3	Professional services industry focusing on IT, tax and accounting consultancy and auditing with branches in 180 countries globally.	Cyber Security Specialist	9
Company 4	ICT sector mainly focusing on offering ICT services to a large hotel and leisure company with operations in several countries in Africa. Also offer services to other clients as well.	IT Manager	20

Company 5	A research group based at in institution of higher learning in the education and training sector. The group focuses on blending atmospheric science, climate modelling, and applied climate analysis.	Senior Systems Engineer	14
Company 6	The organization is in the ICT sector focusing on providing digital services to clients mainly in media and advertising industry; also with clients in other sectors.	Senior Developer	7
Company 7	An international company in the financial services sector. With operations in South Africa and abroad.	Senior Programmer	6
Company 8	Provincial government with a large IT department offering ICT products and services to various entities and departments within the provincial government. These include education, tourism, mining etc.	Technical Lead	21
Company 9	Health services sector specialising in health systems and technologies in public hospitals and pharmacies in South Africa with operations in the Middle East.	Team Leader	13
Company 10	Government department offering ICT support services to government departments.	Chief Network Technologist	14
Company 11	Metropolitan city with a large IT department offering ICT products and services to support the city's day to day operations.	Principal Technician	15
Company 12	IT consultancy specialising in Microsoft technologies that are used in various sectors such as agriculture, engineering and	Lead Data Consultant	15

	construction etc.		
Company 13	The company is in the retail and wholesale sector with operations in South Africa and a number of African countries.	Integration Specialist	13
Company 14	ICT services sector specialising in offering ICT services to clients in various industries and sectors ranging from retail and wholesale, media and advertising, oil and gases industry etc. With operations in several countries around the world	Senior Network Engineer	8
Company 15	An international company in the gaming industry with offices in South Africa and abroad. It offers products and services to various clients around the world.	Software Development Manager	13

As mentioned in Chapter 2, South Africa is home to several subsidiaries of international companies, seven of the selected companies were international or had clients outside South Africa. The purpose of this study was to ascertain whether the current national curriculum develops knowledge and skills that are in line with South African ICT industry requirements as dictated by the technological revolution as mentioned in Chapter 1 of this dissertation. Therefore, by selecting international companies the researcher made sure that data gathered represented current ICT knowledge and skills required by the knowledge economy, not only in the South African context but also globally.

Additionally, companies that identified themselves as ICT companies offer ICT services to various clients who are in different sectors or businesses ranging from media and advertising, hotel and leisure, engineering, construction etc. Therefore, data gathered from these companies represented knowledge and skills required by an entry level IT employee in those various sectors. Therefore, the sample was representative enough.

The rationale of selecting two institutions of high learning was twofold; firstly, because universities educate and train students as well as employing those students after graduation. It should follow that the training they offer is aligned to knowledge and skills they require in various positions including ICT. Therefore, they have a good understanding of the relationship between education and work, making their contributions valuable and relevant to this study. Secondly, universities have many large departments or units focusing on different businesses or roles. Therefore, to holistically cover, knowledge and skills requirements, different departments were selected from the universities.

The sample included companies from various industry sectors including those whose business is not ICT but have large IT departments. By so doing, the researcher made sure that not only one sector or business was represented. This addressed the sampling error as companies from different sectors were represented.

A document review of the current national NCV-IT curriculum was carried out. Subject guidelines of nine vocational subjects were analysed. The rationale of considering core vocational subjects only was based on the fact that, ICT knowledge and skills are discipline specific, meaning they can only be developed through IT and computer science subjects. Therefore, only core vocational subjects are central to ICT knowledge and skills development. Fundamental and optional vocational subjects were not considered, as they do not impart knowledge and skills that make one gain employment in an IT position.

This exercise (interviews and review of curriculum) gathered data that enabled the researcher to answer the research question (Cohen *et al*., 2007).

iii. **Access to the sample.** The researcher had access to companies through his own personal contacts. The researcher also made use of the college's work placement office (responsible for placing NCV-IT graduates) to contact companies. As mentioned earlier, the researcher is currently employed as an IT lecturer by a TVET college and has access to NCV-IT documents.

iv. **The sampling strategy used.** Probability and non-probability sampling are the two main sampling techniques (Adams *et al*., 2007; Cohen *et al*., 2007). Adams *et al*. (2007:88) defined a probability sample "as a sample in which every element of the population has an equal chance of being selected" and a non-probability sample as a sample in which "units are selected on the basis of personal judgement". As mentioned earlier, in order to cover all aspects of knowledge and skills needs of the ICT industry, selected companies had to represent all sectors of the ICT industry. Therefore, based on the above definitions, non-probability sampling was used in this study. This is also in line with Cohen *et al*.'s (2007) recommendation that if a researcher is targeting a certain group, non-probability sampling must be used. In this study, the researcher was targeting a particular group or type of companies so as to fulfil or meet the objectives of the study (Adams *et al*., 2007). Probability sampling could not be used as it will not meet the objectives of this study. In addition, non-probability sampling is cheaper compared to probability sampling (Adams *et al*., 2007). Therefore, due to time and financial constraints non-probability sampling was chosen.

There are many types of non-probability sampling techniques including purposive, convenience, quota and dimensional sampling (Cohen *et al*., 2007). A purposive sample is a sample in which "the researcher has deliberately – purposely – selected a particular section of the wider population to include in or exclude from the sample" (Cohen *et al*., 2007:110). As mentioned earlier, computers and/or ICTs are now ubiquitous across all industries, therefore to accurately identify knowledge and skills needs of the ICT industry as defined in this study, purposive sampling was used to select companies. That is, companies were chosen based on their type of industry/business as well as their use of ICTs (*ibid*). This ensured that various sectors of the ICT industry were represented in order to collect sufficient, relevant and exhaustive (industry wide) data as mentioned earlier. In addition, according to Cohen *et al*. (2007), purposive sampling is the most widely used technique in qualitative research. This shows that it is trusted and considered most appropriate in cases investigating qualitative problems. Other sampling techniques could not be used, as they will not meet the objectives of the study.

Purposive sampling was also used to select individual participants from the fifteen companies that had been identified. The researcher selected individuals who could best help him in understanding the problem, the research question and meet the objectives of the study. These individuals were selected on the basis of their roles and understanding of the ICT field. That is, the individuals were involved in mentoring, training and assigning duties to entry level IT employees. The individuals were also responsible for assessing knowledge and skills of entry level IT employees during the hiring process of entry level IT employees. Therefore, these individuals understood knowledge and skills required by entry level IT employees. These individuals included team leaders, IT managers, senior programmers, developers, engineers and technicians (see Table 3.1 for a detailed description of the profiles of the respondents). Combined together, the respondents have more than one hundred years of experience in the ICT industry. This show how deep, rich and credible was the insights and information provided by the respondents. It also means that the respondents had a good understanding of past and present requirements for entry level IT employees in terms of knowledge and skills.

As mentioned earlier, to make sure that the researcher would obtain correct answers and credible feedback from these individuals (respondents), interview questions together with the consent form were emailed ahead of the scheduled interview date. The consent form (see addendum E) gave a detailed description of the purpose of the interview. This gave participants an opportunity not only to understand the purpose of the interview but also to assess whether they can respond to the questions and subsequently take part or not.

As stated earlier, due to time and financial constraints not every senior IT employee, team leader, IT manager, programmer or technician could be interviewed. Despite this, the researcher believes that this group of individuals was representative and diverse enough to give deep insights about the research and subsequently meet the objectives of this study.

The following section outlines data collection tools and techniques that were used in this study.

3.4 Data collection

As mentioned earlier, the purpose of research determines its design and methodology. The purpose of this study called for a design and methodology that would be able to gather data on knowledge and skills developed by the current national NCV-IT curriculum as well as those required by the ICT industry for entry level IT employees. Therefore, this research employed two methods for data collection: interviews and a document review of the current national NCV IT curriculum. The following section discusses these two methods as they were used in this study.

3.4.1 Interviews

In order to meet the objectives of this study, complete answers and a deep understanding of questions and answers was needed. This could only be achieved through interviews as they give both interviewer and interviewee flexibility to press respondents for answers and understand questions respectively (Cohen *et al.*, 2007). That is, interviews allow for greater depth as compared to questionnaires where respondents can interpret the same question differently. This also addresses the issue of non-sampling error. Additionally, knowledge cannot be counted nor measured, making other tools such as questionnaires irrelevant. Also, according to various authors (Saunders *et al.*, 2007; Creswell, 2009; Alshenqeeti, 2014) qualitative researchers normally use interviews for data collection. This justified the choice of interviews in this qualitative study.

However, interviews are time consuming and open to interviewer subjectivity and bias. Despite this, the researcher chose interviews due to their high response rates as compared to questionnaires (Oppenheim, 1992). In their study aimed at determining the range and level of skills needed by software developers in the Western Cape province of South Africa in order to meet industry needs, Tanner and Seymour (2014) used interviews to gather data. Also, in their research project aimed at finding attributes, skills, and knowledge that are considered necessary for entry-level employment for Engineering, Tourism and Hospitality, and Wholesale and Retail graduates from TVET colleges, Papier *et al*. (2016) used interviews to gather data. Various researchers have also used interviews in similar research topics (Little *et al*., 2003; Nhuta *et al*., 2015; WEF, 2016; Infosys, 2016). To a greater degree, this justified the researcher's choice of interviews as a tool used in this study.

There are various types of interviews including, standardized, structured, unstructured, semi-structured and elite interviews (Cohen *et al*., 2007). As mentioned earlier, the choice of interviews was to allow the researcher to meet the objectives of this study. Among the objectives, was to identify the knowledge and skills required by the ICT industry for entry level employee. In order to meet this objective, one needed large amounts of rich data. Such rich and detailed information can only be gathered through in-depth research interviews using the semi-structured interview approach (Adams *et al*., 2007; Saunders *et al*., 2007). Therefore, the researcher used semi-structured interviews in order to generate in-depth data. In addition, semi-structured interviews suited this study as they allowed for consistency and comparability of responses as all respondents were asked the same questions in the same order. This was important because the objective was to identify knowledge and skills currently required by an entry level employee; hence respondents were asked same questions. Additionally, the researcher opted for semi-structured interviews because they make the organization and analysis of data easy (Cohen *et al*., 2007).

However, one disadvantage of semi-structured interviews is the potential loss of relevance of questions and answers due to the standardized wording of questions (Patton, 1980). Despite this, other types of interviews such as structured and unstructured could not be used due to limited choices by respondents and less or no systematic questions respectively.

The researcher made use of open-ended questions so as to solicit for more information from respondents, in the event of insufficient information being provided (Adams *et al*., 2007; Alshenqeeti, 2014) and also to clear up any misunderstandings (Cohen *et al*., 2007). Creswell's (2009) recommendation that qualitative research should use open-ended questions, also motivated their use. In designing interview questions, the researcher made sure that each question answers or corresponds to the research questions and objectives. To improve the quality and level of feedback received during interviews, questions were e-mailed to respondents beforehand to reduce the risk of respondents being unprepared and unable to provide full, detailed and accurate responses.

An interview guide consisting of two questions was prepared (see Addendum A). Follow up questions were used to solicit for additional information or to further explain a concept or issue. Although, follow up questions were not exactly the same for all the respondents as they depended on what the respondent had said in answering the main question; in most cases it was a repeat of the main question but now asking the respondent to address a specific issue or concept. In instances where the respondent mentioned technologies but did not give an example, the researcher would prompt for an example. This was important, as it would indicate whether the technologies used in industry are the same as the ones used in the current national NCV-IT. This will subsequently determine knowledge and skills needed. However, it should be mentioned that most respondents gave examples on answering the questions.

After conducting an interview, the researcher would go through it before embarking on the next, in order to see how the researcher could improve (Cohen *et al*., 2007). As a result, a general question was added to the interview guide after the first two interviews. This was after the researcher realised that it was important to identify the industry or type of business the respondent's company was in; rather than for the researcher to assume. This also made it possible for the researcher not to collect data from companies that are in the same business or industry; as this would have yielded same data, thereby affecting the representativeness of the data. From this point, the sequence of questions moved from general to more specific questions in accordance with Cohen *et al*. (2007)'s recommendations. This allowed respondents to relax and feel comfortable, in turn enhancing their chances of answering questions honestly.

The interviews were carried out as follows: Upon identifying a company, the researcher will start the process of selecting a participant from the company. As explained in section 3.3, the participant should be involved in training, mentoring and assigning duties to entry level IT employees. Additionally, the individual can also be involved in the selection or interview process when the respective company is hiring entry level IT employees. That is, the individual is usually responsible for assessing ICT knowledge and skills for prospective entry level IT employees.

The researcher contacted respondents via e-mail or telephone in order to set up date, time and place to conduct the interview. In the email or during the telephone call the researcher briefly explained the purpose of the interview to the respondents and assured them that their privacy will be protected, that is, their identity and responses will be kept anonymous and confidential especially in the event of fear of being reported to superiors (Cohen *et al*., 2007). This was done after some respondents either refused to be voice recorded or sign the consent form after the researcher had made a trip to the interview location. At the start of the interview, the researcher asked respondents to sign a consent form in accordance with the University of Stellenbosch's Policy on Research Ethics. In line with Denzin and Lincoln's (2005) recommendation, steps were taken by the researcher to make sure that the respondents and researcher's lives were not in any kind of danger. To avoid data loss and distortion, a digital audio recorder was used to record the proceedings of the interviews. This was also important for the researcher; as an inexperienced interviewer and researcher, during data analysis and review of the interview (to see how the interview process could be improved), the researcher was able to listen to the interview again. Recording also ensured the availability of evidence in case a respondent or any other person requests. The researcher also made notes during the interview, in order to attract and increase the attention of respondents (Saunders *et al.*, 2007); this motivated them to give more information. This was also important in case the recording equipment fails. Notes were also used to capture non-verbal aspects which are normally filtered by audio recording; yet they give more information (Cohen *et al.*, 2007).

After the interview, the researcher would save and store the audio file on his laptop and on the cloud. Audio files were saved as Company 1 to represent the first company, Company 2 to represent second company and so on.

3.4.2 Curriculum review

One of the objectives of this study was to identify knowledge and skills developed by the current national NCV IT curriculum. In order to meet this objective, the researcher analysed subject guidelines and/or syllabi of nine core vocational subjects of the current national NCV-IT curriculum. Additional documents; subject assessment guidelines for each core vocational subject were also reviewed. These guidelines state what knowledge and skills students should demonstrate during and after the course. The following section outlines how these documents as well as interviews were analysed.

3.5 Data Analysis

Data analysis is a process of making sense out of data gathered during research. It is a rigorous process that involve preparing the data, understanding the data, analysing the data, representing the data and interpreting the data (Creswell, 2009). Two approaches to data analysis exist: deductive and inductive (Braun and Clarke, 2006; Saunders *et al.*, 2007; Cohen *et al.*, 2007; Creswell, 2009). Thomas (2003: 2) asserted that:

> the purpose of the inductive approach is to allow research findings to emerge from the frequent, dominant or significant themes inherent in raw data, without the restraints imposed by structured methodologies. Key themes are often obscured, reframed or left invisible because of the preconceptions in the data collection and data analysis procedures imposed by deductive data analysis such as those used in experimental and hypothesis testing research.

The definition and purpose of inductive analysis as stated above matched the aims and objectives of this study. Among the objectives of this study was to: a) identify knowledge and skills required by the ICT industry for entry level employees, b) identify knowledge and skills developed by the current national NCV-IT curriculum. In order to meet these objectives, findings (knowledge and skills) had to emerge from the data collected, not from the researcher's pre-existing conceptions. If this was the case, the whole study would have been meaningless, as this will neither meet the aims of the research nor answer the research question. Therefore, an inductive analysis approach was adopted for this study. In addition, various authors (Braun and Clarke, 2006; Saunders *et al.*, 2007; Creswell, 2009) argue that interpretive qualitative research generally follow an inductive analysis approach.

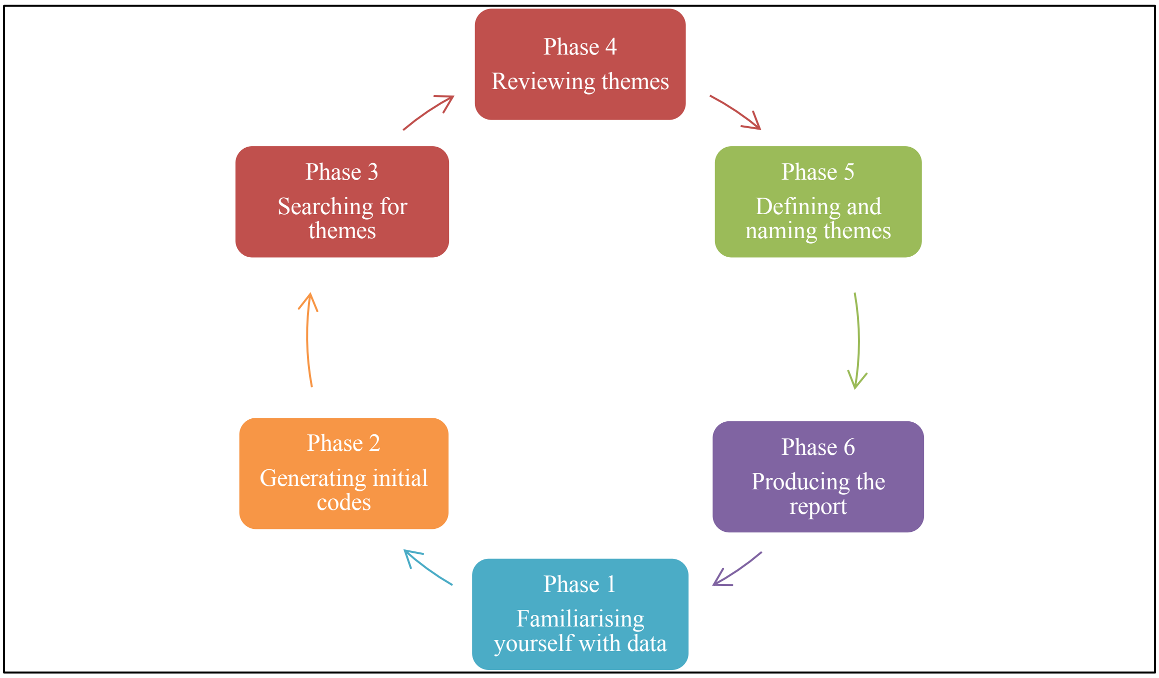
Different inductive analysis approaches can be applied to qualitative data such as grounded theory, discourse analysis, thematic analysis, phenomenology and narrative analysis (Thomas

2003; Braun and Clarke, 2006; Creswell, 2009). However, Creswell (2009:184) argues that, "despite these analytical differences…qualitative inquirers often use a general procedure that outlines the steps in data analysis". Braun and Clarke (2006:86) agree with this view and state that "qualitative analysis guidelines (procedures) are exactly that- they are not rules, and, following the basic precepts, will need to be applied flexibly to fit the research question and data." In this study, the researcher followed a thematic analysis approach as it fitted the research question, research objectives and data.

Braun and Clarke (2006:79) defined thematic analysis as "a method for identifying, analysing and reporting patterns (themes) within data". Braun and Clarke (2006: 82) noted that a theme "captures some important features about the data in relation to the research question and represents some level of *patterned* response or something within the data set". They contended that researchers need to practice flexibility when defining what constitutes a theme. They cautioned against using "quantifiable" measures to make decisions on the importance of themes (2006: 82) but rather on "whether it captures something important in relation to the overall research question". These characteristics of thematic analysis necessitated its use in this study. The use of thematic analysis was also motivated by lack of research in NCV-IT programme and the TVET sector (Braun and Clarke, 2006).

Thematic analysis involves six phases or steps of analysing qualitative data (Braun and Clarke, 2006). Analysis is not a linear process, but a recursive process that involves moving back and forward between the phases as illustrated in Figure 3.1 below.

Figure 3. 1: Six phases of thematic analysis



Source: adapted from Braun and Clarke (2006)

Thematic analysis was applied to interviews conducted with companies as well as in the document review of the current national NCV IT curriculum. The analytical processes taken are outlined below.

3.5.1 Data analysis of interviews

The first step in the analysis process was to organize and prepare the data. This step involved transcribing interviews using audio recordings and field notes that were taken during the interview. This was a strenuous and time consuming exercise. However, it was a key step in in the analysis process as it gave the researcher the opportunity to familiarise himself with the data; enabling him to get a general idea of what the respondents were saying. The researcher will go through the transcribed interview and recordings a number of times. During this step, the researcher will go back to the recordings and field notes to make sure that the interviews have been transcribed correctly, that is, validating the accuracy of the information. After this step, the researcher moved to the coding phase. As someone new to qualitative research, the researcher opted for manual coding over computer aided coding using a software program, to develop a better understanding of qualitative analysis. In addition, software programs take time to learn before one can use them effectively, which the researcher did not have. Rossman and Rallis (1998: 171) defined coding as "the process of organizing the material into chunks or segments of text before bringing meaning to information". Charmaz (2006: 43) defined coding as "the process of defining what the data are about … coding means naming segments of data with a label that simultaneously categorizes, summarizes and accounts for each piece of data".

To develop codes, the researcher worked from the transcribed interviews. The coding process was done as follows: After familiarising himself with all the recorded interviews as stated earlier, the researcher selected the most interesting interview from the transcribed interviews as he envisages that it was going to be easy to understand and interesting to code. Sections or segments of text that were important to the research question and objectives were written down in the margins (See addendum B for an example of a transcribed and coded interview). That is, the codes (sections or topics) represented information relevant to the study. With this list in hand, the researcher will go back to the transcribed interview as well as listening to the recording a number of times whilst making changes to the list. That is, refining, combining, removing and adding topics, sections or words to the list. After the codes were developed, similar topics were clustered together into two main categories, namely knowledge and skills. This process was repeated for each of the fifteen participants. At the end of this process, the researcher had a table listing topics or key text segments as identified by each participant. These tables are presented in section 4.1.1 of this dissertation.

The next step of analysis moved to assembling data belonging to each category of knowledge and skills in one place for all the fifteen participants. That is, the researcher sat down with the fifteen lists developed earlier and went through the process of searching for similar topics and grouping them together- searching for themes. That is, at this stage, the analysis moved to the phase of searching for themes or descriptions. The researcher would make sure that the collated coded data extracts form a coherent pattern before finalising the theme. This process involved finding the most descriptive words based on: actual words of participants, literature and common sense. This process yielded eight themes. The researcher would continuously listen to the recorded interviews and transcribed interviews a number of times to make sure that codes and themes were exhaustive as suggested by Cohen *et al*. (2007) as well as validating the accuracy of the information.

3.5.2 Analysis of the national NCV-IT curriculum

After familiarising himself with the current national NCV IT curriculum, the researcher went through the rigorous process of line-by-line summarising and the listing of topics (Tesch, 1990) covered in the subject guidelines of all vocational core subjects. Line-by-line analysis of text is helpful as it forces the researcher to look at the data again (Charmaz, 2006). The current national NCV-IT curriculum consists of nine core vocational subjects. Due to the number of subjects, a summary of topics covered in the respective subjects as well as the assessment criteria are listed and attached as addendum C; otherwise, the amount of data would have been enormous.

Among the objectives of this study was to determine the existence or non-existence of knowledge and skills gaps between the NCV-IT curriculum and the ICT industry needs in South Africa. In order to meet this objective and subsequently answer the research question, the summarised topics (from curriculum review) were not turned into categories or themes, but were compared against the categories or themes that emerged from the analysis of interviews. This comparison was necessary for bringing similarities, commonalities and differences between the two data sets. This is discussed in the next chapter.

3.6 Research validity and reliability

Validity and reliability are used to test and evaluate the quality of data, research design methods and the accuracy and credibility of the research results (Adams *et al*., 2007). The following sections discuss how the validity and reliability of this study were enhanced.

3.6.1 Validity

Cohen *et al*. (2007) states that, validity is central to a successful research for invalid research is worthless. Internal and external validity are the two common types of validity that are generally examined in research methods (Adams *et al*., 2007). Internal validity refers to the accuracy of the research findings in relation to the phenomena under study (Cohen *et al*., 2007). According to Cohen *et al*. (2007), internal validity can be increased by selecting an appropriate research methodology, research tools and sample. In the researcher's opinion and based on literature, an appropriate research tool, methodology and sample were selected. Also, in order to increase internal validity and reduce bias, respondents' views and opinions were respected; interviewees were asked the same questions in the same order; follow up questions were used to clear any misunderstandings; the researcher did not lead interviewees into what he wanted; data was not selected unfairly and finally, data was accurately reported.

External validity, also referred to as generalizability, refers to the extent which one can generalise or transfer the results to other cases or settings (Cohen *et al*., 2007; Saunders *el al*., 2007). According to Saunders *et al*. (2007), the generalizability of qualitative research using semi-structured or in-depth interviews is very difficult if not impossible due to the small sample size and unrepresentativeness of the sample. Creswell (2009) agrees with this view and states that the intent of qualitative research is not to generalize findings. This qualitative study used semi-structured interviews; therefore, its generalizability is difficult. However, in a similar study aimed at determining skills requirements for ERP graduates, Boyle and Strong (2006) generalized their findings after conducting 105 surveys across the globe. Similarly, findings of this study can be generalized, albeit to a lesser extent. This will be made possible, firstly by the fact that the NCV-IT curriculum offered in public TVET colleges in South Africa is the same, therefore knowledge and skills imparted are the same. Secondly, companies from different sectors of the ICT industry were selected. However, given that only fifteen out of more than 23 000 ICT companies (this number excludes companies that fall out of the MICT SETA (2015) categorization, but have IT departments) were selected, a very larger number of companies were left out. It is therefore, recommended that the study be duplicated at a much larger scale.

3.6.2 Reliability

According to Adams *et al*. (2007), reliability is necessary for validity. It refers to the consistency of data, that is, data without bias (*ibid*). To ensure reliability in this study, the researcher used the same interview schedule for all the selected respondents. That is, the researcher did not modify questions, nor change the order thereof. The researcher also avoided asking leading questions (Alshenqeeti, 2014), imposing his beliefs and frames of reference (Saunders *et al.*, 2007). Furthermore, to enhance the reliability of the data gathered, a sample representative, given the researcher's resource constraints, was selected as described earlier. However, it has to be noted that, the reliability of qualitative findings derived from semi-structured interviews is problematic as it is not feasible to replicate; since they reflect reality at the moment they were gathered (Saunders *et al*., 2007). The environment, situation and settings are susceptible to change. However, to enhance the reliability of this study, the researcher has returned notes on research design and justified the choice of research strategy and methods used to collect the data (Saunders *et al.*, 2007). This will enable other researchers to understand the process that was used as well as to reanalyse data collected.

3.7 Ethical considerations

This research was conducted in accordance with the University of Stellenbosch's Policy on Research Ethics in conjunction with the Human Research Ethics (Humanities) and Standard Operating Procedure documents. Before proceeding with data gathering (interviews), the researcher applied for ethical clearance from the Departmental Ethics Screening Committee, through the submission of all relevant documentation. The researcher also obtained a permission letter from the Principal of College of Cape Town where he is currently employed.

In accordance with the Human Research Ethics, every interviewee was asked to sign a 'Consent to Participate in Research' form. The researcher explained the purpose of the study to interviewees and assured them that their identity would not be revealed, and their responses will be treated with the highest degree of confidentiality (Cohen *et al*., 2007). The researcher intended to submit the findings of this study to DHET. Therefore, he assured respondents that identities and who said what was not going to be revealed when submitting the findings to DHET. The researcher also made it clear to the participants that there was no payment for participating in the research. The researcher also informed participants that if they were not willing to participate or finish the interview they were free to pull out without offering any explanation.

3.8 Research Limitations

One of the major limitations of this study is the small scale under which it was carried out. This study presented findings based on data collected from only fifteen companies in an ICT industry with more than 23 000 companies. There are a number of companies that were left out, meaning that not all knowledge and skills required by entry level employees were covered. Also, this study presented knowledge and skills based on interviews with IT managers, team leaders, consultants and senior (technicians, programmers, developers, engineers). Groups such as human resources practitioners, chief information officers, knowledge management practitioners could have provided more skills and knowledge requirements for entry level IT employees. In order to cover knowledge and skills requirements of the ICT industry holistically, future research should have a large sample size and include as many groups as possible.

The other limitation to this study was the refusal by a number of participants to be voice recorded. A number of participants, notably in the banking sector and international companies would agree to the interview but on being informed that the interview will be voice recorded and a consent form signed they would refuse. They cited security as their main concern especially in this era of social media; one will never know where the audio file will end up. As a result, these companies that formed an important part of this study did not participate.

3.9 Conclusion

Considering the research problem, the researcher adopted an interpretive research paradigm. Qualitative data was collected and analysed using thematic analysis. Open-ended questions using semi-structured interviews and document review of the current national NCV-IT curriculum were adopted as data collection methods. The next chapter presents data gathered from interviews as well as data gathered from the review of the NCV-IT curriculum. A comparison between the two data sets follows.

Chapter 4: Findings and Discussion

4.1 Introduction

This chapter presents the findings of the study and a systematic analysis of the data collected. Key findings are summarised and discussed to address the research objectives and answer the research questions.

Presented first are findings from the review of the current national NCV-IT curriculum; followed by qualitative data gathered from interviews with companies. Presented last is a comparison between the two data sets.

The following section presents findings from the review of the current national NCV-IT curriculum.

4.2 Research findings

This section presents qualitative data gathered from interviews with companies as well as findings from the review of the current national NCV-IT curriculum. Firstly, findings from the national NCV-IT curriculum review are presented. Secondly, a summary of key issues identified by each respondent are presented separately.

4.2.1 Findings from curriculum review

In Chapter 1 section 1.7, the researcher outlined the scope of this study. One of the boundaries of this study, that is worth reiterating at this stage, is that this study did not seek to analyse and understand how the current national NCV-IT curriculum is delivered and executed at TVET colleges. This is because the aim of the study was to ascertain the relevance of knowledge and skills imparted by the current curriculum to the needs of the ICT industry in South Africa. In other words, the study did not seek to find out whether colleges are well resourced in terms of equipment and human resources among other things necessary to offer the course. Whilst these issues might have an effect on the type and quality of NCV-IT graduates, the study focused on the content of the NCV-IT curriculum. In other words, the study focused on the topics, subject outcomes and learning outcomes outlined in the curriculum. Whether these topics, outcomes and related issues are covered and achieved respectively was not part of the aims and objectives of this study. Another boundary worth mentioning is that the study only considered core vocational subjects as explained in chapter 1.

The National Certificate (Vocational) - Information Technology and Computer Science is a three-year qualification, which consists of three levels. The structure and combination of subjects for NCV-IT Level 2, 3 and 4 is shown in Table 4.16**.**

Table 4. 1: NCV-IT subject matrix- 2017

Key: (O) = optional subjects. *Optional subjects can also be chosen from any other programme.

	Level 2 **SAQA ID NO: 50440**	**Level 3** **SAQA ID NO: 50442**	**Level 4** **SAQA ID NO: 50441**
Fundamentals. The 3 fundamental subjects are compulsory	• English/Afrikaans/IsiXhosa (First Additional language) • Life Orientation • Mathematics **OR** Mathematical Literacy	• English/Afrikaans/IsiXhosa (First Additional language) • Life Orientation • Mathematics **OR** Mathematical Literacy	• English/Afrikaans/IsiXhosa (First Additional language) • Life Orientation • Mathematics **OR** Mathematical Literacy
The 3 core vocational subjects are also compulsory. A **4th vocational subject** must be taken but can also be a vocational subject from another programme	• Electronics • Introduction to Information Systems • Introduction to Systems Development • Contact Centre Operations(**O**)* **OR** • Multimedia Basics (**O**)*	• Computer Hardware and Software • Principles of Computer Programming • Systems Analysis and Design • Contact Centre Operations(O)* **OR** • Multimedia Content (**O**)*	• Computer Programming • Data Communication and Networking • Systems Analysis and Design • Contact Centre Operations(O)* **OR** • Multimedia Service (**O**)*

Source: (DHET, 2017:1, 3)

One of the objectives of this study was to identify knowledge and skills developed by the current national NCV-IT curriculum. In order to meet the objectives, subject guidelines and subject assessment guidelines, for the three core vocational subjects per level, were respectively analysed. The subject guideline outlines topics, subject outcomes and learning outcomes, whilst the assessment guideline outlines what knowledge and skills should be assessed and how they will be assessed. Knowledge and skills developed by the current curriculum were identified from this analysis.

The next paragraphs give a synopsis of each of the nine core vocational subjects listed in Table 4.1. This is followed by a brief description of requirements necessary for NCV-IT certification. A detailed summary of topics covered per subject together with assessment criteria is given in addendum C and a subject guideline for Computer Programming Level 4 is included in addendum F.

Electronics

In electronics, students are introduced to knowledge and theoretical concepts of engineering and applied physics that focus on the design and application of devices, usually electronic circuits, the operation of which depends on the flow of electrons for the generation, transmission, reception and storage of information. Students are also introduced to various electronic parts and their functions. These include programmable logic controllers; such components are important in the development of computer systems and related technologies. In addition, students gain knowledge and skills of how to handle and assemble electronic components. Students build actual circuits, see, and measure the effects that the different components have on the electrical circuits.

Introduction to Information Systems

Introduction to information systems imparts students with a solid foundation of important concepts in information technology. Students also gain an understanding of information needs of organizations and the information systems, tools and technologies used to support management and add value to organisations.

Introduction to Systems Development

In introduction to systems development, students are introduced to the principle of problem solving using a computer programming language. The subject also gives students the foundation necessary to understand and develop computer programs and applications. On completion, students should be able to identify and solve systems development problems faced by businesses and organisations by collecting, organising, analysing and critically evaluating relevant information.

Computer Hardware and Software

In this subject, students learn about various computer components and their respective functions. In other words, students are able to identify computer components and gain an understanding of how they all work together. In addition, students gain knowledge and understanding of computer hardware, application and system software. In computer hardware and software, students are imparted with knowledge and skills that enable them to assemble, fix and install computer hardware and software. Students also develop both hardware and software troubleshooting skills.

Principles of Computer Programming

Principles of computer programming enable students to understand the principles of programming through the use of a current programming language. Students develop software design principles as well as software testing skills. Students will also be able to identify and solve problems, and collect, analyse, organise and critically evaluate information that is related to computer programming.

System Analysis and Design

Systems analysis and design at Level 3 introduce students to important foundational steps and concepts to the analysis of organisational systems. Students are imparted with knowledge and skills necessary to collect, organise and analyse data related to businesses and organizations.

Computer Programming

Computer programming builds on the knowledge and skills developed in introduction to systems development and principles of computer programming at Level 2 and 3 respectively. Computer Programming involves the designing and programming of well-tested and user-friendly computer based solutions to meet specific requirements.

Data Communication and Networking

Data communication and networking provide students with knowledge and understanding of how computer networks operate. In other words, students develop basic and complex concepts related to data communication, computer networking, designing and installation of local area computer networking. In this subject, students develop network installation skills as well as network troubleshooting skills.

System Analysis and Design

At Level 4, system analysis and design builds on knowledge and skills developed in the same subject at Level 3. At Level 4, system analysis and design provides students with a broad understanding of how to conduct a systems analysis starting with information gathering and moving on to data analysis. Based on the findings from the analysis, students develop knowledge and skills on how to design and implement computer systems.

The following paragraphs give a brief description of requirements necessary for NCV-IT certification.

NCV-IT certification requirements

There are three compulsory components in all core vocational subjects. The three compulsory components are internal continuous assessment (ICASS), integrated summative assessment task (ISAT) and external examination. ICASS is made up of two practical assessment tasks (PAT) and three internal assessments (theoretical examinations written at the end of each term). PATs are regarded as the closest that NCV-IT students can get to the workplace, therefore, DHET places highest importance on them as the only way to reduce the gap between classroom learning and the workplace. As a result, a third and final practical assessment is included in the form of an ISAT. The pass mark for all the core vocational subjects is 50% for both internal (ICASS and ISAT) and external assessment. An external examination is a theoretical assessment written at the end of the year. In order to be ultimately certified, students must pass all the core vocational subjects at each level. In other words, to obtain the NCV-IT NQF Level 4 certificate, all core vocational subjects must have been passed.

The next section presents the findings from the interviews conducted.

4.2.2 Findings from interviews

As explained in Chapter 3, interviews were conducted with fifteen companies from the South African ICT industry. See Table 3.1 in Chapter 3 for a detailed description of the company profiles as well as the profiles of the respondents. To begin the process of analysing the qualitative data generated from interviews, the researcher began by transcribing each interview. The coding process, which involved writing down sections or segments of text that were salient to the research question and research objectives, followed this (see addendum B). Given the researcher's background in the ICT industry and TVET sector, these segments of text or topics were concepts or ideas that are considered important in the field of ICT. That is, some of these topics were known theories and concepts in the ICT field. In some instances, the respondent would have explicitly stated that, the information was important. Codes were also formulated based on literature as well as from common sense. To reduce bias, the researcher stayed as close as possible to the transcribed interviews as well as recordings. Again, using the researcher's knowledge of the ICT field, codes were combined, added, removed, refined and redefined as the coding process continued. The next step was to present results from the coding process.

There are various ways of presenting and organising interview data including; per participant, per question, by an issue and per instrument (Cohen et al, 2007). Among the objectives of this study was to identify knowledge and skills requirements of the ICT industry in South Africa; these were identified by conducting interviews with companies. To present the findings in an understandable and detailed manner, the researcher decided to present (coded) responses per participant. This was also important for showing various knowledge and skills requirements, as participants were drawn from various industries and sectors. Presenting data this way made the grouping of similar codes from various participants and subsequent formulation of themes easy.

Based on the coded results and the research question, data was grouped into two categories, namely: knowledge and skills. The key concepts or topics raised by each respondent under each category are listed in the following tables. Key concepts related to knowledge required by an entry level IT employee are listed under the column 'Knowledge'. This knowledge is necessary for entry level IT employees to be able to execute their duties as assigned to them by the respective company. The second column 'Skills' indicates a summary of key skills identified by the respondent as necessary for entry level employees to execute their duties efficiently and effectively.

Table 4. 2: Interview data from Company 1

Knowledge	Skills
• Knowledge of computer components and how they operate together. • Knowledge of operating systems such as Windows and Linux. • Knowledge of application software such as Microsoft packages. • Knowledge of IP addresses, static and dynamic configuration. • Basic networking concepts. • Basic knowledge of network operating systems such as Windows server 2016 and Linux. • Knowledge of vendor based technologies.	• Ability to assemble and configure various hardware computer components. • Install and configure desktop operating systems (both Linux and Windows). • Install (application) software. • Install network operating systems such as Microsoft Windows server 2016 and Linux. • Ability to configure network servers. • Ability to configure dynamic and static IP addresses. • Perform network support services. • Ability to add or join a computer to a network.

Data gathered from interview with Company 2 is presented in Table 4.3 below.

Table 4. 3: Interview data from Company 2

Knowledge	Skills
• Knowledge of object oriented programming. • Understand the concepts of software development. • Knowledge and understanding of different types of forms such as web forms, windows forms etc. • Knowledge of industry software development best practices. • Knowledge and understanding of web	• Ability to write computer programs. • Ability to write a code using an object oriented language such as Java, C#, VB.NET etc. • Ability to use a scripting language to develop a website. • Debug and maintain computer programs. • Ability to review a code. • Ability to transform objects into

scripts. • Knowledge and understanding of user interfaces (UI) design concepts. • Understand the concept of objects as they relate to a business. • An understanding of business processes and concepts. • Knowledge and understanding of business or system specifications. • Knowledge of basic accounting, human resources and marketing. • Knowledge of Windows and UNIX operating systems. • Knowledge of computer components and related hardware. • Knowledge of computer networks. • Knowledge of relational databases. • Knowledge of foreign keys and primary keys. • An understanding of computer hardware and software and how they all work together.	business solutions. • Create databases. • Ability to design and develop UI.

Table 4.4 below shows data gathered from interview with Company 3.

Table 4. 4: Interview data from Company 3

Knowledge	**Skills**
• An understanding of all IT aspects. • Understanding of databases. • Understanding of software development concepts. • Understanding of system analysis. • Knowledge of cyber security and computer security. • Knowledge of cyber security models (predict, protect, detect and respond) and tools. • Knowledge and understanding of computer components and how they operate.	• Solve problems using computer systems. • Ability to use technology to solve problems. • Write a computer code using Java. • Install and use Kali Linux. • Ability to use Kali Linux to implement cyber security. • Create flow chats. • Create a database, install and upgrade the database (using Windows and Oracle). • Manipulate a database using

• Knowledge and understanding of programming languages. • Knowledge of systems thinking approach. • Understanding of business problems. • Basic understanding of business processes. • Knowledge of mobile applications. • Knowledge and understanding of tables, foreign keys, relationships (inner and outer joints). • Knowledge of open source and licensed software products. • Understanding of MySQL. • Knowledge of Internet and computer communication. • Knowledge of various network types and network topologies. • Knowledge of network cables and associated hardware. • Knowledge and understanding of network design. • Knowledge of Kali Linux. • Knowledge and understanding of various network servers. • Knowledge of vendor based technologies. • Knowledge of mobile applications. • Knowledge and understanding of assembly languages.	MySQL. • Install desktop operating systems such as Windows and Linux. • Configure desktop computers. • Install network operating system such as Windows, Linux and UNIX. • Activate and configure server applications. • Manage network operating systems. • Configure IP address on servers and clients. • Install cables. • Terminate cables. • Identify different networking devices (routers, switches and hubs) • Ability to maintain and troubleshoot a network.

Data gathered from interview with Company 4 is presented in Table 4.5 below.

Table 4. 5: Interview data from Company 4

Knowledge	**Skills**
• Knowledge and understanding of IT and computers in general. • Knowledge of website development	• Install Linux, Ubuntu and Windows operating systems. • Configure a router.

processes. • Knowledge of different programming languages (Java, HTML) • Understanding of computer hardware and how the various components interact. • Knowledge of computer communication. • Knowledge of routers and switches • Knowledge and understanding of routing and switching concepts. • Knowledge of network operating systems. • Knowledge of IP address (IPv4 and IPv6), subnet masks and sub networks. • Knowledge of network cables (copper and fibre optic). • Knowledge of data centres. • Knowledge of cloud computing. • Knowledge and understanding of virtualization concepts. • Knowledge of TCP/IP. • Understanding network protocols (DHCP, DNS etc.).	• Configure a switch. • Configure routing protocols. • Terminate and install cables. • Develop a website using either HTML or Java or any other language. • Configure IP addresses (IPv4 and IPv6). • Subnet networks. • Install network operating systems. • Configure DHCP and DNS servers.

Data gathered from interview with Company 5 is presented in Table 4.6 below.

Table 4. 6: Interview data from Company 5

Knowledge	**Skills**
• Knowledge of different IT environments. • Knowledge of C and Intel compilers. • An understanding of system life cycle. • Knowledge and understanding of system integration and migration. • Knowledge and understanding of	• Install desktop operating systems- Ubuntu and CentOS. • Install network operating systems- Linux Redhat and Windows server 2016. • Install vendor based software. • Maintain computer systems.

system maintenance. • Knowledge and understanding of system administration. • Knowledge of troubleshooting concepts and techniques. • Knowledge of operating systems, such as Ubuntu, Redhat and CentOS. • Knowledge and understanding of clusters. • Knowledge of vendor based software. • Knowledge and understanding of networking concepts. • Knowledge and understanding of virtualization and virtualization technologies (VMware). • Knowledge and understanding of cloud computing. • Understand business processes. • Knowledge and understanding of programming languages. • An understanding of the link between programming languages, compiler vendors and processor vendors and hardware in general. • Knowledge of IT infrastructure. • Understand the link between computer hardware and computer software such as operating systems. • Knowledge and understanding of systems analysis.	• Upgrade computer systems. • Update software and programmes. • Patch systems. • Install, configure and optimize VMware. • Troubleshoot both hardware and software problems. • Configure software. • Configure networks. • Create, add and delete users on the network. • Ability to analyse systems. • Ability to solve business problems using computers. • Ability to gather user requirements. • Ability to turn user requirements into system requirements.

Table 4.7 below shows interview data gathered from Company 6.

Table 4. 7: Interview data from Company 6

Knowledge	**Skills**
• An understanding of business concepts. • Knowledge of business analysis	• Ability to gather both system and user requirements. • Ability to understand client needs.

concepts. • Knowledge and understanding of the Model View Controller (MVC) concept or framework. • Knowledge and understanding of UI and user experience (UIX) concepts. • Understanding of how MVC, UI, UIX and Oracle work together. • Knowledge and understanding of the CodeIgniter framework. • Knowledge and understanding of the Angular framework. • Knowledge and understanding of the Laravel framework. • Knowledge and understanding of database concepts. • Knowledge of MySQL. • Knowledge and understanding of web and mobile applications. • Knowledge and understanding of mobile operating systems - Android and iOS. • Knowledge of Internet/web programming. • Knowledge and understanding of web content management systems (CMS). • Knowledge and understanding of mobile programming. • Knowledge and understanding of hybrid programming. • Knowledge of object oriented programming languages such as Java, PHP and .NET. • Knowledge of different software development environments. • Knowledge and understanding of current software development industry best practices. • Knowledge of network operating systems such as Windows server and	• Understand user/client requirements. • Create user interfaces. • Install Oracle, MySQL and Windows based databases. • Add, delete or modify entries in a database. • Manipulate databases using structured query language (SQL). • Install Windows and Linux operating systems. • Write a code. • Debug a code. • Develop mobile applications in Android and iOS. • Develop web applications for different environments. • Develop hybrid applications. • Solve business problems. • Ability to develop technical solutions to business problems. • Ability to troubleshoot hardware, network and software problems.

Linux. • Knowledge of computer networks. • Knowledge and understanding of network security. • Knowledge of computer components or IT infrastructure and how they operate together. • Knowledge and understanding of business analysis concepts.	

Data gathered from interview with Company 7 is presented in Table 4.8 below.

Table 4. 8: Interview data from Company 7

Knowledge	Skills
• An understanding of basic computer components (hardware and software) and computing elements. • Understand computer languages; binary and hexadecimal. • Knowledge and understanding of different environments or platforms. • Knowledge of operating systems such as iOS, Windows and Linux. • Understanding of computing processes of input and output. • Knowledge and understanding of machine programming and fourth generation languages. • Knowledge and understanding of the MVC framework. • Knowledge and understanding of data models. • Knowledge of user interfaces (UI) • Knowledge of database concepts. • Knowledge of Windows and MySQL databases. • Knowledge and understanding of software development principles. • Knowledge and understanding of	• Ability to operate a computer. • Install MySQL database. • Configure MySQL server. • Write MySQL queries. • Create tables. • Normalise tables. • Manipulate databases using SQL. • Install Microsoft based database systems. • Configure Windows based databases. • Write a computer or program code using C++ and Java. • Ability to gather user requirements.

current software development best practices. • Knowledge of data types such as integers and strings. • Understand tables, objects, keys, attributes and products as they relate to databases. • Knowledge and understanding of business processes. • Knowledge and understanding of open source and licensed software • Understand system integration and scalability. • Knowledge and understanding of business requirements. • Knowledge and understanding of system analysis.	

Data gathered from interview with Company 8 is presented in Table 4.9 below.

Table 4. 9: Interview data from Company 8

Knowledge	**Skills**
• Understand computer packages such as Microsoft Office. • Knowledge about computer hardware components such as CPU, memory, NIC etc. • Understand how different computer components interact and work together. • Knowledge of database theory. • Understand objects and their associated characteristics. • Knowledge about tables, attributes, columns, unique and/or primary keys. • Knowledge of data files both physical and logical files. • Knowledge of database programming using database	• Ability to tweak computer memory. • Ability to optimize CPU. • Create a database using SQL, MySQL, Oracle, DB2, Informix and Microsoft Access. • Write a database query using TSQL. • Ability to manipulate a database. • Ability to add, delete and update data in a database. • Ability to validate information in a database. • Create tables. • Ability to administer a database. • Ability to troubleshoot databases. • Ability to do backups. • Ability to perform daily tasks both

procedures and triggers. • Understand database validation. • Knowledge and understanding of various error codes in databases. • Knowledge of database services. • Understand decision making in programming. • Knowledge of Transactional- SQL (TSQL). • Understand iteration, sequence and condition in programming. • Knowledge of any popular programming languages such as Java and C#. • Knowledge and understanding of web development. • Knowledge of SQL Service Integration Service (SSIS). • Knowledge and understanding of data warehousing. • Knowledge and understanding of (data) analytics. • Knowledge and understanding of ETL (Extract, Translate, Load). • Understand cubes. • Knowledge of reporting. • Understanding of business concepts. • Knowledge of business forecasting. • Understand. • Knowledge and understanding of business performance and performance indicators. • Knowledge of artificial intelligence. • Knowledge of networking hardware such as network interface cards (NIC). • Knowledge and understanding of the OSI model. • Knowledge and understanding of	manually and automatically in databases. • Perform data migration using SSIS. • Write programs. • Create code. • Develop applications (both windows and web applications). • Debug errors both for code and databases. • Ability to analyse data. • Ability to write and/or create reports • Ability to extract, translate and load information in the data warehouse. • Arrange data into cubes. • Create Online Analytical Processing (OLAP) cubes. • Ability to terminate cables. • Ability to create subnets (Variable Length Subnet Mask (VLSM) and Equal sized subnets). • Ability to design networks. • Install network interface cards. • Configure a router. • Configure switches and hubs. • Configure routing protocols.

TCP/IP protocol suite. • Knowledge and understanding of DNS and IP protocols. • Knowledge and understanding of packets and packet switching. • Knowledge and understanding of routing. • Knowledge and understanding of IP addresses, IP address classes, subnet masks and subnetting. • Understanding of business concepts, business management, business processes and project management. • Knowledge of accounting.	

Data gathered from interview with Company 9 is presented in Table 4.10 below.

Table 4. 10: Interview data from Company 9

Knowledge	**Skills**
• Knowledge of desktop and network operating systems. • Knowledge of relational databases. • Database concepts. • Knowledge and understanding of hypervisor and virtualization. • Knowledge of virtualization technology (resource, server, storage device and network virtualization). • Knowledge of computer networks. • Diagnosis and troubleshooting concepts. • Knowledge of system monitoring. • Knowledge of computer components. • Knowledge of database administration. • Knowledge of foreign and primary keys.	• Ability to troubleshoot network problems. • Configure IP addresses on servers and workstations. • Design and configure wireless networks (Wi-Fi). • Install both desktop and network operating systems. • Configure DHCP and DNS. • Configure firewalls. • Configure proxy servers. • Configure ACLs. • Test for connectivity. • Set up network servers. • Install InterSystems Cache, MySQL and Microsoft SQL databases. • Configure database schemas. • Create tables.

• Knowledge about database queries. • Knowledge of database development. • Knowledge and understanding of database infrastructure. • Knowledge and understanding of TCP/IP. • Knowledge of server software. • Knowledge of network firewalls. • Knowledge and understanding of network proxies. • Knowledge of access controls lists (ACLs). • Knowledge and understanding of TCP/ UDP ports. • Knowledge of software development life cycle. • Knowledge of software engineering processes. • Knowledge of current industry software development tools. • Differentiate between in-house software development and outsourced software development. • Knowledge of how to extract meaning from a given set of data. • Knowledge and understanding of data and data warehousing. • Knowledge of reporting. • An understanding of business processes. • Knowledge and understanding of business analysis. • Knowledge and understanding of business intelligence. • Knowledge of business concepts. • Knowledge and understanding of system implementation and consultation. • Knowledge and understanding of	• Ability to administer a database. • Declare variables. • Ability to do links. • Create foreign keys. • Write simple queries using SQL. • Ability to analyse data. • Ability to write reports.

mathematics.	

Data gathered from interview with Company 10 is presented in Table 4.11 below.

Table 4. 11: Interview data from Company 10

Knowledge	Skills
• Knowledge and understanding of Boolean algebra. • Knowledge and understanding of digital concepts. • Knowledge of computer application software such as MS Office. • Knowledge of computer repairs. • Knowledge and understanding of various computer components such as memory, CIMOS, hard drive etc. • Knowledge of databases. • Knowledge of tables. • Knowledge of foreign and primary keys. • Knowledge of indexes as they relate to databases. • Knowledge of database manipulation and administration. • Knowledge and understanding of data and/or computer communication. • Knowledge and understanding of software project management. • Knowledge and understanding of the OSI model. • Knowledge and understanding of encapsulation and de-encapsulation processes. • Knowledge of switching concepts. • Knowledge of routers and routing concepts. • Knowledge and understanding of different networking media. • Knowledge of distributed systems.	• Ability to gather system requirements. • Ability to interpret and build a system solution from data or information gathered. • Ability to troubleshoot computer hardware problems. • Ability to disassembly and re-assembly a computer. • Create database tables. • Install and configure databases. • Ability to diagnose computer hardware problems. • Ability to interpret different hardware and software errors. • Ability to update basic input/output system (BIOS). • Write a database query using SQL. • Ability to write scripts. • Ability to write a code. • Write a report. • Analytical skills. • Ability to analyse data. • Ability to use business intelligence to harvest data. • Ability to extract valuable information from given data. • Problem solving skills.

• Knowledge of wireless networks including WiMAX. • Knowledge and understanding of ADSL. • Knowledge of very small aperture terminal (VSAT). • Knowledge and understanding of cloud computing. • Knowledge of different types of cloud based systems. • Knowledge and understanding of virtualization and virtualization technologies. • Knowledge of business intelligence concepts. • Knowledge and understanding of data analytics. • Knowledge of business analysis. • Knowledge of business concepts. • Knowledge and understanding of various hardware and software errors.	

Data gathered from interview with Company 11 is presented in Table 4.12 below.

Table 4. 12: Interview data from Company 11

Knowledge	**Skills**
• Knowledge of computer networks. • Knowledge of routers and routing protocols. • Knowledge of Windows and Linux operating systems. • Knowledge of TCP/IP. • Knowledge of switches and switching concepts. • Knowledge of spanning-tree. • Knowledge of computer components such as hard drive, CPU, RAM etc. • Knowledge of firewalls and proxies. • Knowledge and understanding of	• Install Linux and Windows operating systems. • Ability to update firmware. • Format hard drives. • Connect network printers. • Terminate and install network cables. • Ability to create subnets. • Configure firewalls and proxies. • Configure ACLs. • Install network cabinets. • Resolve email and login problems.

data encryption. • Knowledge of HTTP and HTTPS. • Knowledge of copyright principles and pirated software. • Knowledge of power over Ethernet. • Knowledge of network cables. • Knowledge of IP addresses and subnetting. • Knowledge of ACLs. • Knowledge of intrusion detection systems (IDS) and intrusion prevention systems (IPS). • Knowledge of password management. • Knowledge of IP telephony and voice over IP (VoIP). • Knowledge of wireless networks. • Knowledge of wireless access points. • Knowledge and understanding of security applications, appliances and concepts. • Knowledge and understanding of computer security threats.	

Data gathered from interview with Company 12 is presented in Table 4.13 below.

Table 4. 13: Interview data from Company 12

Knowledge	**Skills**
• Knowledge of different types of IT organizations. • Knowledge of system development processes. • Knowledge and understanding of Microsoft TSQL. • Knowledge of entity relationship	• Ability to convert business requirements into technical requirements. • Write code using Java or .NET. • Ability to use Scrum and Agile. • Gather data.

modelling (ERM). • Knowledge of Use Case theory (scenarios and diagrams). • Knowledge of unified modelling language (UML) concepts. • Knowledge of functional requirements specification (FRS). • Knowledge of database concepts and technologies. • Knowledge of set theory. • Knowledge of relational databases. • Knowledge of entity relational design. • Knowledge of Microsoft SQL, Sybase, Teradata and Oracle database systems. • Knowledge and understanding of business intelligence concepts. • Knowledge of how to turn data into opportunity. • Knowledge of business intelligence tools. • Knowledge of visual modelling. • Knowledge of data analysis and concepts. • Knowledge of different models in which data can be stored (relational, multidimensional and tabular). • Knowledge of project development. • Knowledge of business analysis. • Knowledge of software development. • Knowledge of current software development tools. • Knowledge of Scrum and Agile frameworks. • Knowledge of technology trends. • Knowledge and understanding of crypto currency and block chain	• Ability to analyse data. • Ability to turn data into opportunity. • Write a TSQL code. • Write a query. • Ability to install a database. • Ability to use SQL server analysis services, click view and tableau. • Ability to design systems. • Ability to mine data from an organization's computer systems.

concepts. • Knowledge and understanding of big data concepts. • Knowledge of business concepts.	

Data gathered from interview with Company 13 is presented in Table 4.14 below.

Table 4. 14: Interview data from Company 13

Knowledge	Skills
• Knowledge of clients and servers. • Knowledge of TCP and UDP. • Knowledge of computer networks. • Knowledge of TCP/IP. • Knowledge of the OSI model. • Knowledge of virtual local area network (VLANs). • Knowledge of firewalls. • Knowledge of demilitarised zone (DMZ). • Knowledge of IP addresses. • Knowledge of ACLs. • Knowledge of virtual private networks (VPNs). • Knowledge of Linux, UNIX and Windows servers. • Knowledge of computer components. • Knowledge of software development • Knowledge of object oriented programming. • Knowledge of network traffic types (quality of service). • Knowledge of project management concepts. • Knowledge of software development cycle models (V-Model).	• Ability to assemble a computer. • Identify computer components. • Ability to do backups. • Ability to install and configure Linux, UNIX and Windows servers. • Ability to create a database. • Ability to update a database. • Ability to manipulate a database. • Ability to administer a database. • Ability to secure a database. • Ability to set access levels in a database. • Ability to configure firewalls. • Configure IP addresses. • Ability to create subnets. • Configure VLANs. • Ability to create and configure VPN. • Ability to configure ACLs. • Write a report for business analysis. • Ability to use business intelligence tools like MS excel. • Ability to write a code in Java, C# and .NET. • Ability to interpret a code. • Ability to extract data or

• Knowledge of the waterfall model. • Knowledge of database concepts. • Knowledge of relational databases. • Knowledge of structural databases. • Knowledge of software testing tools. • Knowledge of business analysis. • Knowledge of business intelligence. • Knowledge of database manipulation. • Knowledge of database administration. • Knowledge and understanding of computer security. • Knowledge of business intelligence tools. • Knowledge of selenium and SoapUI.	information. • Ability to analyse data. • Ability to create or represent data (from a computer) using visuals.

Data gathered from interview with Company 14 is presented in Table 4.15 below.

Table 4. 15: Interview data from Company 14

Knowledge	Skills
• Knowledge of network implementation. • Knowledge of wireless and wired networks. • Knowledge of routers and routing concepts. • Knowledge and understanding of internet of things (IoT). • Knowledge of routing protocols. • Knowledge and understanding of switches and switching concepts. • Knowledge of wireless access points and wireless controllers. • Knowledge of autonomous and light weight access points. • Knowledge of internetwork operating systems (IOS).	• Configure a router. • Configure OSPF, RIP and BGP routing protocols. • Optimise routing protocols. • Configure spanning-tree. • Configure EtherChannel. • Use riverbed. • Configure UTM systems. • Install and configure Fortinet/FortiGate devices. • Write network policies. • Write a script. • Configure ACLs. • Configure network load balancing, security and traffic management using F5.

• Knowledge of network topologies. • Knowledge of riverbed. • Knowledge of Fortinet/FortiGate. • Knowledge of F5. • Knowledge of network and access policies. • Knowledge of unified threat management (UTM) systems. • Knowledge and understanding of cloud computing. • Knowledge and understanding of virtualization. • Knowledge and understanding of IP and MAC addresses. • Knowledge of subnets and subnetting. • Knowledge and understanding of computer security. • Knowledge of firewalls. • Knowledge of VLANs.	• Configure a firewall. • Configure VLANs. • Configure IP addresses.

Data gathered from interview with Company 15 is presented in Table 4.16 below.

Table 4. 16: Interview data from Company 15

Knowledge	Skills
• Knowledge of functional and object oriented programming languages. • Knowledge of software development processes. • Knowledge of software design concepts or models. • Knowledge of web design and development concepts. • Knowledge of network topologies. • Knowledge of the OSI model. • Knowledge and understanding of subnetting.	• Write a working programme. • Create a database. • Create a relational database. • Terminate cables. • Design a simple network of at least two computers. • Create subnets. • Ability to type in troubleshooting commands. • Write a report. • Extract information from a given set of data.

• Knowledge of routing concepts. • Knowledge of network cabling. • Knowledge of database concepts. • Knowledge of relational and document databases. • Knowledge of ERM. • Knowledge of data mining concepts. • Knowledge of neural networks. • Knowledge of data mining algorithms. • Knowledge of fuzzy logic. • Knowledge of cloud computing. • Knowledge of virtualization and virtualization technologies.	• Documentation skills.

4.3 Discussion

In order to generate themes or categories, key concepts, topics and related issues arising across individual companies as presented in section 4.1 were combined with participants' responses to the interview question: What knowledge or key theoretical concepts should an entry level IT employee have? Some of the responses are given below:

> "You gonna get a different answer to that question based on different people you speak to. The entry level skills for a software developer will be different from the entry level skills for a network engineer, which will be different for entry level skills for a cyber-security consultant. The entry level skills will differ based on the job or role that you employ the person in. Further to that even if you have two software developers working for company A and company B even though they are both being employed as software developers; the two companies will have different requirements. That is how broad the IT spectrum is." (Company 3)

> "IT is a fairly broad area; my area of speciality is software development. The other area as well is IT hardware and networking, which I am not very familiar to, but my honest understanding by way of what I see is that, students must be very technically competent." (Company 2)

> "It's a bit of a broad question, but I think it all depends on what (IT) field the IT person wants to go into. If you want to do web development and thus his passion and what he wants he should start by learning different languages that they write websites in such as HTML, Java whatever it is. If you are more into the server side of things, I think you should start off with a basic knowledge of how everything fits in. Like how

a network cable connects a server to a network, that is, the basics of networking." (Company 4)

"It is important that when someone is getting into the industry they know the various theoretical concepts of IT. IT is very broad, it's not only about software development, not only about hardware, there is also networking waiting for you, there is also databases waiting for you, and there is also business analysis. Those are the four I can say are the main ones." (Company 6)

"For me I think these days it is a little bit subjective, it depends on the front where you are coming from, but I would just want to give you an overview of what I think an IT entry-level employee should have is a broad spectrum, an understanding of the concepts of IT…understand packages like (Microsoft) office, understand networking, understand software development… understand computer fundamentals. You must have basic knowledge of everything in IT, so that when you get further you now specialise in an area say programming, say database administration, say BI development, say .NET development." (Company 8)

"IT is a very broad field; within IT there are a lot of sub disciplines that one will find themselves in. It will be very unfair for an entry level person to know everything on software development, networking, database administration, business/ systems analysis, business intelligence and enterprise architecture." (Company 13)

"In today's world IT services are very broad and very varied, you can touch on network infrastructure, you can touch on system development/product development, business analysis, data (space of data) etc." (Company 12)

"I am the Technical lead, and this is not a small organization, it's a medium to large organization. My main area of focus is purely in the Technical or system engineering or system administration, the reason why I mentioned the (organizational) structure is because within our organization we have software development department, business intelligence/ business analysis department and the implementation and consultancy department." (Company 9)

The analysis of these responses together with interview data collected from all fifteen companies and presented in tables **4.2 to 4.16** highlighted eight themes within the IT field with regards to knowledge and skills requirements of entry level IT employees. In line with ICT practices, these categories are from here on referred to as disciplines. These disciplines are listed below:

1. Software development
2. Computer networks
3. Databases
4. Computer hardware and software
5. Business intelligence
6. Cyber security/Computer security
7. Business analysis/Systems analysis

8. Cloud computing and virtualization

Furthermore, knowledge and skills are discipline specific. Therefore, to holistically cover the knowledge and skills requirements of an entry level IT employee and meet the objectives of this study, disciplines were analysed individually. The tables below explicate the disciplines as they emerged from the data analytical process. The tables consist of two columns. The first column is data from interviews with companies that fall within a specific discipline. In order to discover commonalities, differences and similarities (Cohen *et al.,* 2007), which will, eventually answer the research question. The second column is a comparison with curriculum and lists topics, concepts and related issues covered in the national NCV-IT curriculum. The second column only lists the topics that are covered by the curriculum and relevant to that discipline. Each table is followed by a comparison of the two sets of data, with illustrative direct quotations from respondents used in some instances. The codes, Company 1, Company 2 etc. are used as explained in Chapter 3 to indicate the respondent.

In the following sections, each category of knowledge and skills is discussed separately (see 4.2.1 and 4.2.2).

4.3.1 Comparison between interview data and curriculum: Knowledge

This section is a comparison of discipline specific knowledge as it emerged from interviews with companies against the content of the current national NCV-IT curriculum.

4.3.1.1 Software development

In Table 4.17, the data gathered on software development knowledge from interviews with companies is listed. The topics covered by the current national NCV-IT curriculum are listed. Analysis and discussion follows the table.

Table 4. 17: Data summary on software development knowledge

Data from interviews with companies	Comparison with curriculum
• Knowledge of object-oriented and functional programming languages. • Knowledge of machine and assembly languages. • Knowledge and understanding of software development concepts. • Knowledge and understanding of web and mobile applications. • Knowledge and understanding of mobile operating systems - Android and iOS. • Knowledge of Internet/web programming. • Knowledge and understanding of web content management systems (CMS) • Knowledge and understanding of mobile programming.	Computer programming Level 4 covers object oriented programming, objects, web programming, internet programming, website development and scripting. Principles of computer programming Level 3 deals with program design, error handling and debugging, software development environments, systems development life cycle, data structures and user interface design.

• Knowledge and understanding of hybrid programming. • Understanding of iteration, sequence and condition. • Knowledge and understanding of web, windows forms etc. • Knowledge of different software development environments or platforms. • Knowledge of current industry software development tools and best practices. • Knowledge and understanding of web scripts (scripting). • Knowledge and understanding of UI design concepts. • Understand objects as they relate to a business. • Knowledge of C and Intel compilers. • Knowledge and understanding of the Model View Controller (MVC) concept or framework. • Knowledge and understanding of user experience. • Knowledge and understanding of UI and UIX concepts. • An understanding of how MVC, UI, UIX and Oracle work together. • Knowledge and understanding of CodeIgniter, Laravel and Angular frameworks. • Knowledge of V-Model and waterfall software development life cycle models. • Differentiate between in-house software development and outsourced software development. • Knowledge of ERM. • Knowledge of Use Case theory (scenarios and diagrams). • Knowledge of UML concepts.	

• Knowledge of Scrum and Agile frameworks. • Knowledge of software testing tools. • Knowledge of selenium and SoapUI.	

Based on the qualitative findings from respondents, an entry level software developer should have knowledge of both functional and object oriented programming. The current national NCV-IT curriculum covers procedural programming and not functional. This shows a mismatch between the curriculum and industry requirements.

The respondents also mentioned a number of software development frameworks, models and theories as shown in Table 4.17. These include MVC, CodeIgniter, Laravel, Angular, Scrum and Agile; V-model, ERM and UML models; use case theory. The respondents stressed the importance of these frameworks, models and theories in software development as can be attested to by the response below. These are not covered in the current national NCV-IT curriculum.

> "I am always given that job, that is, get us someone into the industry these are the things I look into; do they understand MVC, are they able to link from the MVC the view to the user experience (UIX) that the designers come up with, are they able now to link the model on the MVC concepts with the databases we work with, you talk of Oracle, you talk of MySQL all those are things I look into when picking someone. These have to be there." (Company 6)

In addition, respondents mentioned knowledge of mobile application development and hybrid programming as a requirement for entry level employees. They further underlined the importance of current industry software development tools and best practices.

> "Get into hybrid, learn about hybrid, the thing with hybrid is you are able to build in one go systems that gonna be able to work on iOS, Android and on Web. Hybrid is the new thing these days, that is one thing that I also look into when I am getting my people I am gonna be working with." (Company 6)

According to comScore, an international analytics company, in May 2014 mobile application usage surpassed that of desktop as the trend towards mobile continues to grow at a rapid pace (Lipsman, 2014). The MICT SETA (2012; 2015) agrees with this and states that recent years have seen an increase in demand for mobile technology knowledge and skills. Respondents of this study confirmed this and mentioned that knowledge of mobile application development coupled with hybrid programming is vital for entry level employees as attested to by the responses above. The current NCV-IT curriculum designed way back in 2007 does cover neither mobile nor hybrid programming. This shows that the current curriculum is out dated and urgently needs to be reviewed and updated.

Although the current NCV-IT curriculum covers Internet/web programming, there are a few concepts such as content management systems, as mentioned by respondents, are not covered. Also, the NCV-IT curriculum covers user interface concepts but not user experience concepts which were mentioned as important by companies. This concurs with Tanner and Seymour (2014) who too found that user experience knowledge is vital for software developers. Furthermore, ACM/IEEE Information Technology Curricula (IT2017) guidelines states that contemporary information technology curriculum should include user experience as they are replacing traditional user interfaces such as icons and menus by integrating video, voice, touch and real-time (ACM, 2017).

It can be concluded that the current NCV-IT software development curriculum falls short of industry requirements, in terms of knowledge, despite having some concepts or areas that are in line with industry requirements as indicated in Table 4.17.

4.3.1.2 Computer networks

From the interviews, it became clear that entry level IT employees should have knowledge of computer networks. Responses from companies concerning knowledge of computer networks are listed in Table 4.18. Computer networking topics covered by the current national curriculum are also listed. A comparative discussion of the two follows the table.

Table 4. 18: Data summary on knowledge of computer networks

Data from interviews with companies	Comparison with curriculum
• Knowledge of computer networks. • Knowledge of Internet and computer communication. • Knowledge of network cables and associated hardware. • Knowledge of network types and network topologies. • Knowledge and understanding of network design and implementation. • Knowledge and understanding of network servers. • Knowledge of routers, routing concepts and routing protocols. • Knowledge and understanding of switches and switching concepts. • Knowledge and understanding of packets and packet switching. • Knowledge of network operating systems. • Knowledge and understanding of TCP/IP protocol suite. • Knowledge and understanding of the OSI model. • Knowledge and understanding of DHCP and DNS network protocols. • Knowledge of IP addresses (IPv4 and IPv6); MAC addresses, address	Data communication and networking Level 4 covers computer networks and communication, network cables, network topologies, switches and switching concepts, network design, maintenance and monitoring. It also covers network operating systems, network administration and networked computer application software. Networking hardware and infrastructure such as routers, switches, servers and hubs.

classes, subnet masks, sub networks and subnetting. • Knowledge and understanding of system integration, migration and scalability. • Knowledge and understanding of system maintenance. • Knowledge and understanding of system or network administration. • Knowledge of troubleshooting concepts and techniques. • Knowledge and understanding of clusters. • Knowledge and understanding of Internet of Things (IoT). • Knowledge and understanding of network firewalls, proxies, ACLs and network policies. • Knowledge and understanding of TCP/ UDP ports. • Knowledge and understanding of encapsulation and de-encapsulation processes. • Knowledge of ADSL, VSAT and VPNs. • Knowledge of VLANs. • Knowledge of wireless networks, wireless access points and wireless controllers. • Knowledge of autonomous and light weight access points. • Knowledge of internetwork operating systems (IOS). • Knowledge of riverbed. • Knowledge of IP telephony and voice over IP (VoIP).	

Wireless networks are everywhere today; at home, in shopping malls, at coffee shops, at the airport, at the office, and so on. IP telephony and VoIP have also become popular networking technologies and concepts of the past decade. As shown in Table 4.19, respondents pointed out that entry level IT employees must have knowledge of these technologies and concepts. However, the current national NCV-IT curriculum does not cover any of these. This shows that not only is the current national NCV-IT curriculum outdated, but also misaligned with industry requirements. The curriculum urgently needs to be reviewed and updated so that it is aligned to the needs of the ICT industry.

The last few years have seen an increase in the number of physical devices such as vehicles, homes and other appliances being connected to the Internet, marking the dawn of the Internet of Things. Respondents of this study confirmed this and mentioned that it is vital for entry level employees to have knowledge of IoT and network clusters; as the internet is no longer a preserve for computers only. In addition to this, respondents also mentioned VSAT, VPN and ADSL. These technologies and concepts are not covered in the current national NCV-IT curriculum. The respondents' responses are in line with ACM's (2017) information technology curricula guidelines for 2017 which states that an information technology curriculum like NCV-IT should cover knowledge of IoT. This shows that a curriculum designed more than ten years ago is no longer in touch with current industry realities and requirements.

Although the current national NCV-IT curriculum covers networking devices including routers, switches and hubs; it does not cover routing concepts, which was mentioned by respondents as important in computer networks.

Perhaps, even more remarkable is the fact that the current curriculum covers a little portion of network protocols, IP addresses, OSI and TCP/IP models and no data encapsulation and de-encapsulation, MAC addresses, IP subnets and subnetting, TCP and UDP ports. In terms of IP addresses, respondents reported that knowledge of both IPv4 and IPv6 is important. The IPv6 protocol is not covered in the curriculum. Yet interview results reveal that these are considered fundamentals for anyone to understand the concepts of a network. These massive gaps and misalignments might be the reason why industry prefer industry certifications as attested to by the responses below.

> "I think within the area of networking they should be able to have like your N+ (Network Plus) it is a good qualification, because it will be able to introduce somebody to the technical concepts such as the OSI model, switching and routing of data." (Company 10)
>
> "Entry-level employees I would say just a fundamental of networking which will probably be your N+ (Network Plus) offered by CompTIA or the Cisco CCNA 1 and 2 perhaps." (Company 3)
>
> "The other one is N+ certification- which will help in knowing the basics of networking. From there you can advance yourself by getting certified by major companies such as Microsoft, HP and Cisco which cover most of the things that deals with networks." (Company 14)

The preference of industry certifications may be attributed to the following reasons. Firstly, industry certifications are developed by industry itself. Therefore, the certifications are considered relative and in line with industry requirements. Secondly, industry certifications are current; that is, most industry certifications expire after a period of three years, with others having an expiration period as low as twelve months. After the twelve months or three years, the knowledge is considered obsolete and no longer valid as new technologies, practices and concepts enter the market. The holder of the certificate must seat for a re-certification exam in order to renew the certification. That is, to update one's knowledge and skills. This concurs with what was pointed out in the review of literature that the shelf life of IT and computing knowledge is two and half years.

Respondents also mentioned that the knowledge of network and internetwork operating systems are important for entry level employees. However, the current curriculum covers ample amounts of application software and little on network operating systems, yet respondents put more emphasis on the later. There is no coverage of internetwork operating systems at all. This shows gaps and misalignments between the two.

Additionally, respondents mentioned that knowledge of network firewalls, proxies and ACLs is vital for entry level IT employees. These are not covered in the current curriculum. This again shows the gap between the current national NCV-IT curriculum and the ICT industry's knowledge requirements.

It can be concluded that not only is the current computer networks discipline (NCV-IT curriculum) significantly misaligned but also outdated; as respondents mentioned many new technologies and concepts that are not part of the current curriculum. It should also be pointed out that some of the concepts covered by the current curriculum are basic to the extent that companies don't consider them as a requirement for employment. In other words, the level of imparted knowledge is too low, compared to the knowledge requirements of the ICT industry. However, there are some areas of the curriculum which are aligned to industry requirements such as switching concepts, network topologies, cables and networking concepts as can be seen from Table 4.18 above.

4.3.1.3 Databases

Table 4.19 shows data summary on knowledge of databases as gathered from both interviews with respondents and analysis of current national NCV-IT curriculum.

Table 4. 19: Data summary on knowledge of databases

Data from interviews with companies	Comparison with curriculum
• Knowledge and understanding of database theory and concepts. • Knowledge and understanding of relational, multidimensional, document, tabular and structured databases. • Knowledge and understanding of tables, attributes, foreign keys, primary keys and relationships (inner and outer joints). • Knowledge of SQL, MySQL and TSQL. • Knowledge of physical and logical data files. • Knowledge of database programming, database procedures and triggers. • Knowledge of database	In Principles of computer programming Level 3: relational databases; tables and relationships. In computer programming Level 4: primary and foreign keys; normalisation; writing queries using SQL; database programming; data validation.

administration. • Understand database validation. • Knowledge and understanding of database error codes. • Knowledge of database services. • Knowledge of SQL Service Integration Service (SSIS).	

Findings from companies indicated that entry level IT employees should have knowledge of relational, document, structured and multidimensional databases. The current curriculum only covers relational databases. This shows that there is a gap between industry requirements and the current curriculum. Furthermore, companies mentioned database administration, procedures and triggers as important knowledge for an entry level employee. Further, companies indicated database services and SSIS as important knowledge for entry level employees. These concepts are not covered in the current curriculum. This shows that the current national NCV-IT curriculum is not aligned to industry needs in terms of database knowledge.

The current curriculum deals with the printing of both databases and forms. However, none of the respondents mentioned this as important knowledge for entry level employees. Also, the curriculum covers knowledge of SQL and query wizard, whereas on the other hand companies want knowledge of SQL, MySQL and TSQL. This shows that there is a mismatch and some of the knowledge imparted by the current curriculum is too low as compared to high quality knowledge required by companies. This concurs with the notion that was raised in literature that vocational education has no place in the knowledge economy; as it imparts low level knowledge and skills that are not applicable in the knowledge economy (see Chapter 2).

Furthermore, companies mentioned knowledge of logical and physical data files as important for entry level employees. Such knowledge is not covered in the current curriculum.

However, there are some notable similarities between the current curriculum and industry requirements as mentioned by respondents in Table 4.19. Despite these similarities, companies seem to prefer industry certifications over academic qualifications.

> "These (databases) usually come with certification qualification attached to them, where you can write entry level certification, intermediate and senior level certification which equips you with in-depth technical knowledge. The theoretical database knowledge you can also get from a database fundamentals course." (Employee 12)

As mentioned earlier, industry certifications seem to be preferred as they are relevant and current. That is, certifications are considered current and impart knowledge which is relevant and aligned to industry requirements as they are developed by industry. As a result, one of the respondents suggested that learning and training institutions should consult industry when it comes to developing course content and qualifications.

> "Organizations must probably talk to, say universities and any other organization that provides these courses to students and then come up with a way of they can sort of

synthesise the qualifications they are providing vis-à-vis the IT requirements that they need, some might require certifications such as Cisco." (Company 5)

4.3.1.4 Computer hardware and software

ACM's IT2008 curricular framework emphasises that IT graduates require breadth and depth in information technology, specifically in IT fundamentals (ACM, 2017). Findings of this research indicate that for entry level IT employees this is indeed the case, with more emphasis placed on understanding a computer and its various components.

From the interviews, it became clear that entry level IT employees should have knowledge of computer hardware and software. Table 4.20 lists the responses from companies with regard to knowledge of computer hardware and software. The topics covered by the current national NCV-IT curriculum are listed and a comparative discussion of the two follows the table.

Table 4. 20: Data summary on knowledge of computer hardware and software

Data from interviews with companies	Comparison with curriculum
• Knowledge and understanding of all IT and computer concepts. • Knowledge of computer components and related hardware. • Knowledge of computer packages such as MS Office. • An understanding of how computer hardware and software work together. • Knowledge and understanding of Boolean algebra, binary and hexadecimal. • Understand computing processes of input and output. • Knowledge of Windows, Ubuntu, CentOS and UNIX desktop operating systems. • Knowledge of open source and licensed software. • Knowledge of vendor based technologies and software. • Knowledge of IT infrastructure. • Diagnosis and troubleshooting concepts. • Knowledge and understanding of hardware and software errors.	Introduction to information systems Level 2 covers the following topics: IT components and concepts; computer storage, input and output processes; using a computer. Computer hardware and software Level 3 covers computer architecture; hardware components; application and system software; diagnosis and troubleshooting. Principles of computer programming Level 3 deals with Boolean algebra, binary and hexadecimal numbers.

As can be seen from Table 4.20 knowledge imparted by the current national NCV-IT curriculum is in line with what respondents indicated as key knowledge or theoretical concepts in the discipline of computer hardware and software.

However, despite the alignment, respondents seem to prefer industry certifications ahead of academic certifications.

> "When it comes to hardware and software, your A+ certification should be able to help you because it has two components, one that looks at the hardware component and the other at the software component." (Company 10)

> "The skills that you will need are A+ certification; which help you know the basic of a computer." (Company 14)

As stated earlier, the preference of industry certifications over academic certificates like NCV-IT is due to industry's involvement in the development of the certifications as well as their relevance to industry requirements. This might explain why the current national NCV-IT curriculum designed in 2007 without industry participation is misaligned, out dated and irrelevant to industry knowledge and skills requirements. However, this is not conclusive given the fact that a comparison between NCV-IT (computer hardware and software knowledge) and industry knowledge requirements show that the two are in line. This then raises the question- why NCV-IT graduates are not being employed? This could be attributed to the unwillingness of industry given that: a) there were not consulted when the current NCV-IT curriculum was designed and b) industry's negative perception of NC (V) and TVET in general.

4.3.1.5 Business Intelligence

The collection, integration, analysis and presentation of business information has become vital in an increasingly complex, competitive and globally connected business environment. Respondents of this study confirmed the above statement and mentioned a number of business intelligence concepts that entry level IT employees should possess. These are listed in Table 4.21 below.

Table 4. 21: Data summary on knowledge of business intelligence

Data from interviews with companies	Comparison with curriculum
• Knowledge of business intelligence concepts. • Knowledge and understanding of data warehousing. • Knowledge and understanding of analytics. • Knowledge and understanding of ETL. • Knowledge and understanding of cubes. • Knowledge of reporting. • Knowledge and understanding of	Computer programming Level 4 deals with creating reports in databases.

business forecasting, business performance and performance indicators. • Knowledge of extracting meaning from a given set of data. • Knowledge and understanding of big data and data analytics. • Knowledge of how to turn data into opportunity. • Knowledge of data mining algorithms.	

Findings from the research show that the current curriculum barely covers knowledge or concepts of business intelligence as mentioned by respondents. This is despite the fact that business intelligence and its associated domains of big data and data analytics are becoming big and more popular as attested to by the following response. This is in line with the MICT SETA's findings that business intelligence knowledge and skills are in demand and did not exist more than ten years ago (MICT SETA, 2012; MICT SETA, 2015), but have become mainstream (JCSE, 2016).

> "In addition to that, BI or Business Intelligence is becoming a very big area as well. Data analysis skills are also becoming scarce and also very much in demand." (Company 10)

This confirms that the current national NCV-IT curriculum of more than ten years ago is out dated and has lost touch with industry realities. Therefore, it urgently needs to be reviewed and updated in order to be aligned to ICT industry requirements.

4.3.1.6 Cyber security/Computer security

The definitions of the terms computer security and cyber security can be confusing; and one of the respondents stated that most people do not know what cyber security is and what it involves. In its glossary of key information security terms, the National Institute of Standards and Technology (NIST) (NIST, 2013:41, 58) defines:

> Computer security are measures and controls that ensure confidentiality, integrity, and availability of information system assets including hardware, software, firmware, and information being processed, stored, and communicated.
>
> Cyber security as the ability to protect or defend the use of cyberspace from cyber attacks. In which cyberspace refers to a global domain in the information environment consisting of the interdependent network of information systems infrastructures including the Internet, telecommunications networks, computer systems, and embedded processors and controllers.

Although responses from respondents of this study as well as literature show that, there is a difference between cyber security and computer security; in practice, there is an overlap between the two. Therefore, for simplicity in this study, the two domains are presented as one. From the interviews, it became clear that entry level IT employees are required to have knowledge of cyber security and computer security tools and concepts. Such concepts are listed in Table 4.22. Concepts on cyber security/computer security covered by the current national NCV-IT curriculum are listed.

Table 4. 22: Data summary on cyber security/computer security knowledge

Data from interviews with companies	Comparison with curriculum
• Knowledge of cyber security and computer security. • Knowledge of cyber security models-predict, protect, detect and respond. • Knowledge of cyber security tools. • Knowledge of Kali Linux. • Knowledge and understanding of network security. • Knowledge of demilitarised zone (DMZ). • Knowledge and understanding of security applications, appliances and concepts. • Knowledge of intrusion detection systems (IDS) and intrusion prevention systems (IPS). • Knowledge and understanding of data encryption. • Knowledge of password management. • Knowledge of Fortinet/FortiGate. • Knowledge of F5. • Knowledge of UTM. • Knowledge of system monitoring. • Knowledge of copyright principles and pirated software.	In data communication and networking Level 4: knowledge of network access systems; knowledge of security exposures and violations. In systems analysis and design Level 4: knowledge of computer security; acceptable and unacceptable ICT usage; usage policies and procedures; computer software piracy.

Respondents mentioned that the protection of systems, Internet, networks and data in cyberspace has increasingly become very important for all businesses. Therefore, entry level IT employees need to have knowledge of these cyber security tools and concepts. As can be seen from Table 4.22, the current curriculum does not include knowledge or concepts of cyber security. For example, respondents mentioned knowledge of Kali Linux, IPS and IDS, DMZ and data encryption as key for an entry level IT employee. Kali Linux is very important in cyber security as it used to test, predict, protect and respond to cyber threats and attacks. The current curriculum does not cover these concepts. Likewise, intrusion prevention and intrusion detection systems and mechanisms are not covered, yet they have become very important for securing businesses' cyberspace. This shows that the current national NCV-IT curriculum implemented in 2007 is out dated and out of touch with current industry requirements.

Additionally, respondents mentioned knowledge of various security appliances and mechanisms such as UTM, F5 and Fortinet/FortiGate in securing the Internet and wireless networks as very important for entry level employees. Again, these concepts are not covered.

The current curriculum deals with computer security; acceptable and unacceptable ICT usage, usage policies, procedures and network access systems. Although some of these corresponds with what respondents mentioned as some of the key theoretical concepts and knowledge, it still falls short by a wide margin of what is required of a computer security employee. Firstly, the curriculum does not cover the entire domain of computer security as defined by industry. The current curriculum only covers hardware security – specifically personal computer security and a small portion of network security. There is no coverage of data, disruption of service, integrity and availability of systems, wireless network security, physical and systems security as mentioned by companies. Secondly, it is questionable if the knowledge is good enough to meet industry's requirements. That is, the level at which the content is pitched at is lower than industry requirements as attested by the response below.

> "In our organization, for cyber security you must have an honours degree in computer science or information systems. We don't look for graduates that come from private colleges or public TVET colleges." (Company 3)

This finding is in line with some of the notions that were raised in literature that vocational education (which produces low level skills), specifically in information technology and computer science programmes does not have a place in the knowledge economy which is driven by massive technological advancement and dominated by high level technical skills and knowledge (see Chapter 2).

4.3.1.7 Business Analysis/System Analysis

Table 4.23 shows data summary on knowledge of business analysis/system analysis as gathered from interviews with companies and review of the current national curriculum. Following the table is a comparison of the current curriculum and industry knowledge requirements in the business analysis/ systems analysis discipline.

Table 4. 23: Data summary on knowledge of business analysis/system analysis

Data from interviews with companies	Comparison with curriculum
• Knowledge and understanding of business or system specifications. • Knowledge and understanding of system analysis. • Knowledge and understanding of business analysis concepts. • Knowledge of systems thinking approach. • An understanding of business problems.	Systems analysis and design Level 3 deals with: system analysis concepts; information systems departments in business organizations. Systems analysis and design Level 4 covers the following topics: information gathering for computer systems development; analysing information systems; artificial intelligence, fuzzy logic and neural networks.

• Knowledge and understanding of business processes. • Knowledge and understanding of business concepts: accounting, human resources, marketing, business management and project management, • Knowledge of system life cycle. • Knowledge of functional requirements specifications. • Knowledge of neural networks and artificial intelligence. • Knowledge of fuzzy logic.	

Findings from the research indicated that companies use the terms business analysis and system analysis interchangeably. However, most responses by respondents show that companies look at the components of the organization or business holistically not just computer systems as currently done by the curriculum. As a result, companies mentioned business analysis, business specifications and business processes as important concepts for any entry level IT employee. Respondents also mentioned systems thinking as an important concept for business analysis/system analysis. In other words, it is important for entry level employees to understand how a business operates and not only focusing on computer systems. This assists entry level employees in understanding business problems; which was also mentioned as an important part of business analysis. Once one understands business problems, it is easy to come up with business solutions, which are ultimately, what companies, want from employees.

Whilst the curriculum deals with accounting information systems, respondents mentioned knowledge of accounting as well as marketing, business management, human resources and project management as important for entry level employees. The current curriculum covers none of these. This shows a disparity between ICT industry requirements and the current curriculum.

Furthermore, respondents mentioned functional requirement specifications, which are not covered in the curriculum.

However, despite the mentioned differences, there are some similarities between the curriculum and industry requirements as indicated in Table 4.23. Therefore, it is recommended that the curriculum be updated for it to be aligned with industry requirements.

4.3.1.8 Cloud computing and virtualization

According to Brown (2018), the last five years have seen a sharp increase on cloud computing by South African companies. He further reported that last year (2017) alone saw 74% of South African companies doubling their cloud computing expenditure (Brown, 2018). Respondents of this study confirmed this as can be seen from the responses in the table below and attested to by the verbatim response following the table.

Table 4. 24: Data summary on knowledge of cloud computing and virtualization

Data from interviews with companies	Comparison with curriculum
• Knowledge and understanding of cloud computing. • Knowledge of cloud based systems. • Knowledge of cloud technologies. • Knowledge of data centres. • Knowledge and understanding of virtualization concepts. • Knowledge of virtualization and virtualization technologies (resource, server, storage device and network virtualization). • Knowledge of hypervisors and VMware.	Cloud computing and virtualization are not covered in the current national NCV-IT curriculum.

> "It is also quite pivotal that one has very good cloud computing skills and understanding of the various forms of clouds that we have." (Company 10)

> "I touched on cloud computing skills which are becoming quite prevalent and a common place in many areas. There is also a concept of virtualization, upon which cloud computing sits. An entry level person should be able to have very good skills in virtualization. It is also very important that entry level employees have access to and knowledge of virtualization technologies because they are becoming more and more prevalent and very much in demand." (Company 10)

As can be seen from Table 4.24, the current curriculum does not cover cloud computing and virtualization; yet respondents emphasised that these technologies and concepts are very important for entry level employees. The lack of coverage of cloud computing and virtualization knowledge in the current national NCV-IT curriculum confirms that not only is the curriculum misaligned but also outdated and in urgent need of renewal and review. This is in line with what emerged from the review of literature, that a computing curriculum has a life span of two and half years. Therefore, a curriculum (NCV-IT) of more than ten years ago cannot be relevant today.

4.3.2 Comparison between interview data and curriculum: Skills

As previously mentioned, data gathered from respondents during interviews showed that each of the eight identified computer disciplines has its own set of skills. This section is a comparison of industry skills requirements as identified by respondents during interviews against skills imparted by the current national NCV-IT curriculum.

4.3.2.1 Software development skills

Table 4.25 shows data summary on software development skills as gathered from interviews with companies and analysis of the current national NCV-IT curriculum. A comparative discussion follows the table.

Table 4. 25: Data summary on software development skills

Data from interviews with companies	Comparison with curriculum
• Write, test, review, debug and maintain computer programs or codes. • Write a code using an object oriented language such as Java, C++, C#, .NET and PHP. • Ability to use a scripting language. • Ability to develop a website. • Ability to transform objects into business solutions. • Ability to design and develop user interfaces. • Develop Android and iOS mobile applications. • Develop web applications for different environments. • Develop hybrid applications. • Test software using selenium and SoapUI.	In computer programming Level 4 students should be able to write, test, review, debug and maintain computer programs written in an object oriented programming language. Develop HTML websites, web-based applications with scripting and user interfaces.

The respondents mentioned that entry level software developers should have scripting, object oriented programming and web development skills. The most popular programming languages are Java, C++, C# and .NET. Respondents further noted that entry level software developers also need user interface development skills. These skills correspond with what the current national NCV-IT curriculum imparts.

However, respondents also mentioned mobile development skills focusing mainly on Android and iOS development skills. The current national curriculum does not cover these skills. Respondents also mentioned that entry level software developers should have hybrid application development skills. Again, the current curriculum does not develop these skills.

The most preferred website development language by industry is PHP, whereas the curriculum focuses on HTML skills. Respondents also mentioned software testing skills using selenium and SoapUI. The current curriculum does not cover software testing tools. This shows that there are some gaps and mismatches between the skills imparted by the current national NCV-IT curriculum and the skills needs of the ICT industry.

4.3.2.2 Computer networking skills

From the interviews, it became clear that entry level IT employees should have computer networking skills. These skills are listed in Table 4.26. Computer networking skills developed by the current national curriculum are also listed and a comparison of the two follows the table.

Table 4. 26: Data summary on computer networking skills

Data from interviews with companies	Comparison with curriculum
• Install and manage Windows, Linux and UNIX network operating systems. • Activate and configure DHCP and DNS server applications. • Administer servers. • Ability to terminate and install cables. • Identify routers, switches and hubs. • Configure routers and switches. • Configure internetwork operating systems. • Configure and optimise OSPF, RIP and BGP routing protocols. • Configure IPv4 and IPv6 addresses on networking devices. • Ability to subnet and create VLSM and Equal sized subnets. • Create, add and delete users and computers on a network. • Ability to design and implement networks. • Install network interface cards. • Configure wireless access points and wireless networks (Wi-Fi). • Write network scripts. • Configure VLANs, EtherChannel and Spanning-tree. • Configure VPNs and ADSL. • Maintain and troubleshoot networks. • Test for connectivity.	Data communication and networking Level 4 states that students should be able to: install network operating systems; install networked computer application software; configure IPv4 addresses; support local area network users, that is, add and remove users and/or computers to a network, install user applications, prepare log in scripts, maintain and troubleshoot a local area computer network.

As mentioned in 4.2.1.3, wireless networks are everywhere today; also common are IP telephony and VoIP networks. Respondents of this study confirmed this and pointed out that entry level IT employees should have wireless networking skills; wireless access point configuration skills, IP telephony and VoIP installation and configuration skills. The current national NCV-IT curriculum does not develop these skills. This shows that the current curriculum is out dated and out of touch with industry skills requirements.

Furthermore, respondents mentioned that entry level IT employees should possess router and switch configuration skills. These skills include configuring and optimising OSPF, RIP and BGP routing protocols. On switching, the skills include configuring VLANs, EtherChannel and Spanning-tree. The current national NCV-IT curriculum does not cover these skills. This shows that there are gaps between the skills developed by the current curriculum and the skills need of the ICT industry.

With the advent of mobile workers and teleworkers, that is working from home and online, VPNs have become more prevalent and important by providing a secure private connection across the Internet. Also linked to this is ADSL, that is, VPNs are in most cases supported by ADSL. Respondents of this study confirmed this and mentioned that entry level IT employees must have VPN and ADSL configuration skills. The current national NCV-IT curriculum does not impart these skills. This again confirms that a curriculum of eleven years ago is no longer in touch with the realities and requirements of a fast moving ICT industry.

In addition to the above gaps and disparities, the current national NCV-IT curriculum further falls short in IP addresses and subnetting skills. The respondents mentioned that entry level IT employees should be able to create subnets and configure both IPv4 and IPv6 addresses. The curriculum only covers the configuration of IPv4 addresses and leaves out IPv6 which industry adopted and started implementing a long time ago. The current curriculum does not develop network-subnetting skills, that is, creating variable length subnets and equal sized subnets.

Although the current curriculum develops network operating system installation skills, it does not cover sever administration skills as mentioned by respondents; with DHCP and DNS server administration skills being the most common ones. Respondents also mentioned internetwork operating system installation and configuration skills. The current national NCV-IT curriculum does not develop these skills.

However, despite a myriad of gaps and mismatches identified above, there are still a number of skills being developed by the current NCV-IT curriculum that correspond to the ones required by the ICT industry as shown in Table 4.26.

4.3.2.3 Database skills

Respondents indicated that entry level IT employees must possess database skills. Table 4.27 lists the various database skills mentioned by respondents. Database skills developed by the current national curriculum are listed. A comparative discussion follows the table.

Table 4. 27: Data summary on database skills

Data from interviews with companies	Comparison with curriculum
• Ability to create a database. • Create flow chats. • Install Oracle, MySQL and Windows based databases. • Update and upgrade a database.	Principles of computer programming Level 3 deals with: creating databases and tables; adding, deleting and modifying entries in a database. Computer programming Level 4 deals with: gathering and reviewing database

• Write MySQL, TSQL and SQL queries. • Manipulate a database using MySQL, SQL, and TSQL. • Add, delete or modify entries in a database. • Ability to validate information in a database. • Configure database schemas. • Ability to administer a database. • Ability to troubleshoot databases. • Ability to do backups • Ability to perform daily tasks both manually and automatically in databases. • Perform data migration using SSIS. • Create and normalise tables. • Debug errors for both code and databases. • Ability to use SQL server analysis services, click view and tableau. • Ability to set access levels in a database.	requirements; normalising tables; implement SQL; writing a database code, troubleshooting databases; validating databases.

As can be seen from Table 4.27 some of the database skills developed by the current curriculum are in line with industry requirements as mentioned by respondents. However, there are some notable differences between the two. For example, respondents mentioned that entry level employees should have data migration skills, database schema configuration skills, database updating and upgrading skills. The current curriculum does not cover these skills. Furthermore, entry level employees should be able to set database access levels as well as performing backups and administering databases.

Additionally, respondents stated that entry level employees should have SQL server analysis, click view and tableau skills. The current curriculum does not develop these skills.

Furthermore, respondents emphasised that entry level employees should be able to manipulate a database and write MySQL, TSQL and SQL queries. The curriculum only covers SQL queries. This shows a gap between the skills imparted by the curriculum and the skills required by the ICT South African industry.

4.3.2.4 Computer hardware and software skills

Information technology is a technical practical field; respondents of this study confirmed this and emphasised the importance of being able to use a computer, computer components and IT related technologies for anyone to be employable in the ICT industry.

> "Any entry level person in IT should be comfortable using a computer, that is, how to log into a computer, using basic tools such as a mouse, keyboard, accessing the internet, Microsoft tools, email services etc." (Company 13)

As mentioned earlier in this chapter (4.2.1.4), computer hardware and software knowledge and concepts imparted by the current national NCV-IT curriculum are in line with industry requirements. Consequently, responses from respondents with regard to computer hardware and software skills showed that the skills developed by the current national curriculum are comparable to industry skills requirements as shown in Table 4.28 below.

Table 4. 28: Data summary on computer hardware and software skills

Data from interviews with companies	Comparison with curriculum
• Ability to identify computer components. • Ability to operate a computer.	Introduction to information systems Level 2 covers IT components; using a computer.
• Install Windows, Linux and UNIX desktop operating systems. • Install vendor based software. • Maintain computer systems. • Upgrade computer systems. • Update software and programmes • Patch systems. • Troubleshoot both hardware and software problems. • Configure software. • Ability to tweak computer memory. • Ability to optimize CPU. • Ability to interpret different hardware and software errors. • Ability to update BIOS. • Ability to disassembly and re-assembly a computer.	Computer hardware and software Level 3 covers computer hardware components; installation of application and system software; monitor and maintain computer systems; computer assembly and disassembly; diagnosis and troubleshooting.

However, there are few slight differences. For example, respondents indicated that entry level IT employees should be able to patch systems, update BIOS, optimize computer memory and CPU, whereas the current curriculum only focuses on the installation of these components.

Processes such as updating BIOS, commonly known as flashing BIOS are very delicate and need high level of skill and greater caution (Microsoft, 2011). The current curriculum does not develop this skill. This shows that the current curriculum is pitched at a lower level than what the ICT industry wants and expects from an entry level IT employee. As such, skills (flashing BIOS) are no longer considered high level skills but entry level. It is recommended that the current curriculum be updated so that it can be at the same level as the requirements of the ICT industry.

4.3.2.5 Business intelligence skills

In today's complex, competitive and globally connected business environment, decision making is vital. Executives, managers and other corporate end users need to make informed business decisions. Therefore, it has become important for businesses to collect, integrate, analyse and present business information to make informed decisions. Data gathered from companies showed that entry level IT employees should have these skills and abilities as listed in Table 4.29. Business intelligence skills developed by the current national curriculum are listed. A comparison of the two follows the table.

Table 4. 29: Data summary on business intelligence skills

Data from interviews with companies	Comparison with curriculum
• Ability to analyse data. • Ability to write and/or create reports. • Ability to extract, translate and load information in a data warehouse. • Arrange data into cubes. • Ability to create Online Analytical Processing (OLAP) cubes. • Ability to interpret and build a system solution from data or information gathered. • Ability to mine data from an organization's documents and computer systems. • Ability to use business intelligence tools like MS excel. • Ability to create or represent data (from a computer) using visuals.	Computer programming Level 4 deals with creating reports in databases.

The respondents mentioned a number of business intelligence skills (see Table 4.29) that an entry level IT employee should possess. The current national NCV-IT curriculum barely covers or develops any business intelligence skills. That is, business intelligence skills developed by the current curriculum are negligible; it just about, touches on database reporting skills. This shows that there is a large gap between the skills imparted by the current national NCV-IT curriculum and business intelligence skills requirements of the ICT industry in South Africa. Respondents mentioned that business intelligence has become a big area, which continues to grow as businesses continue to use computer technologies to come up with novel business solutions, processes and products. Therefore, a static curriculum like NCV-IT implemented in 2007 cannot meet the skills demands of a fast changing ICT industry. This shows that the current national NCV-IT curriculum urgently needs to be reviewed and updated, not only in line with skills demands of the South African ICT industry but also with international ICT curriculum practices as discussed in the review of literature (see Chapter 2).

4.3.2.6 Cyber security/Computer security skills

As mentioned in section 4.2.1.6 cyber security threats and risks are ever present in our world today. In 2014, South African companies had an estimated loss of R5.8 billion due to cybercrime (Alfreds, 2015). This was mainly due to attacks carried out by employees, hackers and rivals. Three years later in 2017, Venktess (2017) reported that South African businesses will lose up to R78 trillion by 2021 due to cybercrime. Respondents of this study emphasised that it is imperative for entry level IT employees to have cyber security/computer security skills. Table 4.30 lists cyber security/computer security skills as mentioned by companies.

Table 4. 30: Data summary on cyber security/computer security skills

Data from interviews with companies	Comparison with curriculum
• Install Kali Linux. • Use Kali Linux to implement cyber security solutions. • Ability to configure UTM devices. • Install and configure Fortinet/FortiGate devices. • Configure network load balancing, security and traffic management on F5. • Configure firewalls, proxy servers, ACLs and network policies. • Configure IPS and IDS security appliances.	The current NCV-IT curriculum does not impart cyber security/computer security skills.

Although, the current national NCV-IT curriculum develops some cyber security/computer security knowledge as explained in 4.2.1.6, it does not impart any cyber security/computer security skills as can be seen from Table 4.30 above. This shows that there is a large gap between cyber security/computer security skills requirements of the ICT industry and the current national NCV-IT curriculum. As mentioned above, the last three to four years have seen a dramatic increase in cybercrimes in South Africa and the number is expected to grow exponentially. At an international level, cyber Security Company, McAfee and research group Center for Strategic and International Studies (CSIS), reported an estimated global economic loss of $600 billion in 2018 up from $500 billion in 2014 due to cybercrime (Lewis, J, 2018). They attributed the increase to the use of digital and crypto currencies, which respondents of this study mentioned. Therefore, it is quite clear that a curriculum designed in 2007 when networks were small, less interconnected and cyber-attacks, threats and crimes were minimal cannot be relevant today; where networks have become very interconnected and attackers and cyber-attacks have become sophisticated.

Additionally, the introduction of mobile workers, virtual data centres and cloud computing based services has made security a top priority for organizations and at the same time making security management and implementation complex. It follows then that cyber security specialists should be more sophisticated than attackers should. That is, security specialists should have knowledge and skills to out-smart attackers so that they can protect business computer systems. It is such skills, which the current national NCV-IT curriculum does not impart. As mentioned earlier, the current curriculum does not cover teleworking (mobile workers), cloud computing and virtualization (virtual data centres), therefore it does not develop any skills to secure these modern networking trends. These findings show that, there is an urgent need for curriculum update and renewal as the current curriculum clearly lags behind industry skills requirements. That is, the curriculum has completely lost touch with industry cyber security /computer security skills requirements.

4.3.2.7 Business analysis/System analysis skills

Respondents indicated that entry level IT employees must possess business analysis/system analysis skills. In Table 4.31 the various business analysis/system analysis skills as mentioned by respondents are listed. Business analysis/system analysis skills developed by the current national curriculum are listed. A comparative discussion follows the table.

Table 4. 31: Data summary on business analysis/system analysis skills

Data from interviews with companies	Comparison with curriculum
• Ability to analyse systems. • Ability to solve business problems using computers and technology. • Ability to gather both system and user requirements. • Ability to turn user requirements into system requirements. • Understand user/client needs and requirements. • Ability to develop technical solutions to business problems. • Solve business problems.	In systems analysis and design Level 4 students should be able to gather data and information from interviews, using questionnaires, documents and personnel observation. Students should also be able to analyse information systems.

Majority of the respondents mentioned that entry level IT employees should have system analysis skills, data and information gathering skills. These skills correspond with what the current national NCV-IT curriculum imparts to NC (V) students. Respondents further mentioned the ability to understand user needs and requirements. Similarly, the current curriculum develops these skills.

However, respondents mentioned that entry level IT employees should be able to look at a business or system and identify weak areas and develop and implement a computer solution. The current curriculum does not cover these skills.

It can be concluded that in terms of business analysis/system analysis skills the current national NCV-IT curriculum is almost in line with industry requirements. That is, there are minor differences between the two.

4.3.2.8 Cloud computing and virtualization skills

As mentioned earlier in 4.2.1.8 cloud computing is becoming increasingly more critical to the South African ICT industry and businesses at large. Respondents of this study confirmed this and mentioned that entry level IT employees should possess cloud computing and virtualization skills. These skills are listed in the table below.

Table 4. 32: Data summary on cloud computing and virtualization skills

Data from interviews with companies	**Comparison with curriculum**
• Install, configure and optimize VMware. • Install and configure hypervisors. • Manage and administer VMware and hypervisors.	In the current NCV-IT curriculum, there is no coverage of cloud and virtualization skills.

As mentioned again in 4.2.1.8 the current national curriculum does not develop any knowledge or concepts on cloud computing and virtualization. Accordingly, there are no cloud computing and virtualization skills developed by the current national NCV-IT curriculum as can be seen from Table 4.32 above. This is despite the fact that, the last few years have seen an introduction of numerous cloud computing and virtualization industry certifications (Florentine, 2017). This shows that there is a large gap in cloud computing and virtualization skills between NCV-IT curriculum and ICT industry requirements. With the emergence of cloud computing and virtualization technologies, industry responded by introducing cloud and virtualization certifications; there was no such response from the national NCV-IT curriculum. This shows that the current national NCV-IT curriculum not only falls short in skills development but also in curriculum best practices, as it remains stagnant despite technological changes. It is suggested that the curriculum be updated to be aligned to industry skills requirements.

4.4 General responses

Interviews with companies generated some general responses. These points are worthy discussing as they were mentioned by a number of respondents and refer to the NCV-IT curriculum as a whole not to specific disciplines as discussed above. These responses also tie in with what was found in the review of literature. These responses are discussed below.

4.4.1 Mismatch between education and training institutions and industry requirements

In the review of literature (see Chapter 2), it was found that, IT is moving at a rapid rate such that education and training institutions are failing to keep pace with industry knowledge and skills requirements. Likewise, respondents of this study confirmed this as attested to by the response below.

> "IT Industry is evolving at a rapid pace while IT institutions are not able to keep up with the pace of the evolution in technology and through that we see that the demands of industry and the realities of what's happening or being taught at institutions are misaligned." (Company 3)

In order to keep pace at an individual level, respondents indicated that entry level IT employees should always research and learn about new technologies and trends. At TVET and national levels, the current NCV-IT curriculum designed in 2007 urgently needs updating in order to align it to the South African ICT industry's knowledge and skills needs. Also, as previously suggested in this chapter, national NCV-IT curriculum review must happen after every three years in line with industry requirements as well as ICT curriculum best practices.

> "In terms of knowledge they should be able to research because IT is a constantly changing trade, so you need to keep up to date with trends." (Company 13)

> "If I was to advice any entry level person or someone who is studying towards an IT qualification, I would encourage them to be widely read on technology trends; where technology is going. For example, maybe in today's world the buzz words are big data, business intelligence, and crypto currencies and block chain technologies." (Company 12)

In addition to the above, another point of mismatch between education and training and industry is the inclusion of mathematics in an IT and computer science course. Although most IT and computer science courses have a mathematics module or require that one must have done and passed mathematics at high school. In addition, some respondents of this study mentioned that entry level IT employees must have a mathematics background. However, one respondent indicated that this practice might be a misalignment as attested to by the following verbatim response.

> "We have people that have not done computer science, they have actually done politics and administration, but he is currently working in software development and they are one of good developers we have in our team. This throws away the idea that many universities want students to do computer science only if they had done mathematics at Matric level. That way you have a lot of creative people being thrown out of the system because they are believed not to be mathematics oriented, but most of them turn to be very innovative and contribute positively." (Company 2)

This view concurs with what was mentioned in literature review that the present technology driven economy (knowledge economy) requires creative and critical thinking skills rather than only traditional scientific and mathematical skills.

Respondents further mentioned knowledge of business subjects such as accounting, business management, project management, marketing and human resources as important for entry level IT employees. This is similar to the findings of Tanner and Seymour (2014) who found that IT companies in the Western Cape province of South Africa require IT employees with knowledge and understanding of the greater business domain. This shows another discrepancy between the current national NCV-IT curriculum and industry requirements, as the current curriculum does not cover any of the mentioned business disciplines.

> "Students who want to do software development must be exposed to business related courses. I strongly think it's important to include business related courses in IT curricula especially to students who want to do (software) development. Courses like accounting, business, marketing and human resources." (Company 2)

Also, in the review of literature (see 2.3.2), it emerged that an ideal ICT curriculum should include business as one of the knowledge areas. This shows that the current NCV-IT curriculum is inadequate and misaligned with ICT industry requirements and expectations.

4.4.2 Industry certifications vs. academic certificates

The majority of the respondents indicated that industry certifications equip entry level IT employees with the right knowledge and skills. This seem to indicate that industry prefers industry certifications ahead of academic certificates such as NCV-IT as discussed and corroborated to by various verbatim responses presented in this chapter. However, one respondent seems to disagree with this and indicated that industry certifications are incomplete and inadequate. In short, industry certifications only equip someone with knowledge and skills specific to a discipline and this is not enough for an entry level IT employee who needs grounding in each IT core discipline. The respondent further stated that in a rapidly changing IT field one need to adapt and adopt quickly. This is similar to Tanner and Seymour's (2014) findings that IT companies look for candidates with sound ability to adapt to new technologies and trends. It is always difficult for those without academic qualifications as they lack an understanding of the entire field; making it difficult for them to adapt to changes.

> "There are two flavours in terms of entry level people. You have those that have specialised in one IT field and then you have those that have been trained in such a way that they can adapt. I will focus on the second group because for me thus the most preferable one. I would expect someone to have some basic grounding in each IT core field." (Company 15)

4.5 Comparison between NCV-IT curriculum and international IT and computing curriculum models.

Even though the aims and objectives of this study were not to compare the current national NCV-IT curriculum against international IT and computing curriculum models, it became clear from the literature review (see Chapter 2) that such comparisons are necessary. Firstly, it emerged from literature that there is a high presence of international ICT companies in South Africa; therefore, the NCV-IT curriculum should be comparable to international models to produce graduates with knowledge and skills required by these international companies. Secondly, comparisons like these interrogate the content and structure of NCV-IT in relation to international models. This will help in designing an 'ideal' NCV-IT curriculum, which is not only relevant in South Africa but globally.

The following paragraphs give a brief comparison of the current national NCV-IT to international IT and computing curriculum models as reviewed in Chapter 2 section 2.3.2.

In comparison with international curriculum models, the NCV-IT curriculum structure is comparable to that of international computing curriculum models (see Table 2.2). Firstly, the

ACM/IEEE IT2008 framework declares that programming, networking, human computer interaction, databases, and web systems are the five key major pillars of any IT curriculum. Similarly, the current national NCV-IT curriculum includes these domains except for human computer interaction. Secondly, (see Table 2.2 in Chapter 2) software (programming), hardware (computer architecture and networking) and business are the most common knowledge areas or subjects across all computing curriculum models. Similarly, the NCV-IT curriculum lists the same subjects (except business) as core subjects. The NCV-IT curriculum also includes electronics under its core subjects similar to the CSP model. Scime (2008) found that mathematics is also common across all the models. Likewise, mathematics is compulsory in the NCV-IT curriculum.

However, there are some notable differences between the current national NCV-IT curriculum and international computing models. The ACM/IEEE IT2017 curricular framework declares that in addition to the five domains mentioned above, a modern IT curriculum should include mobile applications, social platforms, user experiences, Internet of Things, big data, cyber security and automation. These knowledge areas are not included in the current national curriculum. In addition, business, social skills, interpersonal skills, science and general education are common knowledge areas across all computing curriculum models (see Table 2.2), however the current national NCV-IT curriculum excludes them. Additionally, at least three international models (ACM/IEEE-CS, CSP, CDIO and GRIN) include Operating systems/System administration as core knowledge areas whereas the current national NCV-IT curriculum excludes them. In addition, the NCV-IT curriculum lists system analysis and design as a core subject whilst none of the models includes system analysis and design in its list.

4.6 Conclusion

In this chapter, the researcher presented and analysed the findings of the study. During interviews with respondents, it emerged that IT is a broad field with many disciplines. After the analysis of the interview data eight core disciplines of the IT field were identified, namely; computer hardware and software, software development, computer networks, databases, business analysis/system analysis, business intelligence, cyber security/computer security and cloud computing and virtualization. Discipline specific knowledge and skills as identified by companies were compared against what is included in the current national NCV-IT curriculum, with illustrative direct quotations used to elucidate important concepts, skills and key points. The findings are summarised in the next paragraphs.

It is clear from the findings of this study that there are gaps and misalignments between knowledge and skills imparted by the current national NCV-IT curriculum and the ICT industry's knowledge and skills requirements in South Africa. Firstly, the research found that the current national NCV-IT curriculum is out of touch and lags behind current ICT industry requirements in three specific disciplines namely, business intelligence, cloud computing and virtualization and cyber security/computer security. The current national NCV-IT curriculum does not cover any knowledge or skills on cloud computing and virtualization; and barely develops any business intelligence knowledge and skills as required by industry. In the cyber security/computer security discipline, the current curriculum does not impart any knowledge and skills on cyber security and it barely covers computer security knowledge and skills as required by the ICT industry. In other words, the knowledge and skills developed seem to be insignificant and inferior to what the ICT industry in South Africa requires.

Secondly, the current national NCV-IT curriculum includes electronics as one of the core vocational subjects, yet no single company during interview indicated or mentioned that entry level IT employees require knowledge and skills of electronics. In other words, the ICT industry in South Africa does not require electronics knowledge and skills.

The study also found that, although the current curriculum develops knowledge and skills in software development, business analysis/system analysis, databases, computer networks disciplines as identified by companies; there are a number of gaps and misalignments between industry requirements and what the curriculum develops. That is, the current curriculum does not cover all knowledge or key theoretical concepts and skills required by an entry level IT employee. It looks certain from the findings that an entry level IT employee would require additional knowledge and skills, in order to be employable, other than what the current curriculum imparts. For example, in the computer networks discipline the study found that the current curriculum falls far short of industry requirements, despite covering some of the skills and concepts identified by companies. This shows that the computer networks domain defined by industry is far much broader than what the current curriculum covers. The research also found that there are considerable gaps between industry and current curriculum in the software development and databases disciplines. The gaps are mainly a result of the current curriculum’s failure to keep pace with the on-going technological revolution and trends. For example, the current curriculum does not cover mobile application development and user experiences yet companies and literature indicated that mobile application usage has surpassed that of desktop as the inclination towards mobile continues to grow at a rapid pace. These findings are in line with ACM’s (2017) IT Curricular Framework, which states that modern IT curriculum should include knowledge and skills of mobile applications, user experiences, Internet of Things, big data, cloud computing, and cyber security.

The research also found that industry seem to prefer industry certifications to academic certificates like NCV-IT. This is mainly because industry certifications are developed by industry therefore aligned to industry knowledge and skills requirements. Secondly, industry certifications are considered current as the curriculum is frequently reviewed and updated. However, despite gaps and misalignments in many disciplines as indicated above, the study found that in the computer hardware and software discipline, the current national curriculum is comparably aligned to industry requirements.

To conclude this chapter, findings of this study showed that the current national NCV-IT curriculum designed in 2007 is out dated and big gaps exist between the ICT industry and the curriculum. In terms of employer ICT knowledge and skills requirements, the findings of this study are similar to the ones by the JCSE skills survey of 2016. All of the knowledge and skills domains, which this study identified, are included in the JCSE employer ICT priorities. These include software (mobile and web) development, business intelligence, cloud computing and virtualization, big data/internet of things, computer security, computer networks and hardware. The next chapter discussed the conclusions and recommendations of this study.

Chapter 5: Conclusions and recommendations

5.1 Introduction

In this final chapter, a summary of the research, conclusions and recommendations for immediate implementation as well as for future research are presented.

5.2 Summary of the research

Presented in this section is a synopsis of each chapter.

In the introductory chapter of this study, the researcher gave a background to the research by highlighting the impact of rapid technological advances on knowledge, skills, jobs and occupations. The speed at which technology changes in the 21st century creates problems for education and training institutions, such as TVET colleges, as they need to keep pace with the rate of change in order to produce graduates with relevant knowledge and skills. This led to the problem statement, which questioned whether the current NCV-IT curriculum offered in public TVET colleges is appropriate and/or effective as per mandate, given the greater digitization of all sectors of the South African economy. The main research question and sub-questions were formulated around the problem statement. Also presented in this chapter were the research aims and objectives. The main aim was to ascertain the gap between the current national NCV-IT curriculum and the ICT industry's knowledge and skills needs in South Africa and subsequently draw conclusions on the relevance of the curriculum.

The significance of the study as well as delimitation of research was given. Also given were definitions of key terminology in the context of the study.

In Chapter 2, literature perspectives on the background, introduction and mandate of NC (V) programmes in general and NCV-IT in particular were presented. It was argued that a country's vocational education should be aligned with its stage of economic development. Perspectives on South Africa's TVET education, ICT skills and economic developmental stage were presented. The impacts of technological advances on ICT jobs, knowledge and skills requirements in an ICT-driven knowledge economy discussed. Curriculum perspectives were also discussed with international computing curriculum models reviewed in order to see how an ideal IT and computer science curriculum could be designed to meet South Africa's ICT industry knowledge and skills requirements. Also discussed were curriculum best practices, update and renewal in a fast changing industry like the ICT industry.

In order to meet the aims and objectives of the study outlined in Chapter 1 and subsequently answer the research questions, Chapter 3 presented the research design and methodology used in this study. This chapter outlined qualitative method as the best-suited approach for meeting the objectives of the study. Interviews were used to gather qualitative data from fifteen companies in the ICT industry. Interview questions were formulated in such a way that they answer or meet the objectives of the study and eventually answer the research question. Thematic analysis was used for data analysis.

Chapter 4 presented findings from interviews with companies as well as findings from the review of the current national NCV-IT curriculum. A comparison of the two data sets was performed in order to ascertain any knowledge and skills gaps between the current national NCV-IT curriculum and the requirements of the South African ICT industry.

In this final chapter, the findings of this study as reported in Chapter 4 are discussed and interpreted in the context of the research, research problem and literature review as covered in Chapter 2. That is, the main purpose of this chapter is to provide conclusions of the study. The other purpose of this chapter is to further provide recommendations for immediate implementation based on the findings as well as recommendations for future research.

5.3 Conclusions

Based on the findings of this qualitative study presented in the previous chapter and the findings from the review of literature presented in Chapter 2, the following conclusions can be drawn:

There are gaps between the current national NCV-IT curriculum and the ICT industry's knowledge and skills needs.

In the review of literature, it emerged that the current technological revolution widens the gap between education and work; as the introduction of new technologies, changes the nature of knowledge and skills required by companies. Of the eight IT disciplines identified by respondents of this study, the current curriculum is only aligned to computer hardware and software, with significant gaps identified in software development, computer networks, databases, business intelligence, cyber security/computer security, business analysis/system analysis, cloud computing and virtualization disciplines. Massive gaps were identified in business intelligence, cloud computing and virtualization and cyber security/computer security disciplines. The current national NCV-IT curriculum does not cover any knowledge or skills on cloud computing and virtualization; and barely develops any business intelligence knowledge and skills as required by industry. In the cyber security/computer security discipline, the current curriculum does not impart any knowledge and skills on cyber security and it barely covers computer security knowledge and skills as required by the ICT industry. In other words, the knowledge and skills developed seem to be insignificant and inferior to what the ICT industry in South Africa requires.

Although the current curriculum develops knowledge and skills in software development, business analysis/system analysis, databases and computer networks disciplines as identified by companies; there are a number of gaps and misalignments between industry requirements and what the curriculum develops. However, the gaps are not as large as in business intelligence, cloud computing and virtualization and cyber security/computer as mentioned in the preceding paragraph. For example, in the computer networks discipline the study found that the current curriculum falls far short of industry requirements, despite covering some of the skills and concepts identified by companies. This shows that the computer networks domain defined by industry is far much broader than what the current curriculum covers. The research also found that there are considerable gaps between industry and current curriculum in the software development and databases disciplines as well as in business analysis/system analysis, even though at a small scale.

This shows that the current curriculum does not cover all knowledge and skills as mentioned by companies in this qualitative study. Based on literature and largely on these empirical findings, it can be concluded that there are knowledge and skills gaps between the current national NCV-IT curriculum and the South African ICT industry's knowledge and skills requirements.

Misalignment between the current national NCV-IT curriculum and the ICT industry's knowledge and skills requirements

Due to the gaps identified in Chapter 4, it can be concluded that the current national NCV-IT curriculum is not aligned to the South African ICT industry's knowledge and skills needs. In the review of literature in Chapter 2 it emerged that knowledge and skills of mobile technology, social platforms, cyber security, Internet of Things, big data, business intelligence, user experiences and software as a service should be part of any IT and computer science curriculum. Companies in this study mentioned these skills as well as cloud computing and virtualization skills and stated that entry level IT employees should be in possession of these skills; yet the current national NCV-IT curriculum does not develop these skills. Instead, the current curriculum concentrates on other skills such as electronics, which the ICT industry does not require.

It also emerged from the findings of curriculum analysis that the current curriculum does not develop any knowledge or skills in business domains such as accounting, human resources and marketing, yet empirical findings and literature review show that an IT and computer science curriculum must include these. This shows that there is a misalignment between the current national NCV-IT curriculum and the South African ICT industry needs. The other point of misalignment is the exclusion of work integrated learning in the current delivery of the NCV-IT curriculum. In literature review, it emerged, that vocational education should include classroom learning as well as on the job training (work integrated learning). The lack of work integrated learning- a misalignment in its own; subsequently leads to more mismatches and misalignments in terms of knowledge and skills, as students are not given a chance to see what knowledge and skills are being applied in the work place.

The current NCV-IT curriculum is old and lags behind a rapidly changing ICT industry

The importance of curriculum review, renewal and update was highlighted in literature review where it emerged that an IT and computer science curriculum cannot remain stagnant for more than two and half years. It also emerged that most countries update their IT and computer science curricula regularly in order to keep pace with the racing technological changes. Findings from the review of the current national NCV-IT curriculum as presented in Chapter 2 and Chapter 4 show that the current curriculum has not changed since implementation in 2007. Since then a number of new technologies and practices have entered the market resulting in gaps and misalignments between the curriculum and ICT industry requirements as the curriculum remain unchanged. This lack of curriculum review and reorientation leads to lack of ICT skills in African countries, South Africa included (see Chapter 2). Therefore, the current curriculum of more than ten years ago is too old and lags behind the South African ICT industry's knowledge and skills requirements.

Preference of industry certifications over academic certificates

It is clear from responses by respondents presented in Chapter 4 that the majority of companies seem to prefer ICT industry certifications over academic certificates such as NCV-IT. The preference is largely due to the relevance and alignment of industry certifications to knowledge and skills needs of the ICT industry in South Africa.

The preference of industry certifications can be attributed to the following reasons. Firstly, industry certifications are developed by industry itself. Therefore, the certifications are considered relative and in line with industry requirements. Secondly, industry certifications are current; that is, most industry certifications expire after a period of three years, with others having an expiration period as low as twelve months. After the twelve months or three years the knowledge is considered obsolete and no longer valid as new technologies, practices and concepts enter the market. The most preferred certifications for entry level positions are A+ (A plus), N+ (Network plus), Cisco certified network associate (CCNA), Microsoft certifications as well as HP certifications. According to industry, these certifications equip individuals with the right knowledge and skills necessary for entry level IT employment.

The current NCV-IT curriculum is pitched at a lower level than the requirements and expectations of the ICT industry.

It was argued in literature (see Chapter 2) that TVET is becoming less relevant in the contemporary knowledge led economy, as high specificity of low skills does not value the knowledge economy which requires high level skills associated with general education. That is, vocational education is considered low quality education, which is less applicable in the technology driven knowledge based economy. Respondents (although only a few) of this study indicated that NCV-IT equips students with low quality and irrelevant knowledge and skills that are not useful in the contemporary ICT industry, which is characterised by rapid technological advances, automation and high level knowledge and skills. Companies prefer graduates who hold university degrees, which are of high quality and relevant. Therefore, it can be concluded that the current national NCV-IT curriculum is pitched at a lower level than what is required by the ICT industry in South Africa.

Finally, it is clear from the findings of this research that NCV-IT graduates would require additional knowledge and skills before taking up employment in the ICT industry due to the existence of gaps and misalignments between the curriculum and industry requirements. However, due to the following reasons, it cannot be explicitly concluded that the current national NCV-IT curriculum is irrelevant to the knowledge and skills requirements of the ICT industry, in the wake of the technological revolution. Firstly, the curriculum develops knowledge and skills in software development, business analysis/systems analysis, computer networks, databases, computer hardware and software and cyber security/computer security, even though in most instances the gaps are massive. Secondly, the current curriculum includes four of the five key pillars or domains of any IT and computer science curricular as identified by the ACM/IEEE information technology curricular framework. These are programming, networking, databases, web systems and human computer interaction (ACM, 2017). Only the human computer interaction pillar is not included in the current curriculum. The other pillars are included, albeit at lower or insufficient knowledge and skills levels. In order to make NCV-IT more relevant to the knowledge and skills requirements of the South African ICT industry, a number of recommendations are proposed in the next section.

5.4 Recommendations

Research studies usually have recommendations for further research as well as recommendations for implementation of the findings. Both of these recommendations are applicable to this study.

5.4.1 Recommendations for immediate implementation

To address the research problem; the following recommendations are given:

Firstly, from the empirical findings of this study as well as findings from the review of literature discussed in Chapter 2, it is clear that the current national NCV-IT curriculum designed in 2007 is outdated and urgently need reviewing and updating. Curriculum review should happen at least after every three years and should include all stakeholders (designers, lecturers, companies and students) as indicated in literature (see Chapter 2).

Secondly, in addition to filling in the knowledge and skills gaps that were identified in Chapter 4, the following disciplines should be included: cloud computing and virtualization, business intelligence and cyber security/computer security as indicated by the findings of this study as well as findings from literature review. In addition, user experiences, mobile application development, Internet of Things and big data should be included as identified by findings of this study as well as review of literature.

Thirdly, it is recommended that the subject electronics be removed from the current curriculum as findings from literature as well as empirical findings of this study show that knowledge and skills on electronics are irrelevant and not required by the ICT industry in South Africa.

Fourthly, findings of this study indicate that in data communication and networking, even though the current curriculum covers a significant part of knowledge and skills requirements of the ICT industry, it still falls short of industry expectations. This is simply because the data communication and networking domain defined by industry is much broader than what the current curriculum defines and covers. It is therefore recommended that data communication and networking be divided and spread over two levels like system analysis and design that has Level 3 and Level 4. This will enable the curriculum to cover all knowledge and skills requirements as per industry expectation.

Finally, it is recommended that work integrated learning (on the job training) be made compulsory to NCV-IT students during their time of studying so as to bridge the gap between work and education as described in literature (see Chapter 2). As mentioned in literature and findings from the review of the current curriculum, work based training is optional with few colleges making efforts to secure work integrated learning for their students.

5.4.2 Recommendations for future research

As mentioned in Chapter 3, one of the limitations of this study was the small scale at which it was carried out. It is recommended that the research be duplicated at a larger scale to include more companies as a number of companies were left out, meaning that not all knowledge and skills required by entry level employees were covered. In addition, this study presented knowledge and skills based on interviews with IT managers, seniors (technicians, programmers, engineers) or their representatives. Groups such as human resources practitioners, chief information officers, knowledge management practitioners could have provided more skills and knowledge requirements for entry level IT employees. In order to cover knowledge and skills requirements of the ICT industry holistically, future research should have a large sample size and include as many groups as possible. Also, to clearly gauge the gaps between NCV-IT curriculum and industry knowledge and skills requirements, future research can consider companies that have employed NCV-IT graduates as well as NCV-IT graduates who are now employed; this way the exact similarities, differences and commonalities will be revealed.

One of the findings from this study, as well as from literature, was the fact that IT is a very broad field that consists of several disciplines. During data collection, most of the respondents indicated that they were not in a position to talk about other disciplines, as they were not experts or lacked knowledge and understanding of those disciplines. This means that not only were some disciplines not covered but also the corresponding knowledge and skills were not covered, as some participants did not have a full understanding of the disciplines that they talked about. It is therefore recommended that future research be done per discipline, similar to Tanner and Seymour's (2014) research on the range and level of skills developed by a software development course as well as Boyle and Strong's (2006) study on ERP course. This will ensure that discipline specific knowledge and skills are exhaustively covered.

References

Abrahamson, S. 1978. Diseases of the Curriculum. *Journal of Medical Education*, 53(12):951-957.

ACM. 2005. *Computing curricula 2005: The overview report*. New York: The Association for Computing Machinery (ACM), Association for Information Systems (AIS), The Computer Society (IEEE-CS).

ACM. 2017. Information Technology Curricula 2017-IT2017. https://www.acm.org/binaries/content/assets/education/curricula-recommendations/it2017.pdf [23 June 2018]

Adams, J., Khan, H. T. A., Raeside, R. & White, D. 2007. *Research Methods for Graduate Business and Social Science Students*. New Delhi: Response Books.

Akoojee, S. 2009. Scarce skills and public technical and vocational education and training in South Africa: Twin challenges or two sides of the same coin? *Southern African Review of Education*, 15(2): 117-138.

Allais, S. 2011. What are skills? Reflections on policy in South Africa in the light of international debates. Paper presented at the Global Labour University Conference 28-30 September 2011. University of the Witwatersrand: Johannesburg.

Alfreds, D. 2015. Cybercrimes costs SA firms billions. *Fin24,* 20 March 2015. [Online] https://www.fin24.com/Tech/Companies/Cybercrime-costs-SA-firms-billions-20150320 [15 May 2018]

Allais, S. 2012. Will skills save us? Rethinking the relationships between vocational education, skills development policies, and social policy in South Africa. *International Journal of Educational Development*, 32(5):632-642.

Alshenqeeti, H. 2014. Interview as a data collection method: a critical review. English Linguistics Research, 3(1):39-45.

Anderson, D., 2009. Productivism and ecologism: changing dis/courses in TVET. In:

Fien, J., Maclean, R., Park, M.-G. (Eds.), Work, Learning and Sustainable Development. Springer, Dordrecht.

Asian Development Bank . 2008. Education and Skills: Strategies for Accelerated Development in Asia and the Pacific. Author.

Bakari, A.H., & Kemenade, K.V. 2013. Effectiveness of Technical and Vocational Education and Training (TVET) Insights from Ethiopia's reform, *The TQM Journal*, 25(5):492-506.

BBC. 2017. *Vocational training shake-up 'most ambitious since a-levels'* http://www.bbc.com/news/uk-39169490 [27 March 2017]

Boisot, M. 1998. *Managing Knowledge Assets: Securing Competitive Advantage in the Information Economy*. Oxford University Press.

Braun, V., & Clarke, V. 2006. Using thematic analysis in psychology. *Qualitative research in psychology, 3*(2), 77-101.

Brown, J. 2018. Why spending on cloud computing is increasing in SA. *Fin24*, 22 April 2018.[Online] https://m.fin24.com/Companies/ICT/spend-on-cloud-computing-is-increasing-in-sa-kenya-and-nigeria-20180420 [22 April 2018]

Brynjolfsson, E. & McAfee, A. 2012. *Race Against The Machine: How The Digital Revolution Is Accelerating Innovation, Driving Productivity, and Irreversibly Transforming Employment and The Economy*. MIT Center for Digital Business.

Business Dictionary. 2017. http://www.businessdictionary.com/definition/entry-level-job.html [18 January 2017]

Charmaz, K. 2006. *Constructing grounded theory: A practical guide through qualitative research*. SagePublications Ltd, London.

Capgemini Consulting. 2015. *Going digital: General Electric and its digital transformation*. https://www.capgemini-consulting.com/general-electric-and-its-digital-transformation [14 September 2017]

Cedefop. 2011. *Vocational education and training is good for you: The social benefits of VET for individuals*. Luxembourg. Cedefop.

Cohen, L., Manion, L. & Morrison, K. 2007. Research Methods in Education. New York: Routledge.

Cook, D.A. 2010. Twelve tips for evaluating educational programs. *Med Teacher*, 32:296–301.

Creswell, J.W. 2009. *Research design: Qualitative, quantitative and mixed methods approaches.* London: Sage.

Dede, C. 2010. Comparing frameworks for 21st century skills. In J. Bellanca and R.Brandt (eds), 21st century skills (Bloomington, IN: Solution Tree Press), 51–76.

Deng, Z. 2015. Michael Young, knowledge and curriculum: an international dialogue, *Journal of Curriculum Studies*, 47(6):723-732.

Denzin, N., & Lincoln, Y. 2005. *The Sage Handbook of Qualitative Research*. Sage Publications, Thousand Oaks.

DHET. 2009. Further Education and Training Colleges - National Certificate (Vocational) and Report 190/191, Report on the Conduct of National Examinations 2009. Pretoria. Department of Higher Education & Training.

DHET. 2011. National Skills Development Strategy III. Pretoria. Department of Higher Education & Training.

DHET. 2012. Ministerial task team appointed for the review of the national policy regarding Further Education and Training programmes: approval of documents, policy for the National Certificates (vocational): qualifications at levels 2 to 4 on the national qualifications framework, gazetted in government notice no. 28677 on 29 march 2006. http://www.dhet.gov.za/Reports%20Doc%20Library/FINAL%20REPORT%20-%20REVIEW%20OF%20THE%20NCV%20BY%20THE%20MTT%20,31%20March%202013.pdf [4 September 2017]

DHET. 2013. White Paper for Post-School Education and Training. Pretoria: Department of Higher Education & Training.

DHET. 2017. National Certificate Vocational Subject matrix 2017. http://www.dhet.gov.za/Further%20Education%20and%20Training%20College/National%20Certificate%20Vocational%20Subject%20Matrix%202017.pdf [1 September 2017]

DOL. 2007. National Scarce Skills List 2007. http://www.labour.gov.za/DOL/downloads/documents/useful-documents/skills-development-act/Useful%20Document%20-%20NSDS%20-%20Scarce%20Skills%20List%202007.doc/view [1 February 2017].

Doyle, K.2014. State of ICT Training in SA. *TrainingWeb*. http://www.trainingweb.co.za/news/training/1764-state-of-ict-training-in-sa [20 April 2017]

Dzvapatsva, G.P., Mitrovic, Z. & Dietrich, A.D. 2014. Use of social media platforms for improving academic performance at Further Education and Training colleges. *South African Journal of Information Management*, 16(1).

Eisner, E. 1985. *The Art of Educational Evaluation*. Lewes: Falmer.

FETI. 2012. Facilitating College to Work Transitions for FET college students in the Western Cape. University of the Western Cape.

Florentine, S. 2017. The most valuable cloud certifications today. [Online] https://www.cio.com/article/3207553/certifications/the-most-valuable-cloud-computing-certifications-today.html [26 April 2018]

Field, S., Hoeckel, K., Kis, V., & Kuczera, M. 2009. Learning for jobs: OECD policy review of vocational education and training: Initial report. Paris: Organisation for Economic Cooperation and Development (OECD).

Fielding, N. G. & Fielding, J. L. 1986. *Linking Data*. Beverly Hills, CA: Sage.

Frye, A.W. & Paul A. H. 2012. Program evaluation models and related theories: AMEE Guide No. 67, *Medical Teacher*, 34(5): 288-299

Fullan, M. & Scott, G. 2009. *Turnaround Leadership for Higher Education*. San Francisco: Jossey-Bass.

George, E.S.T. 2006. Positioning higher education for the knowledge based economy. *Higher Education,* (52): 589–610.

Gewer, A. 2010. Improving quality and expanding the further education and training college system to meet the need for an inclusive growth path. Development Bank of Southern Africa.

Gillwald, A., Moyo, M., & Stork, C. 2013. Understanding what is happening in ICT in South Africa: A supply-and demand-side analysis of the ICT sector. Research Africa Net. Evidence for ICT Policy Action. Policy Paper, 7, 1-81.

Glossary of education reform. 2017. http://edglossary.org/curriculum [21 April 2017].

Guruz, K. 2011. *Higher education and international student mobility in the global knowledge economy*. State University of New York Press.

Henning, E. 2004. Finding your way in qualitative research. Pretoria: Van Schaik.

Hoadley, U. 2015. Michael Young and the curriculum field in South Africa, *Journal of Curriculum Studies*, 47(6):733-749.

Houghton, J. & Sheehan, P. 2000. *A Primer on the Knowledge Economy.* CSES Working paper no 18.

HRDC. 2014. TVET colleges' purpose in a developmental state: imperatives for South Africa. Human Resource Development Council of South Africa.

Infosys. 2016. Amplifying human potential: Education and skills for the fourth industrial revolution.

Jackson, M. C. 2003. *Systems Thinking: Creative Holism for Managers*. John Wiley & Sons.

JCSE. 2016. 2016 JCSE ICT skills survey. JCSE. Johannesburg. http://www.jcse.org.za/sites/default/files/%5Bfilename%5D_5.pdf [17 April 2017]

Kraak, A. 2010. The collapse of the graduate labour market in South Africa: evidence from recent studies. *Research in Post-Compulsory Education*. 15(1):81-102. http://dx.doi.org/10.1080/13596740903565384 [4 April 2017].

Kumar, S.2017. IT outsourcing addresses SAs IT skills shortage. ICT Monitor Worldwide. 9 March 2017

Lancee, B. 2016. The Negative Side Effects of Vocational Education: A Cross-National Analysis of the Relative Unemployment Risk of Young Non-Western Immigrants in Europe. *American Behavioural Scientist,* 60(5-6):659-679.

Legnick-Hall, M. L. & Legnick-Hall, C. A. 2003. *Human resource management in the knowledge economy: New challenges, new roles, new capabilities*. San Francisco: Berrette-Koehler.

Lewis, J. 2018. Economic impact of Cybercrime - No slowing down. [Online] https://csis-prod.s3.amazonaws.com/s3fs-public/publication/economic-impact-cybercrime.pdf?kab1HywrewRzH17N9wuE24soo1IdhuHdutm_source=Pressutm_campaign=bb9303ae70-EMAIL_CAMPAIGN_2018_02_21utm_medium=emailutm_term=0_7623d157be-bb9303ae70-194093869 [14 May 2018]

Lewis, T. 2009. Towards reclaiming the high ground in the discourse on vocationalism in developing countries. *International Journal of Educational Development*, 29(6): 558–564.

Lincoln, J. 2014. Information & Communication Technology (ICT) Industry - South Africa. Pretoria. Swiss Business Hub South Africa

Lipsman, A. 2014. Major mobile milestones in May: Apps now drive half of all time spent on digital. [Online] https://www.comscore.com/Insights/Blog/Major-Mobile-Milestones-in-May-Apps-Now-Drive-Half-of-All-Time-Spent-on-Digital [26 April 2018]

Little, B., Connor, H., Lebeau, Y., Pierce, D., Sinclair, E., Thomas, L. & Yarrow, K. 2003. *Vocational higher education– does it meet employers' needs?* London. LSDA

Lotriet, H.H., Matthee, M.C. & Alexander, P.M. 2010. Challenges in Ascertaining ICT Skills Requirements in South Africa. *SACJ*. Research Article No. 46

Magnus G, Bird A, Prinsloo F and Singh A. 2013. Concept paper: building a TVET system in South Africa. DHET: Pretoria.

Mashongoane, T.S. 2015. The impact of national certificate vocational on the continued learning: patterns and destination of the FET colleges engineering graduates in the North West province. Unpublished PhD dissertation, Unisa, Pretoria.

McGrath, S., Needham, S., Papier, J., Wedekind, V., Attwal, H., Calitz, M., & Van der Merwe, T. 2010. Employability in the College Sector: A Comparative Study of England and South Africa: Draft report. [London]: Department for Business Innovation & Skills.

McGrath, S. 2012. Vocational education and training for development: A policy in need of a theory? *International Journal of Education Development*, 32(5):623-631.

MICT SETA. 2012. Sector Skills Plan 2013-2018. Pretoria

MICT SETA. 2015. Sector Skills Plan 2016-2021. Pretoria

Microsoft. 2011. *Windows server administration fundamentals*. USA: John Wiley.

Mohlala, J., Goldman, G.A., & Goosen, X. 2012. Employee retention within the information technology division of a South African Bank. *SA Journal of Human Resource Management*.

Mulder, F., & van Weert, T.2001. IFIP/UNESCO's informatics curriculum framework 2000 for higher education. *Inroads SIGCSE Bulletin*, 33(4):75–83.

National Skills Development Handbook 2010/11. 2010. RainbowSA

Newell, S., Robertson, M., Scarbrough, H. & Swan, J. 2009. *Managing knowledge work and innovation.* Palgrave Macmillian.

Nhuta, S., Makuyana, T., Makoni, R. & Chauke, A. 2015. The disparity between the tourism education/training and the needs of the tourism and hospitality industry manpower needs. *Journal of Educational Policy and Entrepreneurial Research*, 2(5): 63-83

NIST. 2013. Glossary of Key Information Security Terms. https://nvlpubs.nist.gov/nistpubs/ir/2013/NIST.IR.7298r2.pdf [29 June 2018]

OECD. 2001. *Knowledge management in the learning society*. Paris. OECD.

OECD. 1999. *The knowledge-based economy: A set of facts and figures*. Paris. OECD

OECD. 2010. *Learning for Jobs*. Paris. OECD

Oketch, M.O. 2007. To vocationalise or not to vocationalise? Perspectives on current trends and issues in technical and vocational education and training (TVET) in Africa. *International Journal of Educational Development*, 27: 220-234.

Ogude, N., Nel, H. & Oosthuizen, M. 2005. *The challenge of curriculum responsiveness in South African higher education.* Council on Higher Education. http://www.che.ac.za/media_and_publications/che-events-presentations/challenge-curriculum-responsiveness-south-african [23 January 2017]

Oppenheim, A. N. 1992. *Questionnaire Design, Interviewing and Attitude Measurement*. London: Pinter.

Papier, J., Needham, S. & McBride, T. 2012. *Contemporary Issues in Public FET Colleges*. Further Education and Training Institute, University of the Western Cape, Working paper no 17.

Papier, J., Needham, S., Prinsloo, N. & McBride, T. 2016. Preparing TVET college graduates for the workplace employers' views. In Kraak, A., Paterson, A. & Boka, K. (eds). *Change management in TVET colleges Lessons learnt from the field of practice*. Cape Town. African Minds.

Patton, M. Q. 1980. *Qualitative Evaluation Methods*. Beverly Hills, CA: Sage.

Pawson, R. &Tilley, N. 1997. *Realistic Evaluation*, SAGE Publications Limited, London.

Pilz, M. (2012). *The future of vocational education and training in a changing world*. Wiesbaden: Springer VS

Powell, L. 2012. Reimagining the purpose of VET – Expanding the capability to aspire in South African Further Education and Training students, *International Journal of Education Development*, 32(5):643-653.

Powell, L., & McGrath, S. 2014. Exploring the value of the capability approach for vocational education and training evaluation: Reflections from South Africa. In G. Carbonnier (Ed.), *Education, learning, training: critical issues for development* (International development policy series, (5):126–148). Boston: Brill-Nijhoff.

Psacharopoulos, G. 1997. Vocational education and training today: challenges and responses. *Journal of Vocational Education and Training*, 49(3): 385-394.

Rauner, F., Heinemann, L., Hauschildt, U., & Piening, D. 2012. Project report: COMET-Pilot test South Africa including the pilot test Vocational Identity/Occupational Commitment and results of the QRC pilot project. Prepared as part of the project: Implementing modern VET Research Tools in South Africa: QRC, COMET and VI. Bremen: University of Bremen.

Roberts, J. 2009. The global knowledge economy in question. *Critical perspectives on international business*, 5(4):285-303.

Robertson, S.L. 2005. Re-imagining and rescripting the future of education: global knowledge economy discourses and the challenge to education systems. *Comparative education*, 41(2):151 – 170.

Rossman, G., & Rallis, S.F. 1998. *Learning in the field: An introduction to qualitative research.* Thousand Oaks, CA: Sage

Ruddock, J. 1981. *Evaluation: A Consideration of Principles and Methods*. Manchester Monographs 10. Manchester: University of Manchester.

Saunders, M., Lewis, P. & Thornhill, A. 2007. *Research methods for business students*. England, Pearson Education.

Schwab, K. 2015. *The fourth industrial revolution: What it means and how to respond*. Council on Foreign Relations. WEF. https://www.foreignaffairs.com/articles/2015-12-12/fourth-industrial-revolution [10 November 2016]

Scime, A. 2008. Globalized computing education: Europe and the United States, *Computer Science Education*, 18(1): 43-64.

Scott, D. 2014. Knowledge and the curriculum, *The Curriculum Journal*, 25(1): 14-28.

UNESCO. 2010. Guidelines for TVET Policy Review: Draft, UNESCO, Addis Ababa.

Scott, M & Fisch, K. n.d. *Shift Happens*. https://shifthappens.wikispaces.com. [2 February 2017]

South Africa. 2006a. National policy regarding further education and training programmes: approval of the documents, policy for the national certificates (vocational): qualifications at levels 2 to 4 on the national qualifications framework (NQF). *Government Gazette*, 302(28677), March 29.

South Africa. 2006b. Act No. 16 of 2006: Further education and training colleges Act, 2006. *Government Gazette*, 497(29469), December 11.

South Africa. 2011. The Presidency: National Planning Commission. 2011. National Development Plan 2030. http://www.gov.za/sites/www.gov.za/files/devplan_2.pdf [20 June 2017]

South Africa. 2014a. Skills or qualifications determined to be critical for the Republic of South Africa in relation to an application for critical skills visa or permanent residence permit: 2014. *Government Gazette*, 588(37716), June 3.

South Africa. 2014b. Department of Higher Education and Training: List of occupations in demand: 2014. *Government Gazette*, 593(38174), November 4.

South Africa. 2016. Department of Higher Education and Training: List of occupations in demand: 2015. *Government Gazette*, 607(39604), January 19.

Stiglitz, J.E. 1999. Public policy for a knowledge economy. London. Department for Trade and Industry and Center for Economic Policy Research. World Bank

Struwig, F. & Stead, G. 2001. Planning, designing and reporting research. Cape Town: Pearson Education South Africa.

Tanner, M. & Seymour, L. 2014. The range and level of software development skills needed in the Western Cape, South Africa. *Proceedings of the e-Skills for Knowledge Production and Innovation Conference 2014, Cape Town, South Africa,* 487-505. http://proceedings.e-skillsconference.org/2014/e-skills487-505Tanner814.pdf [19 August 2017].

Tesch, R. 1990. *Qualitative research: Analysis types and software tools*. New York: Falmer

Thomas, D. R. 2003. *A general inductive approach for qualitative data analysis*. School of Population Health, University of Auckland. New Zealand.

Tilak, J. 2002. Vocational education and training in Asia. In: Keeves, P.J., Watanabe, R. (Eds.), The Handbook on Educational Research in the Asia Pacific Region. Kluwer Academic Publishers, Dordrecht.

Umalusi. 2006. Apples and Oranges -A comparison of school and college subjects. Pretoria: Umalusi.

Umalusi. 2013. Directives for certification: National Certificate (Vocational) Levels 2-4. Pretoria: Umalusi.

Venktess, K. 2017. Cybercrime to cost business up to R78 trillion in four years. *Fin24*, 7 March 2017. [Online]https://www.fin24.com/Tech/Cyber-Security/cybercrime-to-cost-business-up-to-r78-trillion-in-four-years-20170307 [15 May 2018].

Voogt, J & Roblin, N.P. 2012. A comparative analysis of international frameworks for 21st century competences: Implications for national curriculum policies, *Journal of Curriculum Studies*, 44(3), 299-321.

Walker, M., McLean, M., Dison, A. & Peppin-Vaughan, R. 2009. South African universities and human development: towards a theorisation and operationalization of professional capabilities for poverty reduction. *International Journal of Educational Development,* 29 (6): 565–572.

Webb, M., Davis, N., Bell, T., Katz, Y.J., Reynolds, N., Chambers, D.P. & Sysło, M.M. 2017. Computer science in K-12 school curricula of the 2lst century: Why, what and when? *Education and Information Technologies*, 22(2):445–468

WEF. 2015. *Disrupting unemployment: Business-led solutions for action*. Geneva.

WEF. 2016. *The Future of Jobs Employment: Skills and Workforce Strategy for the Fourth Industrial Revolution*. Geneva

Wheelahan, L. 2015. Not just skills: what a focus on knowledge means for vocational education, *Journal of Curriculum Studies*, 47(6): 750-762.

Wheelahan, L., & Moodie, G. 2011. *Rethinking skills in vocational education and training: from competencies to capabilities*. Sydney: Board of Vocational Education and Training.

Winch, C. & Clarke, L. 2003. "Front-loaded" vocational education versus lifelong learning. A critique of current UK government policy. *Oxford Review of Education*. 29(2):239-252.

World Bank. 2003. *Lifelong Learning in the Global Knowledge Economy: Challenges for Developing Countries*. Washington.

World Bank. 2007. *Building Knowledge Economies: Advanced Strategies for Development*. Washington.

World Bank. 2014. *Science, Technology and Skills for Africa's Development*. Washington.

ADDENDA

Addendum A: Interview guide

Interview guide for companies

The interviews were open-ended, but all industry respondents were asked the following starting and follow-up questions. Of course, further follow-up questions might have been asked for clarification.

1. What knowledge or key theoretical concepts should an entry-level IT employee have?

   Are there any other key concepts you would like to add?

2. Which technical skills should an entry-level IT employee have?

   Are there any other skills you would like to add?

Addendum B: An example of a transcribed and coded interview

An example of a transcribed and coded interview from a respondent.
Respondent: Company 2

What knowledge or key theoretical concepts should an entry level IT employee have?

As you are probable aware that IT is a very broad area, my area of specialist is software development and I am of the understanding that anyone who wants to join the industry after studying should have done object oriented programming. It doesn't matter what language they have learned or used to do (software) development. They might have used C#, VB.NET, Java or any other object oriented programming language. I think students must be exposed to development and mainly object oriented, in the sense that we deal with objects in the industry, so the understanding of objects and transforming them into business solutions is very important. I also think that students who want to do development must also be exposed to some business related courses so that when they join development they will be able to hear or understand what they need to computerise. A lot of students that we get normally have a technical understanding of what development is, but when you talk of profit for instance as a basic concept they don't know what profit is, they don't know what is a return. So when they participate in most of the meetings that we do, where we define specifications is very difficult for them to understand what is going on. I strongly think that it is important to include business related courses in IT curriculums especially for students who want to do development. Include courses like basic concepts to accounting, basic concepts to business, basic concepts to marketing, basic concepts to HR; courses that will enable them to understand how a business is configured.
The other area is IT hardware and networking which I am not very familiar to. But my honest understanding by way of what I see is that students must be very technically competent. I think higher education institutions should spend more time training them in the popular operating systems that we find in industry today, such as Windows, UNIX etc. I think thus what I can say

Which technical skills should an entry level IT employee have?
From my experience, I have had quite a number of interns that I have worked with. Before anything else, every aspiring candidate should be able to work in a team. I personally think that whatever training you are giving them is not enough to make them technically competent without giving them some social/human, team skills that will enable them to have the right attitude to work in a team environment. Most of the work that we do is team based. There is very little work that you have to do or complete as an individual. You start some work(assignment) and pass it to the next person. One of the key things which is very important is the attitude of the individual- that is, the soft skills of the candidate. Most of the people that we get are very raw. They are generally difficult to work with because they don't have the right soft skills. I also think apart from soft skills there must be in a position to learn, and well-grounded to be able to learn new skills. I understand whatever software development language you teach them at colleges and universities, which should enable them to learn any other language (software) on their own with very little difficulty. They must have strong cognisant skills; skills that will enable them to self-teach, skills that will enable them to learn new tools that are available for use in our industry. Most importantly they must be able to work under a lot of pressure because the entails a lot of deadlines, a lot of shifting of tasks, a lot prioritisation of tasks, a lot of de-prioritisation of tasks. They should be able to work under a lot of pressure.

Commented [d1]: Knowledge of object oriented programming
Commented [d2]: Knowledge of software development.
Commented [d3]: Knowledge of objects.
Commented [d4]: Transform objects into business solutions
Commented [d5]: Knowledge of business courses
Commented [d6]: Knowledge of business processes
Commented [d7]: Business and system specifications
Commented [d8]: business concepts
Commented [d9]: knowledge of marketing, accounting and HR
Commented [d10]: business models
Commented [d11]: knowledge of hardware
Commented [d12]: knowledge of networking
Commented [d13]: knowledge of operating systems
Commented [d14]: people skills
Commented [d15]: attitude
Commented [d16]: soft skills
Commented [d17]: learn on their own
Commented [d18]: time management

I see you talk much on soft skills, but not on technical skills. What technical skills should an entry level IT employee have?

The really truth is we kind of have an understanding that students or who would be potential employees should be highly technical for them to be able to write a software program. We have since realised that even people who have done sociology can come into development and be able to write computer programs, and be able to be trained to write computer programs so that they can deliver their tasks. Why I was emphasising the issue of soft skills is because it is always the attitude that determines whether someone will be successful or not.

Having said that, from a technical perspective it is important that the students or who would be employees have been exposed to being able to write code, understand a particular development environment in detail, even though they might not necessarily be using the same environment in industry. They should be able to write a sound code, efficient code, a code that performs well according to what it is meant for. A code that is error free. I think what is important for them is to able to understand the best practices that are followed in industry. But like I was also saying, the moment you get an entry person in our teams we don't expect them to be experts in anything. We normally assume that they don't know anything. Unfortunately, you tend to get a few people who comes in and think that they know. From our experience we normally have big issues with such people. We normally assume that people don't know anything and we tell them that this is how we write our codes. In other words, they must have basic development skills in C# or Java. They must have basic technical skills in debugging a program. Basic skills in writing unit test, basic skills in reviewing code to make sure that the code is doing what it is intended for. It is also important for them to have skills in databases. In terms of being able to understanding how databases are created; things like primary keys, foreign keys, relational databases and all those things. They should have UI, what we call UI skills to be able to handle Java script to be able to handle Windows forms, to be able to handle web forms and all those things. But the bottom line is we don't expect a student coming from college or university to be well equipped with anyone of these but should have the right frame of mind that we should be able to introduce these concepts to them and show them how to do it and produce products that organizations want.

Is there anything else you would like to add in terms of knowledge and skills?

Just to summarise I was trying to say that, in industry right now where I am working we have people that have not done computer science. Someone has done politics and administration but is currently working in software development. We have people that have not done computer science, they have actually done politics and administration, but he is currently working in software development and they are one of good developers we have in our team. This throws away the idea that many universities want students to do computer science only if they had done mathematics at Matric level. That way you have a lot of creative people being thrown out of the system because they are believed not to be mathematics oriented, but most of them turn to be very innovative and contribute positively.

Commented [d19]: write computer programs

Commented [d20]: write a code

Commented [d21]: understand software development environment

Commented [d22]: industry best practices

Commented [d23]: write a code in C# or Java

Commented [d24]: debug code

Commented [d25]: test computer programs

Commented [d26]: review a code

Commented [d27]: create databases

Commented [d28]: knowledge of databases

Commented [d29]: knowledge of primary keys, foreign keys

Commented [d30]: knowledge of relational databases

Commented [d31]: knowledge of UI

Commented [d32]: UI skills

Commented [d33]: Knowledge of scripts

Commented [d34]: Develop websites

Commented [d35]: Create forms

Commented [d36]: Mathematics not necessary for programming

Addendum C: National Certificate (Vocational) - Information Technology and Computer Science curriculum

Subject	Topics covered	Assessment criteria
Introduction to information systems Level 2	Computerised information processing in the business organization; Information technology and its components; The impact of information technology on business practices and the economy; Introduction to computer architecture- computers and electronic information processing; Introduction to computer architecture-input; Introduction to computer architecture-output; Introduction to computer architecture-storage	Assessment consist of three compulsory components: • ICASS- made of two PATs and three internal examinations. • ISAT-draws on the students' cumulative learning achieved throughout the year. The task requires integrated application of competence and skills. • External examination- set by DHET at the end of the year in October/November. Pass mark is 50%
Introduction to systems development Level 2	Basic concepts of systems and application software; Software development and programming languages concepts; Computer data storage; Basic computer programming; Principles of computer program quality assurance and project viability.	Assessment consist of three compulsory components: • ICASS- made of two PATs and three internal examinations. • ISAT-draws on the students' cumulative learning achieved throughout the year. The task requires integrated application of competence and skills. • External examination- set by DHET at the end of the year in October/November. Pass mark is 50%
Electronics Level 2	Fundamentals of electricity; Basic electronic theory and concepts; Electrical safety standards; Use and care of hand-held electrical test instruments; Soldering techniques; Basic electronic circuits; Principles of digital logic; Basic programmable logic controllers (PLC);	Assessment consist of three compulsory components: • ICASS- made of two PATs and three internal examinations. • ISAT-draws on the students' cumulative learning achieved throughout the year. The task requires

	Basic concepts of telecommunications	integrated application of competence and skills. • External examination- set by DHET at the end of the year in October/November. Pass mark is 50%
Computer hardware and software Level 3	Concepts of computer architecture; Types of computer systems and hardware configurations; PC or handheld computer hardware components; Assemble a PC or handheld computer and peripherals into modules; Install system and application software for a PC or handheld computer; Installation of PC or handheld computer peripherals; Testing of IT systems against given specifications; Preventative maintenance, environment and safety issues in a computer environment; Technical computer problems; Computer user's problems; Problem solving strategies; Repair a PC, handheld computer and peripherals to module level	Assessment consist of three compulsory components: • ICASS- made of two PATs and three internal examinations. • ISAT-draws on the students' cumulative learning achieved throughout the year. The task requires integrated application of competence and skills. • External examination- set by DHET at the end of the year in October/November. Pass mark is 50%
Principles of computer programming Level 3	Principles of electronic logic for computing; Program development environments; Data structures; Program Design; Database application development; Error handling in a computer environment; User interface and output design	Assessment consist of three compulsory components: • ICASS- made of two PATs and three internal examinations. • ISAT-draws on the students' cumulative learning achieved throughout the year. The task requires integrated application of competence and skills. • External examination- set by DHET at the end of the year in October/November. Pass mark is 50%
Systems design and analysis	Concepts associated with	Assessment consist of three

Level 3	systems analysis and development; Data processing, IT, business support and control systems; Information systems departments in business organisations; Acquisition of computer technology; Information systems planning and strategy; Preliminary investigation in a systems development life cycle	compulsory components: • ICASS- made of two PATs and three internal examinations. • ISAT-draws on the students' cumulative learning achieved throughout the year. The task requires integrated application of competence and skills. • External examination- set by DHET at the end of the year in October/November. Pass mark is 50%
Computer programming Level 4	Object Oriented Programming; Database application design; Principles of developing software for the internet; Design and build a website using simple HTML; Create multimedia, web-based applications with scripting	Assessment consist of three compulsory components: • ICASS- made of two PATs and three internal examinations. • ISAT-draws on the students' cumulative learning achieved throughout the year. The task requires integrated application of competence and skills. • External examination- set by DHET at the end of the year in October/November. Pass mark is 50%
Data communication and networking Level 4	Principles of computer networks; Synchronous / asynchronous communication of computers; Computer network architectures and standards; Computer network communication; Computer cabling; Install a local area network (LAN); Install networked computer application software; Principles of supporting local area network users; Support a local area computer network; Compare WAN with LAN	Assessment consist of three compulsory components: • ICASS- made of two PATs and three internal examinations. • ISAT-draws on the students' cumulative learning achieved throughout the year. The task requires integrated application of competence and skills. • External examination- set by DHET at the end of the year in October/November.

		Pass mark is 50%
Systems analysis and design Level 4	Ethics and professionalism for the computer industry in South Africa; ICT risks and threat management; Information gathering techniques for computer systems development; Analysing information systems; Principles of designing computer system inputs and outputs; Implementing and maintaining an information system; Concepts of artificial intelligence	Assessment consist of three compulsory components: • ICASS- made of two PATs and three internal examinations. • ISAT-draws on the students' cumulative learning achieved throughout the year. The task requires integrated application of competence and skills. • External examination-set by DHET at the end of the year in October/November. Pass mark is 50%

Addendum D: Ethics committee approval notice

UNIVERSITEIT
STELLENBOSCH
UNIVERSITY

NOTICE OF APPROVAL

REC Humanities New Application Form

9 February 2018

Project number: 1875

Project Title: A fit-gap analysis of the NCV-IT curriculum against the needs of the South African ICT industry.

Dear Mr Darlington Hove

Your response to stipulations submitted on 7 February 2018 was reviewed and approved by the REC: Humanities.

Please note the following for your approved submission:

Ethics approval period:

Protocol approval date (Humanities)	Protocol expiration date (Humanities)
10 January 2018	9 January 2021

GENERAL COMMENTS:

Please take note of the General Investigator Responsibilities attached to this letter. You may commence with your research after complying fully with these guidelines.

If the researcher deviates in any way from the proposal approved by the REC: Humanities, the researcher must notify the REC of these changes.

Please use your SU project number (1875) on any documents or correspondence with the REC concerning your project.

Please note that the REC has the prerogative and authority to ask further questions, seek additional information, require further modifications, or monitor the conduct of your research and the consent process.

FOR CONTINUATION OF PROJECTS AFTER REC APPROVAL PERIOD

Please note that a progress report should be submitted to the Research Ethics Committee: Humanities before the approval period has expired if a continuation of ethics approval is required. The Committee will then consider the continuation of the project for a further year (if necessary)

Included Documents:

Document Type	File Name	Date	Version
Research Protocol/Proposal	Proposal	06/02/2018	
Informed Consent Form	Consent Form_Employers	06/02/2018	
Informed Consent Form	Consent Form_Lecturers	06/02/2018	
Data collection tool	Interview Questions	06/02/2018	
Request for permission	Darlington Hove - approval to conduct research	06/02/2018	
Default	DHET 004 - Approval to conduct research in public colleges [email]	06/02/2018	

If you have any questions or need further help, please contact the REC office at cgraham@sun.ac.za.

Sincerely,

Clarissa Graham

REC Coordinator: Research Ethics Committee: Human Research (Humanities)

National Health Research Ethics Committee (NHREC) registration number: REC-050411-032. The Research Ethics Committee: Humanities complies with the SA National Health Act No.61 2003 as it pertains to health research. In addition, this committee abides by the ethical norms and principles for research established by the Declaration of Helsinki (2013) and the Department of Health Guidelines for Ethical Research:

Principles Structures and Processes (2nd Ed.) 2015. *Annually a number of projects may be selected randomly for an external audit.*

Investigator Responsibilities

Protection of Human Research Participants

Some of the general responsibilities investigators have when conducting research involving human participants are listed below:

1.Conducting the Research. You are responsible for making sure that the research is conducted according to the REC approved research protocol. You are also responsible for the actions of all your co-investigators and research staff involved with this research. You must also ensure that the research is conducted within the standards of your field of research.

2.Participant Enrolment. You may not recruit or enrol participants prior to the REC approval date or after the expiration date of REC approval. All recruitment materials for any form of media must be approved by the REC prior to their use.

3.Informed Consent. You are responsible for obtaining and documenting effective informed consent using **only** the REC-approved consent documents/process, and for ensuring that no human participants are involved in research prior to obtaining their informed consent. Please give all participants copies of the signed informed consent documents. Keep the originals in your secured research files for at least five (5) years.

4.Continuing Review. The REC must review and approve all REC-approved research proposals at intervals appropriate to the degree of risk but not less than once per year. There is **no grace period.** Prior to the date on which the REC approval of the research expires, **it is your responsibility to submit the progress report in a timely fashion to ensure a lapse in REC approval does not occur.** If REC approval of your research lapses, you must stop new participant enrolment, and contact the REC office immediately.

5.Amendments and Changes. If you wish to amend or change any aspect of your research (such as research design, interventions or procedures, participant population, informed consent document, instruments, surveys or recruiting material), you must submit the amendment to the REC for review using the current Amendment Form. You **may not initiate** any amendments or changes to your research without first obtaining written REC review and approval. The **only exception** is when it is necessary to eliminate apparent immediate hazards to participants and the REC should be immediately informed of this necessity.

6.Adverse or Unanticipated Events. Any serious adverse events, participant complaints, and all unanticipated problems that involve risks to participants or others, as well as any research related injuries, occurring at this institution or at other performance sites must be reported to Malene Fouche within **five (5) days** of discovery of the incident. You must also report any instances of serious or continuing problems, or non-compliance with the RECs requirements for protecting human research participants. The only exception to this policy is that the death of a research participant must be reported in accordance with the Stellenbosch University Research Ethics Committee Standard Operating Procedures. All reportable events should be submitted to the REC using the Serious Adverse Event Report Form.

7.Research Record Keeping. You must keep the following research related records, at a minimum, in a secure location for a minimum of five years: the REC approved research proposal and all amendments; all informed consent documents; recruiting materials; continuing review reports; adverse or unanticipated events; and all correspondence from the REC

8.Provision of Counselling or emergency support. When a dedicated counsellor or psychologist provides support to a participant without prior REC review and approval, to the extent permitted by law, such activities will not be recognised as research nor the data used in support of research. Such cases should be indicated in the progress report or final report.

9.Final reports. When you have completed (no further participant enrolment, interactions or interventions) or stopped work on your research, you must submit a Final Report to the REC.

10.On-Site Evaluations, Inspections, or Audits. If you are notified that your research will be reviewed or audited by the sponsor or any other external agency or any internal group, you must inform the REC immediately of the impending audit/evaluation.

Addendum E: Informed consent form

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jou kennisvennoot • your knowledge partner

STELLENBOSCH UNIVERSITY

CONSENT TO PARTICIPATE IN RESEARCH

A fit-gap analysis of the National Certificate Vocational- Information Technology and Computer Science (NCV-IT) curriculum against the needs of the South African ICT industry in the wake of the knowledge economy.

You are kindly requested to participate in a research study conducted by Mr Darlington Hove. The researcher is conducting this investigation to fulfil the requirements of a postgraduate degree at the University of Stellenbosch. Results obtained from the study will contribute to the above named thesis. You were selected as a possible participant in this study because your organization is a stakeholder in the ICT industry.

1. PURPOSE OF THE STUDY

To determine the relevance of the current national NCV-IT curriculum to the knowledge and skills needs of the ICT industry in South Africa.

2. PROCEDURES

If you volunteer to participate in this study, the researcher, Mr Darlington Hove will ask you to participate in a semi-structured interview conducted in the privacy of your office or any other venue suitable for this purpose at a time convenient to both parties. The interview will be digitally recorded.

3. POTENTIAL RISKS AND DISCOMFORTS

The interview process and the nature of the questions asked during the interview sessions will not pose any potential risk or discomfort to you.

4. POTENTIAL BENEFITS TO SUBJECTS AND/OR TO SOCIETY

To identify possible gaps in the current national NCV-IT curriculum in order to align it to the knowledge and skills needs of the ICT industry.

5. PAYMENT FOR PARTICIPATION

There is no payment involved in participation.

6. CONFIDENTIALITY

Confidentiality and anonymity of the details and comments you provide in this study are guaranteed. All comments and details will be treated in strict confidence and will be used strictly for the sole purpose of the aforementioned research study. You may request permission to listen to digital voice recordings in the presence of the researcher and edit any of your statements. The researcher will keep the digital voice recordings in a safe place for a long as deemed necessary for the completion of the research project or as stipulated by Stellenbosch University for assessment and moderation purposes.

7. PARTICIPATION AND WITHDRAWAL

You can choose whether to be in this study or not. If you volunteer to be in this study, you may withdraw at any time without consequences of any kind. You may also refuse to answer any questions you don't want to answer and still remain in the study. The investigator may withdraw you from this research if circumstances arise which warrant doing so.

8. IDENTIFICATION OF INVESTIGATORS

If you have any questions or concerns about the research, please feel free to contact the principal researcher: Darlington Hove on 073 7326891 or email: musaigwad@gmail.com OR the Supervisor: Mr Christiaan Maasdorp on (021) 808 3803 or email: chm2@sun.ac.za

9. RIGHTS OF RESEARCH SUBJECTS

You may withdraw your consent at any time and discontinue participation without penalty. You are not waiving any legal claims, rights or remedies because of your participation in this research study. If you have questions regarding your rights as a research participant, contact Ms. Maléne Fouché [mfouche@sun.ac.za; 021 808 4622] at the Division for Research Development.

DECLARATION BY PARTICIPANT

The information above was described to me [the participant] by Mr Darlington Hove [the researcher] in English. I am in command of this language. I [the participant] was given the opportunity to ask questions and these questions were answered to my satisfaction.
I hereby consent voluntarily to participate in this study. I have been given a copy of this form.

____
Name of Participant

____ ______________

Signature of Participant **Date**

____ ______________

Signature of Investigator **Date**

Addendum F: Computer Programming Level 4- Subject guidelines

education

Department:
Education
REPUBLIC OF SOUTH AFRICA

NATIONAL CERTIFICATE (VOCATIONAL)

SUBJECT GUIDELINES

COMPUTER PROGRAMMING

NQF Level 4

September 2007

COMPUTER PROGRAMMING – LEVEL 4

CONTENTS

INTRODUCTION

A. What is Computer Programming?

Computer Programming involves the designing and programming of well-tested and user-friendly computer-based solutions to meet specific requirements.

B. Why is Principles of Computer Programming important in the Information Technology programme?

Principles of Computer Programming is important in the Information Technology programme as it enhances the development of the IT environment.

C. The link between the Learning Outcomes for Principles of Computer Programming and the Critical and Developmental Outcomes

The student will be able to identify and solve problems, and collect, analyse, organise and critically evaluate information that is related to computer programming. The student will also demonstrate an understanding of the world as a set of related systems by recognising that problem-solving contexts do not exist in isolation.

D. Factors that contribute to achieving Computer Programming Learning Outcomes

- Analytical and logical ability
- Keen powers of observation
- Transferring of skills from familiar to unfamiliar situations
- Meticulous attention to detail
- Interest in computers and related topics

1 DURATION AND TUITION TIME

This is a one year instructional programme comprising 200 teaching and learning hours. The subject may be offered on a part-time basis provided the candidate meets all of the assessment requirements.

Course preparation should take consideration of students with special education needs.

2 SUBJECT LEVEL FOCUS

- Apply computer-programming skills.

3 ASSESSMENT REQUIREMENTS

3.1 Internal assessment (50 percent)

3.1.1 Theoretical Component

The theoretical component will form 30 percent of internal assessment.

Internal assessment of the theoretical component of Computer Programming Level 4 will take the form of observation, class questions, group work, (informal group competitions with rewards), individual discussions with students, class, topics and semester tests, internal examinations. Daily observation can be made when marking exercises of the previous day and class questions.

Assignments, case studies and tests can be done at the end of a topic. Tests and internal examinations must form part of internal assessment.

3.1.2 Practical Component

The practical component includes applications and exercises. All practical components must be indicated in a Portfolio of Evidence (PoE)

The practical component will form 70 percent of internal assessment.

Internal assessment of the practical component of Computer Programming Level 4 will take the form of assignments, practical exercises, case studies, practical examination in a simulated business environment.

Students may complete practical exercises on a daily basis. Assignments and case studies can be done at the end of a topic. Practical examination can form part of internal assessment.

- **Some examples of practical assessments include, but are not limited to:**
    - Presentations (lectures, demonstrations, group discussions and activities, practical work, observation, role play, self activity, judging and evaluation)
    - Use of aids
    - Exhibitions
    - Visits
    - Guest speaker presentations
    - Research
    - Task performance in a simulated/structured environment
- **Definition of the term "Structured Environment"**

"Structured environment" for the purposes of assessment refers to an actual or simulated workplace, or workshop environment. It is advised that a practicum room is available on each campus for practical assessment.

- **Evidence in practical assessments**

All evidence pertaining to evaluation of practical work must be reflected in the student's Portfolio of Evidence. The tools and instruments constructed and used for the purpose of conducting such assessments must be clear from evidence contained in the PoE.

3.1.3 Processing of internal assessment mark for the year

A year mark out of 100 is calculated by adding the marks of the theoretical component and the practical component of the internal continuous assessment.

3.1.4 Moderation of internal assessment mark

Internal assessment is subjected to both internal and external moderation procedures as contained in the *National Examinations Policy for FET College Programmes.*

3.2 External assessment (50 percent)

A national examination is conducted annually in October or November by means of a paper set externally and marked and moderated internally.

Details in respect of external assessment are contained in the *Assessment Guidelines: Computer Programming* (Level 4).

4 WEIGHTED VALUES OF TOPICS

TOPICS	WEIGHTED VALUE
1. Object Oriented Programming	20
2. Database application design	20
3. Principles of developing software for the internet	20
4. Design and build a web-site using HTML	20
5. Create multimedia, web-based applications with scripting	20
TOTAL	**100**

5 CALCULATION OF FINAL MARK

Continuous assessment:	Student's mark/100 x 50/1 = a mark out of 50	(a)
Theoretical examination mark:	Student's mark/100 x 50/1= a mark out of 50	(b)
Final mark:	**(a) + (b) = a mark out of 100**	

All marks are systematically processed and accurately recorded to be available as hard copy evidence for, amongst others, purposes of moderation and verification, as well as purposes of reporting.

6 PASS REQUIREMENTS

The student must obtain at least fifty (50) percent in ISAT and fifty (50) percent in the examination.

7 SUBJECT AND LEARNING OUTCOMES

On completion of Computer Programming Level 4, the student should have covered the following topics:

Topic 1:	Object Oriented Programming
Topic 2:	Database application design.
Topic 3:	Principles of developing software for the internet
Topic 4:	Design and build a website using simple HTML
Topic 5:	Create multimedia, web-based applications with scripting

7.1 Topic 1: Object Oriented Programming

7.1.1 Subject Outcome 1: Describe basic object oriented terminology

Learning Outcomes

The student should be able to:

- Explain the basic principles of a class.
- Explain the basic principles of an object.
- Explain the basic principles of information hiding and encapsulation.
- Explain the basic principles of inheritance.
- Explain the basic principles of polymorphism.

7.1.2 Subject Outcome 2: Describe the fundamental differences between object oriented and procedural programming

Learning Outcomes

The student should be able to:

- Explain the implementation of classes in object oriented programming, using examples.
- Explain encapsulation of data and functions/ methods (in classes)
- Describe how global sharing is minimised to enable weak coupling
- Describe how modules exhibit functional cohesion
- Explain and identify possible classes for simple examples and problems.

7.1.3 Subject Outcome 3: Implement object oriented techniques in development of a solution

Learning Outcomes

The student should be able to:

- Identify objects and classes.
- Implement objects and classes
- Implement a class/ classes in a solution to a given problem/ scenario

7.2 Topic 2: Database application design

7.2.1 Subject Outcome 1: Review the requirements for database access for a computer programming solution.

Learning Outcomes

The student should be able to:

- Identify and explain the feasibility of the requirements.
- Explain and identify database access objectives and critical performance factors
- Explain how to estimate costs for the development effort required.
- Explain the need for adopting a review procedure to ensure that the outcomes meet the database access requirements.

7.2.2 Subject Outcome 2: Design database access for a computer application

Learning Outcomes

The student should be able to:

- Describe and demonstrate design implementation per user requirements
- Describe and demonstrate the design of the database structure that resembles the output from the data analysis
- Describe and demonstrate how to ensure that the structure of each table in the database adheres to the third normal form
- Identify and demonstrate the methods of accessing data.
- Identify the key relationships between the tables within the database
- Explain and demonstrate how to ensure that the data types for primary and foreign keys are consistent throughout the database.

7.2.3 Subject Outcome 3: Write program code for database access for an application implementing SQL

Learning Outcomes:

The student should be able to:

- Identify and implement a method for external data connection and access using program code
- Demonstrate how the program code will use language constructs to facilitate the implementation of the solution.
- Explain and demonstrate how to join tables in a query to satisfy a requirement
- Describe how to construct program code that preserves the integrity of data being accessed by multiple users and processes.

7.2.4 Subject Outcome 4: Test programs for an application that accesses a database

Learning Outcomes:

The student should be able to:

- Describe and demonstrate how testing checks all program logic paths.
- Describe and demonstrate how testing corrects program code to eliminate errors identified.
- Describe and demonstrate how testing verifies that the database access functions in the required environment
- Describe and demonstrate how testing verifies that the database access performs according to the design requirements.
- Describe and demonstrate how testing verifies that the database functions according to the design requirements.

7.2.5 Subject Outcome 5: Document programs for a computer application that accesses a database

Learning Outcomes:

The student should be able to:

- Describe how the documentation enhances the understanding of the program code.
- Describe how the documentation complements the self-documenting attributes of the program code.
- Develop documentation to support the design, program code and solution

7.3 Topic 3: Principles of developing software for the internet

7.3.1 Subject Outcome 1: Explain the network issues related to internet applications

Learning Outcomes

The student should be able to:

- Explain the internet in terms of a session-less network protocol.
- List the implications of session-less application development.
- Explain the impact of band-width on internet usage and data transfer
- List the implications of band-width for application design.

7.3.2 Subject Outcome 2: Explain the implications of copyright, ownership and royalties

Learning outcomes

The student should be able to:

- Explain copyright issues related to internet development.
- Explain ownership issues related to internet development.
- Explain royalty issues related to internet development.

7.3.3 Subject Outcome 3: Explain version control and security issues related to internet applications

Learning outcomes

The student should be able to:

- Explain version control issues related to internet development.
- Explain security issues related to internet development.
- Explain ways of managing security issues related to internet development.

7.3.4 Subject Outcome 4: Demonstrate the basic implementation of different user interface methods used for internet applications

Learning outcomes

The student should be able to:

- Identify and explain different user interface technologies used primarily for internet application development.
- Indicate the implications of each technology
- Demonstrate the basic implementation of each of the user interface technologies above.

7.4 Topic 4: Design and build a web-site using HTML

7.4.1 Subject Outcome 1: Explain basic guidelines for web-page design

Learning Outcomes

The student should be able to:

- Explain the nature and use of a web-site.
- Identify and explain the physical content of web-pages
- Explain the typical transactions which can be carried out via a web-page

7.4.2 Subject Outcome 2: Use core HTML to build a web-page

Learning Outcomes

The student should be able to:

- Discuss the advantages and disadvantages of HTML editors and other web-site design tools.
- Integrate basic HTML functions in the design of a simple web page
- Define the HTML facilities that apply to typical web transactions

7.5 Topic 5: Create multimedia, web-based applications with scripting

7.5.1 Subject Outcome 1: Plan the use of a multimedia, web-based authored application

Learning Outcomes

The student should be able to:

- Identify the user-specified topic, purpose, target audience and objectives of the application according to agreed development plan.
- Explain how the tools selected to create multimedia, web-based applications with scripting are justified in relation to agreed development plan.
- Identify the hardware and software required to create and run the application according to the agreed development plan.
- Outline and monitor the plan for the creation of a multimedia, web-based application according to project planning principles and financial requirements.
- Describe the configuration of the computer and associated systems necessary for the creation of the application according to the agreed development plan.

7.5.2 Subject Outcome 2: Design a multimedia, web-based application

Learning Outcomes

The student should be able to:

- Design story-boards and flow-diagrams of the multimedia, web-based applications to ensure effective communication between the developer and user.
- Explain and motivate a design for a multimedia, web-based application according to user specifications.

7.5.3 Subject Outcome 3: Identify appropriate text, graphic elements and animation

Learning Outcomes

The student should be able to:

- Explain and demonstrate how to align multimedia, web-based application text, graphic elements and animation with agreed topic, purpose and target audience for the application, considering South African copyright and privacy laws.
- Explain and demonstrate how text, graphic elements and animation are saved according to agreed design specification, considering South African copyright and privacy laws.
- Explain and demonstrate how text, graphic elements and animation are saved in a format that allows them to be integrated into the multimedia, web-based application.

7.5.4 Subject Outcome 4: Create multimedia, web-based application scripts.

Learning outcomes

The student should be able to:

- Explain and demonstrate the script using a diagram
- Explain and demonstrate how to configure the operating environment of the computer and associated applications and software so that it may be used as outlined in the plan.

- Explain and demonstrate how one or more scripts are written using standard features of a scripting language.
- Explain and demonstrate how the scripts are tested, errors identified and corrected for most likely conditions.

7.5.5 Subject Outcome 5: Assemble a multimedia, web-based application including scripts

Learning Outcomes

The student should be able to:

- Explain and demonstrate how to assemble a multimedia, web-based application using the saved text, graphics and animation, and written application scripts to conform to the planned specification and user requirements.
- Explain how the content and function of the application are consistent with the design specification and specified computer system environment

8 RESOURCE NEEDS FOR THE TEACHING OF COMPUTER PROGRAMMING - LEVEL 4

8.1 Physical resources

The following teaching aids should be made available, if possible:

- Lecture room
- Computer for facilitator
- Overhead projector
- Networked computer laboratory with internet access

8.2 Human resources

- The facilitator must have as a major subject Computer Programming at NQF Level 5.
- It will be to the advantage of facilitator if they have already been declared competent as assessor and/or moderator.
- Training in OBE

8.3 Other resources

- Computer per learner
- Networked laser printer
- SQL software
- Programming software
- Web page design software
- Multimedia software
- Animation software
- File per learner for PoE
- DVD-RW per learner
- Ream of paper per learner
- 1 GB flash disk per learner
- Programming magazines and journals
- Multimedia magazines