THE STRATEGIC ROLE OF SOFTWARE DEVELOPMENT WITHIN THE SOFTWARE INDUSTRY OF THE WESTERN CAPE (SOUTH AFRICA)

by

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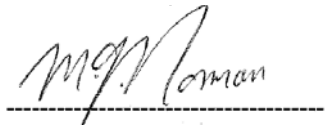
Declaration of Authorship

I declare that *The strategic role of software development within the software industry of the Western Cape (South Africa)* is my own work, that it has not been submitted for any degree or examination in any other university, and that all the sources I have used or quoted have been indicated and acknowledged by complete references.

Signed: 

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Abstract

Africa's mobile phone penetration has surpassed that of the United States of America and information communication technologies, according to the World Bank, contribute more to its gross domestic product than the global average. What has been the enabling environment for the development of software and mobile applications to sustain this information revolution? India, an affiliate of the family of economic nations consisting of Brazil, Russia, China and South Africa, has enjoyed remarkable success as a software developing country and thus could provide some guidelines in this respect. Ireland on the other hand, as a developed country, has also established a successful software industry. In this thesis, the key initiatives taken by both India and Ireland to establish their software industries were investigated. A grounded research approach, incorporating case studies of India, Ireland and South Africa, using a content analysis approach, was used to analyse cited literature about software development in these countries. India's approach, which includes enabling policies, economic incentives, educational and human resource initiatives, attracting outsourced businesses from other countries and a combination of government and industry initiatives, has contributed to its software industry's success. Ireland's approach was industry initiatives, policies, software products and educational developments. Since India and South Africa share similar challenges and Ireland and South Africa have a common heritage, the initiatives by India and Ireland were juxtaposed with known initiatives in South Africa to determine what initiatives are needed for potential success of the software industry in the Western Cape region and in developing countries beyond. A better understanding of the software industry in the Western Cape Province of South Africa and the views of software practitioners in the region has been formulated. Recommendations on what needs to be done to promote the software industry in the Western Cape Province in terms of policy (local, provincial and national government), educational (school, tertiary), practice and other criteria are presented.

Keywords: software industry, software development, software engineering, information technology, information technology policy, software engineering education, computing profession, computing societies, grounded theory, content analysis

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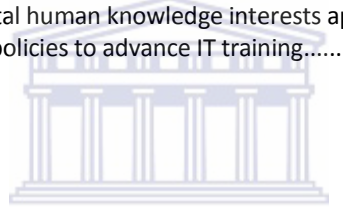

List of Abbreviations

ACM	Association of Computing Machinery
ASEET	Advanced SE Education and Training
BRICS	Brazil, Russia, India, China and South Africa
BPO	Business Process Outsourcing
CMM	Capability Maturity Model
CS	Computer Science
CSDA	Certified Software Development Associate
CSDP	Certified Software Development Professional
CSEET	Conference on SE Education and Training
GNI	Gross National Income
IBM	International Business Machines
IBSA	India, Brazil and South Africa Information Society
ICT	Information and Communications Technology
IEEE	Institute of Electrical and Electronics Engineers
ISO	International Organization for Standardization
IT	Information Technology
ITU	International Telecommunication Union
MSE	Master of Software Engineering
NDP	National Development Plan
OO	Object-Oriented
RAD	Rapid Application Development

SA	South Africa
SE	Software Engineering
SEE	Software Engineering Education
SWEBOK	Software Engineering Body of Knowledge
UN	United Nations
UNCTAD	United Nations Conference on Trade and Development
USA	United States of America
WEF	World Economic Forum

Chapter 1

Statement and Analysis of the Problem

1.1 Introduction

For most people, in all walks of life, software has become inextricably part of their lives. Software is embedded in modern devices, appliances and machines found in homes, businesses and industry. Furthermore, modern society is increasingly connected with mobile devices and technologies such as email, instant messaging and social media which are all underpinned by the software available on these devices. Software is pervasive in this connected society, and governments and businesses have become more and more dependent on software when delivering services and products to people.

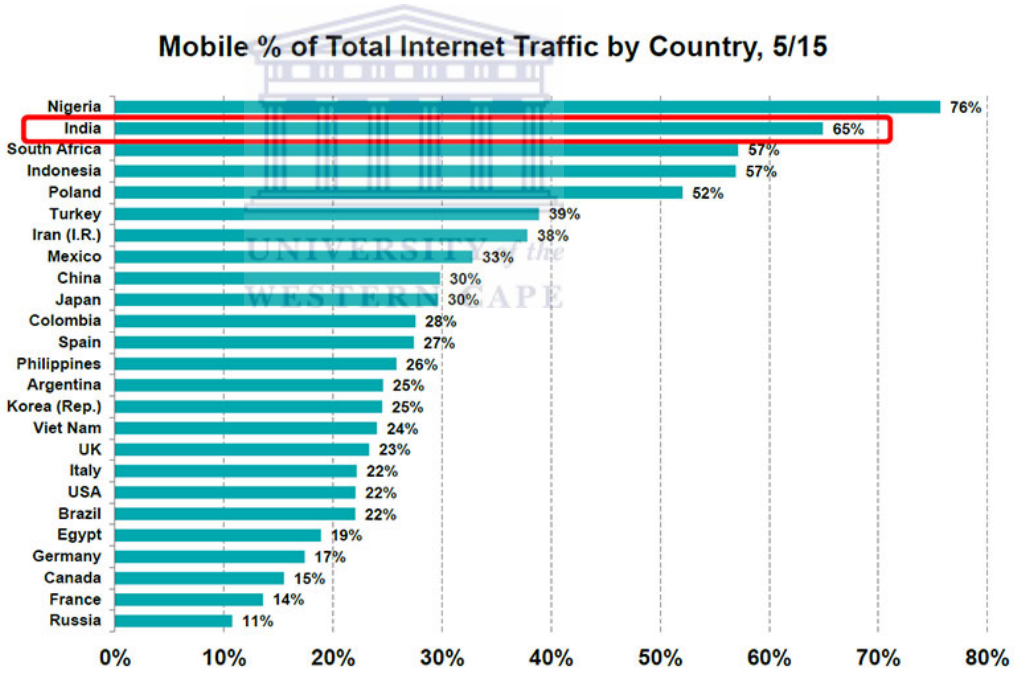

Figure 1: Internet traffic using mobile phones[1]

These services require connectivity and it is interesting to note that a 2015 report found that in developing countries, more so than in developed countries, most Internet traffic was generated by mobile devices (see Figure 1).

[1] Taken from http://mybroadband.co.za/news/smartphones/127556-south-africas-big-smartphone-internet-uptake.html

Mobile phone penetration, in particular smartphone penetration, in developing countries is relatively high (see Figure 2) when compared with the penetration for developed countries such as the United States of America (USA) and the United Kingdom (UK), which are 56% and 62% respectively (Google, 2013). This situation creates numerous opportunities for software development in these countries. The International Telecommunications Union (ITU), an agency of the United Nations (UN), reports that in 2015 there were 7 billion mobile subscriptions worldwide (ITU, 2015).

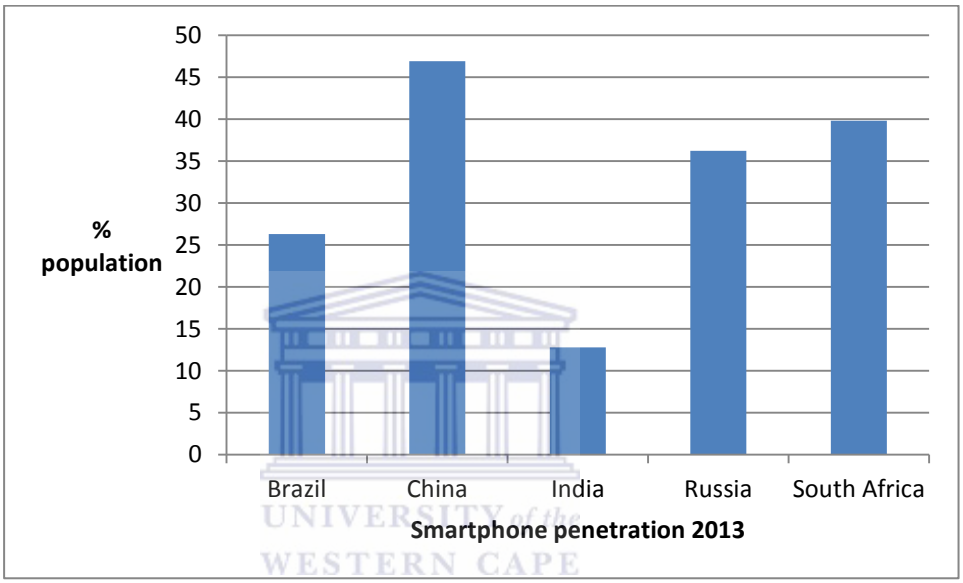

Figure 2: Smartphone penetration according to Google (Our Mobile Planet), (Google, 2013)

As countries, in particular developing countries, continue to transform their economies, the drive towards the knowledge economy will accelerate. In a global context, the software industry (and the knowledge economy) has grown significantly. According to the United Nation's Conference on Trade and Development (UNCTAD) report, the potential for software development in developing countries is still untapped. Furthermore, since these countries do not have legacy systems to take into account, they can leapfrog into new computing paradigms such as cloud computing and mobile applications (UNCTAD, 2012).

Gartner, a respected information technology and research company, indicated that globally, software revenue grew almost five per cent in only one year from

2012 to 2013 (Gartner, 2014). The demand for software to deliver the required applications for education, health, goods, services and e-government will thus increase.

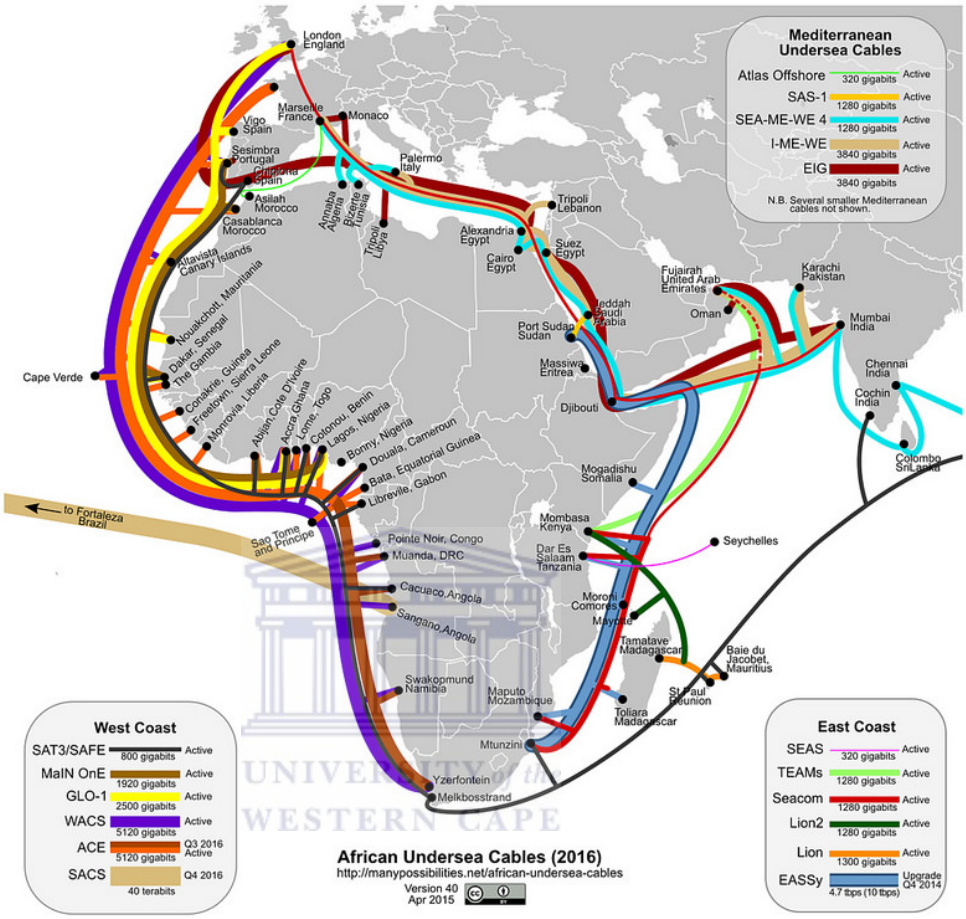

Figure 3: African undersea cables 2016 (Song, 2015)

Smartphone usage demands bandwidth and the provision of infrastructure for a connected world, which in turn demands an evolving software ecosystem for the developing world (UNCTAD, 2012). For Africa the connectedness has become a reality with several high-speed undersea fibre-optic cables that connect Africa with the international community (see Figure 3).

The BRICS (Brazil, Russia, India, China and South Africa) countries are an economic group of major emerging countries established to improve their economic positions and to develop financial instruments to assist with this (BRICS, 2015). In addition to India and South Africa (SA) being linked via BRICS, they are also co-operating via the India, Brazil and South Africa

(IBSA) Information Society Annual Programme (IBSA, 2012), both use English in business and share a historical British influence and BRICS will, by 2020, contribute nearly 50% of the world's gross domestic product (GDP) growth (South African Government, 2012).

South Africa's impact (economic and social) is rated much lower than that of India. The World Economic Forum's (WEF) Impact Sub-index, which gives the broad economic and social impact of countries, ranks India's position as 60th compared to South Africa's 89th position (WEF, 2014). The growth of South Africa's software industry lags behind that of India according to Gartner who states that the Indian software market grew by 10% in 2013 compared to the 6.3% growth in South Africa (Gartner, 2014). The SA software industry thus needs to find ways to develop and grow so that it can be competitive and provide the necessary impacts, as India has done.

A country is classified as developed or developing by the United Nations depending on economic conditions (United Nations, 2013). According to the UN classification of countries, based on economic conditions, both India and South Africa (SA) are listed as developing economies.

Since India has enjoyed remarkable success as a software developing country, its software industry has created many developmental opportunities in terms of employment, development of businesses and the establishment of an import/export market (UNCTAD, 2012). India's software success has been confirmed in that many of its software producers have attained software development capability ratings, e.g. Capability Maturity Model (CMM). India was thus chosen to be investigated further to determine what contributed to that software success.

The Indian software industry has been ranked 2nd only to the United States of America (USA), a major achievement for a developing country (Rai, 2002), (Palmer, 2012). So a study of how India achieved this and continues to sustain its software industry could provide useful guidelines for South Africa.

The UN classification on the other hand lists Ireland as a developed economy. Developing countries need to ensure that they continually bridge the digital

divide to realize the benefits of ICTs and can learn from each other and from developed economies about how to develop their software industries and thus strengthen their ICT sector to close the digital divide. An aim of this research is to explore what SA can learn from India (a developing economy) and Ireland (a developed economy).

The success of Ireland's software industry is recognised internationally and is ranked 26th out of a 148 countries in the 2014 networked readiness index (Cochran, 2001), (Giarratana, Pagano, & Torrisi, 2003), (WEF, 2014). The reason for choosing Ireland as a study subject is because the Irish government has a particular interest in SA as it has striven to invest in SA with software and IT services as a focus as well as to put an emphasis on education and skills development (South African Government, 2015), (Department of Foreign Affairs and Aid Ireland, 2015). The Irish government is also assisting SA to set up special economic zones (Irish Aid, 2013). It is interesting to note that Ireland and South Africa are similar in that they are both "isolated" from the USA and the UK and Europe. It would therefore be appealing to look at what initiatives and factors played a role in the establishment of the successful software industry, not only in India, but also in Ireland.

Software development can play a major role in attaining the ICT goals, and the consequential economic development for South Africa as outlined in the National Development Plan 2030 (NDP2030, 2013). Studying the software industry in India and Ireland could identify the contributing factors and these may have applicability in South Africa and in particular in the Western Cape region as an "instance" thereof.

Since the "landing" of the undersea cables in South Africa, various efforts have been made by government and businesses to ensure a connected country. Fibre-optic cables have been installed in towns and cities in order to advance the Information and Communications Technology (ICT) sector in South Africa. This increased connectedness, and, as a result of the provision of broadband, has created opportunities for ICT development in specific regions such as Gauteng and Cape Town (Gauteng Provincial Government, 2012), (Wesgro, City of Cape Town, PWC, 2013). At government level a

National Development Plan was designed which, amongst other areas, outlined the role of ICTs in the development of South Africa (NDP2030, 2013).

The Western Cape region is being positioned as the "Digital Gateway to Africa" by the City of Cape Town (Wesgro, City of Cape Town, PWC, 2013). This publication reports that since 2006 an amount of R1.5 billion has been invested in Cape Town's software and IT services areas. It further states that the following are in place to support this sector: an entrepreneurial environment; innovation support; venture capital; the presence of four universities; opportunities in the IT market in South Africa and others, e.g. improved bandwidth.

One specific example of the software success coming from the Western Cape region is the internationally well-known software application which was developed by Thawte Consulting. This company was founded by the South African Mark Shuttleworth in 1995 (Cape Venture Partners, 2015). The software provides a certificate authorization to safeguard financial transactions done via the Internet and was later purchased by Verisign (Verisign, 2015). There are also other software successes associated with this region such as Benguela Technologies (cloud computing), BetTech Gaming (gaming) and Celtic Molecular Diagnostics (molecular research) amongst others (Cape Venture Partners, 2015).

1.2 Research problem

To address the problem of identifying criteria that promote software development, the following question can be posed:

How should software development be promoted and strengthened to develop a competitive software industry?

This question can be refined by asking the following sub-questions:

- What criteria are important when establishing and growing a software industry?

- What are the obstacles that could hinder software development?

- How should developing countries create an enabling environment for software development?

This research effort focused on the software development success of India and Ireland. It considered the status of the software industry in SA with a specific emphasis on the Western Cape region.

The research investigated the software ecosystem and made recommendations as to which criteria are lacking or need improvement in terms of the contribution to software development.

The South African National Development Plan 2030 was accepted by the South African government in 2012 (NDP2030, 2013), (National Planning Commission, 2012). In this document, the role of ICTs in the development of South Africa's economy is outlined. In particular the plan mentions the need for skills development in enabling and developing the ICT sector and the need for closer collaboration between academia, industry and government in realising the ICT goals within the NDP 2030 goals.

1.3 Research framework

A number of factors and initiatives lead to the successful establishment of the software industry in both India and Ireland. Using a content analysis and case study approach, a number of high impact publications, documents by credible associations (e.g. industry) and trusted web sites (e.g. governments) will be used to identify the factors that contributed to this success. As a further case study, South Africa's current status in terms of its software industry and software development will be investigated, and the Western Cape's software industry will be evaluated with a survey.

It is assumed that a study of the software industry in India and Ireland will reveal factors which contributed to its establishment and success. These factors will be useful for the advancing and strengthening of the software industry in SA and in particular the Western Cape region and may have

relevance for other developing economies where software industries are developing.

It is also assumed that Software Engineering (SE) is a well-defined discipline with a SE code of ethics (IEEE, 2004), (ACM, 1999). Furthermore SE, although it can stand-alone as a discipline, is also a knowledge area within the body of knowledge of Computer Science and therefore is important as part of Computer Science education.

1.4 Research design and methodology

The software industry in India, Ireland and South Africa were considered in three case studies. A survey was undertaken to explore the software industry in the Western Cape region. For the case studies a grounded theory approach, incorporating content analysis, was used.

1.5 Original contribution of this research thesis

The contribution of this thesis is determining to what extent software development can be promoted and strengthened to develop a competitive software industry, with a specific focus on the Western Cape province of South Africa.

The results obtained in this regard are as follows:

- A better understanding of the software industry in the Western Cape Province of South Africa and the views of software practitioners.

- Identification of the challenges faced by the software industry in the Western Cape and potential solutions to these challenges.

- Recommendations on what needs to be done to promote the software industry in the Western Cape Province in terms of policy (local, provincial and national government), educational (school, tertiary), practice and other criteria.

- Quantitative analysis of a survey conducted in the Western Cape about the current status of its software industry. Measures were identified that the Western Cape could adopt to strengthen its software industry.

The contribution will be validated against Whetton's criteria in section 7.5.

1.6 The IT skills shortage crisis

It is reported that South Africa is currently burdened by a large estimated shortage of ICT professionals (Plaatjies & Mitrovic, 2014). For countries to benefit from ICTs and the knowledge economy, skills are essential to ensure that the beneficial effects of ICTs are realized (WEF, 2015).

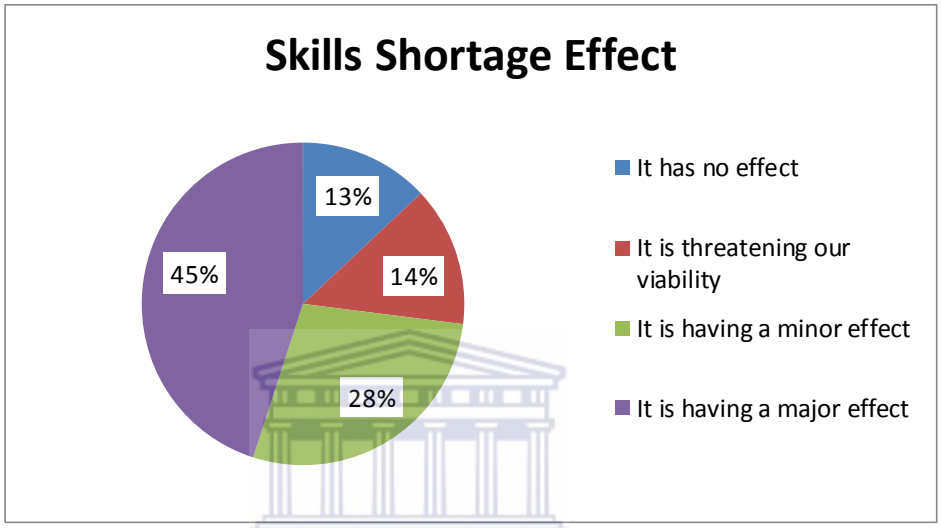

Figure 4: Skills shortage adapted from (Joburg Centre for Software Engineering, 2014)

In Figure 4, we see that a shortage of ICT skills can have a major impact on the success of business as shown by this South African study (Joburg Centre for Software Engineering, 2014). This shortage is being addressed in SA through efforts made by tertiary educational institutions and by others such as the national Ikamva e-skills institutes (Ikamva National eSkills Institute, 2015). South Africa urgently needs 200 data scientists to fill positions within the local component of the global Square Kilometre Array radio telescope project (SKA Project, 2015). A data science degree, the first in Africa, has been introduced at the Sol Plaatje University in South Africa as a first initiative to address this need (University World News, 2015).

The UK has taken urgent new steps to address their shortage of digital workers by establishing the National College for Digital Skills (NCDS) which will develop software and programming skills for apps, games and analysis

methods for (big) data. Its first students will start in September 2016. The founding document says that "*NCDS will be a centre of excellence, taking a fresh approach to the teaching and learning of computing and placing it at the heart of the curriculum*" (National College for Digital Skills, 2015).

The Raspberry Pi Foundation, a spin-off from the Department of Computer Science at Cambridge University in the UK, also strives to promote computing and programming. This foundation was originally launched in 2009 to encourage the younger generation to engage in the engineering of software, a consequence of a focus on being users of software packages and not designers of it (University of Cambridge, 2015). This 'generation gap' between engineers and users in regard to Software Engineering has become a key factor in the reduction of the skills required to advance the ICT industry in the UK, for example. The UK software industry has to rely on recruiting software engineers from overseas and/or outsourcing projects abroad.

1.7 Work-based learning

Work-based learning bridges the difference between academic learning and the work place needs and is an attempt to address skills required by employers. Learning occurs within the work place and helps individuals to obtain the skills needed to execute their job functions effectively via a partnership between the employer and the learning organization such as a university (Rhodes & Shiel, 2007). This approach can be applied to address the shortage of software engineering skills, particularly in high demand areas such as mobile software development. The Learning Tree International is an example of an organization which, since 1974, provides work-based IT learning which has industry certification and college recognition (Learning Tree International, 2015).

1.8 Curriculum relevance

In the ACM/IEEE curriculum guidelines published under the title *Computer Science Curriculum 2013*, Computer Science (CS) is organized into 18 knowledge areas (ACM & IEEE, Computer Science Curricula 2013, 2013).

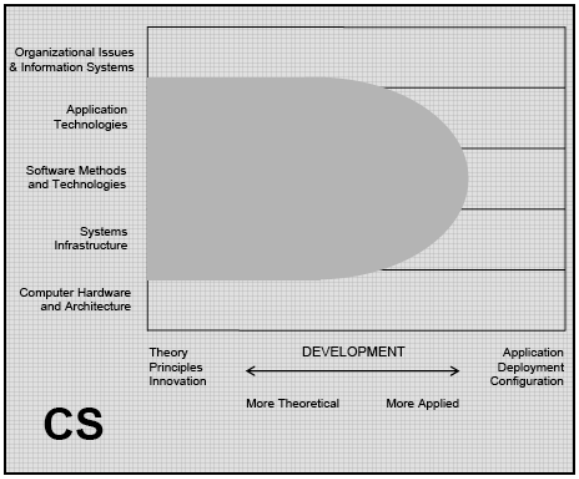

Figure 5: Computer Science as depicted on page 18 of Computing Curricula 2005 – The Overview Report

Software Engineering (SE) and Software Development Fundamentals (SDF) are both knowledge areas within the Computer Science curriculum (see Figure 5, (ACM & IEEE, Computing Curricula 2005)). These knowledge areas are concerned with software development processes which are applicable to software being developed in all areas of computing. SE is thus fundamental to many areas of Computer Science (e.g. Client-server systems, Mobile computing, etc.) and graduates of CS are often employed in areas where they need to develop software and subsequently are employed in the broader software industry or within departments developing software for non-software companies (e.g. banks).

Besides being part of Computer Science, Software Engineering has also matured into a discipline on its own (see Figure 6) with the latest Software Engineering curriculum being published as recently as February 2015 (IEEE Computer Society and Association for Computing Machinery, 2014).

Information Systems, as defined by the ACM/Association for Information Systems (AIS) lists Systems Analysis and Design as part of its core courses (Association for Computing Machinery and Association for Information Systems, 2010). Systems Analysis and Design are part of the larger area of Software Development and Software Engineering.

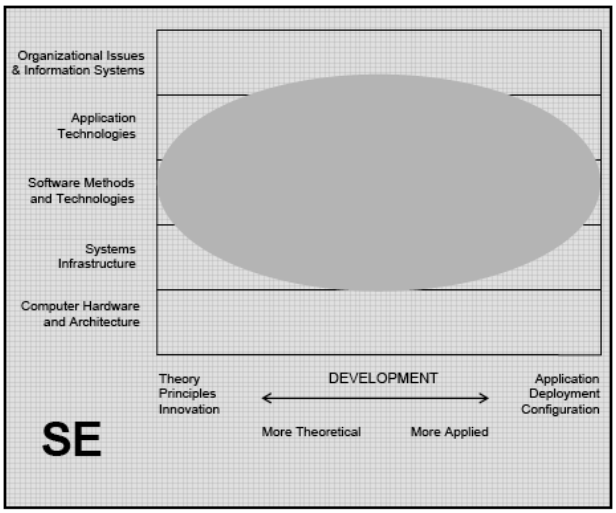

Figure 6: Software Engineering as depicted on page 21 of Computing Curricula 2005 – The Overview Report

The software industry and its demand for software developers, is highlighted by this research. This industry and its needs are important for academics involved in SE, CS and IS. This research is therefore of value to the broad community involved in academic teaching, developing software, the software industry in general and in particular to stakeholders in the Western Cape region who desire to further develop the software industry.

1.9 Summary and organization of the thesis

The introductory chapter gave an overview of the scope of the research, the research methodology, research contribution and an overview of the challenges to provide the necessary skills. Chapter 2 provides a brief history of Software Engineering; the literature is surveyed in Chapter 3; in Chapter 4 the research design and methodology is discussed; Chapter 5 deals with the results of the case studies; in Chapter 6 the overall results are analysed and finally in Chapter 7 the conclusions and recommendations will be given.

Chapter 2
Software Engineering History

The previous chapter introduced the scope of this research thesis. In this chapter the main milestones in the history of Software Engineering are discussed.

2.1 Brief history of Software Engineering

Some Software Engineering milestones worth mentioning are: associations and societies emerged with their various publications; programming languages and constructs; structured programming and Object Oriented techniques; process improvements; programming environments; new SE methodologies (e.g. Agile); software crisis; and hardware developments (e.g. integrated circuits, PCs).

2.1.1 The early years

The 1950's – Software Engineering was expected to be done like hardware engineering; there was a hardware inclination; the names of associations were hardware based, e.g. The Association of Computing Machinery and The IEEE Computer Society (Boehm, 2006).

The 1960's – a number of developments took place in the 1960's such as: improved computing infrastructure (better operating systems, high-level languages, e.g. FORTRAN, COBOL); smaller applications (easier to manage but spaghetti code difficult to maintain); Computer Science and Informatics departments started (more emphasis on software); software development companies for profit started; mission-critical software (IBM's OS/360, Apollo mission); ability to provide needed software problematic; code-and-fix still prevalent (Boehm, 2006);

The 1970's – structured approaches to replace the code-and-fix approach of the previous decade; avoid the *goto* statement; program correctness methods (formal and technical/managerial); top-down structured approach; chief

programmer team arrangements; modularity; information hiding; abstract data types; structured design; prototyping; waterfall methodology for software development; formal methods (program correctness); technical and management mix (program correctness); Royce's sequential "waterfall" process model; quantitative approaches, e.g. productivity issues (Boehm, 2006);

The 1980's – productivity and scalability improvements; Carnegie Mellon University's Software Engineering Institute established in 1984 to promote software process capability maturity; CMM developed by Carnegie Mellon University; International Standards Organization developed ISO-9001 to cover software related practices; improved practices lead to a reduction in re-work; software tools development (e.g. testing tools, versioning) and integrated development and support environments were major developments (e.g. Integrated Programming Support Environments (IPSE), Computer-Aided SE (CASE), software factories; improved software processes (e.g. staffing, reuse, prototyping, process, tools, management); expert systems; Object-Oriented (OO) approaches; visual programming; powerful workstations (Boehm, 2006);

The 1990's – continued use of OO methods; Unified Modelling Language (UML); Internet expanded; movement away from the sequential Waterfall approach to concurrent engineering of software phases; changing requirements accommodation; Rational Unified Process (RUP); Rapid Application Development (RAD); Agile methods; open source software development (e.g. Linux, Apache, Python); emphasis on Human-Computer Interaction (HCI) (Boehm, 2006);

2.1.2 The modern years

The 2000's – continued RAD emphasis; IT developments (e.g. Google, web-based collaboration); Agile proponents develop the Agile Manifesto; adaptive and risk driven process models; demands for higher quality; commercial-off-the-shelf (COTS) systems development approach; continued software reuse;

model-driven development (e.g. domain models (e.g. banking)); the role of Systems Engineering related to Software Engineering (Boehm, 2006);

The 2010's – rapid change and the need for Agility; global connectivity and large systems of systems and the challenges which these present; integration of skills (e.g. software, systems, marketing, finance, domain skills); systems of systems (SOS); Enterprise Resource Planning (ERP) systems (Boehm, 2006);

The 2020's – increased computational ability on various devices such as smartphones; new platforms (e.g. smart materials, nanotechnology); sensor networks; software engineering challenges for these new platforms and technologies; better and improved SE approaches (e.g. higher levels of abstraction) and tools; bio-computing; autonomic software (e.g. self-reconfigure to cope with changes); improved machine learning (Boehm, 2006);

Another new Software Crisis - There is now even talk of a 2nd Software Crisis characterized by disjointed efforts such as cloud services, parallel processing, etc. which do not seem to address the needed software development capacity (Fitzgerald, 2012).

2.2 The computer industry

The advent of the Industrial era increased the number of calculations (arithmetic) which needed to be reckoned and there was also an increase in the volume of information to be processed efficiently (Eischen, 2000). The human error factor within this large volume also further advanced the need for some form of mechanical machine (i.e. a computer) to do the processing. Charles Babbage's Difference Engine (1821) was just such an attempt (Charles Babbage Institute, 2012).

Another important development in the history of the mechanical computer was the mechanical system developed by Herman Hollerith (Eischen, 2000) in 1890 to process census data. The census data was processed in a record 6 weeks as opposed to the previous period of seven years (University of Columbia, 2011). Hollerith is regarded as the father of modern automatic

computation and started a company which eventually become International Business Machines (IBM) in 1924 (University of Columbia, 2011).

Another important development was the Colossus computer built by Thomas H. Flowers at Bletchley Park for code breaking during the 2nd world war. The computer assisted with the cryptanalysis of the Lorenz cipher (Copeland, 2015).

An important development occurred at Harvard University where the Mark I programmable computer was built in 1944 which used digital architectures and data (Eischen, 2000). This computer was also implemented by IBM as a combination of computing and business machines.

In 1944/45, Moore School of Electrical Engineering (Pennsylvania university), completed the ENIAC which is recognised as the world's first electronic computer (Eischen, 2000). There was also a 2nd version called EDVAC.

John Von Neumann (Princeton University/Manhattan Project) and others in 1949 defined an architecture consisting of: stored-programs; binary logic; input/output units; control unit; arithmetic unit. Computers used today still have this basic architecture (National Academy of Sciences, 2012), (Eischen, 2000).

Large scale mainframe computers (data processing machines) were dominant throughout the 1950's and 1960's. Hardware and software were packaged together as solutions to address the specific data processing needs of users despite the invention of the stored program which had the possibility of splitting this hardware/software combination.

Another major hardware development which advanced computing power and reduced size was the integrated circuit (IC) (1959) which allowed for a number of transistors to be mounted on one silicon chip (Eischen, 2000). This reduced size lead to the broader use of computers.

In 1964, IBM launched the System/360 which allowed for software to be used on all similar systems. This accelerated the divide or split between hardware and software which ultimately led to the development of the software industry.

Commercial use of computers started in the early 1950's with the career or job title of *programmer* being defined in the late 1950's by IBM (Mahoney, 1990). By 1968, according to Mahoney, there were about 500 companies producing software and the number of programmers in employment in these and allied companies was about 100 000 with the need for about 50 000 more. During the 1960's, these programmers used assembler or machine language as the primary programming language. The following programming languages emerged thereafter: FORTRAN (1957), Algol (1958) and COBOL (1962) (Wirth, 2008).

In 1971 Intel created the microprocessor which was housed on a single chip where all the components needed for computation resided, (Intel, 2011), (Eischen, 2000).

2.3 The software industry and the role of the United States

Although it may be costly to produce software, it is relatively inexpensive to reproduce multiple copies of the same software. This is in contrast to hardware where the costs associated with reproduction of similar multiple copies can be as costly as producing the first product. This low reproduction costs of software is said to be quite unique in the services industry (Steinmueller, 1995).

The way in which a particular country's software industry developed and evolved proved to be dependent upon historical and institutional (e.g. government) factors.

2.3.1 Prior to 1965.

Early computers were programmed by wiring and rewiring. The work of Alan Turing (Hodges, 2012) and John von Neumann (National Academy of Sciences, 2012) after the 2nd world war, made this rewiring effort redundant

with the development of the stored program (Steinmueller, 1995). This meant that a general purpose device (i.e. a computer) could be used for a multiplicity of different applications depending on the purpose of the stored program. Initially computers were mainly used for scientific problems, but as early as 1956 the development of the Semi-Automatic Ground Environment (SAGE) defence system showed that computers could also be used for non-scientific problems (Lincoln Laboratory, 2012). The development of high level languages such as FORmula TRANslation (FORTRAN) in 1957/58 enhanced the in house development of software for these general purpose machines (i.e. computers) (IBM, 2012). The demand for a more general purpose langange for business applications (i.e. software) led to the development in 1960 of the Common Business Oriented Langage (COBOL) (National Museum of American History, 2012). Most programming was done in-house but there was also the emerging trend to use service bureaux for programming/software development. These bureaux were able to develop specific software such as payroll and accouting systems.

2.3.2 Period after 1965

IBM decided to unbundle software and hardware which resulted in the push for the establishment of the software industry in the USA during the period 1965 – 1970.

2.4 Summary

This chapter gave a brief history of Software Engineering from the early 1950's up until the 1970's. The next chapter covers the literature review for the scope of this research.

Chapter 3
Literature Review

The previous chapter gave a brief overview of the history of Software Engineering; this chapter examines the literature relevant to the research. In this chapter, the literature is reviewed based on the key concepts that define this study, namely: the software industry; information technology; education and curriculum; the computing profession and other related surveys.

3.1 The software industry

When referring to the software industry the definition used by the Institute of Electrical and Electronics Engineers (IEEE) was used, namely, that it comprises companies involved in the development, operation and maintenance of software products (IEEE, 1993). The industry consists of software developers which produce software as commercial products and receive revenue via licences (IBM, 2012).

3.1.1 The software crisis and the emergence of Software Engineering

The term software was first used in 1958 when it appeared in a mathematical journal (Mathematical Association of America, 2000).

Ten years after this, in 1968, the German computer scientist, Prof Friedrich Ludwig Bauer, stated the following: "*The whole trouble comes from the fact that there is so much tinkering with software. It is not made in a clean fabrication process, which it should be. What we need, is software engineering"* (Brennecke & Keil-Slawik, 1996).

The above statement was made at the NATO conference on Software Engineering held in 1968 which formally marked the start of Software Engineering as a discipline (Naur & Randell, 1969).

Prior to 1968, problems around the development and delivery of software had created a perception of a software crisis, hence the planning of the 1968 conference.

The conference was in response to a software crisis which emerged during the 1950's and 1960's (Haigh, 2010). This software crisis was characterized by a number of problems, amongst them, but not exclusively, the following: running over budget; late delivery; increased complexity, ad hoc methods; poor quality (bugs); demand for new products and software backlogs (Randell, 1979). There existed a "code and fix" approach to developing software and in response to this Boehm writes that what was needed was well organized methods and improved and better disciplined practices to deal with the rise in demand for an increasing number of large and complex software projects/products (Boehm, 2006).

By the late 1960's there was much activity in the area of computing but techniques to manage the quality of programming work and programming staff was still lacking.

3.1.2 Software Engineering

In a seminal paper published in 1975 the principles, goals and processes associated with Software Engineering are clearly stated (Ross, Goodenough, & Irvine, 1975). This paper promotes a more disciplined approach to software development to avoid or minimize the so-called "software crisis" (e.g. complexity, late delivery, over budget, etc.) which had manifested itself within software construction. Prior to 1975, Structured Programming, which was promoted in 1973 and 1975, gave a number of guidelines to help introduce a more disciplined approach to programming in order to produce software systems with improved realiability on time and within budget (Ammann, 1973), (Baker, 1975).

There are many definitions available for Software Engineering. One of the original well-known ones which is often referred to is that by Naur and Randell who defined Software Engineering as *the establishment and use of sound engineering principles in order to obtain economical software that is reliable and works efficiently on real machines* (Naur & Randell, 1969).

A formal definition of Software Engineering has been produced by the IEEE which states that *Software Engineering is the application of a systematic, disciplined and quantifiable approach to the development, operation and maintenance of software; i.e. the application of engineering to software* (IEEE, 1993).

3.1.3 Software development

According to an article by Brooks, three developments are mentioned which contributed to software development (Brooks, 1987). These are: High-Level Languages (e.g. an abstract program) which promoted productivity, reliability and simplicity; Time-sharing (i.e. reduced system response time) which enhanced productivity and quality; and Unified Programming Environments (e.g. tool-benches) which promoted productivity by intergrating previously developed individual tools. Brooks also mentions Object-Oriented Programming, Artificial Intelligence, Expert Systems, "Automatic" Programming, Graphical/Visual Programming, Program verification, Environments and Tools and more powerful workstations as contributing aspects. Brooks further identifies a number of developments which address the heart of Software Engineering: buying versus building; requirements refinement and rapid prototyping; incremental development and great designers with good practices.

3.1.4 Certification

Due to the increasingly strategic role that software was playing in many aspects of industry, commerce and life, it was necessary to ensure that people developing software had the required knowledge and skills to build good quality software. Certification was an approach to verifying that software engineers and developers had the necessary abilities.

The Certified Software Development Associate (CSDA) certification which is also an International Organization for Standardization (ISO)-accredited certification, was introduced in 2002 as a means to test the abilities of entry-level software professionals (IEEE, 2012). There are no formal requirements but it is recommended that applicants are either recent graduates or have

programming experience. The CSDA is a preparatory step for the certification as discussed in the next paragraph.

The Certified Software Development Professional (CSDP) certification which is an ISO-accreditated certification, was introduced in 2002 as a means to test the abilities of mid-career software professionals (IEEE, 2012). The basic requirements to be eligible are a degree plus four years experience.

3.2 Information Technology

The following section highlights important aspects within information technology.

3.2.1 Gartner's nexus of forces

Gartner has proposed that the latest developments in IT, such as the cloud, mobile communications, big data and social networks will, in future, integrate to form a nexus (or connection) which will have an impact on the way in which business is done (Gartner, 2012). Computing in all its facets (e.g. software development) would need to change to accommodate this new paradigm.

3.2.2 Cloud computing

Cloud Computing is the current computing paradigm which provides computing resources as a utility (Armbrust, 2009). In a recent IEEE Software (March–April 2012) publication, a special section was compiled to consider the practice of Software Engineering in the context of the cloud (Grundy, Kaefer, & Liu, 2012).

3.2.3 Mobile computing

Mobile computing applications for cellular phones, Ipads and similar tablet devices are increasingly in demand as more and more people use these devices for work and recreation—the ITU states that 7 billion mobile subscriptions were recorded for 2015 (ITU, 2015). Processing on these devices has been called *mass-market computing platforms*. The demands of software engineering for mobile applications (e.g. resource constrained devices) are being addressed by

publications such as the one by Salmre which provides guidelines regarding the design and development of software for mobile devices (Salmre, 2005).

3.2.4 Big data

Due to the increased connectivity of smart devices and sensors (with computing capabilities) in what is known today as the Internet of Things, the ability to capture vast volumes of data is now possible (Atzori, Iera, & Morabito, 2010). The way in which this data, which can be structured or unstructured, is stored and processed will impact on software and applications development in terms of the various software layers that will be needed. The role of software middleware will become increasingly important for integration (legacy and new systems) and in easing the way in which applications process the data (Atzori, Iera, & Morabito, 2010).

3.2.5 Social networks

Social networks refers to the way in which people interact with each other in informal ways such as text messaging, photographs, video and audio files in order to share various life experiences (Gartner, 2012). These social applications also generate large volumes of data. It has been reported that Facebook produces 500 terabytes per day (Gupta, Gupta, & Singhal, 2014). The data generated in this way has become increasingly valuable for companies wanting to market products and services to these users based on their habits and behaviours.

3.2.6 End user computing

End user computer Software Engineering (EUSE) is applicable where a computer user creates their own application and where computer support is needed, e.g. a botanist creates a computer application that helps them to classify samples. EUSE has many challenges similar to those faced by professional developers, hence an important role of Software Engineering within EUSE is to ensure quality in such computing applications (Ko & et al, 2011).

Based on the above cutting-edge paradigms and the role of Software Engineering within these, it is clear that Software Engineering continues to evolve to meet the challenges of developing quality software within new contexts.

3.2.7 Information and communication technology policies

Many countries have adopted various ICT policies in order to harness the benefits of information technology and the knowledge society for the improvement of economic circumstances. The presence of such policies promotes the following: development of ICT infrastructure; development of skills; relevant legislation (e.g. data privacy); etc (Yusuf, 2005). India is a particularly good example of a country which has benefited much due to the Indian goverments many policy initiatives to promote ICT (NASSCOM, 2015).

3.2.8 Legal aspects of computing

The legal aspects of computing are concerned with those areas where IT and the law overlap. Since computing today is so pervasive, legal matters need attention in a number of areas such cyber law/Internet law, intellectual property, data privacy, copyright, software licenses, spamming, encryption, censorship, unauthorised access and electronic signatures, amongst others (Ryan & Shpantzer, 2002). Many countries, even states within the USA and other organizations (e.g. International Telecommunication Union) have enacted legislation and policies which address legal matters pertaining to the areas mentioned above. The ITU is an agency of the United Nations attending to ICT issues such as standards and the development of ICTs in developing countries (ITU, 2013). An early example of legislation is the Computer Misuse Act of 1990 (amendments followed) enacted in the UK which subsequently guided other countries when enacting similar laws (The Crown Prosecution Service, 2013).

3.3 Education and curriculum

In the Software Engineering Education (SEE) article by Nancy Read the timeline for SEE is given in Table 1 (Mead, 2009).

Table 1: Software Engineering milestones

1968
Software Engineering as a term starts to be used;
"go-to considered harmful" discussion appears.
1970's
Structured programming and design training offered by IBM;
Master of Software Engineering (MSE) programmes started;
Software Engineering books start to be published.
1980's
Software Engineering Institute established at Carnegie Mellon;
First conference on Software Engineering Education occurs;
MSE curriculum models proposed.
1990's
Forum for the Advancement of SEE starts;
SEI CSEE (Conference on SE Education) becomes IEEE Computer Society CSEET (Conference on SE Education and Training);
SE undergraduate degree programmes obtain accreditation;
Collaborations between industry and universities develop;
Texas Board starts licensing software engineers;
SE Education advanced by distance learning;
IEEE-CS SE code of Ethics developed.
2000's
IEEE-CS adopts SWEBOK;
ASEET (Advanced SE Education and Training) integrated with CSEET;
IEEE-CS offers CSDP (Certified Software Development Professional) certification;
SE programmes offered by many universities;
SE education sessions becomes part of other conferences;

3.4 The computing profession

People with qualifications and work experiences which relate to the broad theme of computing and information technology can obtain membership of international organizations such as the IEEE and ACM and local IT organizations. Often, various levels of membership are possible (e.g. the ACMs senior member) depending on the number of membership years and the number of years of professional experience. These organizations also provide for student membership to encourage students to take on full membership after completion of their studies.

Many countries also provide local organizations or associations, which computing and information technology professionals can join.

In the UK for example, the British Computer Society (BCS), provides a home for such professionals (BCS, 2013). The BCS also fulfils many other roles and functions, e.g. represents and accredits its members, liaises with other bodies in industry and government, awards chartered engineer status, manages various publications, reviews and accredits university courses, etc.

In South Africa, the Institute of Information Technology Professionals of South Africa (IITPSA), formerly the Computer Society of SA, provides a home for all Information and Communications Technology professionals (IITPSA, 2013). IITPSA encourages responsible and professional use of ICTs within SA and interacts with commerce, industry and government to influence policy and support the ICT sector.

The Computer Society of India has been influential in developing the IT industry and is a home to all ICT professionals and students (Computer Society of India, 2013). It also offers many workshops, seminars and courses to further develop its members.

3.4.1 Computing societies

The IEEE Computer Society played a significant role in the development and promotion of computing (IEEE Computer Society, 2012).

The Professional Group on Electronic Computers (PGEC), established in 1951, became the Professional Technical Group on Electronic Computers which was part of the IEEE (formed in 1963). This technical group later became the Computer Group in 1963. The Computer Group changed to the Computer Society in 1971 (Liu, 2011).

The IEEE-CS launched a number of influential publications such as: *Computer Group News* (1966); *IEEE Transactions on Computers* (1968), a monthly publication; The Computer Group News was renamed *Computer* (1972), a

monthly publication as of 1973; *IEEE Transactions on Software Engineering* (1975) (Liu, 2011).

The IEEE-CS formed a number of Technical Committees which arranged conferences, seminars and other meetings to promote its technical scope.

The Association of Computing Machinery (ACM) was established on September 15, 1947 at Columbia University in New York and was in response to the emerging developments and awareness of computers and their applications (ACM, 2013). The ACM and its special interest groups (SIGs) annually sponsor and convene many conferences and technical gatherings which all serve to advance the information technology sector as stated in its constitution. The ACM also publishes many magazines and journals which contain the latest research and industry experiences (e.g. case studies) within the computing and information technology sphere. The most well-known publication of the ACM is the *Communications of the ACM* which covers a broad range of matters of more general interest. All ACM publications are kept within its Digital Library.

3.5 Other software related surveys

There have been recent surveys which covered aspects related to the software industry in South Africa. See Appendix A for details. These surveys were conducted by ITWeb which is a respected and leading business technology media company providing crucial information for SA ICT decision makers for almost 20 years (ITWeb, 2014).

3.6 Software development survey results from ITWeb

3.6.1 Learning's from the ITWeb software development survey:

- By far the majority of companies, nearly 70%, are following an orderly software development process. This is a positive indicator which says that development managers are aware of the advantages of a formal software development approach as opposed to an ad hoc process. This positions SA's software development processes well for pursuing an adoption of the CMM certification. The CMM adoption was an

important factor in putting India into a position where they could attract international companies to perform software development in India. The efforts by the Joburg Centre for Software Engineering in this regard gives impetus to further develop this structured software development approach, and to being increasingly CMM compliant.

- Most companies (about 60%) are performing in-house development exclusively or with some help from external partners. This means that either there is no off-the-shelf software available to be bought that satisfies their requirements or the efforts to customize such software are too great.

3.7 Chief information officer survey results from ITWeb

3.7.1 Learning's from the ITWeb chief information officer survey:

- IT tasks and work is done primarily in-house which is consistent with the Software Development survey which also showed a preference for in-house development.

- Although 67% of CIOs had a concern for the lack of skills, only 27% are attending to it in terms of their strategic priorities. This aspect taken together for the low provision of internships (20%) means that CIOs are dependent on others (e.g. universities) to provide the needed IT human resources.

- The fact that 43% of CIOs are actively looking for specific skills is evidence that there is a shortage of specific IT skills.

3.8 Summary

This chapter gave an overall overview of the software industry, Software Engineering and development, and information technology aspects. It specifically covered aspects which impact on the software industry. What has been learnt from two other surveys which reveal information about software development and the software industry in SA were also discussed. The research design and methodology are presented in the next chapter.

Chapter 4
Research Design and Methodology

Chapter 3 gave an overview of Software Engineering and its development, with a focus on those facets which have impacted the software industry, as well as the key points from other related SA surveys. The study's research methodology and approach are discussed in this chapter.

According to Crotty any research process is guided by four questions: What methods to use? What methodology governs the choice of methods? What theoretical perspective lies behind the methodology in question? And finally, what epistemology informs this theoretical perspective? (Crotty, 1998)

4.1 Epistemology

The word epistemology is derived from the Greek words *epistēmē* (which means "knowledge or understanding") and *logos* (which can be translated as "word"). The term epistemology describes the branch of philosophy that deals with the distinction between justified belief and opinion. According to Crotty, it is about knowing what type of knowledge is valid and possible, see Figure 7 (Crotty, 1998).

4.1.1 Constructionism

For this research constructionism—which assumes that meaning can be derived by interpreting phenomena—was applied. Constructionism is the approach which construes or interprets the world in an attempt to come to terms with the nature of reality employing cognitive processes (Andrew, 2012).

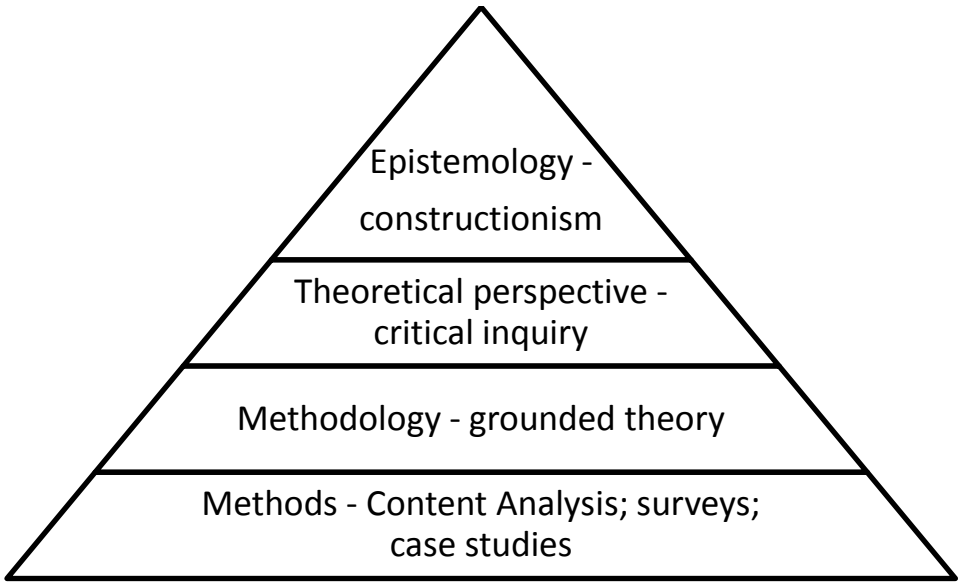

Figure 7: Research elements adapted from Crotty (Crotty, 1998)

4.2 Theoretical perspective

The theoretical perspective is the philosophical stance that informs the methodology, that is, it provides the grounding for the study.

4.2.1 Critical inquiry

Habermas' critical enquiry—his belief is that different kinds of knowledge are shaped by the human interests it serves—was employed as the theoretical perspective (Cohen, Manion, & Morrison, 2001). Critical inquiry attempts to investigate phenomena beyond the usual assumptions and understanding of the phenomena by taking into account the human construction of social forms of life (Habermas, 1972). In his theory of critical social science Habermas opposes the claim that "*science offers an objective or neutral account of reality*" but feels that "*different kinds of knowledge are shaped by the particular human interests that they serve*" (Carr & Kemmis, 1986). Habermas identifies three types of "knowledge interests" which, according to him, drive all human inquiry: the Technical-, Practical-, and Emancipatory knowledge interests (Habermas, 1972).

4.3 Research methodology

A methodology can be described as a set of procedures or methods used to collect and interpret data. The choice of an appropriate method depends on the particular discipline.

4.3.1 Grounded theory

Grounded theory—which suggests that instead of generating theory from *a priori* beliefs, it should be discovered from the data—was employed as the methodology since data was analysed to generate theory (Carr & Kemmis, Becoming Critical, 1983). Grounded theory is the systematic but flexible collection and analysis of data, using different methods, to construct theory. Methods can include interviews, observations, document analysis etc. (Corbin & Strauss, 1990), (Strauss & Corbin, 1994).

The grounded theory model defined by Marey-Perez, Calvo-Gonzalez, & Dominguez-Torres (2014) (see Figure 8), was adapted for this research.

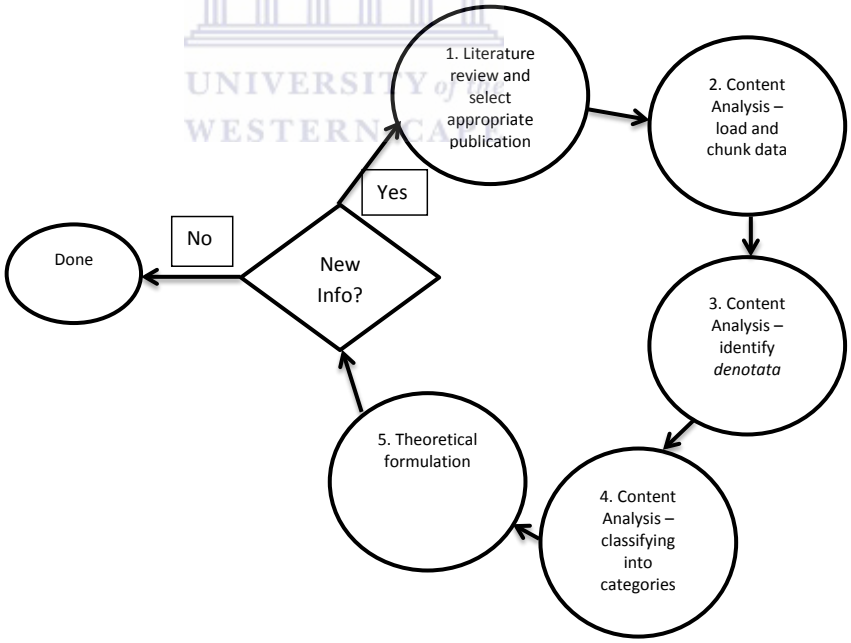

Figure 8: Grounded theory adapted from (Marey-Perez, Calvo-Gonzalez, & Dominguez-Torres, 2014).

The steps carried out by the researcher are as follows:

- Step 1: Selection of relevant literature.
- Step 2: Load the document into the Qualitative Content Analyser software tool, analyse it and break it up (also called *chunking*) into smaller logical sections (Qualitative Content Analyser, 2015).
- Step 3: Identifying *denotata* within the chunks (a section of text which suggests an initiative).
- Step 4: Coding this *denotata* as belonging to a specific existing category or create a new category.
- Step 5: Theory formulation (understanding and explaining the phenomena under study).
- The above steps are repeated iteratively until no new categories can be found.

4.4 Methods

A method describes the way in which data is collected for analysis. The following methods were employed to execute the research.

4.4.1 Content analysis

Content analysis, defined as a multipurpose research method that uses the content of communication as a basis of inference, was the method chosen for this analysis (Cohen, Manion, & Morrison, 2001). It is an activity associated with the examination of documents and text sources to detect the presence of words or concepts relevant to the inquiry or question (Colorado State University, 2014), (Colorado State University, 1993).

Content analysis in essence is a text analysis method which can be used in qualitative research (Kohlbacker, 2006). Originally proposed by Philipp Mayring in the 1980's, it has also been described as a study of human

communications (Mayring, Qualitative content analysis—research instrument or mode of interpretation, 2000), (Babbie, 2001). The types of items which can be studied as part of the content analysis can include any of the following: written documents, transcripts of interviews, observation, video material, etc. At the centre of 'content analysis' is a system of categories (Kohlbacker, 2006). These categories are populated by a process called *coding* which is the act of analysing the text and placing it in one (or more) of the categories which arises from the analysis process. Content analysis has also been described as the identification of underlying themes in the material being considered (Bryman, 2004).

Content analysis is also a quantitative method in terms of the category system where the number of instances of a particular item within a category can be counted (Kohlbacker, 2006).

Mayring's approach results in a qualitative methodology as applied to content analysis and consists of text analysis in terms of a system of categories (Mayring, Qualitative content analysis—research instrument or mode of interpretation, 2000). This text analysis looks for underlying themes in the material being considered (Bryman, 2004).

The content analysis technique applied was inductive category development which is a process that is driven by the research question (Mayring, Qualitative content analysis, 2000). The research question directed the investigation to discover the criteria that contributed to the establishment of the software industry in India and Ireland. The textual analysis searched for any such criteria which satisfied the research question. Identified criteria, referred to as a *denotata*, often shared common properties which lead to the conceptualization and determination of it belong to an existing category which could accommodate it. The existing categories came from an earlier research effort shown in Appendix C. If a *denotatum* does not fit within any of the existing categories, the formulation of a new category is defined. Material is continually worked through until no more new categories emerge. The results are then interpreted often with the help of quantitative analysis

techniques which helps with the calculation of the frequency of *denotata* and categories amongst others. Limitations associated with this technique can occur when the research question is poorly formed (e.g. open ended) and when a holistic analysis is envisaged which does not follow a step-by-step process (Mayring, Qualitative content analysis, 2000).

4.4.2 Survey

A survey is a method to sample individuals from a population in order to determine the respondent's position (view, opinion, beliefs) on certain matters by asking them questions (Mathiyazhagan & Nandan, 2010). For this study a survey was needed to determine the software development situation in the Western Cape region.

An online survey, using the free Google Forms application, was distributed amongst software development practitioners in the software industry of the Western Cape region of SA to gauge the current status of software development for case study 3. The Western Cape was chosen as a subset of SA.

4.4.3 Case study

Yin defines a case study as follows: *a case study is an empirical inquiry that investigates a contemporary phenomenon within its real-life context, especially when the boundaries between the phenomenon and context are not clearly evident* (Yin, 2003).

Hartley gives the following definition of a case study research*: it consists of a detailed investigation, often with data collected over a period of time, of phenomenon, within their context with the objective to provide an analysis of the context and processes which illuminate the theoretical issues being studied* (Hartley, 2004).

Case study research can employ either qualitative or quantitative methods or both (Hartley, 2004), (Yin, 2003). In fact Hartley states that *case study research is a heterogeneous activity covering a range of research methods and techniques* (Hartley, 2004). Case studies can be used when questions starting with *How?* and *Why?* need to be answered and can therefore be used in descriptive or explanatory research (Rowley, 2002).

4.4.3.1 Designing the case study

The research design consists of those steps undertaken to link the research questions to the data collection, analysis and interpretation (Hartley, 2004). Yin identifies the following components of research design as applicable for case studies: the study's questions, the propositions (if any), the units of analysis, linking data to the propositions and the criteria for the interpretation of the findings (Yin, 2003).

4.4.3.2 Conducting case studies

The main steps in conducting a case study are as follows (Yin, 2003):

Collecting evidence

There are many sources of evidence for case studies. Amongst these are the following: documents, archival records, interviews, direct observation, participant-observation and artefacts.

Analysing the case study evidence

Development of categories wherein data, behaviour or processes can be placed, are key activities in analysing the data. Topics, themes or specific questions are all focal points around which data may be organized. Data is also inspected to determine how well or otherwise they fit the various categories. Data analysis involves the searching for patterns in data (Neuman, 1997). In fact it has been said that *the ultimate goal of the case study is to uncover patterns, determine meanings, construct conclusions and build theory* (Patton & Appelbaum, 2003). A software tool called Qualitative Content Analyser (discussed in 4.5) was used to assist in this effort.

Reporting the case study

The results and findings of a case study can be reported in many different ways, with the most typical being a narrative which represents the product of the enquiry (Yin, 2003), (Stake, 2000).

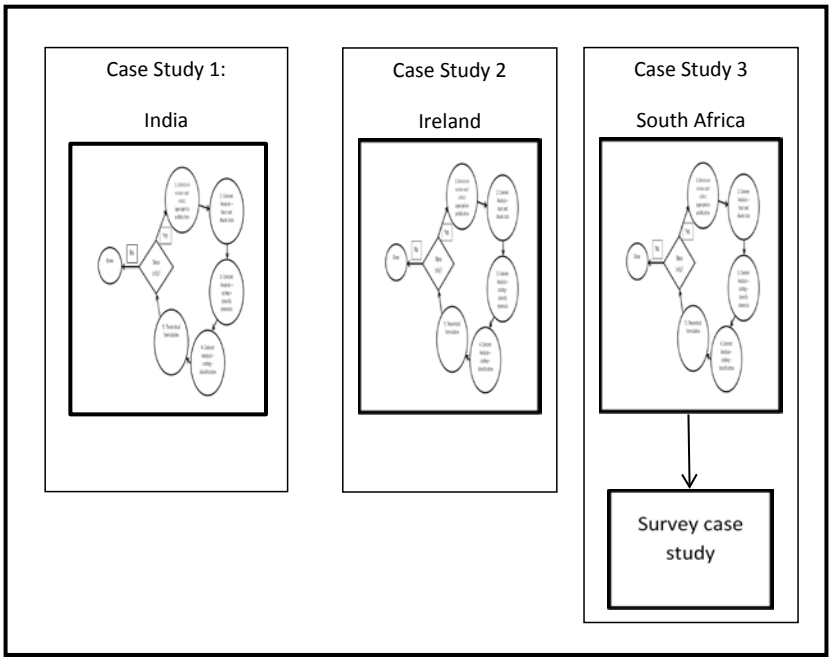

Figure 9: Research design

4.5 Research design

4.5.1 Case studies

Three case studies were conducted using a grounded theory research approach as is shown in Figure 9. For each case study the adapted grounded theory methodology of Marey-Perez et al. (2014), as shown in Figure 8, was employed.

Step 1: Selection of relevant literature

For each case study (dealing with India, Ireland and South Africa) seminal publications and publications with a high number of citations were identified for analysis. At least ten publications were identified (see Table 2, Table 4 and Table 6) in Chapter 5. A few older publications were included in this selection, as they gave information about historical initiatives and factors which helped with the establishment of software industries. Furthermore the information contained in Government Gazettes and trusted websites was also analysed.

High citation publications were chosen since they are indicative of the value and influence of an article (Schoonbaert & Roelants, 1996). Lozano et al. (2012) are of the opinion that there is a "weakening of the relationship between impact factor and a paper's citations in the digital age" and that the number of citations is now a more realistic way of measuring the value of a publication (Lozano et al., 2012).

Steps 2, 3 and 4: Data coding procedures

For these steps the Qualitative Content Analyser (QCA) was used. QCA is a software package that assists researchers with the content (text) analysis of interviews or documents (Bytheway, 2013), (Qualitative Content Analyser, 2015). QCA is based on the work of Schutz (Schutz, 1959). The QCA package was used as supplied without any software modifications. It offers simple methods for content analysis and contains the following main features:

- *Data management*—this allows the user to enter information regarding the data capturers; and allows for categories to be added and structured.

- *Analysis*—this is where most of work is done; text is loaded into QCA from various text sources; after loading, the text is broken up into manageable portions called chunks; by reading through each chunk it can be coded or categorized using identified *denotata*.

- *Browsing*—this feature allows the viewing of the sources, chunks, *denotata*, words and the category hierarchy.

- *Charts and reports*—this allows for the generation of various graphs and reports showing the categories and the chunks associated with these categories.

- *Pair analysis and ontology*—this allows the investigation and reporting of the various co-occurring pairs (within chunks).

Step 2: Text loaded and chunked

The texts of the sources listed were loaded into the QCA tool. The text of each article was then *chunked* (broken up) into smaller logical units of text within the tool.

Step 3: *Denotatum* identification

Each chunk was read and studied for any phrase (*denotatum*), which suggested an initiative (Memidex, 2015). These *denotata* were so identified. The authors Van de Ven et al. (1989) used a similar term (a *qualitative datum)* to define a grouping of words which describes or gives information about an *event*. This *event* then denotes an occurrence of a concept, i.e. the category (Van de Ven & Poole, 1989).

Step 4: Categorization

Each *denotatum* was then classified as belonging to a *category*—a category being a collection of *denotata* which have similar characteristics or properties.

The themes and categories that were defined, or which emerged from the considered text, will be discussed in more in Chapter 5.

Step 5: Theory formulation

Theory formulation is the process of understanding, explaining and even predicting the phenomena under being studied (USC Libraries, 2015). The case studies undertaken were needed to better understand software development and the software industry in the three countries so that the contributing and constraining criteria could be identified. The ultimate aim of the research being the formulation of a strategy for software development and the software industry in the Western Cape region of South Africa.

4.5.1.1 The steps applied to an example

The above process steps are now illustrated by an example.

Step 1: Selection of relevant literature

Consider an extract taken from the source text of Khann & Palepu, 2004.

Step 2: Text loaded and chunked

The full text of the article was loaded into QCA and the text was read with the aim of *chunking* the text into smaller, more manageable portions. The following chunk was created.

Chunk 1—"A U.S. office was opened in 1979 to solicit business, and, with successful projects for various banks, American Express, IBM, and others under its proverbial belt, Tata Consultancy Services (TCS) had established the industry, and its position, by the mid-1980s. In contrast to TCS, Infosys Technologies, another of India's software success stories, is the prototypical example of building a business by leveraging external (i.e., non-India-specific) institutions to compensate for domestic (India-specific) institutional voids. Narayan Murthy, the individual most associated with Infosys today, mused that the biggest challenge facing Infosys was "running a first-world firm in a third world country" (Khann & Palepu, 2004).

Step 3: *Denotatum* identification

From this chunk the following *denotatum* was identified:

> *Denotatum*—"A U.S. office was opened in 1979 to solicit business, and, with successful projects for various banks" (Khann & Palepu, 2004)

However, *chunks* can reveal *denotata* belonging to more than one *category*. As an example, consider the following text chunk:

"Others have started as temporary employment agencies, requiring a few rooms in which to set up a handful of PCs and a telephone. Further, the production of software is not heavily dependent on physical infrastructure such as roads and ports, although a steady supply of electrical power is critical, as is ready access to PCs, workstations and communication, airports, phones, faxes and increasingly, the Internet." (Arora A. , 2002)

The *denotata* "supply of electrical power" was identified and coded as belonging to the category *related factors*, and the *denotata* "ready access to PCs, workstations and communication" was coded as belonging to the category: *computing infrastructure*.

Finally QCA provides the functionality to identify *denotata* that occur with other *denotata* within the same chunk of text. These are then referred to as co-occurring categories. Co-occurring categories may reveal new insights.

Step 4: Categorization

The *denotatum* identified is allocated to an existing category or a new category could be defined to accommodate it. In the first example above, the *denotatum* was classified as belonging to the existing *Business Process Outsourcing* category.

Step 5: Theory formulation

Denotata populating a particular category more than another category indicates that this category had a stronger contribution to the establishment of the software industry. Initially only the contributing factors were searched for, but during this process, so-called constraints *denotata* were also identified and were classified into a category of their own which would hold all such *denotata*. Thus a new category emerged. This helped in forming a holistic picture of "positive" and "negative" factors.

4.5.2 Survey

In addition to the country-wide case study of South Africa, a survey was planned and undertaken amongst software practitioners to better understand software development and the software industry in the Western Cape region so that appropriate interventions may be proposed that would further strengthen and expand it. To prepare a well-organized and productive full-scale survey, a pilot survey was undertaken first to assist with this aim.

4.5.2.1 Pilot survey

A pilot survey was undertaken during May 2015 and June 2015 to evaluate the questionnaire for correctness, clarity, completeness and general effectiveness. Five respondents who were practitioners in the ICT industry were identified and requested to participate anonymously in the pilot survey. This pilot survey consisted of 43 questions about software development and the software industry. See Appendix B for details of the pilot survey and some findings.

4.5.2.2 Full-scale survey

Feedback and comments from the pilot survey participants was noted and the full-scale survey was shortened from 43 questions to 26 more focussed questions and some questions were rephrased to avoid ambiguity.

The full-scale survey, including the initial contacting of companies and individuals was carried out from July 2015 to August 2015. The survey concentrated on the Western Cape region of South Africa, since Cape Town, which is the main city in this region, is being promoted as a software development hub and digital gateway to Africa by business and government (local and provincial) agencies (Wesgro, City of Cape Town, PWC, 2013).

An initial list of software development companies to survey (in the Western Cape) was identified:

- Companies listed under "software" on the web site of the Technology Park Stellenbosch (Technopark, 2012) which is situated in the Western Cape were identified. Each company was telephoned with the request to speak to a software developer or for the contact details of a person involved in software development. An email was then sent outlining the scope of the survey and details of the required profile of the potential respondents. A link to the survey was also provided.

- Companies listed under "software" in the electronic Yellow Pages business directory web site (Yellow Pages, 2015).

- Large companies situated in the Western Cape (e.g. Sanlam, Old Mutual, MWEB, etc.). Personal contacts to software developers within these were made using existing LinkedIn connections or establishing new connections (LinkedIn, 2015). This personal approach was preferred to ensure a good rate of responses.

It was decided to contact at least 100 respondents for information about the status of software development in the Western Cape region (Laerd Statistics, 2015).

Some of the survey questions were open ended and allowed respondents to give textual answers. Such questions were also analyzed using the step process discussed in 4.5.1 and as shown in Figure 8.

4.6 Summary

This chapter gave an overview of the research approach as well as a description of the research design. The results of implementing this research design are discussed in the next chapter.

Chapter 5

Results

In Chapter 4 the research methodology and the design of the research were discussed. The results of the three case studies (India, Ireland and South Africa) are given in this chapter as well as the results of the survey that was conducted in conjunction with the case study of South Africa.

5.1 Case Study 1: India

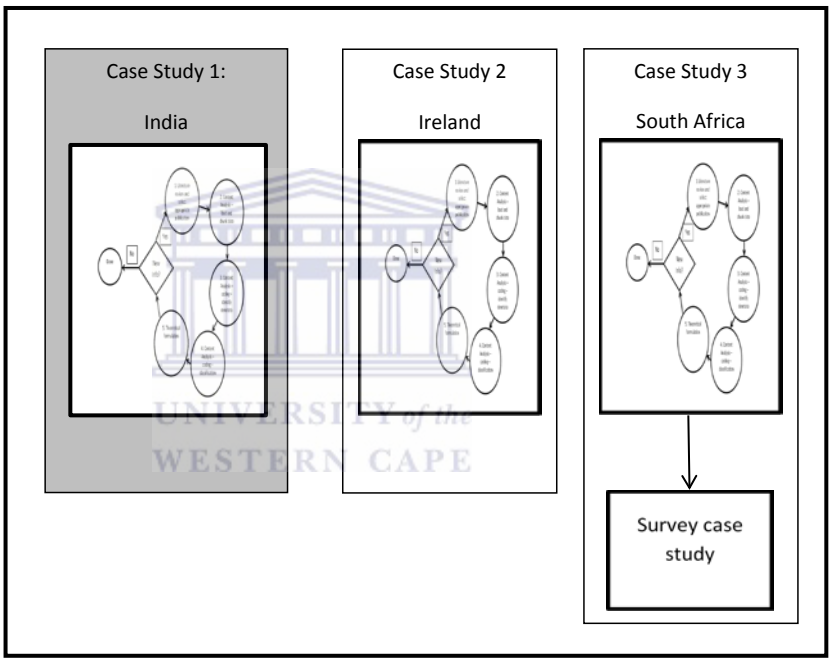

Figure 10: Research design – Case study 1, India

Fourteen seminal publications and a report related to the software industry in India were identified for analysis. This is step 1 of the grounded process model as shown in Figure 11.

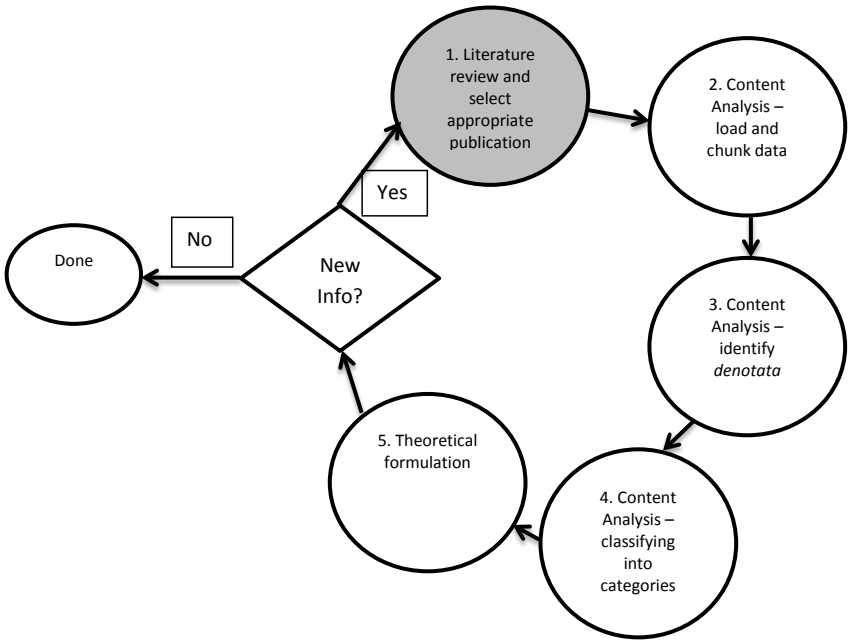

Figure 11: Case study 1: Data source selection

5.1.1 Literature selection

Table 2 depicts the selection of seminal (highly cited) articles and the report selected for the case study about India. The citation number provided by Google Scholar was used as an indicator for all publications used.

5.1.2 Analysis of data

Based on a general literature study of India, a few of the *categories* (or themes) were *a priori* identified and pre-loaded into QCA before the textual analysis started (Norman & Venter, 2013). Other categories emerged during the content analysis process.

Table 2: Publications used for India

Publication name	*Reference*
Embeddedness, knowledge transfer, industry clusters and global competitiveness: a case study of the Indian software industry	(Dayasindhu, 2002)
The Indian Software Services Industry	(Arora, Arunachalam, Asundi, & Fernandes, 2001)
The Indian Software Industry and its Evolving Service Capability	(Athreye, 2005)
Role of Transnational Corporations in the Evolution of a High-Tech Industry: The Case of India's Software Industry	(Patibandla & Petersen, 2002)
The globalization of the software industry: perspectives and opportunities for developed and developing countries	(Arora & Gambardella, 2004)
The Evolution of Concentrated Ownership in India: Broad Patterns and a History of the Indian Software Industry	(Khann & Palepu, 2004)
The software industry and India's economic development	(Arora A. , 2002)
India's Software Industry	(Bhatnagar, 2006)
ICT policy in India in the era of liberalisation: its impact and consequences	(Bajwa, 2001)
New ICT Policy unveiled	(Times of India, 2010)
The road ahead for the Indian IT and ITES industry considering its service offerings, domestic market and technology trends	(Kathpalia & Raman, 2014)
Indian IT outsourcing industry: Future threats and challenges	(Sharma, 2014)
Innovation and internationalisation in the Indian software industry: Wipro - Going forward	(Chatterjee, 2014)
Catching-up or Leapfrogging in the Indian IT Service Sector: Windows of Opportunity, Path-creating, and Moving up the Value Chain	(Lee, Young Park, & Krishnan, 2014)
Indian Software Industry Development: International and National Perspective	(Kumar, 2001)

Chunking

The source documents were loaded and broken into smaller logical chunks. A total of 402 chunks were created from the 15 data sources (step 2 in Figure 12).

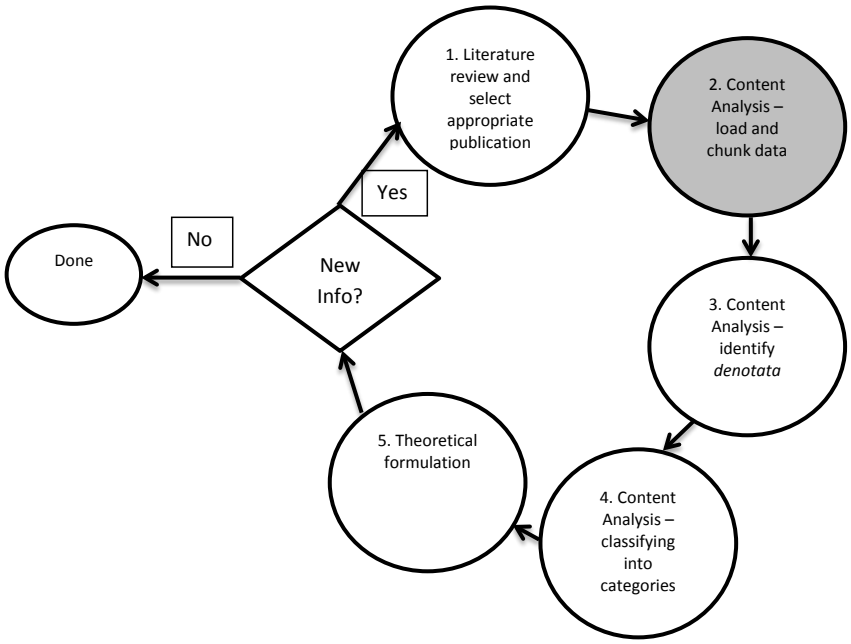

Figure 12: Case study 1: Chunking

Analysis of data—coding and classification

A total of 1066 *denotata* were identified within these chunks and coded into the various *categories*. During the data interpretation process, the new categories that emerged were then added (steps 3 and 4 in Figure 13). The breakdown of the number of *denotata* per *category* (theme) is shown in Table 3 with the newly emerged categories highlighted.

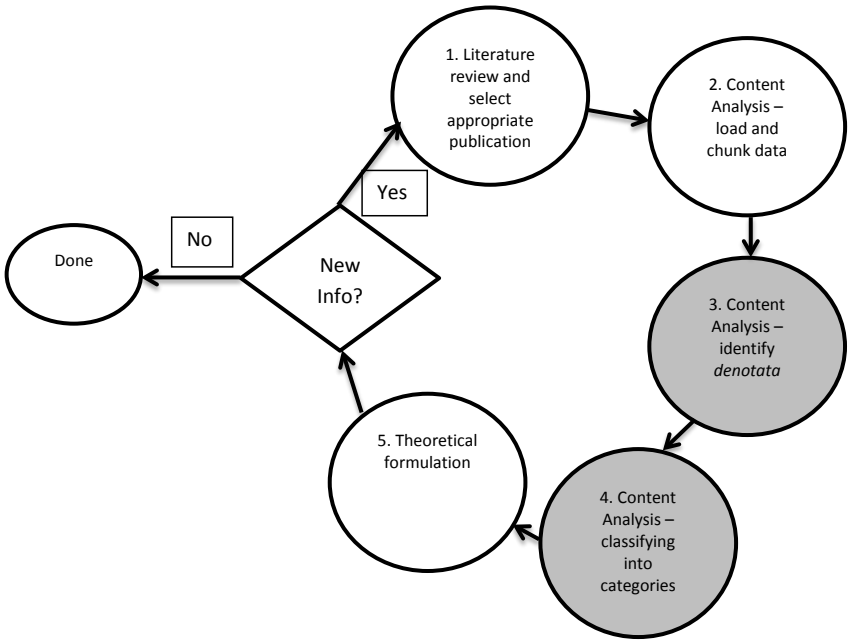

Figure 13: Case study 1: Coding and classification

Table 3: India – count of all data in all categories

Category	*Denotata*
IT/ICT Industry developments	243
Related factors	194
Constraints faced by India	128
New challenges faced by India	81
Policies	81
New initiatives	60
Business Process Outsourcing	56
Human Resource Development	48
IT Training	47
Educational Initiatives	44
Computing infrastructure	26
Capability Maturity Model (CMM)	22
Similarities between India and South Africa	16
Ministry of Information Technology	10
Software Technology Parks	10
Grand Total	**1066**

Theory formulation

The categories that "emerged" during the analysis as factors (criteria) that played a role in establishing the software industry in India and which had not been identified as *a priori* category were then added to the exiting list of categories (Strauss & Corbin, 1994) (step 5 in Figure 14). These are highlighted in Table 3, viz. *New Challenges* and *New initiatives*.

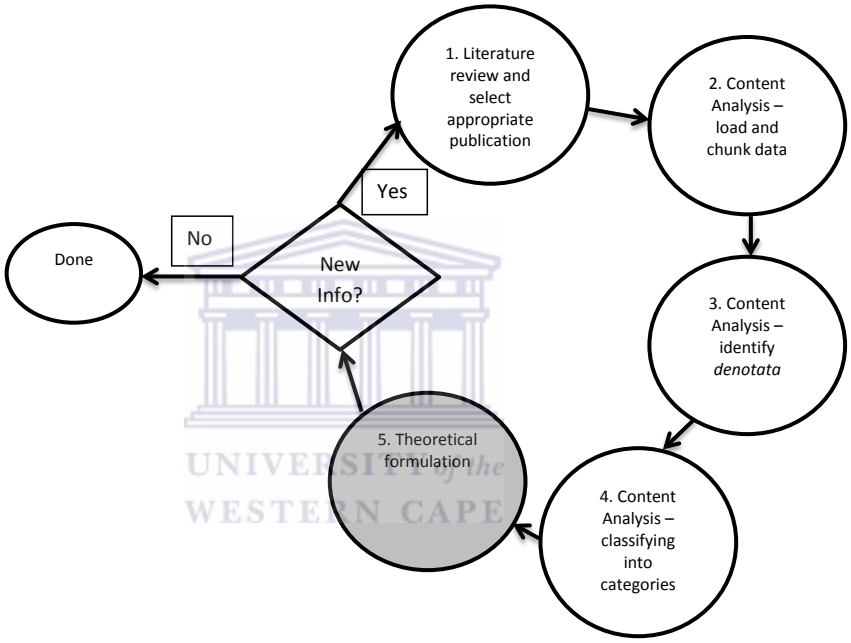

Figure 14: Case study 1: Theory formulation

The *a priori* identified *categories* with the largest (positively contributing) count of *denotata* were: *ICT industry developments*, *Related factors, Policies enacted* and *New challenges faced by India* as shown in Table 3.

Examples of factors listed as *ICT industry developments* were:

- "*The Indian IT companies used the telecom links to facilitate access to client computing environments thus making the Outsourcing work available offshore"* (Kathpalia & Raman, 2014)
- "*The Indian IT industry has been experiencing double digit growth since the last 20 years since its inception*". (Kathpalia & Raman, 2014)

Examples of factors listed as *Related factors* were:

- "*These five firms are TCS, Infosys Technologies, Wipro Technologies, Satyam Computer Services, and HCL Technologies. Wipro, TCS, and Satyam are affiliated with family-owned business groups, which entered the software industry as part of a diversification move by their parent groups*" (Khann & Palepu, 2004)

- "*the NASDAQ listing was designed primarily to gain credibility with customers and to permit the issuance of dollar-denominated stock options to compete in global markets for talent*". (Khann & Palepu, 2004)

Examples of factors listed as *Policies* were:

- "*1992–1999, which saw full financial liberalization in India, large-scale entry by multinational firms and a phenomenal growth in demand for software services*" (Athreye, 2005)

- "*From 1986, software policy was de-linked and made independent of policy directed at the indigenous hardware sector*" (Athreye, 2005)

Examples of factors listed as *New challenges faced by India* were:

- "*So there was now a skewed distribution wherein we had competitors from India, Philippines, China and Russia vying for the same piece of work from one country namely the USA.*" (Kathpalia & Raman, 2014)

Constraints faced by India

India also faced as number of challenges which it has had to address to ensure that these do not become a hindrance to the development of its software industry. Initially when the categories were formed, these hindrances were not specifically looked for but as the coding progressed for other categories, more of these challenges caught the attention of the research. It was then decided to also code these challenges since they could help a country like SA to be aware of these and to thus plan accordingly.

Examples of factors listed as *Constraints faced by India* were:

- "*Until the mid-1960s, there was virtually no software development going on in India. Whatever software sold was bundled with computers sold by multinational companies like IBM*". (Khann & Palepu, 2004)

- "*First, fearing unemployment from automation, the government did not encourage the adoption of computerization in government and state-owned enterprises.*" (Khann & Palepu, 2004)

New information

More publications, recent developments, newer publications and other documentation about the Indian software industry was analysed and this lead to the coining of the *New Challenges* and *New Initiatives* categories. These steps are shown in the highlighted symbols in Figure 15 and the process then repeats itself until all the selected items have been analysed.

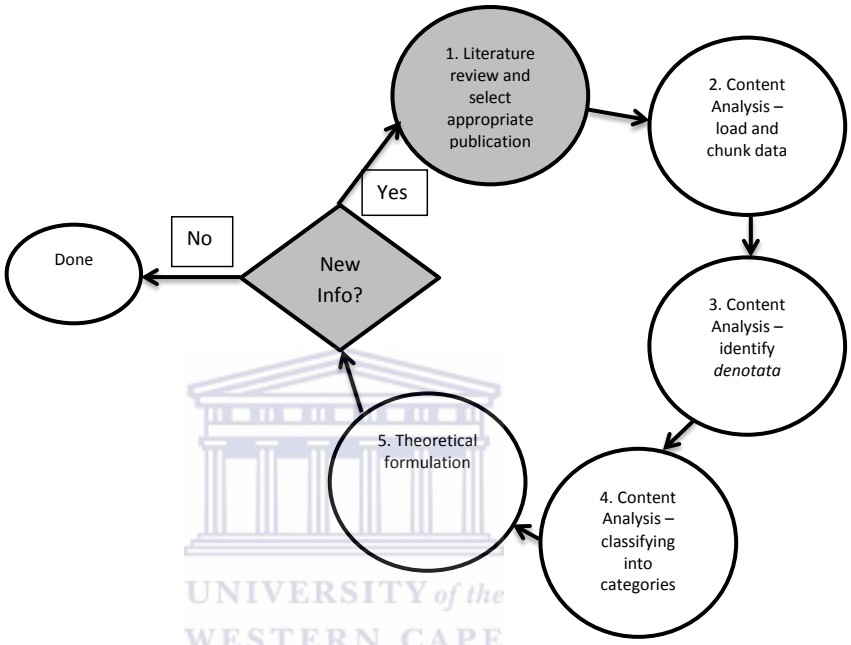

Figure 15: Case study 1: New information search

New challenges which India has to deal with today

The reading of some of the more modern literature about India's software industry revealed that the established Indian software industry faces new "threats" with which it will have to deal with to stay relevant or to improve its position in the world. These challenges are particularly pertinent for SA today, in that the full spectrum of initial and current challenges that India has had to deal with are available for consideration. How India addressed these challenges in terms of policies and strategies and other initiatives and actions needed will be useful when considering SA's case.

Examples of factors listed as *New Challenges faced by India* were:

- "*The problems in the US economy are slowing down the growth rate of the Indian IT industry due to the reliance of the industry on the North American markets. The growth rate for the Indian IT sector has slowed down in the last couple of years*". (Kathpalia & Raman, 2014)

- "*The biggest unique selling proposition (USP) and the single most potent factor for India was the cost arbitrage which was due to the salary of Indian IT technology worker was far more lower as compared to the salary of the US technology worker. This is no longer the case since we now have more and more developing countries like Manila (Philippines), Vietnam, China, Russia offering the same USP of the cost arbitrage*". (Kathpalia & Raman, 2014)

New initiatives to address new challenges in India

The new challenges identified have been addressed in various ways to keep the software industry competitive.

Examples of factors listed as *New initiatives* by India were:

- "*Also there is a lot of technology initiatives which are happening namely the creation of the Indian MNC's , the fact that India is the second largest base of cellular phone users, the technology initiatives of the Indian government, the automation initiatives in the SME (Small and Medium Enterprise)*". (Kathpalia & Raman, 2014)

- "*As per the research firm Zinnov the Indian domestic IT market is expected to grow between 15-18 percent in 2013*" (Kathpalia & Raman, 2014)

5.2 Case Study 2: Ireland

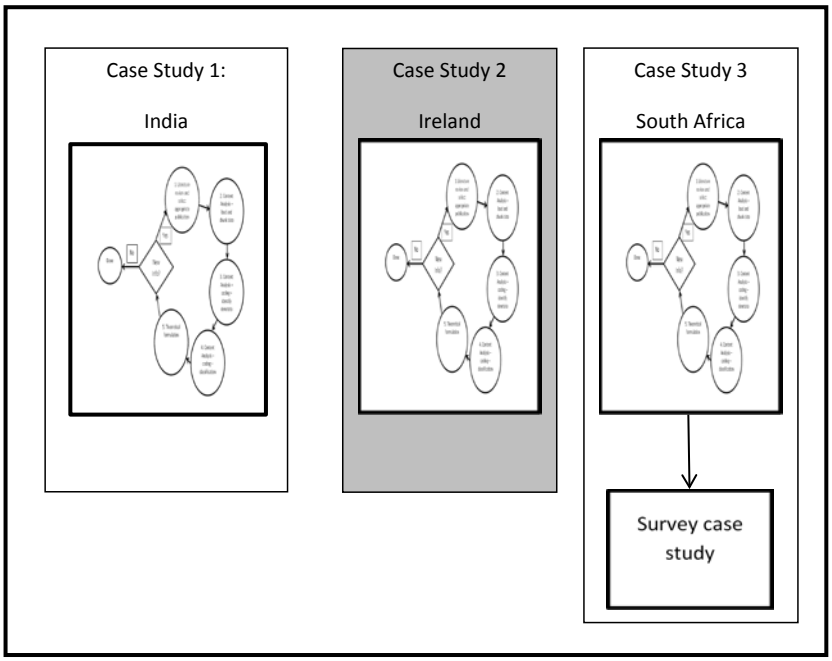

Figure 16: Research design – Case study 2, Ireland

The same grounded process steps (steps 1 to 5) as outlined for India Figure 11 to Figure 15 are similarly applicable for Ireland's case study.

5.2.1 Literature selection

Table 4: Publications used for Ireland

Publication name	*Reference*
Knowledge intensive service activities in the Irish software industry	(Martinez-Solano, Giblin, & Walshe, 2005)
Foreign Direct Investment, Industrial Policy and the Emergence of an Irish Indigenous Software Cluster	(Barry, 2008)
The internationalization of small computer software firms: A further challenge to "stage" theories	(Bell, 1995)
Competitive Advantage in the Irish Indigenous Software Industry and the Role of Inward Foreign Direct Investment	(O'Malley & O'Gorman, 2001)
Software in Ireland: A Balance of Entrepreneurship and…Lifestyle Management?	(Cusumano, 2005)
Links between multinational firms and domestic firms: A comparison of the software industry in India, Ireland and Israel	(Giarratana, Pagano, & Torrisi, 2003)
Ireland: A Software Success Story	(Cochran, 2001)
An Offshore Silicon Valley?	(O'Riain, 1997)
In the footsteps of Silicon Valley? Indian and Irish software in the international division of labour	(Arora, Gambardella, & Torrisi, 2004)
The globalization of the software industry: perspectives and opportunities for developed and developing countries	(Arora & Gambardella, 2004)

Relevant documentation about the software industry in Ireland (see Table 4) was selected.

5.2.2 Analysis of data

These articles were loaded into QCA for analysis. The categories derived for the Indian study were used as a starting point. These were pre-loaded into QCA before the Irish textual analysis started. A total of 380 chunks were created from the ten data sources. A total of 749 *denotata* were identified within these chunks and coded into the various categories. A breakdown of the number of *denotata* per category (theme) is given in Table 5 with the newly emerged category highlighted.

Table 5: Ireland – count of all data in all categories

Category	*Denotata*
IT Industry	231
Related Factors	206
Constraints faced by Ireland	68
Policies	54
Educational Initiatives	38
Software Products	36
BPO	24
IT Training	23
Ministry involved with IT Software Industry	20
Human Resource Development	18
Software Technology Parks	12
Computing Infrastructure	11
CMM	4
Software services	4
Grand Total	**749**

Examples of factors listed as *IT industry* developments were:

- "*Indeed, many markets within the software industry are being consolidated and there has been heavy merger and acquisition activity in recent years. For some top software companies, such as Computer Associates and Symantec, acquisitions have been a large proportion of their growth in recent years."* (O'Riain, 1997)

- "*Some firms which provided `bespoke' or custom services to businesses expanded this business into making consultancy kits and then into products, gradually expanding into export markets"* (O'Riain, 1997)

Examples of factors listed as *Related factors* were:

- "*Although India and Ireland are different on many respects, especially size and development stages, along with Israel, they are the most prominent examples of countries that appear to have benefited from this window of opportunity. Both specialise in software and IT services, and have benefited greatly from the increased demand for software workers"* (Arora, Gambardella, & Torrisi, 2004)

- "*Although we cannot document these forces adequately in this paper, it is noteworthy that though young, in both the countries, the industry is well served by industry associations that have enjoyed high visibility, both domestically and overseas*" (Arora, Gambardella, & Torrisi, 2004)

Examples of factors listed as *Policies* were:

- "*To support applied university-based R&D, the government established a new body, Science Foundation Ireland, to promote and support worldclass R&D in our country. SFI will administer a fund of about US$400 million just for basic software and IT research over the next few years.*" (Cochran, 2001)

- "*As all countries do, we need to raise Ireland's quality and process maturity standards. The government made a key decision around 1990 to promote the raising of the process maturity level. The Centre for Software Engineering, where I work, was set up in 1991 explicitly to be a national focus for assisting industry in doing this.*" (Cochran, 2001)

Constraints which Ireland had to deal with

Ireland faced a number of challenges which it has had to address to ensure that these do not become an obstruction to development of its software industry. This category emerged during the analysis of India and it was thus an existing category when Ireland was studied.

Examples of factors listed as *Constraints faced by Ireland* were:

- "*MNCs may attract demand away from domestic firms and compete with them in the local labour market*" (Giarratana, Pagano, & Torrisi, 2003)

- "*This suggests that, except for few firms like Iona, Massana and Kindle Banking Systems, the majority of domestic firms have a limited presence in the foreign markets.*" (Giarratana, Pagano, & Torrisi, 2003)

Theory formulation

During the data analysis a new category emerged, viz. Software Products, see this entry highlighted in Table 5.

Examples of *denotata* which were coded as *Software products* are:

- "*A notable example is Peregrine Systems Ltd., a firm which supplies products and services for the card payment industry. This firm relies on fixed price agreements, licensing agreements and other IPR arrangement that serve to protect its proprietary technology*" (Arora, Gambardella, & Torrisi, 2004)

- "*Besides Baltimore, a typical example of this strategy in Ireland is Airtel (software products and services for the aeronautical industry).*" (Arora, Gambardella, & Torrisi, 2004)

- "*For instance, Baltimore Technologies is a leading developer of information security products and services for Electronic Commerce and Internet. It provides total security solutions and a security infrastructure from encryption engines to certificates (including e-signature) and key management architecture*" (Arora, Gambardella, & Torrisi, 2004)

5.3 Case Study 3: South Africa

This case study was needed in order to understand the overall situation in SA before focusing on the Western Cape region.

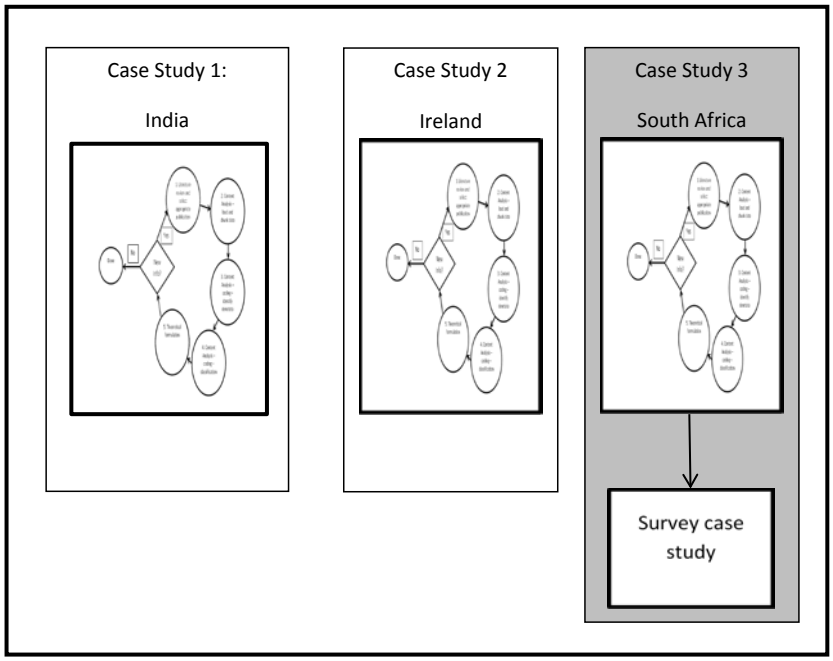

Figure 17: Research Design – Case study 3, South Africa

The same grounded process steps (steps 1 to 5) as outlined for India and Ireland (Figure 11 to Figure 15) were similarly applicable to the South African study (Figure 17).

5.3.1 Literature selection

Nine seminal papers and a report regarding the software industry in South Africa were selected for this case study (see Table 6).

Table 6: Publications used for South Africa

Publication name	*Reference*
South African ICT Skills Deficiency	(de Villiers, Johnson, & Cremer, 2012)
Open source software deployment in the public sector: a review of Botswana and South Africa	(Mutula & Kalaote, 2010)
Digital gateway to Africa - Cape Town's Creative Software Design and Development Sector	(Wesgro, City of Cape Town, PWC, 2013)
Challenges in Ascertaining ICT Skills Requirements in South Africa	(Lotriet, Matthee, & Alexander, 2010)
Africa and the digital divide	(Fuchs & Horak, 2008)
Response: Towards a competitive South African Software Industry	(Hislop, 2011)
The Information Technology (IT) Sector	(Department of Communications, 2014)
Understanding what is happening in ICT in South Africa	(Gillwald, Moyo, & Stork, 2012)
Towards A Better Understanding of the ICT Sector in South Africa: Problems and Opportunities for Strengthening the Existing Knowledge Base	(James, Esselaar, & Miller, 2001)
Building software industries in Africa	(Heeks R. , 1996)

5.3.2 Analysis of data

These publications were loaded into QCA for analysis. Based on the experience gained in studying India and Ireland, the *categories* (or themes) which were identified and emerged for these countries were pre-loaded into QCA before the textual analysis started.

A total of 233 chunks were created from the ten data sources. A total of 375 *denotata* were identified within these chunks and coded into the various categories. The breakdown of the number of *denotata* per category (theme) is shown in Table 7 with the newly emerged category highlighted.

Table 7: South Africa – count of all data in all categories

Category	*Denotata*
Constraints faced by SA	84
ICT Industry	58
Policies	51
Challenges faced by SA	46
Related factors	33
Educational Initiatives	22
Computing Infrastructure	20
IT Training	19
Ministry	19
Software Packages and Products	13
Software Technology Science Parks	6
Business Process Outsourcing	2
Capability Maturity Model	1
Human Resource Development	1
Grand Total	**375**

Examples of factors listed as *ICT industry* developments were:

- "*A relatively sophisticated ICT sector has emerged in South Africa over two decades of telecommunications reform since the mid-1990s*" (Gillwald, Moyo, & Stork, 2012)

- "*Despite South Africa's sub-optimal ICT policy and regulatory environment, its ICT sector continues to grow year-on-year.*" (Gillwald, Moyo, & Stork, 2012)

Examples of factors listed as *Related factors* were:

- "*For example, compared to hardware production, software production has much lower entry barriers because it is less capital-intensive, more labour- intensive, with a lower rate of obsolescence, and (at least for certain types of software) it has far fewer economies of scale.*" (Heeks R. , 1996)

- "*The way forward is clear enough and involves actions such as more staff training, a more professional approach from software company management, and greater customer orientation.*" (Heeks R. , 1996)

Examples of factors listed as *Policies* were:

- "*In South Africa the telecommunications sector has since 2003 been continuously liberalized and privatized.*" (Fuchs & Horak, 2008)

- "*In 1997 the Universal Service Agency (USA) was established, one of its tasks is to finance tele-centres with the help of the Universal Service Fund.*" (Fuchs & Horak, 2008)

Examples of factors listed as *Constraints* were:

- "*South Africa, in spite of its solid political and regulatory environment, is not yet leveraging the potential benefits associated with the ICT sector, according to a World Economic Forum Report. This is due to the lack of basic skills in large sections of the population, the high cost of accessing ICT services and insufficiently developed infrastructure, amongst other things.*" (Department of Communications, 2012)

- "*However, interconnectivity is also introducing new opportunities and challenges in terms of individual rights, privacy, security, cybercrime, the flow of personal data, and access to information.*" (Department of Communications, 2012)

Theory formulation

During the data analysis a new category emerged, viz. *Challenges facing South Africa*. One such challenge is the global shortage of IT staff, which is problem which also impacts South Africa. Taking into account this category allowed for a better understanding of the all the criteria (challenges and constraints) which could impede software development and the software industry in South Africa.

Examples of factors listed as *Challenges* were:

- "*The local operations of many multinational companies in this country are little more than franchises.*" (Hislop, 2011)

- "*We need a national representative Software Society body. While there are many software bodies in South Africa—IEEE, CSSA, SAIEE, BITF, BMF, etc. These tend to represent quite specific markets. While there have also been quite a few attempts to represent the IT industry into government—these have all come to naught. It is really important that the IT industry in general and the software industry in particular speak with one voice".* (Hislop, 2011)

5.3.3 A summary of contributing criteria derived from the case studies

The results of the three case studies are compared and weighted (see Table 8) in order to determine what criteria need to be present to establish a software industry and software development capabilities. This helps to identify the key criteria which will be needed to start or sustain a software industry.

The normalised combined *denotata* count for the three case studies sorted by total weight and placed in decreasing order. It can be seen from Table 8 that the three most dominant contributing criteria are developments and initiatives undertaken within the IT industry, supportive related issues and policies. The table also draws the attention to various constraints and challenges (also

dominant categories) which need consideration so as not to undermine the software industry's growth.

Table 8: Summative count of all *denotata* in all categories sorted

							Total
Category	**India**	**Weight**	**Ireland**	**Weight**	**SA**	**Weight**	**Weight**
IT/ICT Industry developments	243	0.23	231	0.31	58	0.15	0.69
Related factors	194	0.18	206	0.28	33	0.09	0.55
Constraints	128	0.12	68	0.09	84	0.22	0.44
Policies	81	0.08	54	0.07	51	0.14	0.29
Challenges needing attention	81	0.08		0.00	46	0.12	0.20
Educational Initiatives	44	0.04	38	0.05	22	0.06	0.15
IT Training	47	0.04	23	0.03	19	0.05	0.13
Business Process Outsourcing	56	0.05	28	0.04	2	0.01	0.10
Computing infrastructure	26	0.02	11	0.01	20	0.05	0.09
Ministry of Information Technology	10	0.01	20	0.03	19	0.05	0.09
Software Products			36	0.05	13	0.03	0.08
Human Resource Development	48	0.05	18	0.02	1	0.00	0.07
New initiatives	60	0.06		0.00		0.00	0.06
Software Technology Parks	10	0.01	12	0.02	6	0.02	0.04
Capability Maturity Model (CMM)	22	0.02	4	0.01	1	0.00	0.03
Grand Total	**1050**		**749**		**375**		

5.3.4 Online survey

To answer the second and third research sub-question about the status of software development and the software industry in the Western Cape region, an online survey to examine the software industry was undertaken.

Summary of responses

Demographic information

In total 44 IT professionals, out of the 103 contacted, responded via the online survey (thus a 43% response rate).

Forty two of the 44 respondents were male and most were graduates (84%) with 89% employed in their current position for fewer than 10 years. The majority of the respondents were in the age group 20 to 39 years (84%), see Figure 18.

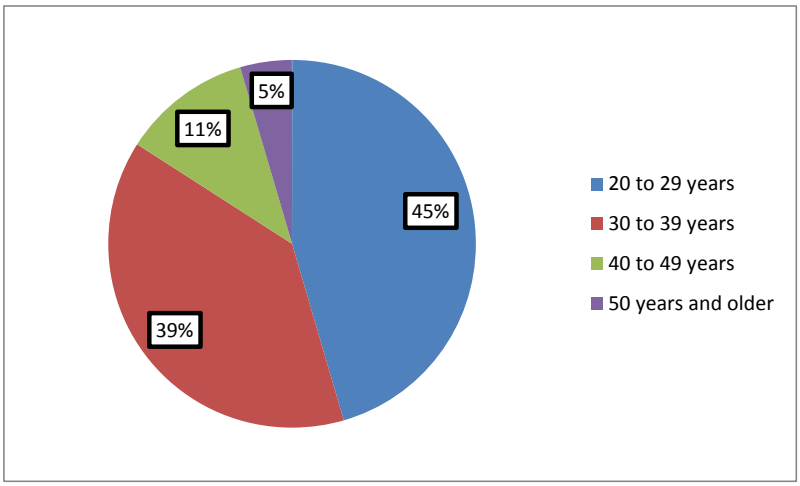

Figure 18: Age distribution

English was the home language of 71% of the respondents, followed by Afrikaans (16%) and isiXhosa (11%).

The majority of the respondents (48%) were employed by ICT companies directly involved in software development (see Figure 19). Most (55%) were small ICT companies (fewer than 250 employees) and some larger companies had their own ICT departments (23%).

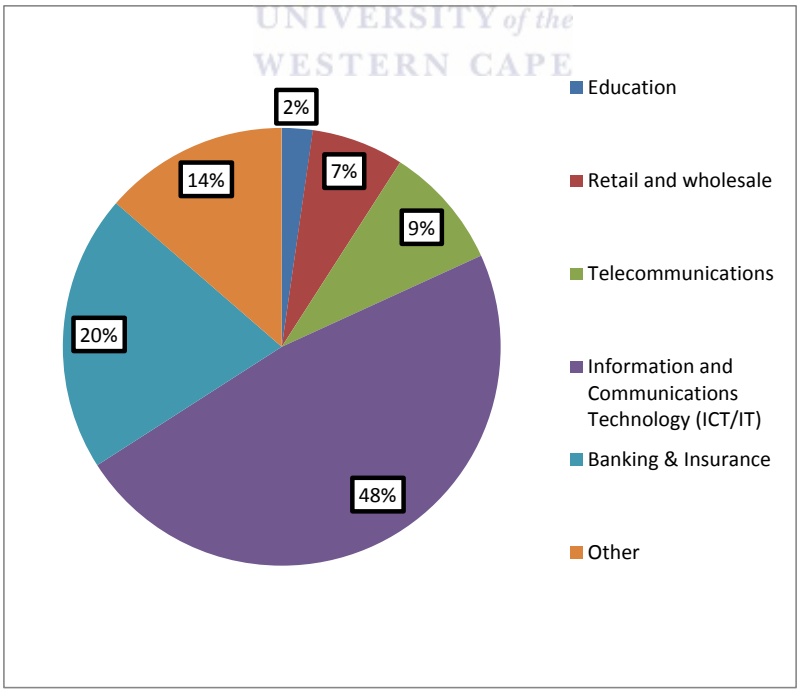

Figure 19: Industry distribution

Most respondents (48%) were software developers or managers of software development teams (Figure 20).

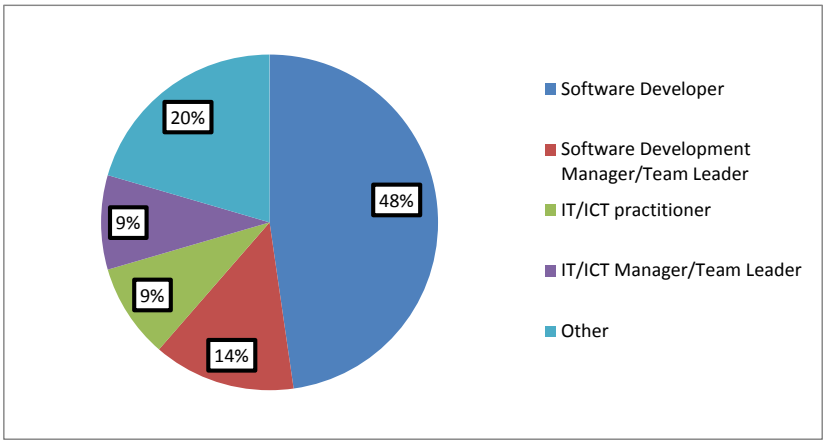

Figure 20: Position/role

Once staff is employed, most were trained further in-house (34%) or a combination of in house and outsourced (41%) training was used.

The majority of the respondents (66%) were satisfied with the software development skills of graduates whom their company employed (see Figure 21).

Software development Skills Information

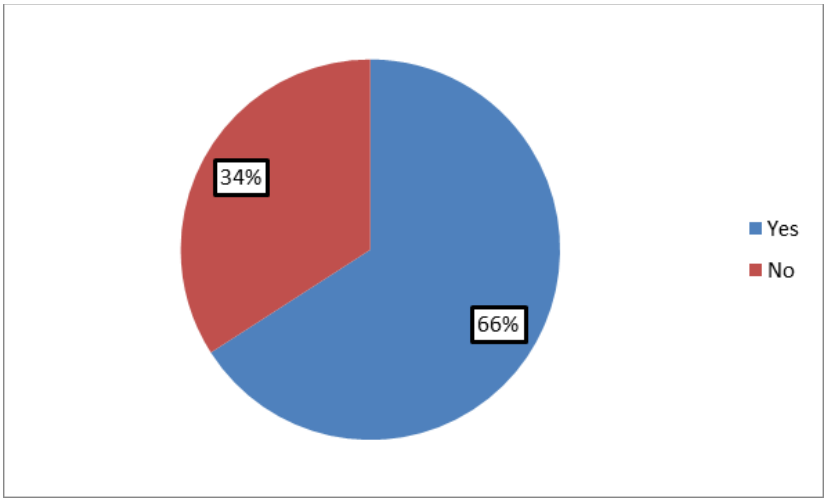

Figure 21: Adequately trained graduates

Most companies (73%) considered a formal qualification important for appointment but also expected their new appointees to have experience (61%).

Most respondents felt that universities (86%) should provide software development education. Many also felt that companies should provide training using internships and training.

The majority of the companies (86%) found it difficult to find staff with suitable ICT skills (see Figure 22).

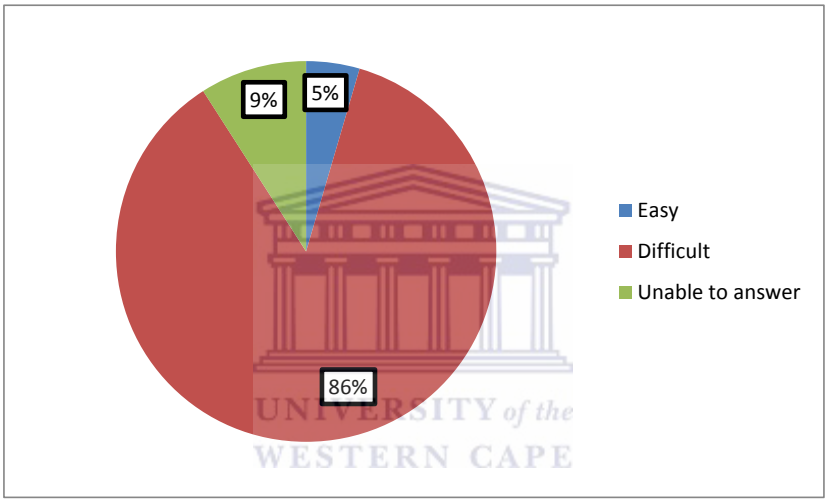

Figure 22: Finding staff with correct skills

Developers/programmers (50%), mobile developers (43%) and software engineers (34%) were the most in demand.

Software development location

Software development was mainly done in-house (59%), however some also outsourced locally and internationally in conjunction with in house development (see Figure 23).

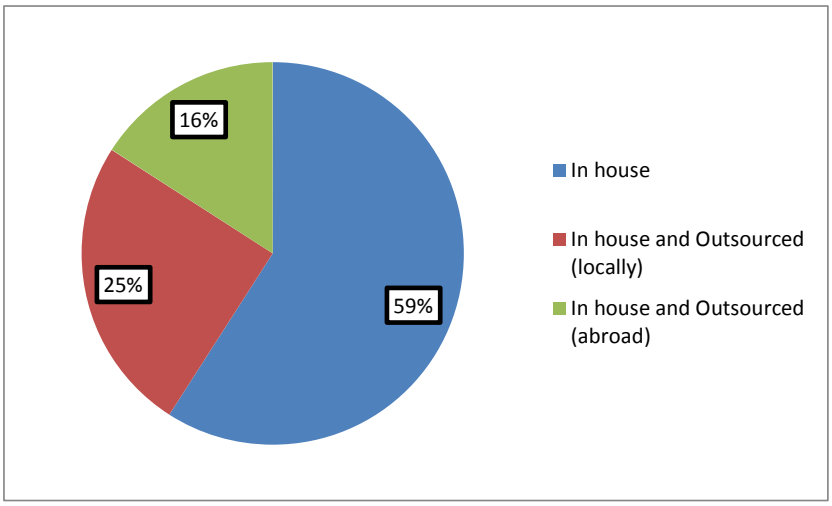

Figure 23: Where software development done

Policies

The majority of the respondents (86%) were unaware of policies that promote IT or software development (see Figure 24).

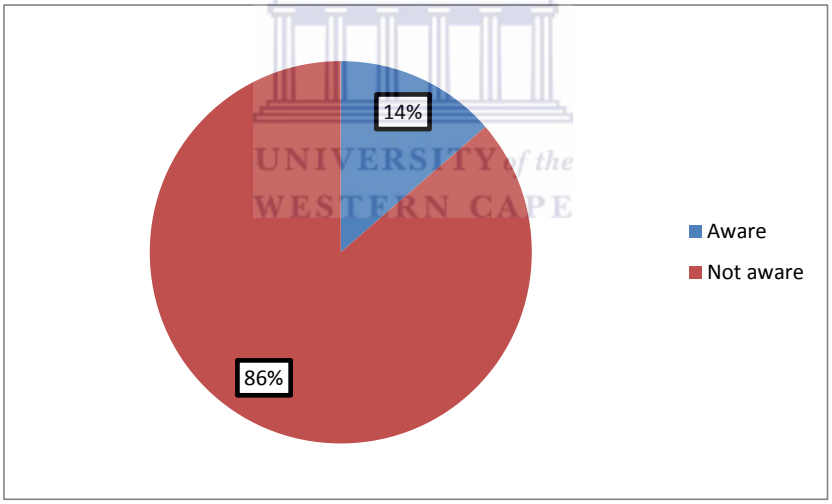

Figure 24: Awareness of ICT policies

Government's role

The majority (82%) felt that government should do more to promote software development (Figure 25).

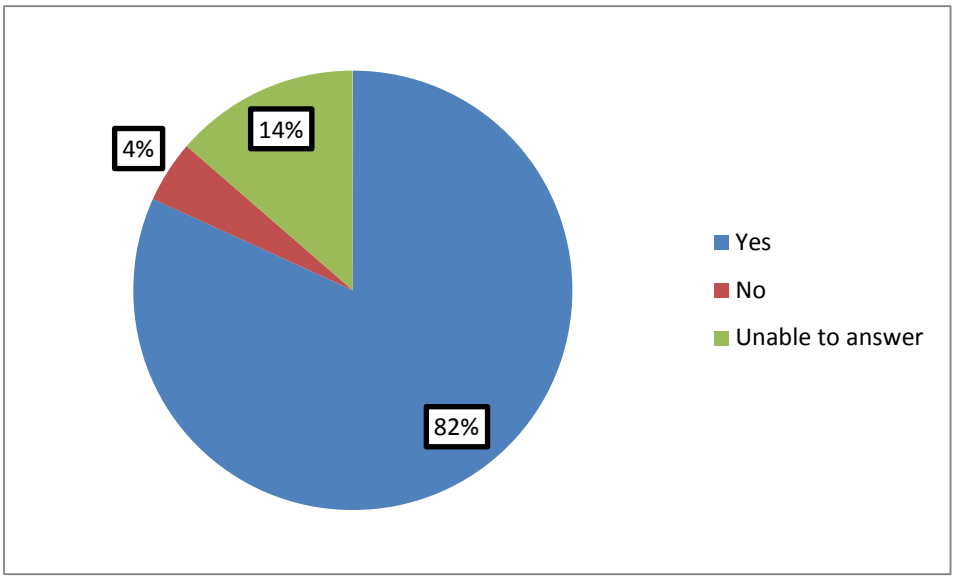

Figure 25: Should government do more

In considering the following open-ended questions where the qualitative results are reported, only the more prominent criteria are commented on.

The categories (or themes) which emerged from the QCA qualitative analysis process, that dealt with what government should do to promote software development, is summarized in Figure 26.

As shown in Figure 26, most respondents felt that government should promote:

- Education at school (expose leaners to software development at school);
- Policies (to make programming one of the compulsory primary/secondary school subjects along with mathematics and physical science; A recent World Economic Forum report confirms that SA's mathematics and science education is lacking as SA was ranked 138 out of 140 nations (WEF, 2015));
- education at university level (The government should invest in tertiary institutions and promote new technologies enabling SA institutions to be at the forefront of innovation in order to compete on an international scale);
- Financial incentives (e.g. Tax & BEE free zones);

- Training—Provide more opportunity for training at school level.

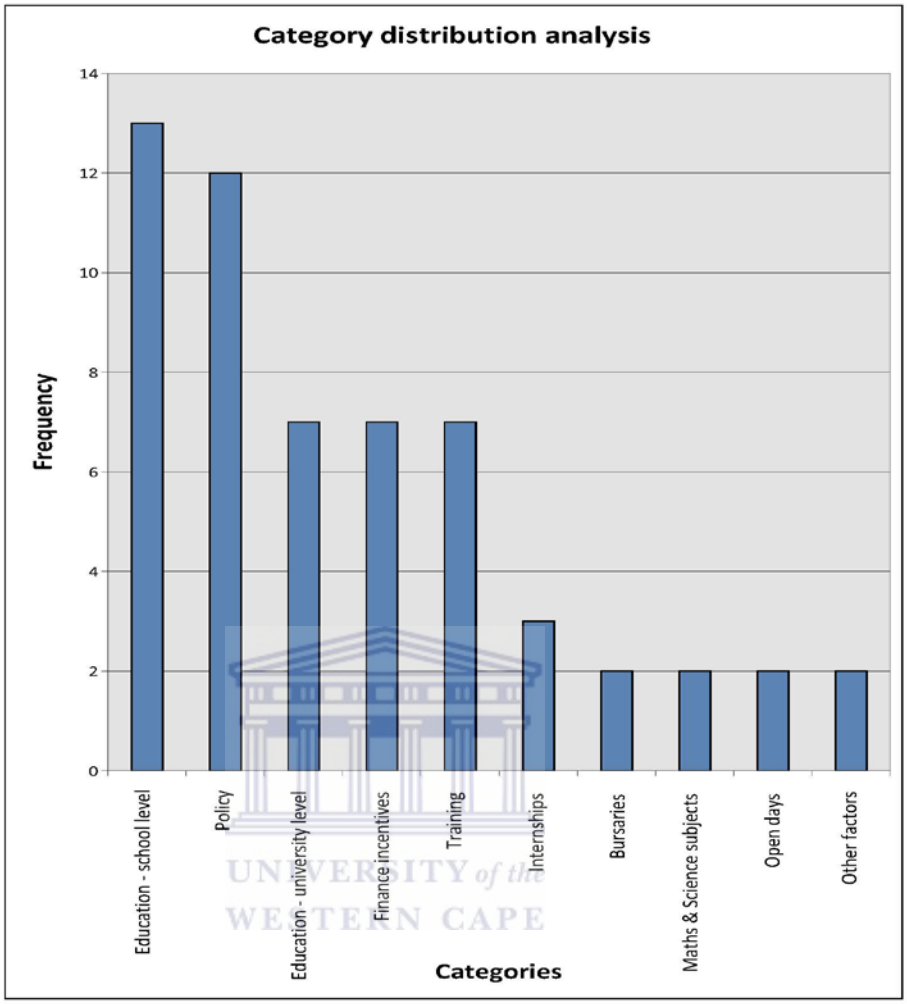

Figure 26: What government should do

The categories that could hinder government in establishing a software development industry are summarized in Figure 27. (This was an optional question for respondents but many choose to answer it.)

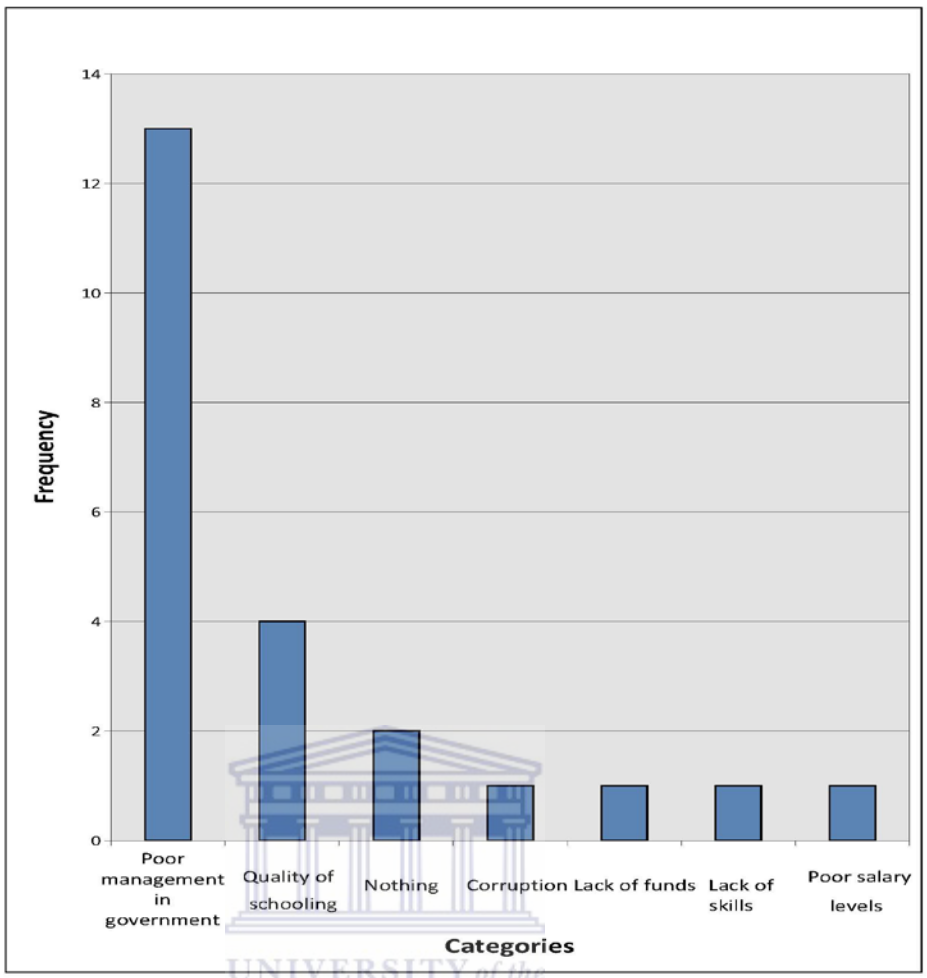

Figure 27: What could hinder government

As shown in Figure 27, the three main areas which respondents felt could hinder government in growing the software development industry:

- Poor management in government (e.g. finding the right candidates to manage the resources)
- Quality of schooling (e.g. reduced requirements around secondary schooling with regards to the quality of mathematics and sciences being taught)
- Nothing—there are no hindrances
- Corruption (e.g. employing unskilled personnel in a highly skilled position)

The role of Universities

The majority of respondents (79%) felt that universities should do more to promote the software development industry (Figure 28).

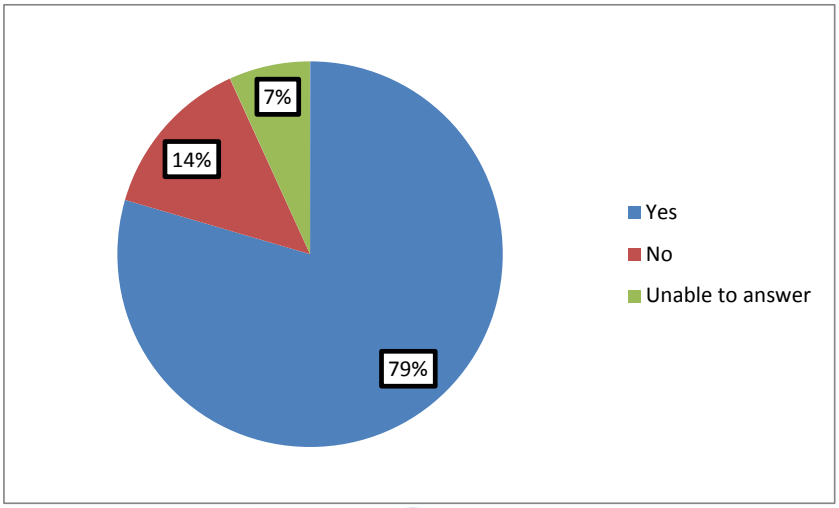

Figure 28: Should universities do more

The three main areas where respondents felt universities could do more were (see Figure 29):

- Curriculum (e.g. align their programs with trends in the local industry);
- Open days and awareness (e.g. organise opportunities for companies and students to meet up more regularly);
- Partnerships (e.g. participate with companies and government in facilitating internships).

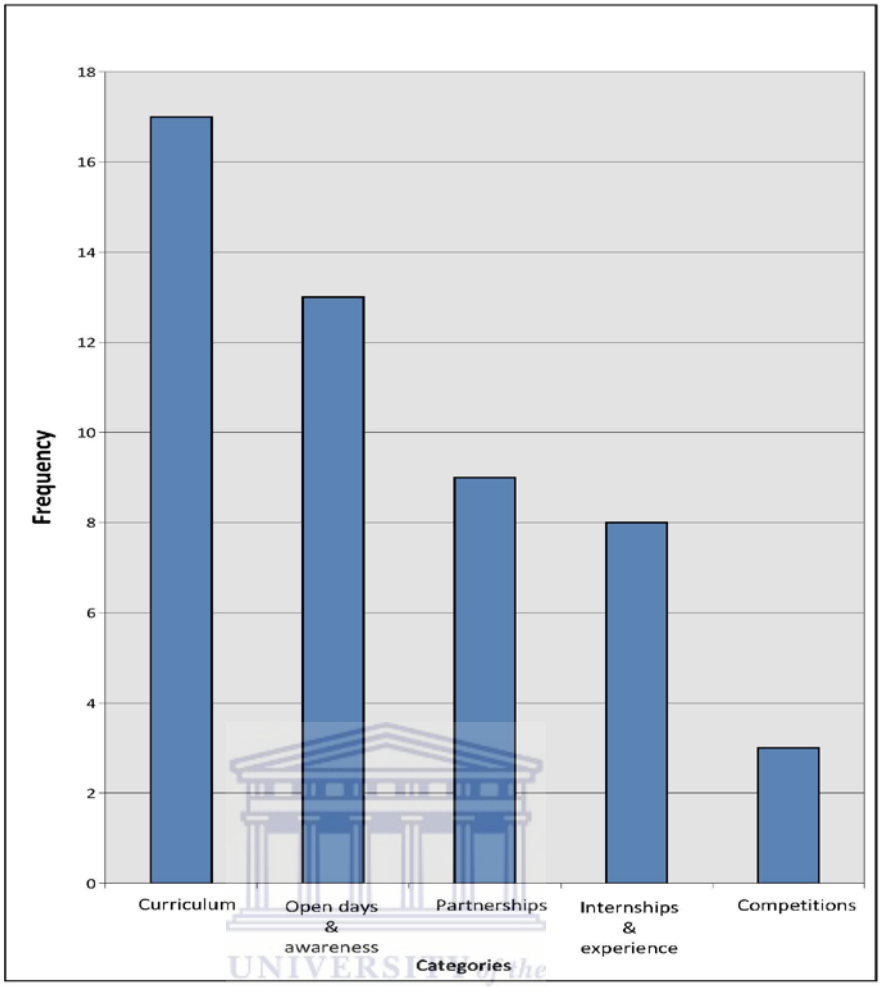

Figure 29: What universities should do

The three main areas which respondents felt could hinder universities were (see Figure 30):

- Lack of vision (e.g. development in a bubble isolated from the rest of the software industry);
- Funding (e.g. lack of funds and interest);
- Staffing (e.g. lack of experienced trainers).

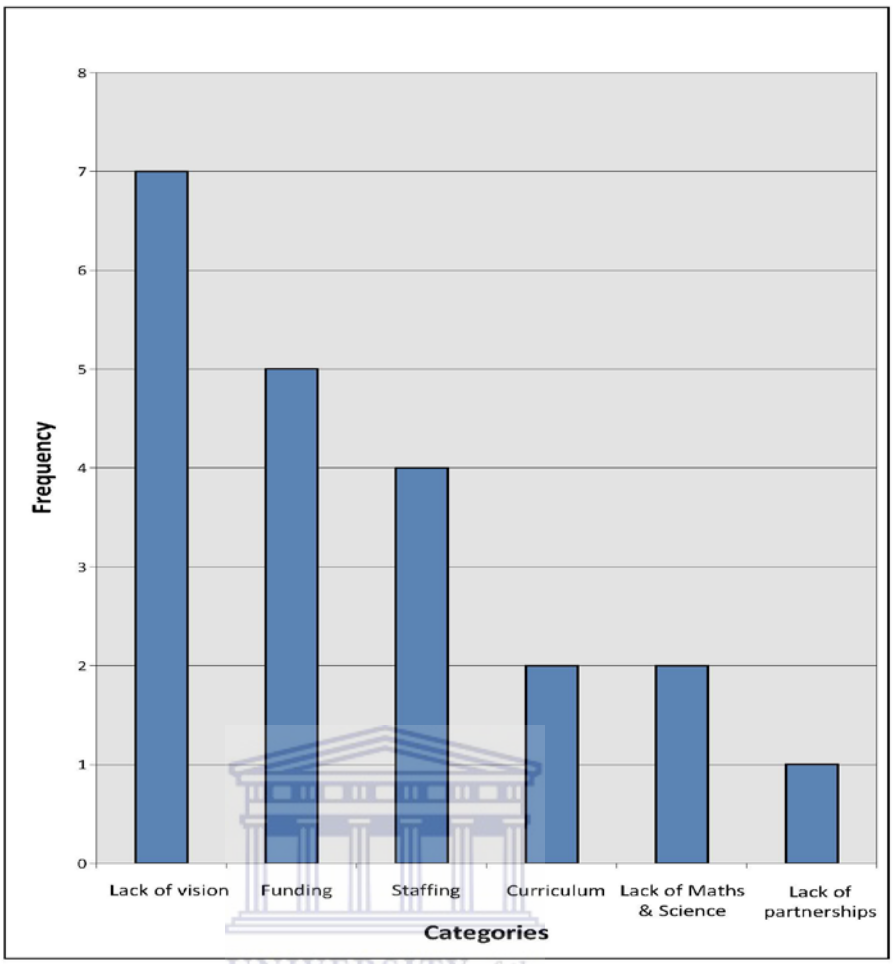

Figure 30: What could hinder universities

Industry's role

The majority of respondents (62%) felt that industry should do more to promote software development (see Figure 31).

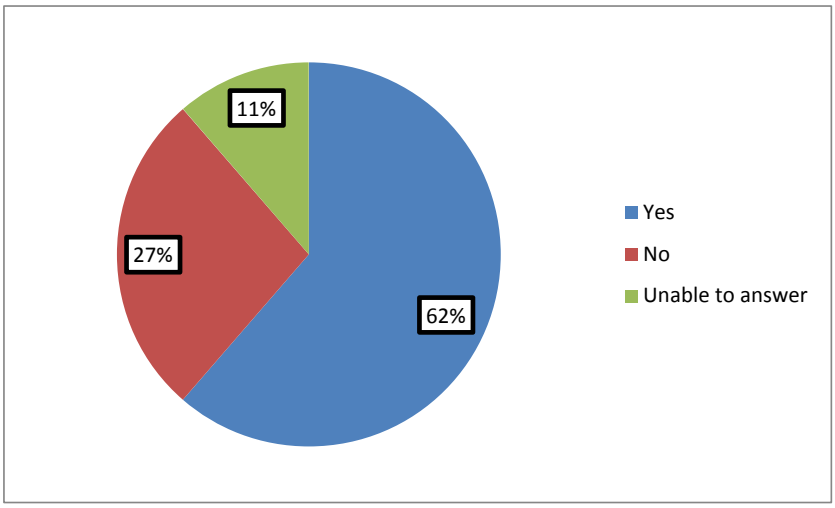

Figure 31: Should industry do more

The areas proposed where industry should do more to promote software development, are summarized in Figure 32.

As shown in Figure 32, the three main areas mentioned by respondents on which industry should focus to promote the software industry are:

- Internships (e.g. internship programs);
- Partnerships (e.g. work closer with educational institutions to ensure that content is relevant to the marketplace);
- Road shows and recruitment (e.g. they should exhibit their software and processes at schools and universities).

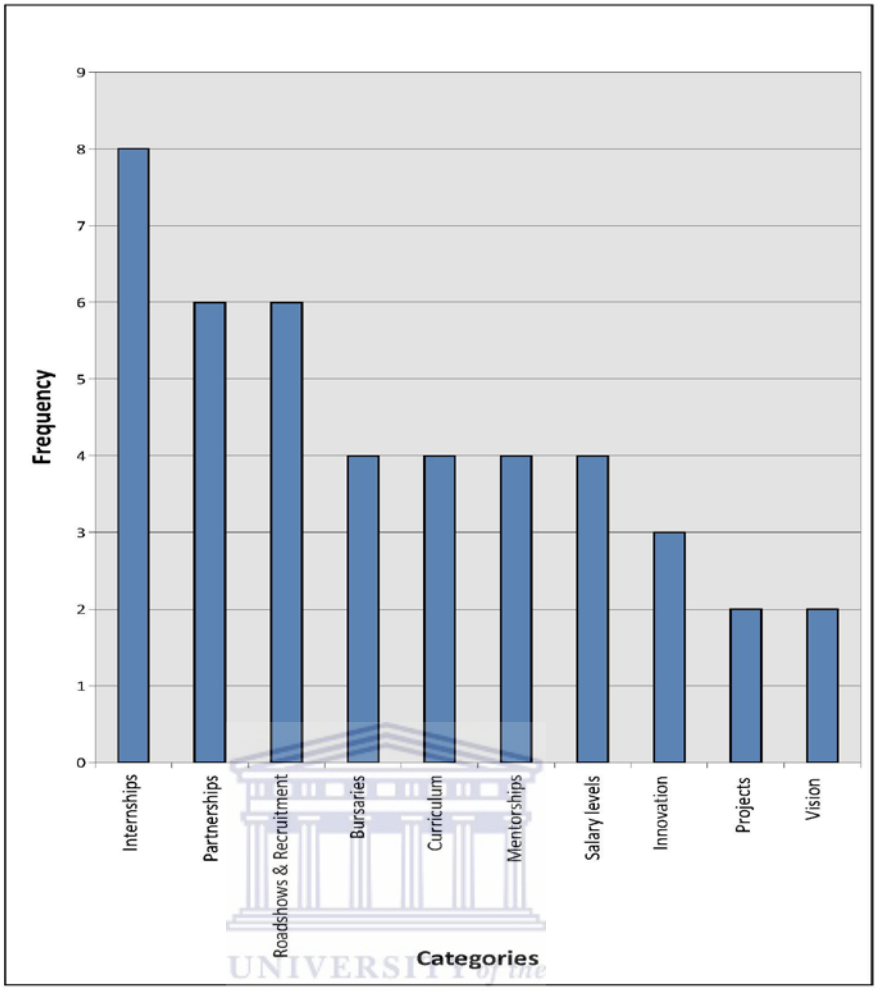

Figure 32: What industry should do

The main categories (or themes) which emerged from the QCA qualitative analysis process, concerning what could hinder industry in promoting software development, are summarized in Figure 33.

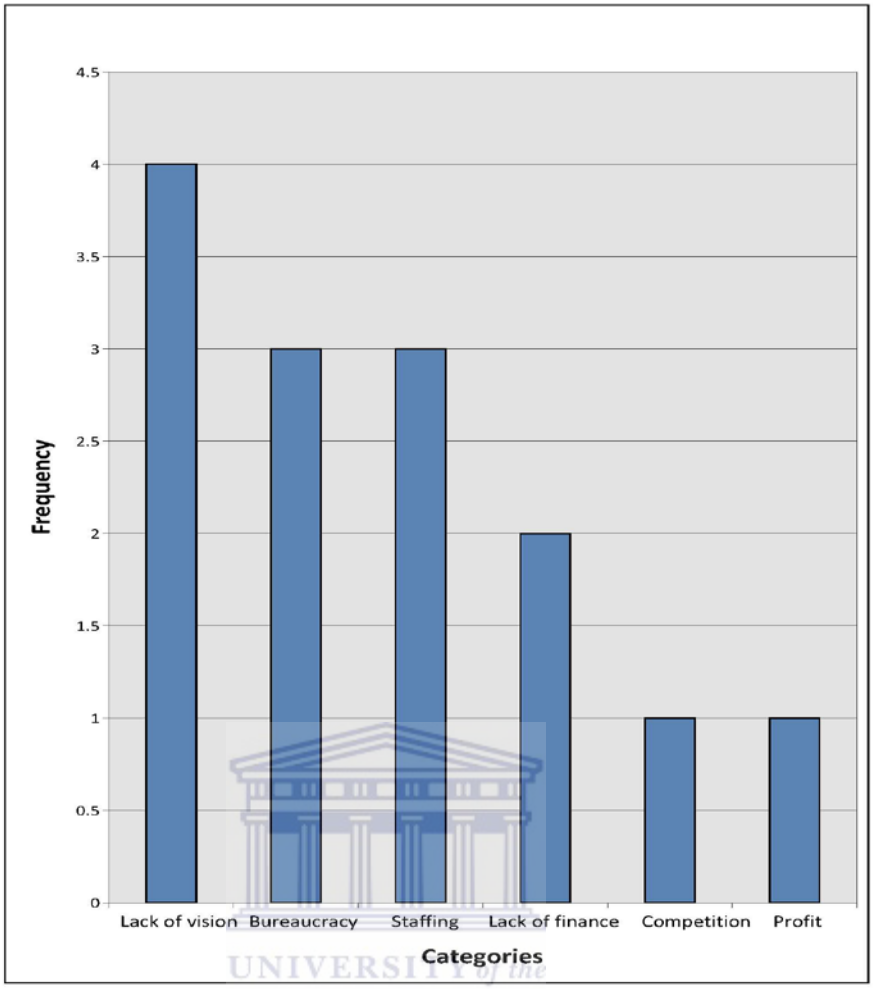

Figure 33: What could hinder industry

These are:

- Lack of vision (e.g. ignorance);
- Bureaucracy (e.g. cumbersome mechanisms to facilitate the engagement of the various parties);
- Staffing (e.g. other professions with more attractive salaries).

The role of Technology Parks

The majority of respondents (73%) were unaware of technology or software parks in SA (Figure 34). Those who were aware mentioned Technology Park in Stellenbosch, Great Westerford, Techno Park in Centurion, Highveld Techno Park and Coega Technology Park.

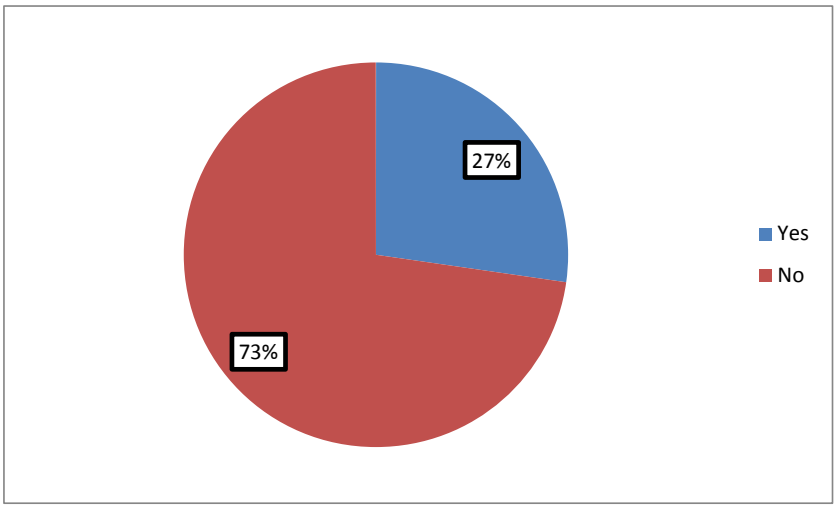

Figure 34: Awareness of IT/technology parks

The majority of respondents (70%) felt technology or software parks are needed in SA (see Figure 35).

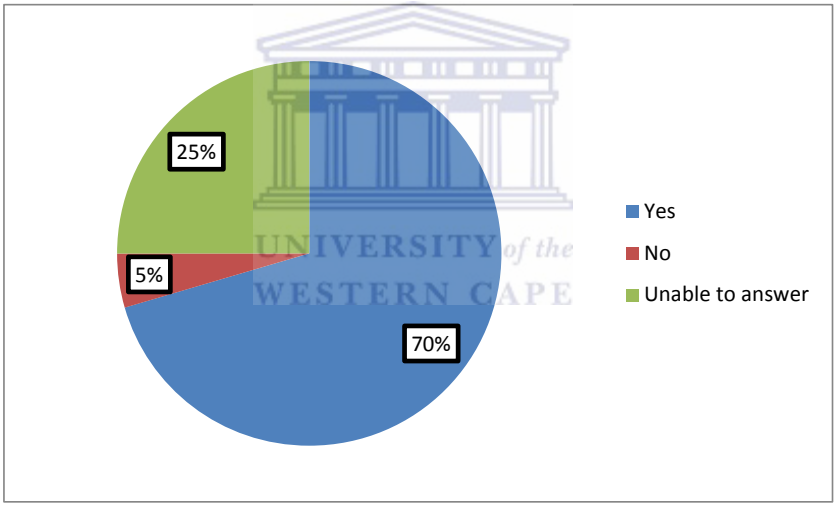

Figure 35: IT/software parks needed

The reasons why technology parks are needed, as mentioned by respondents, are summarized in Figure 36.

Figure 36 shows the main benefit areas which respondents felt are provided by IT/software parks are:

- Knowledge benefits (e.g. needed for interaction and networking in software industry);

- Skills development (e.g. promote more skills and better influence the IT market);
- Awareness (e.g. this will increase the awareness of software industry as a career option);
- Collaboration and partnerships (e.g. need to create a hub for software teams and developers to mix and surround each other).

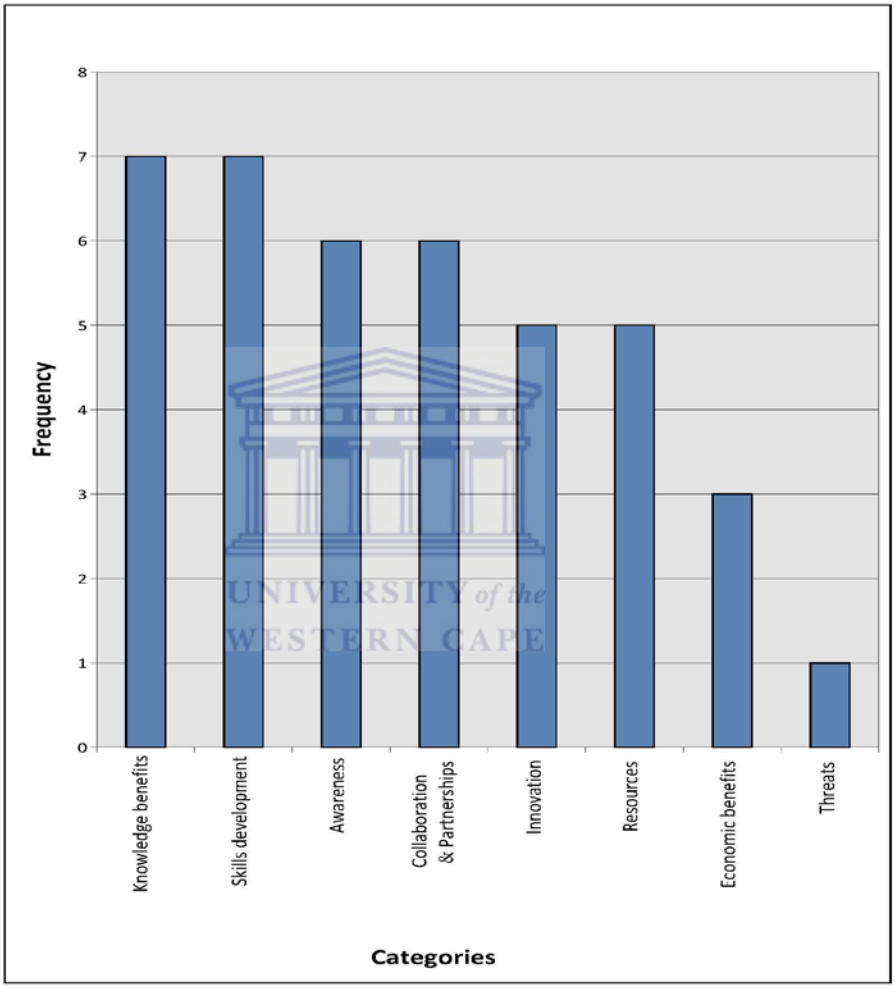

Figure 36: Why IT/software parks are needed

Software Development Promotion

Respondents suggested initiatives which could promote software development in the Western Cape. These are shown in Figure 37.

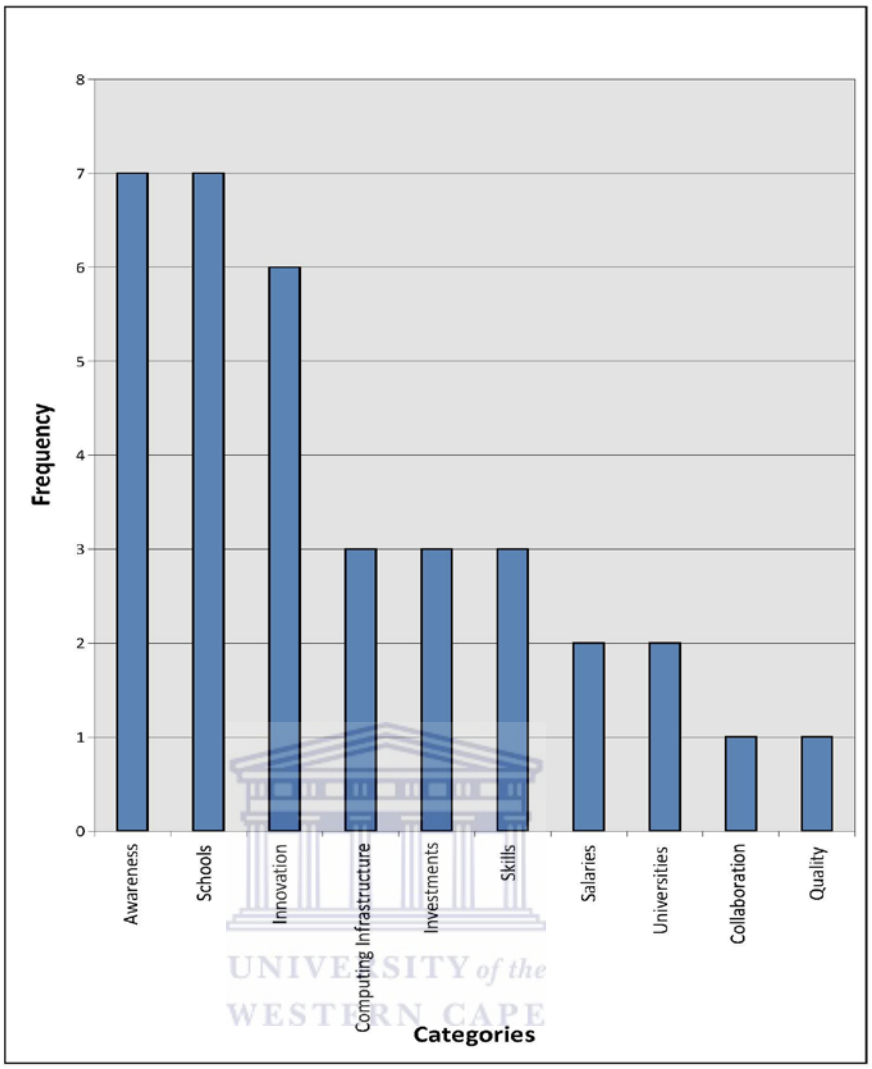

Figure 37: Factors which could promote software development

The main areas of promotion are:

- Awareness (e.g. companies need to be actively involved in tertiary institutions and provide insight into the world of software development from a real world perspective);
- Schools (e.g. Mathematics and Science education needs to be better promoted and the quality thereof must be improved);
- Innovation (e.g. the industry of IT and software development is increasing rapidly and companies need to always be on lookout for new innovative software strategies and skills to supply the needs of consumers).

Software development impediments

The chief impediments which could slow the growth of software development in the Western Cape, as suggested by respondents, are shown in Figure 38.

The dominant areas which respondents felt could impede software development in the Western Cape are:

- Politics (e.g. political rivalry);
- Staffing (e.g. companies are beginning to lose faith in the quality of young software developers entering the market, thereby diminishing the opportunities of employment within the Western Cape for this skill set)
- Computing infrastructure (e.g. lack of tools, infrastructure and technology to provide practical experience in public and private high schools);
- Funding (e.g. lack of resources);
- Schools (e.g. inefficient computer education at school level).

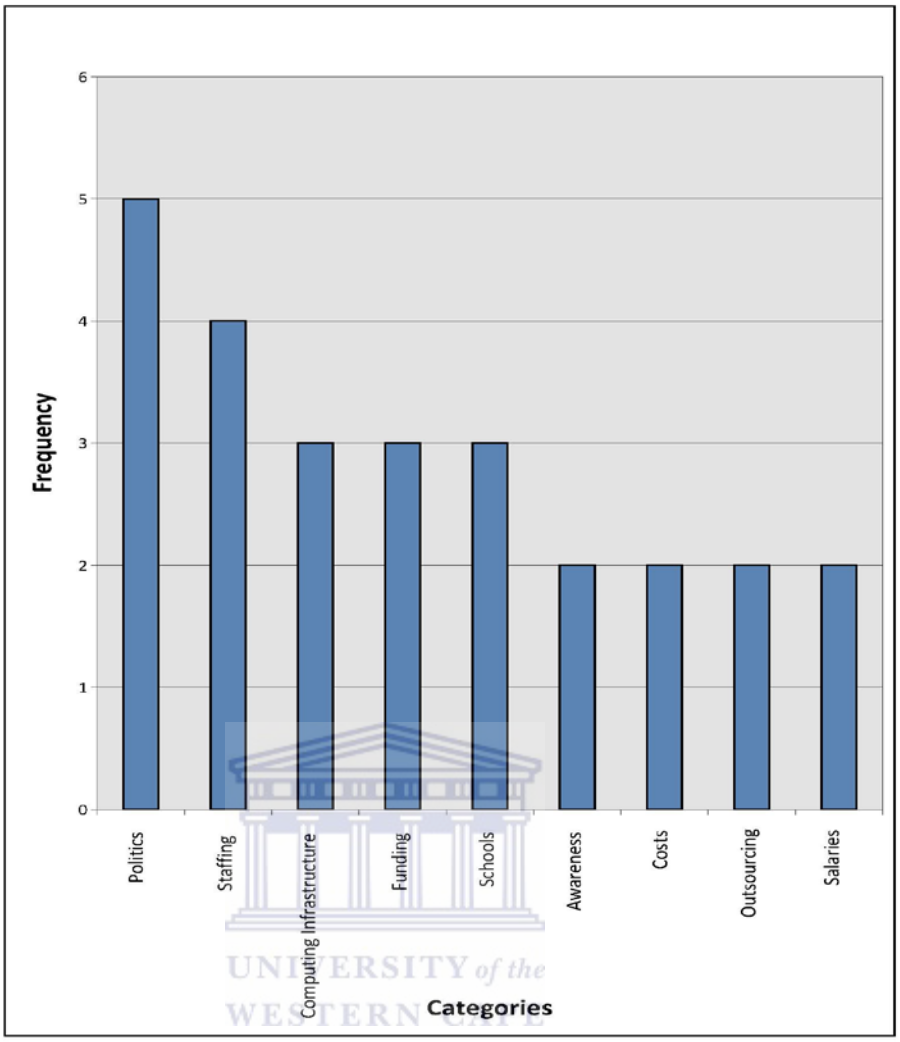

Figure 38: Constraints which could impede software development

5.4 Categories and criteria

Using the four most prominent categories as defined in Table 8 (see page 61, with weights > 0.25), a few examples of the relationship between text, *denotata*, criteria and categories are shown in Table 9. Text was studied and analysed to identify *denotata* which fits the general properties of any of the preloaded categories. If such a fit was found, the *denotatum* was allocated to that category, if not a new category was defined. The categories translate into criteria which need to be satisfied in order to sustain software development and the software industry.

Table 9: Text, *denotata* with categories and criteria

Text	***Denotata***	**Category**	**Criteria**
"The Indian IT companies used the telecom links to facilitate access to client computing environments thus making the outsourcing work available offshore" (Kathpalia & Raman, 2014)	*used the telecom links to facilitate access to client*	*IT/ICT Industry developments*	ICT industry initiatives towards development
"the NASDAQ listing was designed primarily to gain credibility with customers and to permit the issuance of dollar-denominated stock options to compete in global markets for talent". (Khann & Palepu, 2004)	*NASDAQ listing was designed primarily to gain credibility*	*Related factors*	Non-IT initiatives that influences IT development
"First, fearing unemployment from automation, the government did not encourage the adoption of computerization in government and state-owned enterprises." (Khann & Palepu, 2004)	*government did not encourage the adoption of computerization*	*Constraints*	Constraints which limits ICT development
"From 1986, software policy was de-linked and made independent of policy directed at the indigenous hardware sector" (Athreye, 2005)	*software policy was de-linked and made independent*	*Policies*	Government policies or strategies which supports ICT development

Using these four prominent criteria, comparative examples of the three case studies are listed in Tables 10 to 13 to illustrate these criteria's applicability.

5.4.1 IT and software industry size

The development and size of the IT industry is shown in Table 10.

Table 10: ICT industry initiatives towards development

India	South Africa	Ireland
Indian IT industry - USD 100 Billion industry (2011-12) with 80% of the revenues coming from exports.	South African information and communication technologies (ICT) sector - largest Africa - technology leadership - in mobile software and electronic banking services. Exports - South African Electro technical Export Council (SAEEC) – SA ICT market is estimated at US$ 42.6-billion (R468.4-billion) in 2013 with IT accounting for US$ 15.08-billion (R164-billion) and communications US$ 27.18-billion (R297.4-billion);	Software industry - worth about €12 Billion in exports. Indigenous software industry 2009-2013 Lero is the Irish software engineering research centre. Kobo Establishes Software Development Centre in Dublin, Ireland

5.4.2 Related supporting criteria

Examples of other efforts which supported software development and the IT industry are shown in Table 11.

Table 11: Non-IT initiatives that influences IT development

India	South Africa	Ireland
10000 Start-ups – tech start-up program - 10000 Start-ups in India by 2023. NASSCOM initiative.	Scientific and technological research and development (R&D) - can qualify for a 150% tax deduction; Grants worth R157.76-million for BPO. Includes science parks, industrial parks and sector development zones. Telkom – dropping bandwidth costs for BPO.	€10m investment fund (2011) to attract investment & start-ups. Start-Ups - 12.5% Corporation Tax; Research and Development (R&D) Tax Credits; Tax Incentives to Irish Investors in Eligible Start-Ups) IDA Foreign Direct Investment. Horizon 2020 (ICT mentioned)

5.4.3 Constraining factors

Besides the many positive factors already identified, a number of constraining factors also emerged which could retard the development of the software industry and the IT sector. These are shown in Table 12.

Table 12: Constraints which limits ICT development

India	**South Africa**	**Ireland**
Restrictive government policies; Lack of policies to promote ICTs and software; Divesting equity to local companies; Protecting domestic markets; Domestic market not attractive; Lack of funds; Visa and other labour related restrictions; High import tariffs; (Khann & Palepu, 2004) Lack of proper marketing; Weakness in high valued-added services; Lack of training; Lack of R&D; (Lee, Young Park, & Krishnan, 2014)	Lack of policy and regulation and implementation capability; Price-matching, poor quality, competitive behaviour; High prices & lack of affordable access; Lack of new services; Poor planning for ICTs; Lack of prioritization of ICTS; Changing leadership in responsible government departments which enhanced the above items; Lack of network extensions outside of cities; Drop in WEF indices; Poverty; (Gillwald, Moyo, & Stork, 2012)	Lack of development work; Control by foreign companies; Communication within time differences; Skills shortages and higher premiums; Dependence on TNCs; Difficult to negotiate with TNCs; Lack of venture capital; Reliance on export markets; Lack of local markets; Low value-add by TNCs; Commercialization problems; Job-hopping; Lack of resources allocated; (O'Riain, 1997)

5.4.4 Policies

National policies had an influence in all three case studies, see Table 13.

Table 13: Government policies or strategy which supports ICT development

India	South Africa	Ireland
Latest policy: National Information Technology Policy 2012, accepted by Indian government in September 2012	**Latest policy**: National Integrated ICT Policy DISCUSSION PAPER, 14 November 2014 National Broadband Policy (South Africa Connect) 2013 The National Development Plan: 2030	**Latest policy**: National Digital Strategy for Ireland 2013 National Broadband Plan
Earlier policies: Department of Electronics (DoE) & the Electronics Commission (EC) in 1970 - policies to them. A minicomputer policy (1978). The DoE established the National Centre for Software Development and Computing Techniques (NCSDCT) in 1972. First policy paper on this - 1974. Policy on minicomputers - 1984. 1986 – more incentives for software export. 1978 - 90 – initiatives by DoE & others: computer education in IITs (1978); Human Resource development in IT; Electronic Commission; plus many other policies	**Earlier policies:** Telecommunications Act, 1996 [No. 103 of 1996] No. 64 of 2001: Telecommunications Amendment Act, 2001 White Paper on Telecommunications Policy (1996); White Paper on Postal Policy (1998) and; White Paper on Broadcasting Policy (1998). Green Paper on e-Commerce (1999)	**Earlier policies:** 1970s the Industrial Development Authority/Agency (IDA) - policy to attract foreign software companies In 2003, the Minister for Communications, Marine and Natural Resources announced a major new initiative to drive the broadband market in Ireland The Planning and Development Act, 2000 - telecommunications infrastructure required by Local Authorities.

5.5 Possible study limitations

Data collected by means of surveys, questionnaires or interviews can be biased, subjective or even false. To mitigate against this the online survey was completely anonymous and no questions existed which could identify the individual or their company (Ontario Human Rights Commisson, 2014). The respondents were personally contacted to request their participation and thus the expectation is that these limitations have been minimized.

It could not be determined whether or not the sample size is representative (or large enough) and thus the results may not be sufficiently broad. The population could not be quantified since there is no register of software developers. The intention was not to generate inferential statistics but rather only descriptive statistics and this is why a sample size of at least 100 people were approached so that broad participation could be facilitated.

5.6 Summary

This chapter presented the results of the case studies on India, Ireland and South Africa. The results of an online survey done amongst software practitioners in the Western Cape region have also been reported. This survey found that, to promote software development in the region, in terms of the highest *denotata* count, the following should be done: greater awareness about the software industry is needed; government should do more in the area of education at school level; innovation should be promoted; computing infrastructure improvements; investments in the industry is needed and industry should provide more internships. Hindrances which could retard the development and growth were also identified since these also need to be addressed. In the next chapter the research questions are discussed in the light of these results.

Chapter 6
Discussion

The previous chapter presented the results from the case studies of India, Ireland and South Africa. These are now discussed in terms of the research question posed: How should software development be promoted and strengthened to develop a competitive software industry?

For each research sub-question, the results of the case studies are discussed in terms of the dominant criteria.

6.1 What criteria are important when establishing a software industry?

According to this research project, the key criteria for establishing and growing a software industry are: ICT industry developments; supportive related criteria (e.g. associations, financial and tax incentives); appropriate policies; various human resource development initiatives (e.g. education, skills); IT strengths (e.g. India–BPO, Ireland–software products; SA–software products); computing infrastructure; a ministry or department within government championing software; software or IT parks and software quality promotion (e.g. CMM). Some of these criteria were more pronounced in some countries than others.

6.1.1 Criteria contributing to India's software development success

Table 3 shows that the IT industry developments and initiatives obtained the highest *denotata* count. While the government initially had a "hands off" approach, the then emerging IT industry pursued various efforts to develop and grow. The fact that a number of Indian software companies obtained CMM ratings, especially at level 5, which is the highest, spoke to the quality processes used to create software, thereby enhancing its quality attributes and attracting software business (Khann & Palepu, 2004). Initially the Indian software industry offered lower level services in the value chain such as "body shopping" and programming but later the industry evolved to perform the higher value services such and design and development which meant that the

software industry was evolving and expanding (Sharma, 2014). The programming and other software development work done in India was largely made possible by the establishment, by the government, of software technology parks, with the necessary telecommunication links and enabling environment (Kumar, 2001). This facilitated the massive BPO undertaken by Indian companies for clients based in the USA and other countries. This was not only as a result of the improved infrastructure but also the availability of relatively cheap and educated human resources (Chatterjee, 2014).

Related criteria which played a supportive role to the development of the software industry also obtained a high *denotata* count. The role of transnational companies (TNCs) for example offered encouragement such as: Indian firms collaborating with TNCs gained insights into how research and development is done; exposure to good management practices; and access to marketing and markets abroad (Patibandla & Petersen, 2002).

Numerous policies were enacted which directly and indirectly nurtured software development and the IT industry. An example of a direct policy was the approval of the ICT policy for 2010 to 2015 and an example of an indirect policy which assisted was the subsidy on power bills (Times of India, 2010). Thus a combination of core and ancillary policies are needed to establish an industry such as this one.

Educational initiatives were undertaken by both government and industry in order to provide the necessary skills required by the software industry (Patibandla & Petersen, 2002). Government initially established the prestigious Indian Institutes of Technology (IIT), as of the 1950s, which focused on engineering and management (Kumar, 2001). Later (post 1998) the Indian Institutes of Information Technology (IIIT) were established to provide the necessary education and skills needed for the software industry (Patibandla & Petersen, 2002). In addition, industry provided private training institutions to contribute to the provision of the IT skills needed (Bhatnagar, 2006). An industry needs a well-schooled workforce for its growth and development.

In addition to these efforts, the National Association of Software and Services Companies (NASSCOM), a non-profit organization representing companies in the software, BPO and related services industries, has done much to promote the software industry (NASSCOM, 2015). NASSCOM which is funded by industry was established in 1988 and currently has 1400 members. For example, NASSCOM played a strong role in promoting Indian software companies abroad (Bhatnagar, 2006), (Arora, Gambardella, & Torrisi, 2004). An association such as NASSCOM speaks as a collective on behalf of industry and has an important role to play in influencing the role of government and any other stakeholders which could impact the IT industry.

Besides the initial challenges (e.g. no incentives to use IT due to protection in the economy) faced in the establishment of the software industry in India, there have emerged new challenges for it to stay relevant and competitive today (Khann & Palepu, 2004). Some of these new challenges are: graduates not being immediately employable; training costs; ease of relocating software companies and competition from countries like China, Vietnam, and Poland (Sharma, 2014). No industry should become complacent when it achieves success since we live in a competitive world in which others attempt to emulate your success which could affect your market share, relevance and survival.

6.1.2 Criteria contributing to Ireland's software success

IT industry initiatives have emerged as the dominant contributing category in the study of Ireland's software industry. The initiatives and contribution by industry received the most *denotata*, as shown in Table 5 (see p55). Initially the industry focused on localization as a way to attract foreign software development companies who wanted to use Ireland as a launch pad into the European market. The indigenous software development companies specialized in certain niche areas such as financial, telecommunications, middleware, training, data mining, encryption and banking (Cochran, 2001).

IT industry initiatives included the acquisition of successful Irish software companies by transnational companies (TNCs) such as Computer Associates

and Symantec (O'Riain, 1997). A number of these acquisitions were used to provide localization services (e.g. translational services) as USA companies strove to make inroads into the European markets (O'Riain, 1997), (Arora, Gambardella, & Torrisi, 2004). Microsoft also used Ireland for translational services (Cochran, 2001). In these translational instances not much development work was carried out, but mainly re-engineering and repackaging (Arora, Gambardella, & Torrisi, 2004).

These translational services were made possible due to the steady supply of Computer Science and language graduates (O'Riain, 1997). In fact it has been said that an oversupply of science and engineering graduates were available as TNCs established translational services in Ireland (Arora & Gambardella, 2004). This is due to free education and good universities as well as easy access to Europe (Cusumano, 2005). The education, research and innovation efforts are led by the Advisory Council for Science, Technology and Innovation and the Irish Research Council (Advisory Council for Science Technology and Innovation, 2015), (Irish Research Council, 2015).

A number of related criteria also contributed to nurturing the software industry such as: help with marketing; management skills; financial support and business planning from government agencies; software engineers moving from TNCs to start their own companies; English speaking personnel (O'Malley & O'Gorman, 2001); and the support role of IT industry associations (Arora, Gambardella, & Torrisi, 2004)

Policies enacted played a major role as well. The Industrial Development Agency, an agency of the Irish government, undertook educational initiatives to ensure the necessary training and skills were in place for the software industry. These policy efforts, in conjunction with a political environment which welcomed TNCs (e.g. government subsidies), encouraged the software industry in its growth path (O'Riain, 1997).

Irish software research is spearheaded by Lero (The Irish Software Research Centre) which undertakes to promote software through collaboration with

universities and other educational bodies, industry as well as international partners (Lero, 2015).

Software products are a strong aspect of the Irish software industry and many such companies were started by former academics and researchers (Arora, Gambardella, & Torrisi, 2004). Examples of these are IONA Technologies which started initially at Trinity College in Dublin and which specializes in distributed service-oriented architecture (SOA) (Giarratana, Pagano, & Torrisi, 2003). Another example of product-oriented software was Baltimore Technologies (internet security) but this company has since been taken over by others (Reference for Business, 2015).

The Irish Software Association (ISA) was established to promote the software industry and it assists with launching new software companies, software industry advancement and policy issues amongst others (Irish Software Association, 2015). It works in close association with the Irish Business and Employers' Confederation (IBEC) which represents business interests at a national level (IBEC, 2015).

Ireland also had a good telecommunications infrastructure before many other countries had (O'Malley & O'Gorman, 2001).

Some challenges that were faced by Ireland initially are: lack of development work being done in Ireland and the reluctance of USA companies to do this; control from abroad and dependence on foreign companies (O'Riain, 1997).

6.1.3 Criteria contributing to South Africa's software success

ICT industry initiatives, Policies and Related factors have emerged as the dominant contributing categories in the study of South Africa's software industry as shown in Table 7.

Although the regulatory and policy environment needs further development, a fairly strong ICT sector has emerged in SA (Gillwald, Moyo, & Stork, 2012). In a number of IT sectors, e.g. banking, and Internet security and verification,

SA is regarded amongst the best in the world, e.g. Thawte Consulting (Wesgro, City of Cape Town, PWC, 2013), (James, Esselaar, & Miller, 2001).

In terms of educational initiatives, the SA government spends a high percentage of its annual national budget (5.3% of GDP in 2008) on education (Lotriet, Matthee, & Alexander, 2010). More recent figures shows that SA spent 6% in 2013 compared to India which spent 3.9% in 2012 and Ireland which spent 5.9% in 2011 (World Bank, 2014). Many well-funded world class universities are present in SA and they have an important role to play in education and innovation (Hislop, 2011).

The Meraka eSkills Institute is an initiative by government to further develop ICT skills and capabilities in support of the ICT sector (Lotriet, Matthee, & Alexander, 2010). This institute focuses on innovation in ICT research and human resource development amongst other areas such as mobile systems and nanotechnology for example (CSIR, 2015).

The Joburg Centre for Software Engineering (JCSE) is a collaboration between government, industry and academia and has as its goal the support of the software industry in SA (JCSE, 2012). It encourages innovation, educates, develops skills and strives to establish quality software development processes such as CMM.

Infrastructure, in terms of broadband provision, is well established, especially in urban areas and further expansion is being undertaken, not only by government (city and provincial), but also by private companies (Gillwald, Moyo, & Stork, 2012). See Figure 3 (p3) for SA's international broadband connectivity.

There are also a very large number of constraints which SA faces as it strives to develop a software industry. Some of these are: policies needing development/direction and lack of implementation capacity (leadership changes); ICTs do not appear to be a priority and there is a lack of affordable access (Gillwald, Moyo, & Stork, 2012).

The criteria identified which contributed to South Africa's software success were spread across the categories in Table 7with three categories (themes) which emerged as dominant.

Constraints and challenges

For South Africa, two categories, viz. *Constraints* and *Challenges*, were established to better understand those criteria which are limiting (i.e. constraining) the growth of the software industry and those criteria which are in need of attention (i.e. challenges) in the current and near future. This understanding allows for a more holistic approach for providing a favourable environment in which the software industry can develop.

What was learnt from the South Africa's study?

The number of *denotata* for *Constraints* (84) and *Challenges* (46) are quite significant in the context of the South African study. These suggest that much needs to be done to ensure that the SA software industry develops to its full potential by addressing these flagged criteria.

An example of a *constraint* faced by SA is the dependence on imports and the negative impacts of this (Mutula & Kalaote, 2010).

An example of the *challenge* facing SA is the world-wide shortage of ICT staff being experienced currently (Lotriet, Matthee, & Alexander, 2010).

Both the ICT industry and government are taking initiatives to build the software industry. However government needs to strengthen its capability for implementation and stability is needed at the human resource level for those managing this implementation.

The *denotata* for SA for *CMM* or process improvement is much lower than for both India and Ireland. The efforts by the Joburg centre for Software Engineering should be supported and expanded by government and industry.

Educational initiatives and IT training are present within *denotata* although these are at much lower levels than for data on India and Ireland. Educational

programmes in IT, Computer Science and Software Engineering should be expanded and collaboration between industry and government on this aspect will be important.

There is a high count of *denotata* for category *Related factors*, as was the case for India and Ireland, which indicates that other enabling criteria (e.g. research bodies and universities) are present (Gillwald, Moyo, & Stork, 2012). SA does have these bodies and agencies which should be utilized effectively.

Computing infrastructure, particularly in the urban centres, is well established as a result of telecommunications reforms which have taken place (Gillwald, Moyo, & Stork, 2012). These must be extended to rural areas and the costs of access and bandwidth should be lowered. Appropriate deregulation and polices could advance this.

SA falls short regarding IT parks or Software technology parks with efforts at Technology Park (Stellenbosch) and by the Gauteng Provincial government needing support and expansion.

6.1.4 The status of software development in the Western Cape region

Based on the survey responses, it is clear that software development in the Western Cape region is undertaken by both small specialist software development companies (nearly 50% of respondents came from such companies) as well as within other large companies (e.g. retail and telecommunications).

There exists a concentration of software development companies just outside of Stellenbosch near Cape Town in a complex called Technology Park constitutes a software park (Technopark, 2012).

There are initiatives by the Provincial government, the City of Cape Town and Business to develop the area into an ICT hub and as a digital gateway to Africa (Wesgro, City of Cape Town, PWC, 2013). Other initiatives such as the Cape IT Initiative (CITI) and the Silicon Cape initiative are all striving to

make the Western Cape region an ICT innovation centre (Cape Information Technology Initiative, 2012), (Silicon Cape Initiative, 2015).

It is clear from the survey that satisfactory software development skills are produced by institutions such as universities and that most software development is done in-house. It is expected by survey respondents that universities take the lead in providing the necessary software development education and training since most desire to appoint people with formal qualifications. However, companies are also expected to do further training and development as needed.

There is currently a shortage of developers/programmers, mobile developers and software engineers and it is difficult for companies to find suitably qualified candidates to fill their vacancies.

The majority of respondents felt that government, industry and universities should do more to promote software development and made various suggestions for each of these stakeholders.

The stakeholders who are promoting software development have faced many potential hindrances in promoting software development and the software industry.

Although there was a general unawareness of technology parks, most felt these are needed to promote the software industry.

There were suggestions about what needs to be done to promote software development and the software industry, e.g. awareness, education, innovation, infrastructure, investments, skills, salaries, collaboration and improved quality.

The Western Cape region and software development

Universities are graduating software development students with adequate skills due to the fact that there are three universities in the Western Cape region. Employers' desire new appointees to have a formal qualification

probably due to the fact that most, who responded to the survey, are graduates themselves.

Most respondents were unaware of government ICT policies and implementation activities which suggest that government should do more to promote its policies in the media and through IT associations. In the light of this finding, it was not unexpected that most felt that government should do more to promote software development.

To promote software development, government should improve education (at school and tertiary level) so that more students are attracted into these study fields. Schools are an important feeder for universities, so more learners taking Mathematics and Science will position them to study for degree programmes with Computer Science and Information Systems.

The main hindrances for government are poor management and corruption. These negative items hinder the capacity of government to implement their policies which aim to improve the overall situation for software development advancement.

Universities should do more to promote software development using appropriate curriculum, awareness campaigns and partnerships. These suggestions are also useful to address earlier findings that respondents had difficulty filling positions in software development.

The main hindrances for universities as mentioned by respondents are lack of vision, funding issues and lack of staffing. Universities find it difficult to attract staff when vacancies arise and when new posts are created in computing departments due to the competition with other stakeholders for these scarce human resources.

Industry should do more to promote software development by having internships, partnerships and awareness campaigns. The role which related industry associations can play in this regard would help to plan, co-ordinate

and encourage these suggestions. These efforts could be thwarted by lack of vision, bureaucracy and staffing shortages within industry.

Most respondents were unaware of IT/Software parks yet they felt these are needed since they would have knowledge benefits, promote skills development and create awareness. Since this survey was conducted in the Western Cape region and there is a technology park within this area, this is a surprising finding. The technology park needs more promotion about its plans, activities and innovation efforts.

Software development in the Western Cape region could be impeded by politics, staffing and lack of infrastructure at schools. Political infighting resulting in a lack of leadership and vision and deficient capacity, needs to be addressed otherwise the software industry in the Western Cape region will be limited.

6.2 What are the obstacles that could hinder software development?

Although many "positive" criteria were identified in this research, there also emerged a number of aspects which had the potential to limit the software and IT industry development. Such "negative" criteria were coded into a category called *constraints* and *challenges*.

If the Western Cape region desires to grow its software and IT sectors it would be beneficial for it to be cognisant of these potential limiting aspects that have been experienced by India and Ireland. This knowledge would allow appropriate policies and strategies to be put in place to deal with these aspects to offset their rise or curtail their potential harm.

6.3 How should developing countries create an enabling environment?

Based on the studies of India and Ireland, the following criteria emerged as being essential in establishing and growing a software industry:

Industry initiatives such as those of transnational corporations which upgraded their operations in India, according to the latest technical trends, and the role of smaller local start-ups in the software industry, should be

accommodated (Patibandla & Petersen, 2002), (Cochran, 2001). Whereas India had a strong focus on BPO, Ireland had a focus on producing software products for local and export markets, e.g. localization of software, financial services software, telecommunications software and information security software (Cochran, 2001), (Arora, Gambardella, & Torrisi, 2004)

Related factors which are not directly related to IT or software development but which contribute directly (e.g. there is a consensus that firms needed to provide more value-added services) and indirectly (e.g. the low costs of starting a software services firm) are important for software development (Arora, Arunachalam, Asundi, & Fernandes, 2001).

Educational initiatives such as joint investment by government, state and industry in higher education and the provision of quality graduates with skills in software and IT are needed (Patibandla & Petersen, 2002), (Cochran, 2001).

Government policies such as those to boost exports and others when government did not interfere in industry efforts (Patibandla & Petersen, 2002), (O'Riain, 1997) were all effective.

The role of government ministries in policy adoption and other enabling instruments (e.g. software policy) and those policies which influence positively the industry, such as the IDA in Ireland, which promoted education in Computer Science and Engineering are crucial (Lee, Young Park, & Krishnan, 2014), (Barry, 2008).

Software Technology parks, such as those in India, or clustering of software related companies, as in Dublin, Ireland should be developed (Lee, Young Park, & Krishnan, 2014), (Barry, 2008).

Promotion of quality proven processes, as India did with the CMM so as to attract BPO, and as Ireland did when it established its Centre for Software Engineering which promoted ISO and CMM standards are needed to build confidence (Khann & Palepu, 2004), (Cochran, 2001).

6.4 A framework of criteria for a software industry

In summary, Table 14 provides a framework of all criteria both contributing and potentially restraining which should be considered when developing a software industry. The common criteria are usually experienced by all countries and the specific criteria are usually unique to a particular country.

Table 14: Framework of criteria

Contributing	
Common	IT Industry initiatives; Ministry (or government agency); Policies; Human resource development (education, skills); computing infrastructure; Related supportive factors (e.g. financial incentives)
Specific	Software industry orientation/emphasis/niche (e.g. services/BPO and/or products; CMM; software parks)
Constraining	
Common	Restrictive government policies; Lack of policies to promote ICTs and software; Protecting domestic markets; Lack of funds; High import tariffs; Weakness in high value-added services; Lack of training; Lack of R&D; Lack of venture capital;
Specific	Divesting equity to local companies; Domestic market not attractive; Visa and other labour related restrictions; Lack of proper marketing; Changing leadership in responsible government departments; High prices & lack of affordable access; Lack of network extensions outside of cities; Poverty; Communication within time differences; Skills shortages and higher premiums; Reliance on export markets;

The main research question has now been answered in the above three sub-questions. What specifically needs to be done in the Western Cape region is discussed in the next section.

6.5 Impact on the Western Cape region

Using the studies of India, Ireland and SA as a backdrop as well as the Western Cape survey, the following proposals are made to improve software development and the software industry in the Western Cape region:

- An abundant supply of graduates with the necessary software development skills is essential to promote software development and the software industry, as was the case in India and Ireland. Therefore, increased student throughputs in areas such as Computer Science,

Information Systems and Engineering are needed. This needs awareness, bursaries and expanded capacities at universities;

- More focused curricula and perhaps institutes in Software Engineering and Computer Science are needed, as was the case in India and Ireland. This focus could include degrees in Software Engineering and mobile development education and more practical skills in modern up-to-date tools and techniques. Companies should be able to make suggestions regarding the contents of curricula;

- At the school level, there should be more awareness of software development by including programming in the curriculum. There should also be more involvement by industry and universities with schools on career days, and by organizing programming competitions and workshops. Mathematics and science education must be promoted so that learners can gain access to careers in the ICT field;

- Innovation efforts and those that encourage innovation, e.g. competitions should be frequent;

- Access to computing infrastructure and the Internet must be made more affordable and more accessible, as this will promote awareness and innovation;

- Investments should be encouraged through tax breaks (incentives) and investments in the poorer areas should be stimulated to create opportunities and awareness;

- Industry should offer internships and sponsor courses/lecturers at university which are relevant to their requirements, e.g. Agile development;

- Collaboration between the main stakeholders (industry, government, education) should be increased to promote software development and the software industry, e.g. encouraging the building of mobile apps.

6.6 Summary

In this chapter the criteria required to develop a software industry and therefore software development as derived from the study of India, Ireland and South Africa were stated. The constraints and challenges that could retard such developments were also identified. The software industry in the Western Cape was discussed with proposals to develop it even further. The conclusions and recommendations are given in the next chapter.

Chapter 7
Conclusion and Recommendation

7.1 Findings and salient points

The study of India and Ireland revealed that these countries took deliberate initiatives and actions to establish and grow their software development industry and the broader ICT sector. These actions were taken by both government and industry. The main contribution from government was in policy (which included a ministry or agency), educational initiatives (which included human resource development) and the provision of computing infrastructure (such as high speed data communications and software technology parks). Once the software industry had become established, these countries needed to stay attentive to the changing ICT landscape and to be aware of the new countries competing for the same business. They therefore had to launch new actions (such as more services in the higher value chain) to stay relevant and competitive.

For South Africa the study showed that whilst the industry has taken steps to develop software development capabilities and that an advanced ICT sector has grown, government needs to do more in terms of policy matters and the costs associated with data communications needs to be reduced. There is no single ministry or agency which is specifically focused on the ICT sector. Policies and draft policies have been produced. However, a number of changes at the senior level of the ministries involved have led to shifting leadership which has delayed further developments. Some provincial governments and cities have taken steps to accelerate software and ICT activity in their regions. A National Integrated ICT policy discussion paper was released recently in November 2014, which needs to be finalized. There are plans to extend broadband penetration by 2020. The National Development Plan (NDP2030) also makes mention of a connected society in which ICTs are expected to play an important role. There are efforts

underway to promote the CMM in SA but its uptake has been lacking thus far.

The Western Cape region study revealed that whilst software development practitioners were satisfied with the software development skills of graduates and do most of their software development in-house, they found it difficult to find staff to fill vacancies. The most sought after skills were those of developers in general, mobile developers and software engineers. These findings are similar to those reported by a job search engine which found that a large proportion of vacancies in the region are for software engineers and web developers (Independent Online, 2013).

Although most respondents were unaware of government policies they felt that government should do more in terms of education, policy and incentives but that poor management at government level could undermine such government efforts. It was suggested that industry could do more in terms of internships, partnerships and awareness and that universities should improve their curriculum, create more awareness and form partnerships.

Cape Town (located in the Western Cape) is leading the way in start-ups due to four universities in the region providing good education in needed areas as well as efforts by the Silicon Cape initiative (Silicon Cape Initiative, 2015). In fact 59% of South Africa's start-ups are based in the Western Cape region followed by 29% in the Gauteng region of SA (Ventureburn, 2015).

Since one of the key aims of this research was to consider software development and the software industry in the Western Cape and juxtapose it against similar developments in Ireland and India, a survey was used to focus on this region to determine its unique issues. The conclusions and recommendations are thus discussed in the light of this aim with the intention that it may have wider applicability to the rest of SA and other developing countries. The other country case studies helped to provide information on the wider issues which assisted the localized study to concentrate on those issues relevant to its context.

7.2 Anomalies, surprise findings and deviations

One surprise finding was the low awareness amongst respondents of ICT policy initiatives which have been undertaken by the state. It was therefore not surprising that a large majority felt government should do more since they were unaware of the existing government initiatives. Most felt though that government would be hindered in its efforts due to lack of capacity in terms of human resources.

Despite most respondents being happy with graduates they employed, a large percentage felt that universities should do even more by aligning their curriculum with local industry trends and needs.

Most respondents, despite being based in the Western Cape region, which has a technology park where 21 software companies are based, were unaware of its existence. However most felt that IT/technology parks are needed.

The theme of more awareness about software development and the software industry emerged prominently from the study for all key role players, viz. government, universities and industry. Various strategies were suggested for these stakeholders to raise the awareness levels. If not done adequately, a lack of awareness was identified as a potential constraint for software development.

A surprise finding was that it was felt that politics (e.g. political infighting) was the main criteria which could impede software development in the Western Cape region. This criterion was placed above staffing which was elsewhere regarded as a major problem.

7.3 Relevance of the study for the Western Cape

In the light of initiatives by the Provincial Government, the City of Cape Town, businesses as well as other stakeholders (Silicon Cape, Cape IT Initiative, Technology Park, etc.) to establish a software and digital hub in the Western Cape region, this study has particular relevance as it augments the data about the issues that needs to be taken into consideration to plan

policies, strategies and operationalize efforts to further grow the software development industry.

This study gives the positive criteria which contributed to India's and Ireland's software success as well as negative criteria which hindered, or had the potential to delay that progress. The SA study identifies steps already taken as well as challenges which remain and reports on a survey done in the Western Cape region as a focus area within SA. All these help stakeholders who are charged with developing a software industry in the Western Cape region.

Overarching all these regional efforts is the national development plan (NDP2030) which also strives to promote the IT industry as an important enabler to drive the national economy and the knowledge society. Although this study has a specific focus on the Western Cape region, its findings have general applicability in South Africa since there are other regions (e.g. Gauteng Province) that are also interested in developing a knowledge economy (Gauteng Provincial Government, 2012).

7.4 Value-added contribution to theory development

The key contributions of this research are:

- A better understanding of the software industry in India, Ireland, SA and specifically the Western Cape Province of South Africa across a number of criteria (e.g. adequacy of trained graduates, ability to find software development skills, areas of skills shortage, etc.) and the views of software practitioners about a number of related areas (e.g. policy, role of government, universities, industry, software parks, etc.) as obtained via a survey.

- Identification of the challenges faced by the software industry in the Western Cape (e.g. lack of sufficient graduates with software development skills) as well as potential solutions to these (e.g. curriculum, open days and awareness).

- Recommendations on what needs to be done to promote the software industry in the Western Cape Province in terms of policy (local, provincial and national government), educational (school, tertiary) and other criteria (e.g. financial incentives) with applicability to the broader SA software landscape and with potential benefits to other countries wanting to establish a software industry.

7.5 Research contribution

David Whetten in his paper entitled "*What Constitutes a Theoretical Contribution?*" addresses the question about research contribution in his capacity as editor for the Academy of Management Review journal and his arguments presented there have general applicability. Whetten states that four questions must be asked when developing theory. These are *what*, *how*, *why* and *who*, *where* and *when* (Whetten, 1989), (Dubin, 1978). The first two questions, namely *what* and *how*, define the domain (or field) of the research.

What - what factors should be considered when we study the subject of interest, are they comprehensive and has parsimony been considered?

The initial literature review revealed some of the criteria which contributed to the development of the software industry in India, Ireland and SA. Further qualitative analysis, with the support of the software tool QCA, identified additional criteria which played a role and gave the ability to determine the extent of each criterion. Furthermore, the research also started to yield criteria which were inhibiting and needed addressing so as to not undermine the successful development of the software industry. Thus a comprehensive list of "positive/constructive" and "negative/destructive" criteria were identified producing a comprehensive list of criteria for the phenomenon under study.

Whetton defines parsimony as the act of eliminating some criteria since they are insignificant in our understanding and explanation of the subject being studied. Concerning the matter of parsimony, and bearing in mind the comprehensiveness which is desired, it is difficult to apply parsimony to the criteria since all had a *denotata* count of more than 10 and eliminating any

denotata would diminish the identification and the full understanding of all contributing criteria. However, for the Irish study parsimony could be applied to eliminate the categories "*CMM*" and "*Software services*" since the *denotata* associated with these are low. Similarly for SA, "*CMM*" and "*BPO*" could be eliminated since these have low *denotata* counts. However, beneficial criteria with low *denotata* counts also help with our understanding since it means these categories are of low influence and may need attention to increase their effect.

How - how are these identified factors related, identification of patterns and causality ("connection")?

There exists a relationship between some of the categories which have emerged and some may even be grouped into a new parent group. Considering the categories for India, a new category called "*Government*" may be defined which could consist of the existing categories "*Policies*", "*Ministry of IT*" and aspects from "*Human Resource Development*", "*Educational Initiatives*" and "*Software Technology Parks*". The pattern that emerges from this effort reveals that the government of India played a major role in the establishment of software development and the software industry.

The following two questions w*hy* and *who*, *where and when* define how criteria were chosen and the boundaries for the research.

Why – why were these criteria chosen and what are the basic conditions which lead to these factors being chosen?

The criteria such as those identified were not arbitrarily chosen but emerged from the study (reading) and analysis (QCA) of the literature which was guided by an overall investigating phrase, viz. "software development and software industry in India" since this was the focus of the research. A similar phrase was used for Ireland and South Africa.

Who, where and when – setting boundaries when generalizing and establishing the scope of the theory.

The scope of the research is confined to the software industry in India, Ireland and South Africa. The core contributing criteria which emerged for India were used in the study of Ireland and South Africa and were found to be generally applicable to these countries since *denotata* were identified which started to populate these categories for Ireland and SA from the Indian study. The time aspect of the theory development component was also attended to since, as in the case of India, a category "*New challenges faced by India*" emerged which revealed that there were now new criteria needing consideration to sustain the software industry which are different from those in the beginning stages when the software industry started. So over a period of time, criteria have changed with the appearance of new ones.

7.6 Research model

Scott et al. (2003) states that higher education institutions should acknowledge a shift of focus in scientific discovery: from 'Mode 1' knowledge that focuses on traditionally produced knowledge (that is knowledge produced within disciplinary boundaries) to 'Mode 2' knowledge which is a more application-oriented, trans-disciplinary, highly reflexive, socially distributed and subject to multiple accountabilities.

This research can be considered "Mode 2" research in terms of:

- being socially distributed (viz. the survey involved others);
- application-oriented (viz. investigated the software industry);
- trans-disciplinary (viz. identified factors in general which played a role);
- has multiple accountabilities (viz. industry, government and educational authorities)

According to Habermas' theory of critical social science, three types of knowledge interests drive all human inquiry, viz. technical, practical and emancipatory (Habermas, 1972). For the technical knowledge interest, the object of interest in this study is the software industry and the initiatives and contributing criteria which lead to its establishment. For the practical component, the impact of the criteria, both supportive and constraining were considered. The emancipatory dimension considered the way in which the

software industry and the development of software can benefit a country if these aspects are competitive. These three knowledge interests have been applied in this research, as shown in the highlighted text in Table 15 (Ngwenyama, 1991).

Table 15: Fundamental human knowledge interests applied to this research

Knowledge interest	**Object of interest**	**Orientation**	**Knowledge products**
Technical	Natural world Social structures	Prediction Control	Scientific knowledge Technology
	Software industry establishment	Initiatives	Contributing criteria and constraints
Practical	Social relations Tradition	Mutual understanding	Social consciousness Humanity
	Contributing criteria and constraints	Impact	Supporting criteria and constraints
Emancipatory	Technology Social relations	Social Criticism	Norms for justice Freedom
	New or adapted software industry	Benefits and challenges	Competitive

7.7 Implications of this study

There are numerous implications for policy and practice for government, industry and education (school and tertiary).

7.7.1 Implications for government

Provincial government manages school education in each province and should consider exposing learners to software development and coding as part of the school education programme. This is already being done at schools in the subject Information Technology where programming and software engineering principles are taught (Department of Basic Education, 2011). A related subject is Computer Applications Technology (CAT) which is a basic computer literacy subject (Department of Basic Education, 2003).

The numbers of learners doing Information Technology is considered low compared to other subjects, so it is important for authorities to see how to grow this subject (Institute of Information Technology Professionals of South Africa, 2012). Thus policies are needed to promote and enable the schooling curriculum to include subjects (e.g. programming, Mathematics, etc.) which informs and positions leaners for further studies in software development.

Since tertiary education (i.e. universities) is a national mandate, government would need to consider what the optimal throughput should be to provide the higher education graduates needed to support the software development industry. Sufficient graduates in IT, Computer Science, related engineering disciplines and Information Systems would be needed.

Regional government (i.e. provincial government) seems best to champion IT/Software parks and regional economic/industrial zones as has happened already in Stellenbosch and Gauteng (Technopark, 2012), (Gauteng Growth and Development Agency, 2012). These existing initiatives should receive continued support and the necessary encouragement to expand. Financial incentives, such as tax breaks and other investment friendly zones are needed.

On the other hand a number of hindrances were identified which could undermine the above effort by government, the main obstacle being poor management in government. Again the issue of capacity, at government level, to implement these policies comes to the fore.

7.7.2 Implications for education

Universities need to better align their curriculum with what is trending in industry. Based on the survey feedback, the following are their immediate requirements: developers/programmers; mobile developers and software engineers.

Universities need to create more awareness of software development which could be done with open days and engaging with schools in various ways.

Partnerships with other stakeholders such as industry and government are needed to create internships where the necessary software development skills can be developed.

See the section 7.1.1 for national government where requirements for schools have been dealt with.

A number of potential impediments have been identified which could undermine the above efforts in universities. The main ones are lack of vision, funding and staffing.

7.7.3 Implications for industry

The dominant issue raised by respondents is that of internships as a means to capacitate graduates to fully integrate with industry practices. Mentorship was also mentioned as an important cognate activity.

Industry needs to develop partnerships with educational institutions to influence the curriculum so that it is more directly relevant to industry requirements than at present, and to provide bursaries for students in software development.

Industry needs to launch awareness campaigns to promote software development at schools and universities to attract more students into software development.

A number of potential hurdles would have to be overcome by industry to achieve the above objectives. The key hurdles are lack of vision, bureaucracy and staffing.

7.8 Future research

7.8.1 Comprehensive open questions

The role of government (e.g. policy, incentives, etc.), industry (e.g. internships) and universities (e.g. more graduates, curriculum, etc.) in promoting software development and the software industry needs further

investigating since respondents felt that all these stakeholders should do more. Government here includes national, provincial as well as the city of Cape Town (Western Cape). The outcome of such a comprehensive research, which could be divided into components per stakeholder, would address many of the other matters which need further attention, e.g. it is very difficult to find staff with the correct software and IT skills according to the survey.

7.8.2 Specific questions

The influence of the awareness of software development at school level needs attention since the awareness factor was identified by respondents as having significant importance in developing the software industry in the Western Cape region. Collaboration with schools, by industry and universities in fostering this awareness and the forms it will take, needs further research.

It is important to find out why software practitioners are not aware of government policy initiatives which could influence software development and the software industry, and what can be done to improve this situation by government, IT associations and the software industry itself.

Innovation was amongst the prominent items mentioned which could promote software development. The levels of innovation within ICT in the Western Cape region needs further investigation as well as the role of stakeholders and the collaboration within the innovation ecosystem. Investments, which were also highlighted, need to be considered within the innovation system.

The awareness of technology parks by software practitioners was surprisingly low since there is such a technology park in the Western Cape region. The reasons for this can be investigated as well as ways to improve this awareness so that the benefits of such technology parks can be better understood and therefore better utilized.

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Appendix A

Other Software Related Surveys

Software development survey results from ITWeb

A software development survey was conducted in 2013 by ITWeb, a respected and leading business technology media company providing crucial information for SA ICT decision makers (ITWeb, 2014) for almost 20 years. The SA software development survey attracted 117 respondents of which the majority (28%) held IT specialist positions and so were well placed to answer questions particularly those which are technical about the software development process. The majority of the companies polled (40%) where IT companies (some small and others large) which further underpins the technical capabilities of the respondents. The key aspect of the survey was to probe the overall success and main causes of failure of software development projects and whether development was in-house or outsourced.

The key findings can be summarized as follows:

- The majority of respondents (33%) did their own in-house development with some skills provision by outside providers and 29% completely did in-house development.

- The first choice amongst most companies (52%) is to develop their own software with help from partners. The choice of nearly 32% is to buy and customize software.

- A large proportion of 69% said that they followed a standard software development process or life-cycle with the Scrum methodology being the most used (16%) followed closely by the Waterfall approach (15%).

- According to the respondents the main reason for project failure (30%) was unclear specifications.

- The typical length of projects were 4 to 6 months (37%) and 6 to 12 months (32%) with typically 4 to 6 people (44%) per project

Chief Information Officer survey results from ITWeb

A CIO survey was conducted in 2014 by ITWeb, a respected and leading business technology media company providing crucial information for SA ICT decision makers (ITWeb, 2014) for almost 20 years. The SA CIO survey attracted 158 participants.

About 65% of the response bases are large enterprises – employing over 500 people. About 22% of the participants, the large grouping, come from the financial, banking, insurance and accounting sector. The next highest sector was the ICT sector at 13%. The other major groupings, amongst others, were: mining and petrochemical (9%); manufacturing (9%) and government at 7%.

The CIO survey focused on operational priorities, business value of IT, sourcing and strategic priorities.

The key findings can be summarized as follows:

- About 41% of budgets are in line with the Consumer Price Index (CPI) with 17% in fact being above CPI when asked how the current year's budget compares with the previous year.

- The major spend across many categories (e.g. BI, security, cloud, CRM, ERP, etc) was associated with in-house expenditure except for infrastructure and connectivity which should both in-house and outsourcing strategies.

- IT is perceived as a strategic business function by 74%.

- CIO's spend the most time (48%) on aligning IT with the business.
- The lack of skills is the second highest concern at 67% when questioned about their biggest concerns.
- In terms of strategic priorities, only 27% say recruitment and skills are a top priority. The top priority at 57% is supporting new business.
- 43% of CIO's are actively seeking specific skills; the use of contractors and outsourcing is at 22% and internships at 20%.

Appendix B
Pilot Survey Study

Online Pilot Survey Study

This online pilot case study of software industry in the Western Cape region was a preparatory step in response to the research questions which seeks to understand its status in this region and what the role of software development plays.

Five responses were obtained anonymously from participants who were contacted requesting their assistance. Three were from the educational sector, with one involved in teaching ICT and the others in IT management. The others were an IT practitioner and a sole proprietor in IT. Their organizational size ranges from small to large corporations.

Summary of findings from the pilot survey study

The majority did in house management of their ICT strategy.

Training was mainly offered using a combination of in house and outside providers with most requiring a formal qualification when appointing IT staff. The respondents indicated that it was difficult finding IT staff to fill vacancies.

A broad range of skills was desired to fill these vacancies. The most pressing need was for database specialists, information analyst, programmers, web site developers, network specialists, mobile developers and security specialists. Universities were identified by most as the institutions responsible for developing these needed skills with private training providers and internships also featuring prominently.

The respondents felt that most developers were not aware of applicable industry (e.g. IITPSA, CSSA, and IEEE) codes of ethics. The view expressed

was that software developers/engineers should be regulated as other engineering professions.

Software development is accomplished using a combination of in house and outsourced resources and the majority use an Agile developmental approach with the main programming languages being Java and PHP followed by C++ and C#. The team size for most was small (less than 20).

Although most were aware of software process standards and process measuring instruments (e.g. CMM, SPICE, ISO/IEC, IEEE), these are not implemented or used. The software engineering process steps (e.g. requirements, design, implementation and re-engineering) were done using in house and outsourced personnel. Testing and maintenance were done in house. All these process steps were regarded as challenging with no one in particular being identified as the most challenging. Maintenance was mainly driven by new functionality needed.

The project management approach was mainly adhoc.

The respondents mentioned that bandwidth is adequate but the costs are high.

All respondents were not aware of policies in SA to promote software development and the ICT industry but felt that should do more in this regard. Activities which **government** could do to promote the ICT industry: a more effective role for SITAs; introduce programming at school levels; promote in house training; ICT centres of excellence; more integration between universities and companies in terms of internships and more apprenticeships. To promote software development, government should: have programming competitions at various levels of education; more bursaries; incentivise local companies to solve problems in government rather than be dependent on overseas solutions; set standards.

Universities, all felt, could also do more to promote the ICT industry and software development. In terms of the industry, universities could: have engineering faculties at all universities; involve high school learners to create awareness; collaborate with NGOs and government; more support for students; be aware of the gap between what is taught and what industry needs. In terms of the software development, universities could: teach the latest software languages; develop patents; do more in depth work rather than more topics; programming competitions involving high schools and languages should be taught which illustrate concepts rather than popular languages.

The majority felt the **IT industry** could also do more. In terms of the industry: deliver real value; in-house training; offer bursaries; marketing and awareness of the IT industry. In terms of software development: offer bursaries; collaborate with universities and government; in-house training; deliver real value to get recognition.

The majority were aware of technology parks but there was a divided view as to whether these are needed in SA. Respondents felt such parks could: build intellectual capacity; put SA on the international map as a developing country.

Other factors which could promote software development: its value to various sectors, i.e. better show the outcome of software development; more community involvement.

Factors which could constrain software development (and possible solutions): the education system (identify talent); not recognizing the role/value of coding (give recognition); lack of sharing of knowledge/expertise; fear of mathematics (address this aspect);

Learning's from the pilot survey:

- A qualification (e.g. degree, diploma, etc.) is desired for obtaining a job in the ICT sector.

- It's difficult finding staff with the correct skills.

- Skills across all ICT job categories are needed with database specialists being the most sought after.

- All education providers (e.g. university, private, companies, etc.) were expected to contribute to ICT education. More needs to be done to about ethics awareness within these courses.

- There was a strong feeling that software developers/engineers should be licensed/regulated like other engineering professions.

- There is an awareness of software process standards but these are not implemented by most.

- The main programming languages are Java and PHP and all reported small (less than 20) team sizes with the management of these being ad hoc.

- Although the software lifecycle steps are accomplished using in house and outsourced resources, maintenance (primarily new functionality required) was done mainly using in house staff. All lifecycle steps were equally challenging.

- Although telecommunication infrastructure was adequate, the costs were high.

- None were aware of policies to promote software development but all felt that government should do more in this regard. Examples of what government could do: programming competitions; school should offer IT; bursaries; incentives for local problem solutions; standards for training and education.

- All felt universities should do more to promote software development. Examples of what universities could do are: teach latest programming languages; encourage patents; more in depth rather than breadth; teach generic skills.

- Most felt that industry should do more to promote software development. Examples of what industry could do are: bursaries; collaboration with universities and government; in-house training; deliver real value to advance the software industry.

- Most were aware of technology parks but were divided as to whether these are needed in SA.

- Factors which could promote software development: realization of software's value; incentives; take software to communities to help them.

- Factors which could hamper software development: education; lack of recognizing the importance of software; lack of sharing knowledge/expertise; fear of Mathematics.

Appendix C
World Conference on Computers in Education paper

Norman, MJ & Venter, IM. India's Efforts to Promote Software Development – Lessons to be Learnt. *Proceedings of WCCE2013*, WCCE 2013, Toruń, Poland, 1-5 July 2013 (Pages 255-265) (ISBN 978-83-231-3093-2).

India's efforts to promote software development – lessons to be learnt

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Abstract
India, a member nation of the economic forum consisting of Brazil, Russia, India, China and South Africa, enjoyed remarkable success as a software developing country. The question it raised was: what aspects played a role in India's achievements to establish its flourishing software industry which resulted in many economic benefits? A content analysis research approach was used to obtain more information on India's software development success. The research approach involved the examination of various text sources about the software industry in India. This research revealed that their approach included a number of specific key initiatives: enabling policies; economic incentives; educational and human resource initiatives; training; the existence of a Ministry of Information Technology; establishing computing infrastructure such as Software Technology Parks; the adoption of the Capability Maturity Model; and, attracting the outsourcing business of other countries. A number of policies were enacted which served to promote and encourage educational developments within the Information Technology sector. A combination of top-down initiatives and bottom-up factors collectively contributed to the development of the software industry in India which in turn promoted software development/engineering. These initiatives resulted in an environment that was conducive to the establishment of a vibrant software industry The lessons learnt from India's success could be emulated by South Africa and other developing countries in order to cultivate a competitive software industry.

Keywords
Software, software development, software engineering, computer science, information technology, policy, education, developing nation.

Introduction

India, as an emerging/developing member nation of the group of nations consisting of Brazil, Russia, India, China and South Africa (BRICS) (University of Toronto, 2012), has enjoyed remarkable success as a software developing country. This created many development opportunities for India such as: greater employment, development of businesses and economic benefits in terms of import/export transactions. The Indian Information Technology-Business Processing Outsourcing (IT-BPO) expects to exceed an income of $100 billion by the end of 2012, which will represent 7.5% of India's Gross Domestic Product (GDP) (NASSCOM, 2012). India has, over a period of many years, put in place the required policies, infrastructure and training of human resources to achieve this growth in software development (Heeks, 1998). Figure 39 depicts the successes India achieved in the outsourcing of Information Technology (IT), before 2003, as compared to several other countries, some of which are well known for their software development successes (BBC News, 2007).

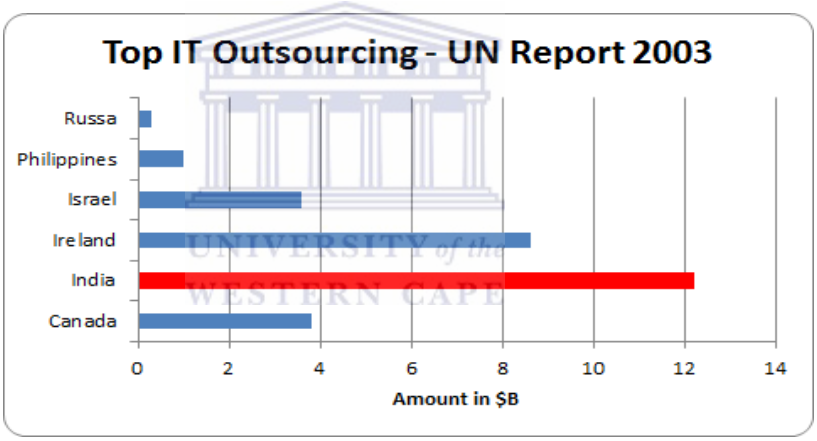

Figure 39: IT outsourcing (BBC News, 2007)

It is worth considering what factors contributed to this success so that South Africa (and other developing countries) can emulate it by implementing similar initiatives to advance its software industries. India and South Africa share many commonalities which may be to South Africa's advantage: the two countries are linked via BRICS, are co-operating via the India, Brazil and South Africa (IBSA) Information Society Annual Programme (IBSA, 2012), use English in business and share a historical British influence. Business process outsourcing (BPO) in South Africa does not form as significant a part of South Africa's GDP when compared to India (ZDNet, 2012). The software industry initiatives in South Africa is compared to that of India in this article, but the lessons to be learnt from India's success, has implications for other developing countries as well.

This research is directed at answering the following questions: How should South African educational institutions and its Information Technology (IT) industry be transformed or assisted to achieve a similar success in terms of software development as India? What key initiatives did India undertake to transform its software industry into a world-class competitive industry?

Currently the Indian software industry is only 2nd to the United States of America (USA) (Rai, 2002), (Palmer, 2012), a major achievement for a developing country (within the BRICS family of nations). How India's initiatives achieved this success could provide information on how to develop South Africa's software industry, especially with regard to its human resources development.

A content analysis approach was used to gather data. General academic publications about India's software industry, historical documents (e.g. Indian government and embassy web sites), National Association of Software and Services Companies (NASSCOM) of India web site and newspaper reports were examined and themes were identified.

The key elements (themes), which emerged from this analysis, are that India undertook a number of specific initiatives w.r.t software development/engineering which resulted in a maturing software industry. These key elements are policies and economic incentives, educational and human resource initiatives, a Ministry of Information Technology, establishment of Software Technology Parks, adoption of the Capability Maturity Model and attracting outsourcing business.

Methodology

The approach involved the examination of various text sources about the software industry in India. Text sources included journal articles, as well as web sites containing information on India's software industry. Amongst the trusted web sites are those hosted by NASSCOM (NASSCOM, 2012) and the official site of the Indian government (Government of India, 2012). Concept analysis (Colorado State University, 1993) was implemented by initially searching for the existence of phrases such as *the software industry in India* and *software development or engineering* mentioned within the context of the Indian software industry. Writings containing these phrases were considered in the light of the research question to determine what measures or initiatives were promoted to establish a strong software development/engineering culture, which in turn enhanced the software industry in India.

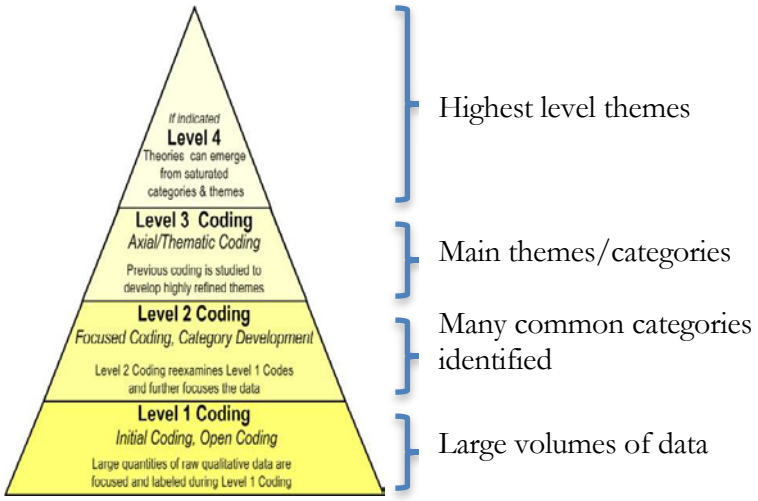

Figure 40: Grounded theory model by Hahn (Hahn, 2012)

The Grounded Theory Process model proposed by Hahn (Hahn, 2012) (see Figure 40) guided this pilot study and a diverse set of writings about the software industry in India was considered. A number of themes emerged from this process which, when analysed, could identify and define the initiatives India took to establish its software industry and what steps in particular it encouraged to develop software development/engineering education and skills. These themes and categories are discussed in the section below.

Results

The main themes that emanated from the Grounded Theory process and the many sources consulted using the level 1 initial coding (see Figure 40) were: implementation policies to encourage software development, educational and government initiatives, human resources development, the development of software technology parks, the adoption of the capability maturity model and the acceptance of the outsourced software development of other countries.

Policies

The Indian government implemented a number of policies which resulted in the promotion of the IT industry and in particular the software industry. One such major step taken in 1998 was the establishment of the National Task Force on Information Technology and Software Development (Chakraborty & Dutta, 2002). It's significant to note that the term *Software Development* appears in the name of the task team, which signalled the importance of software development together with the IT industry. Three reports emerged during 1998/9 from this task team with a number of recommendations to boost the IT industry, e.g. no customs and excise duty on software, all

universities and research institutions to be networked, no license fees for first five years for Internet Service Providers (ISPs), and monopolies on international gateways removed (India News, 1998).

Specific policies were implemented to encourage software development, these included (IT Task Force, 2000): delivery of educational content through various computer mandated networks; special financial help to assist training and education; special venture capital provided for IT education facilities; universities and colleges allowed to establish IT education and training companies with the private sector; companies encouraged to set aside 6% of revenue to support the Human Resource Development (HRD) sector with IT education and training. Thus a multi-pronged intervention, affecting nearly all economic activity, was approved in order to propel IT education and training and the software industry in general.

Educational Initiatives

A number of policies were enacted which served to promote and encourage educational developments within the IT sector. In the Long Term National IT Policy of India, the following initiatives was mentioned which specifically impacted positively on IT and Computer Science education (IT Task Force, 2000):

- All training and education related to IT at all levels will be treated as a Service Industry.

- Special financial instruments will be established to provide capital for investment in IT education. Special lower interest rates were applicable to IT HRD companies and institutions for these special financial arrangements.

- Special financial packages were made available to start IT HRD educational facilities. These were also applicable for non-resident Indians (NRI's).

- Research was encouraged to ensure the IT goals were achieved.

- Promoting IT training and education collaboration between public funded institutions (e.g. universities) and industry and allowing the establishment of education and training companies in this context.

- Public funded IT institutions were allowed to attract community funding to assist in upgrading these institutions.

- All companies were encouraged to set aside 6% of revenue for investment in IT training and education and could allocate such funds to an institution of their choosing.

- Government and IT HRD companies would strive for 100% IT literacy within 5 years at senior secondary schools and within 10 years at secondary schools.

- All engineering institutes were mandated to ensure that graduates were able to not only work in the IT sector, but also in the IT enabled services sector.

- Specific academic policies to advance IT training and education were implemented.

- National infrastructures in support of IT HRD were developed, e.g. government and industry would build a high speed national network backbone.

- Various financial schemes were developed to allow more money be made available for IT training, education and research, e.g. IT investments by IT HRD companies would be deductible.

Table 16: Academic policies to advance IT training

Special encouragement for emphasis on the advanced IT education and specialized areas.
IT HRD companies were allowed to be linked to universities (local and abroad) giving them the ability to award degrees.
Indian Institutes of Technology (IIT's) and Indian Institutes of Information Technology (IIIT's) were allowed to establish Virtual Institutes to promote advanced post graduate studies and continuing education in IT.
Education in Computer Science was encouraged alongside the basic IT skills and education.
Upgrading the remuneration of IT teachers/lecturers and IT professionals (in general) to retain these people within India.
Student performance and their placement in industry to be publicized by institutions. A credit rating system for IT HRD institutes was envisaged.
The uses of IT within education delivery from all levels were encouraged.
Aptitude tests were developed to determine which students (e.g. using a ranking system) will be well suited for studies in IT.
A system of continuous assessments (rather than terminal examinations) were used to assess the various knowledge levels needed by IT professionals.
National IT competency examinations were undertaken.
Institutions allowed (via autonomy) to design own IT courses and modify these as often as needed.
Students can complete IT courses at different institutions and then sit for completing IT examinations.
Respected international Computing organizations such as the Association for Computing Machinery (ACM) (ACM, 2012) and the Institute of Electronic and Electrical Engineers (IEEE) (IEEE, 2012) were invited to participate in development of ethics and standards in IT courses. Employer organizations (e.g. NASSCOM) would similarly be involved.

Ministry of Information Technology (MIT) – A Government Initiative

The Ministry of Information Technology (MIT) (Government of India, 2012) was established in 2000 to create a co-ordinated department within government for national IT policy development and implementation (Drozdowski, Huynh, Lininger, Peng, & Sakulyong, 2007). Prior to this formation, a number of different bodies within the government were promoting IT, but this new ministry would serve to integrate and co-ordinate these initiatives to be more effective. The establishment of this ministry shows the commitment and seriousness with which the Indian government viewed the development of the IT industry as part of developing its economy. Three areas in particular were identified as the core initiatives undertaken by MIT to promote the IT industry (Nagala, 2005): co-ordination of

government's initiatives (e.g. policy) within IT advancement; the establishments of Software Technology Parks (STP's); and the harnessing of the skills and influence of Indians who had left India to pursue jobs and businesses in other countries such as the USA.

Human Resource Development

The establishment of various Institutes of Information Technology at the higher education (i.e. university) level by the Ministry of Human Resource Development sought to increase the human resource development in IT. An example of such an institute is the International Institute of Information Technology (IIIT) at Hyderabad (IIIT-H) which was established in 1998 (International Institute of Information Technology, 2012) with a focus on Computer Science, Electronics and Communications, It is an autonomous university built on a public private partnership and was the first one using this model. There are a number of similar International Institutes (Wikipedia, 2012).

The Indian Institute of Information Technology, Allahabad (IIIT-A) was established in 1999 by the Indian Government to further advance education and training in IT and related areas (Indian Institute of Information Technology, 2012). The IIIT-A obtained university status in 2000.There are also a number of Indian Institutes of Technology (Indian Institute of Information Technology, 2012) such as the Indian Institute of Technology, Mandi (IIT Mandi) (Indian Institute of Technoloy Mandi, 2012) which offers courses in Computer Science via its School of Computing and Electrical Engineering. IIT Mandi is one of sixteen similar Institutes established by the Institutes of Technology Act of 1961 and the Institutes of Technology (Amendment) Act of 2012 (The Gazette of India, 2012).

Software Technology Parks

The establishment of Software Technology Parks (STPs) was a key vehicle in promoting the interaction or collaboration between government, private business, academia and foreign organizations in order to further advance the software/IT industry in India and in particular the export capabilities (Nagala, 2005) (Vaidyanathan, 2008). These STPs were an initiative of the Ministry of Information Technology and allowed various economic incentives to attract investment (e.g. 100% tax rebate for export profits) (Vaidyanathan, 2008). The interaction of the various role players at the STPs allowed research, development and innovation to take place and offered an environment where incubation was encouraged. The first STPs were established in 1991 at Bangalore, Pune and Bhunaneswar (Drozdowski, Huynh, Lininger, Peng, & Sakulyong, 2007) with high speed Internet connectivity plus the necessary IT infrastructure and other facilities (e.g. telephone, back-up, etc.) needed (Vaidyanathan, 2008).

Amongst the key objectives of the STPs was training and human capital development (Drozdowski, Huynh, Lininger, Peng, & Sakulyong, 2007). Thus

STPs were places where software development and software engineering was strengthened within India.

Adoption of the Capability Maturity Model

The Software Engineering Institute (SEI) established at the Carnegie Mellon University in 1984 (Software Engineering Institute, 2012) has developed the Capability Maturity Model (CMM) and CMMI (CMM Integration) to measure the maturity of software engineering processes and to improve processes to ensure quality software production (i.e. software which is reliable, efficient, on time, within budget). There are a number of maturity levels starting at 1 (Initial), 2 (Repeatable), 3 (Defined), 4 (Managed) and 5 (Optimizing) (Herbsleb, Zubrow, Goldenson, Hayes, & Paulk, 1997) with level 5 being the most respected. India encouraged the adoption of the CMM to attract foreign companies to outsource programming and software engineering to Indian based companies (Drozdowski, Huynh, Lininger, Peng, & Sakulyong, 2007). In fact in 1999, the Indian company Wipro was the first level 5 company in the world (Lahagu, Capps, Lingareddy, Mundanda, & Sumitsawan, 2001) and this was evidence of India's seriousness in improving its software production processes in support of its software industry. This attracted outsourcing to Wipro and subsequently many more India software companies achieved various levels on the CMM rating scale (Drozdowski, Huynh, Lininger, Peng, & Sakulyong, 2007) attracting even more outsourcing.

Outsourcing software Engineering to India

Outsourcing or Business Process Outsourcing (BPO) is a business model or strategy whereby a company in one country (e.g. USA) outsources some business process or activity (e.g. software engineering) to another country (e.g. India) (Mehta, Armenakis, Mehta, & Irani, 2006). This model was preferred by many USA based software companies because of the cost reduction (e.g. lower labour costs) in India together with a well-educated English speaking engineering graduates who had been trained in Computer Science and Software Engineering (Lahagu, Capps, Lingareddy, Mundanda, & Sumitsawan, 2001). These factors, as well as the initiatives outlined in the earlier sections (e.g. legislation which opened the economy to attract foreign investment), all played a role in attracting software development projects to India.

Discussion

A combination of top-down initiatives and bottom-up factors collectively contributed to the development of the software industry in India which in turn promoted software development/engineering.

The top-down initiatives are those policies, which were devised and implemented by the Indian government, which resulted in a friendly environment that was conducive to the establishment of the Software Industry. Amongst the key strategies were the founding of the Ministry of IT, the opening up of the economy to attract foreign investment, the provision of

Internet access, the development of software parks, promoting Computer Science and IT education, training through various vehicles and the acceptance of the CMM as a way to instil confidence in the software development/engineering process through improved quality.

The bottom-up factors are those factors which supported the top-down initiatives due to earlier efforts to improve education. One key factor was a large English speaking work force educated in Engineering via the IIT's and later the IIIT's that were available for incorporation within the software industry. The cost of this software engineering labour was relatively inexpensive compared to employing an American software engineer. It was furthermore important that the software work products produced by these engineers were of the highest quality. This required a quality framework such as the CMM or some other form of certification which ensured a process which leads to quality software.

The general lesson for developing countries is that, in the first instance, the overall economic policies and the resulting investment environment, in its broadest scope, must be such that companies from other developed countries would want to outsource software development/engineering to the developing country. Along with these economic incentives, sufficiently educated people in Software Engineering, IT and Engineering, with English fluency needs to be in place as well adequate provisioning of high speed connectivity and Internet facilities.

In South Africa, the government IT initiatives (at national level) are spearheaded under the more broader Information and Communications Technology (ICT) plan of the Department of Communications (DoC) (Department of Communications, 2012). The DoC also oversees a number of portfolio organizations such as the South African Broadcasting Corporation (SABC), the South African Post Office (SAPO) and the Independent Communications Authority of South Africa (ICASA) amongst others. The DoC has set itself the goal of using ICT's to improve the quality of people's lives through socio-economic development. In the DoC's Strategic Plan 2011-2014 (South African Government Information, 2011) mention is made of the following initiatives and plans within ICT relevant to this discussion: ICT policy and legislation; incentives to develop ICT's and attracting BPO; an Integrated National Broadband Plan and ICT infrastructure; e-skills Institute and increased ICT skills; and establishing an International Advisory Panel consisting of specialists to advise on ICT matters.

South Africa's National Research and Development Strategy (SA Government, 2002) also recognizes the important role of ICT and sets itself the goals of building strong research and development in ICT. A number of matters related to ICT development will be given attention to promote ICT, e.g. equipment, skills, and innovation.

South Africa supports a National System of Innovation (NSI) which was recently reviewed (Department of Science and Technology, 2012). This report

contains many references to ICT's and the importance of the knowledge based economy. The report acknowledges that past efforts within the NSI has not achieved the desired affect and makes a number of recommendations to improve the NSI which no doubt will result in an improved ICT infrastructure and human resources which will advance innovation within the ICT sector. Specific mention is made of adequate broadband provision for participators in the innovation system as well as the importance of software development. The importance of SANReN (South African National Research Network) within the innovation system for a knowledge based economy is emphasized.

South Africa's (SA) Department of Trade and Industry (DTI) has recently announced improved incentives to attract BPO. The new scheme makes it 20% cheaper to establish BPO operations in SA (IT News Africa, 2011).

At the provincial government (regional) level, the Gauteng Provincial Government (GPG) has presented an ICT development strategy which, amongst its objectives, lists the following: public-private collaboration; innovations; broadband and network infrastructure; ICT skills and building a software industry (Gauteng Provincial Government, 2012). This strategy mentions that all the basic building blocks (e.g. largest concentration of ICT companies, economic capital, universities, etc.) already exist but needs co-ordination to establish an ICT innovation hub. The CPG has also recently launched the Gauteng Growth and Development Agency (Gauteng Growth and Development Agency, 2012) which incorporated the earlier Blue IQ initiative with one of the objectives being the promotion of The Innovation Hub (a Science Park). This hub has a focus in IT/ICT research and innovation in particular.

South Africa has five Science/Technology Parks listed by the United Nations Educational, Scientific and Cultural Organization (UNESCO) (UNESCO, 2012). These parks are not specific to any particular type of industry or business but are of a general nature accommodating different types of enterprises. The technology park close to the town of Stellenbosch (near Cape Town) called Technopark (Technopark, 2012) has a concentration of 23 companies listed under its software category and is in close proximity with four universities for collaborative ventures.

Another local-based initiative to promote ICT is the Cape Information Technology Initiative (CITi) (Cape Information Technology Initiative, 2012) which is a collaborative effort by the city, provincial authorities, universities and business to promote the technology sector which includes IT and software development.
The Joburg Centre for Software Engineering (JCSE, 2012) is a collaborative effort between industry, government and academia with the aim of promoting software development, software engineering and the ICT industry in SA. This

centre is also encouraging the use of the CMM to strengthen software processes.

Conclusion

A multi-pronged strategy or approach could lead to the successful establishment of a competitive and viable software industry. To achieve this, a number of basic building blocks need to be in place IT friendly economic policies; Internet and IT infrastructure; innovation and collaboration between universities/research bodies and industry; process management; and Computer Science and Engineering education.

This study of the software industry in India shows that it is possible for a developing country to establish a competitive software industry, which can attract foreign investment, create jobs and contribute to the overall economic improvement. Lessons learnt on how India made this possible would be worth noting for South Africa if it wishes to establish a competitive software industry. South Africa's Research and Development Strategy and its innovation efforts does create a broad environment in which ICT in general is recognized as important and in need of promotion for the knowledge economy. South Africa's current framework for the promotion of its software industry would need to be more focused (e.g. the establishment of an IT ministry) with emphasis on IT and software promotion, if it were to emulate the software successes of India. Furthermore, South Africa would need to strengthen its Computer Science education (for example through higher funding levels) and encourage more software institutes modelled in a similar way as the Joburg Centre for Software Engineering.

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