Managing Tacit Knowledge in a Hi-Tech Learning Organisation

By

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Submitted in partial fulfilment of the requirements for the degree of
Masters in Business Administration

Business Studies Unit, Durban Institute of Technology
In the Faculty of Commerce

APPROVED FOR FINAL SUBMISSION

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ACKNOWLEDGEMENTS

I hereby wish to express my gratitude to the following individuals who enabled this document to be successfully and timeously completed.

- Giovanni Gallus for his support and belief in the benefits of the study.
- Trevor Davel for assistance with the technical aspects of the study.
- Heather Gibbs for proof reading and editing many versions of this dissertation.
- Dr Jeeva Govender for meticulously supervising the final product.
- Dr Gerhard Claassen for financial, moral and technical support from Prism Payment Technologies (Pty) Ltd.

DEDICATION

This dissertation is dedicated to my wife Dorothy and children, Tyrone and Jenna-Rae, for sacrificing the many hours we could have spent together.

Abstract

Project managers are faced with the challenge of matching skills to a task rather than merely assigning people to a job. If these skills are not readily available, the project may not be able to be executed with the desired level of quality and timescales may not be met.

Nowadays, organisations need to respond faster to market requirements than before due to increased competition and rapid advances in technology. Coupled to this is the trend for human resources to be more mobile, as lifelong commitment to an organisation becomes a thing of the past. These two trends present modern organisations with the requirement that their human resources require increasing levels of skills, yet they are faced with the risk that these skills may be lost due to their mobility. Organisations, therefore, need to understand what their core competencies are and ensure that these competencies are developed such that the organisation retains an adequate supply of core skills.

The aim of the study is to identify the core competencies and associated skills within an organisation and devise a method whereby these competencies and skills can be measured and duplicated such that core knowledge is retained and developed within the organisation. The aim is achieved by setting four objectives: to define the core competencies, to measure the depth and level of skills within the organisation, to determine the preferred learning styles of the specialists and finally to determine whether there is a common preferred learning style amongst the specialists.

The study commences with a focus group study to determine the core competencies within a South African high technology organisation. The general areas of expertise are electronics, software and the science of cryptology. The output of this focus group study is a questionnaire that is used to measure the depth and level of skills available to the organisation within these fields. This questionnaire is named the Skills Level Questionnaire (SLQ).

A second questionnaire, the Honey and Mumford Learning Styles Questionnaire (LSQ), was distributed with the SLQ. The LSQ was used to analyse the preferred learning styles of the team of core engineers. The results were analysed and indicate that there is a common preferred learning style amongst the specialists in this organisation. A pronounced finding is the lack of preference for the activist learning style amongst the respondents.

Recommendations are presented to utilise the preferred learning styles to enhance the learning process within the development environment. By defining the core competencies, management is able to focus on developing the skills areas that are key to the sustainability of the organisation. Project managers are then more easily able to allocate skills to tasks.

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ABSA	Amalgamated Banks of South Africa
ACM	Association for Computer Machinery
ANSI	American National Standards Institute
API	Application Programming Interface
BSc	Bachelor of Science (degree)
DES	Data Encryption Standard
DUKPT	Derived Unique Key per Transaction
EFT	Electronic Funds Transfer
EMV	Europay, Mastercard & Visa
EPS	Electronic Payment System
FIPS	Federal Information Processing Standards
Ft	Fault tolerant
GUI	Graphical User Interface
HSRC	Human Sciences Research Council
ICSF	Integrated Cryptographic Service Facility
ID	Identity
ISO	International Organisation for Standardisation
LSQ	Learning Styles Questionnaire
MAC	Message Authentication Code
MBA	Masters of Business Administration
MSc	Master of Science (degree)
NIST	National Institute of Standards and Technology
PCI	Peripheral Component Interconnect
PED	PIN Encryption Device
PhD	Philosophiae Doctor (doctor of philosophy)
PIN	Personal Identification Number
POS	Point of Sale
SLQ	Skills Level Questionnaire
STS	Standard Transfer Specification
TGM	Technical Group Manager
TSM	Transaction Security Module
VHDL	Very High Density Logic
WHQL	Windows Hardware Quality Laboratory

Chapter One: Introduction

This chapter provides insight into the events leading up to the study, through to the definition of the problem statement. A synopsis of the problems associated with the management of experiential knowledge is presented in the rationale, followed by the objectives of the study that were set in the attempt to solve key aspects of these problems. A synopsis of the structure and flow of the study is presented which shows the research methodology that was adopted and applied to the problem. The methodology was adopted such that it could be applied to other organisations that may experience similar concerns regarding knowledge management.

1.1 Preamble

The study is an exploratory investigation into knowledge management within a learning organisation. It highlights the need for management to know the competencies and learning styles of individuals so that learning can be stimulated and the risk associated with mobile core competencies can be reduced. It also has the benefit of improving productivity through increased knowledge sharing.

1.2 Background

The researcher has a background in electronic engineering and project management and was faced with the dilemma of managing projects throughout the period in South Africa when the ‘brain drain’ phenomena was identified in the early 1990s, and continued through to the current times of information overload. The early 1990s saw a mass exodus of skilled people leaving the country, resulting in a skills shortage. The early 2000s saw the rapid increase in the availability of information and the resultant need for organisations and their human resources to be able to respond rapidly to changing environments and increasing customer demands. The common factor in these two eras is the need to develop and duplicate human resource skills in as short a space of time as possible. A constant problem that is faced is the matching and assigning of suitable human resources to the project tasks. The dilemma arises from the tendency for the most suitable resource to be allocated to multiple projects for his or her specific skills and is, therefore, seldom available to execute the task due to the demand for their skills on other projects or for new proposals. A resultant snowballing problem is that the most skilled persons are overloaded and hence unavailable to mentor and train others in their skills. This study is an attempt to expose the underlying causes and impact of this problem, and to propose a means to manage the capacity of skills required within an organisation. This capacity is referred herein as the depth of skills. This brings to the fore the next area of the study which is the learning styles of individuals and the learning environment.

1.3 The organisation as a learning environment

The study attempts to determine how an organisation establishes depth in a core competence domain that has been identified as being too shallow. King, Fowler and Zeitham (2001:96) note that in order to be a source of competitive advantage, a resource or competency must be valuable, rare and difficult or costly to imitate. To recreate or imitate the core competencies, as identified in this study, from first principles would be costly. There is, therefore, a strong motive to retain and transfer this knowledge within the organisation.

Knowing the core competence domains provide a broad indication of what knowledge needs to be managed. Identifying the depth of these competencies provides an indication of the organisation's capacity of the skills and indicates areas in which human resources need to acquire skills and develop through learning. The means to implement the learning process is assessed in the final part of this study. This phase identifies the preferred learning styles of the human resources. According to Honey and Mumford (2000:5), '*learning styles can be used as a basis for constituting teams or work groups, helping them to harness the skills of other people*'. The learning environment and the means of knowledge transfer could be adapted to meet the individual's needs. If the learning environment remains relatively constant, there is a possibility that human resources with a preference to a particular learning style, which may be suited to this particular environment, may have a learning advantage over their peers who are not suited to the particular environment. It is hypothesised that if the learning environment was changed to suit the needs of an individual's preferred learning style then he/she are likely to learn quicker than he/she would otherwise. Alternately, the individual could develop and strengthen his/her weak style, to adapt to an environment. Honey and Mumford (2000:5), state that: "*courses and other training events can be designed to appeal to different learning styles*". Management also benefit from knowing their own and their team's learning styles (Wyrick, 2003:32).

"*Whilst the potential for improved performance is undoubtedly increased when managers help members of staff to broaden their repertoire of learning styles, we recognise that many managers will not want to do so*" (Honey & Mumford, 2000:51). This is a potential source of tension that could resist change and would need to be overcome if new learning strategies are implemented. Wyrick (2003:27) identifies the benefits of understanding learning styles and states that: "*by understanding different learning styles, engineering managers can easily adapt to more effectively communicate and work with others*".

1.4 Definitions

Tacit knowledge: Is defined as that specific knowledge learned from experiences and observations (Nonaka & Takeuchi, 1995:57).

Level of competency: For the purposes of this study, the researcher defines level of competency as a qualitative evaluation of an individual's proficiency and understanding of a defined set of skills and experiences.

Depth of skills: For the purposes of this study, the researcher defines depth of skills as the number of human resources that possess an identified set of skills and experiences at the level of a specialist.

Cryptography: Is defined as the science of encryption and decryption of data in order for it to be stored or transferred securely (Banisar, 1999:253).

1.5 Problem statement

The problem that this study addresses is that of tacit knowledge being mobile. From the definition of tacit knowledge, it is seen that this form of knowledge is learned from experiences and observations. The knowledge resides in the minds of those individuals who have acquired the knowledge from observations and experiences. When an organisation's core competencies are largely resident in the form of tacit knowledge and the only means of retaining such tacit knowledge is by means of an employer to employee employment contract, this is deemed to be a potential risk for the organisation. The study addresses the problem of identifying the core competencies that are required for the organisation's sustainability and competitive advantages and finding a means to effectively duplicate, or manage such tacitly acquired knowledge.

1.6 Rationale for the study

In an organisation with a project structure, temporary teams are drawn from a range of functional expertise (Cleland & Ireland, 2002:32). This requires that there be sufficient expertise (depth) available within these domains to execute tasks without having uneconomical delays due to a lack of capacity of the required skills.

When the required expertise level is very high and is exclusive to a relatively small industry, the risk of unavailability or short supply of skills could be detrimental to core business operations. Precautions are not always taken to plan ahead for the sudden need to replenish or replace key skilled resources. When expertise is specific to an organisation, the probability of recruiting a suitable replacement resource is low.

The researcher assumes that when allocating human resources to project tasks, the project manager should allow for sufficient spare human resource capacity to be available to enable the effective transfer and sharing of knowledge. An analogy can be drawn between the sharing of knowledge and the sharing of water, where in both cases there is a need for a suitable recipient for acquiring the contents to be shared. A bucket, for example, is needed for receiving water and another human resource for receiving knowledge. A situation that allows an expert to work in isolation doesn't cater for knowledge sharing.

The proposed study will focus on a stated strategy of an organisation, which is to pursue minimal cost through minimal human resource utilisation. This is perceived within the organisation's management as being a 'maximum efficiency' approach. This strategy spreads one 'key' human resource across multiple tasks, with little or no provision to have spare human resource capacity available for sharing knowledge. The study investigates the need to have spare human resource capacity available for mentoring, and hence, knowledge transfer and creation.

A particular observation in this industry is that there appears to be a tendency for specialists to be constrained to working within their specialised domain and often on their own. From this, it is perceived that learning is minimal and no knowledge transfer is taking place. An investigation using the Honey and Mumford (2000) learning styles questionnaire was used to provide some clarity to the possibility that specialists in this industry may have a tendency to prefer a particular learning style.

Management within the organisation believe that allocating more than one person to perform a task is wasteful. It is argued that; "*companies that fail to concentrate their resources across all product lines are at a disadvantage*" (Greer, 2001:125). It is evident that tasks requiring core expertise should have more than one human resource capable of performing these tasks. This will reduce risk in the event of the organisation losing the services of this human resource. To approach this ideal, the core competencies need to be identified, and thereafter, the knowledge transfer within these competence domains needs to be managed efficiently. The current study could benefit an organisation by identifying the strengths and weaknesses within human resource core competence domains such that Management can focus on the knowledge management techniques required to provide a concentration of these core competencies. By ensuring that resources are continually learning the core competencies, the individual’s abilities increase and the organisation benefits from the collective increase in total intellectual capacity. This could result in an increase in competitiveness of the learning organisation.

This is an exploratory study, which the researcher believes could lead to cost savings through risk reduction and increased competitiveness by decreasing response time for any similar industry. Cooper & Schindler (2001:139) imply that exploration ultimately saves time and money.

1.7 Benefit of the study

The benefit of the study is to establish whether there is a need to provide a backup of tacit knowledge of core competencies in the organisation, and to identify methods of achieving this through the identification of learning styles and the learning environment. The Hi-Tech learning organisation to be explored in the study has its core competencies based in the field of cryptography. Cryptography is the science of encryption and decryption of data in order for it to be stored or transferred securely. The organisation relies on the specialist skills of its human resources. These skills are almost exclusive to the organisation and have been acquired and developed from within the organisation. They, therefore, cannot be purchased or acquired through the recruitment process. This study provides insight into an organisation’s skills base such that strengths and vulnerabilities therein can be identified. A method is provided by which the acquired domain knowledge may be effectively retained and developed within the organisation, hence reducing the risk of core competencies being lost and at the same time boosting productivity through additional depth of specialist skills.

1.8 Research objectives

The aim of the research is to establish a method by which to manage tacit knowledge within an organisation such that core skills may be identified and an effective means devised to enable this knowledge to be shared efficiently in order to build up depth of core competencies. The aim is achieved through the following four objectives, which provide the direction of the research:

- To determine the specific domains of core competence required within the cryptographic business unit in order for it to have a competitive advantage in the strategic group in which it competes.
- To determine the actual number of human resources in possession of the defined competencies (depth), and their relative experience within the defined domain (level).
- To determine the preferred learning styles of the human resources, using the Honey and Mumford Learning Styles questionnaire.
- To determine whether there is any relationship between levels of expertise and learning styles within this industry that would warrant change to be implemented to create a learning environment conducive to creating more specialists.

1.9 Limitations of the study

The research has been conducted within a business unit of an organisation in the electronics payment sector and the core competencies identified are exclusive to this sector of the industry. The definitions of the competencies are not transferable to other organisations. The design of the research is such that if the concepts were to be applied to another organisation, the core competencies within that organisation would need to first be identified. This would be the first stage in the application of the concept as identified in the first objective in section 1.8.

The sample size is limited to fifteen respondents, all from within the same organisation and all within the group referred to as engineering/science graduates. The data acquired from this group is specific to this group and may not necessarily apply to other groups.

1.10 Structure of the study

The study consists of six chapters and a brief discussion on each chapter ensues:

1.10.1 Chapter one

Chapter one presents an overview of the study. It encompasses the background of the problem and the need to identify and regenerate core competencies within an organisation. The rationale, objectives and limitations of the study are presented.

1.10.2 Chapter two

Chapter two reviews the literature on knowledge management in general and focuses specifically on the skills availability within the domain of cryptology. Literature was reviewed that pertained to the need for managing knowledge in specific forms and the use of human resources as a repository for such information.

1.10.3 Chapter three

Chapter three details the research methodology that was designed and employed to gather the primary data for the study. The chapter describes how a focus group was used to qualitatively identify the core competence domains that formed the content of the skills level questionnaire (SLQ). The methodologies of quantitative data capture and analysis by means of two questionnaires, the SLQ, and a learning styles questionnaire (LSQ) are detailed.

1.10.4 Chapter four

Chapter four presents the results from the two questionnaires. This research is a cross-sectional analysis. The SLQ used an ordinal data type and was used to gather a cross-section of the level and depth of skills available in each of the defined domains. The purpose is to indicate areas where depth and level require further development. The data from the Learning Styles Questionnaire (LSQ) provide an indication of the respondent's learning styles preferences. The styles are defined as Activist, Theorist, Pragmatist and Reflector.

1.10.5 Chapter five

Chapter five presents an analysis and discussion of the quantitative data as obtained from the two questionnaires. The skills levels and learning styles are analysed to determine whether there is any relationship between levels of expertise (variable 1) and learning styles (variable 2) within this organisation.
The analysis and statistical results of the acquired data are presented.

1.10.6 Chapter six

This final chapter presents the conclusion, and recommendations. The research attempts to determine whether the organisation should implement changes to accommodate the preferred learning styles conducive to creating specialists. Recommendations are presented that could benefit senior management in their assessment of areas of vulnerability in the organisation's human resource pool.

1.11 Summary

The first chapter gave a brief synopsis of the background to the problem, and the environment in which the problem is likely to be found. The environment is an organisation in which core competencies are found largely in human resources, generally specialists in their field. An overview of the problem is presented together with a set of objectives by which core competence domains are identified and the associated tacit knowledge of the employees measured within these domains. The study may be benefit learning within the organisation with the objective of establishing increased depth of core competencies.

The following chapter is a literature review pertaining to knowledge management, and focuses on the exclusivity of knowledge within the field of cryptology. The study presents a process that may be repeated within an organisation or in a department, where the intellectual property or 'tacit' knowledge is deemed to be an important component of the organisation's assets.

Chapter Two: Literature review

2.1 Introduction

The literature review investigates other research that has been conducted in fields similar to those pertaining to this study. Suitable answers will be sought to the questions arising from the problem statement, overall aim and objectives of the study. The first issue arising from the problem statement is to determine whether the problem actually exists. The field of knowledge management is investigated to determine whether the problem is common across organisations and whether suitable methods and tools have been developed to solve similar problems. The claimed benefits of the study relating to increased productivity and reduced risk are investigated and substantiated.

2.2 Determining the need for knowledge management

The research design is such that, for measurements and observations to be valid, it requires the skills to have been developed within the organisation's learning environment and should not have been acquired from outside the organisation. The reason for this is that the research design investigates whether there is an association within the learning environment between an individual's learning style preference and the level of competence obtained by the individual. It is preferable that the domain of knowledge is exclusive to the organisation. The literature review evaluates the exclusivity of the domain.

As information is becoming easier and faster to create and generate, the need to manage this information becomes greater. Business trends and customer expectations adapt to this need for speed and a resultant new management trend is to replace the command and control management style of old with one of sense and respond (Malhotra, 2000:11). Managing knowledge is now as important as managing ones products. Active knowledge management programmes are becoming more common in developed countries as is evident from a recent knowledge management report by KPMG. In their survey, 423 organisations in the UK, mainland Europe and the US were asked whether they had a knowledge management (KM) programme. In summary, KPMG state that over four-fifths [81 percent] said they had, or were considering, a KM programme. 38 Percent had a KM programme in place, 30 percent were currently setting one up and 13 percent were examining the need. The majority of leading organisations are now actively pursuing knowledge management (KPMG, 1999:3). It is noted that this report is extremely broad, has no clear definition of the extent or methods of KM and is based on the perceptions of a few people within each organisation. It is also noted that this study was conducted in the UK.

In South Africa, Botha and Fouché of the Centre for Knowledge Dynamics and Decision-Making, University of Stellenbosch, have been conducting a longitudinal study to describe prevalent knowledge management (KM) practices, to identify patterns and trends and to develop knowledge management benchmarking tools for the business sector. In the first phase of their study, they record that only 18 percent of companies have some metrics on the exploitation of intellectual capital and intangible assets, on the deployment of KM applications and tools, and on the effectiveness of KM programmes and practices, whilst only 10 percent actually use these tools to align KM practices with organisational vision, objectives and strategy. They conclude that these findings are derived from a relatively small sample that should not be seen as representative of the South African business sector (Botha & Fouché, 2002:18).

2.3 Backing up explicit and tacit knowledge

Knowledge can typically be categorised in two basic forms: tacit knowledge and explicit knowledge. Explicit knowledge is knowledge that can be expressed in words and numbers and can be easily shared. Tacit knowledge is that specific knowledge learned from experiences and observations (Nonaka and Takeuchi, 1995:57).

According to the Delphi Group, tacit knowledge is considered to be an essential target of many knowledge management initiatives because it is the repository of the organisation's most strategically valuable knowledge (Romaldi, 2002:1357). Ambrosini, (1998:3), states that "*core competence analysis will help organisations to compete successfully by enabling them to see beyond their end products and served markets to their core technologies and sources of competitive advantage*". This highlights the need to identify core tacit knowledge, identify the personnel who have this knowledge and determine their level of competence.

In determining the core competencies, there should be some consensus amongst managers with regard to the definition of these competencies. King, Fowler and Zeitham (2001:97) propose that a measurement of consensus is done to determine the extent to which middle managers agree on the value of each identified competency. This ranges from a unanimous agreement or high consensus that a particular competency is important to the competitive advantage of the organisation to the other extreme where there is total disagreement regarding the importance of the competency. Ambrosini (1998:5) goes on to state that the cost of misunderstanding competencies can have severe adverse effects on a business. Once these competencies are identified, managers need to implement strategies to develop and expand this knowledge base.

According to Romaldi (2002:1364), the theory of organisational knowledge creation suggests the sharing of tacit knowledge is a critical component of successful knowledge management efforts. Management should, therefore, encourage this sharing of tacit knowledge in the areas of the core competencies rather than wasting them on general competencies. Encouraging this knowledge transfer may require new processes and technologies which, in turn, consume financial and human resources. It is better, therefore, for an organisation that is new to knowledge management concepts to focus on the key areas.

2.4 The economics of knowledge management

Management tends to evaluate the economics of labour costs versus their benefits from a short-term perspective only, a term known as denominator management, where the return on investment increases when the denominator, namely salary costs, are reduced (Hamel & Prahalad, 1994:125). Improved efficiency and improved ability to adapt can be achieved through resources that are multi-skilled as a result of there being less idle time in waiting for a specific human resource to have time available. Multi-skilling requires human learning and a duplication of skills.

Dingsoyr & Conradi (2002:399) set out to answer the following three questions about knowledge management in the software development environment: "*Does it improve the quality of software, lower the cost of developing software and improve the work situation of employees in an organisation?*" The evidence implies that quality is improved by not making the same mistakes twice. There is evidence to support the lowering of costs as a result of time saving and generally ease of access to data and better visibility into projects did improve the work environment. They conclude that the very relevant observation arising from this study is the predominant method in which knowledge is transferred in the software development environment, and that is primarily through lessons-learnt reports.

2.5 The medium for storing tacit knowledge

Explicit data can be stored on computer systems and books. However, tacit information requires human knowledge storage. Nonaka and Takeuchi (1995) emphasise that only human beings can take the central role in knowledge creation and argue that computers are merely tools, while information generated by computer systems are not a very rich carrier of human interpretation for potential action. They further state that knowledge resides in the user's subjective context of action based on that information. In the context of the proposed study, it is imperative to measure the intellectual property and knowledge management capabilities of an organisation by its human resource intellectual capacity, and not the investment in computerised knowledge management equipment.

Malhotra (2002:1) observed that the confusion between knowledge and information has caused managers to sink billions of dollars in information technology investments that have often yielded marginal results. The study emphasises the need to manage tacit knowledge. It is common in industry to hear of requirements to upgrade hard disk space, but uncommon to hear reference to the upgrading of tacit capacity. In terms of explicit knowledge, the measurement of programmes, data and hard disk space is currently measured in giga-bytes. Measurement of the capacity of tacit knowledge is not that simple.

2.6 Measurement tools

According to Botha and Fouché (2002:18), there is a perceived absence of instruments and practices to measure and assess the quality of organisational knowledge management practices. This provides further motivation for the need to develop such tools and practices.

Dingsoyr & Conradi (2002:410) identify that there is a great interest in developing technology to support knowledge management but empirical analysis of how experience sharing actually works is lacking. One measurement approach that could be considered is the proposal by Malhotra (2003:23) that experience should be measured by the expert’s ability to perform a task using their expertise. This realises the financial benefit of the expertise. Such estimation is used regularly in the project management function of forecasting.

Persons experienced in a particular field are unlikely to ascend new learning curves if they are retained in their current position. This assumes that they draw primarily on experience they have previously acquired. Conversely, those human resources that ascend learning curves at the most rapid rate are more likely to be those who learn new skills whilst utilising their preferred learning style (Wyrick, 2003:27). The current study provides insight to the possibility that an organisation that identifies its core competencies and understands its human resource learning needs and styles could make it more effective.

Consider this example of a conventional learning institution where a teacher is teaching to an empty classroom. If the teacher is teaching an exclusive subject that is instrumental in attracting students to the institution, yet the classes are held at a time when students are unable to attend, the class would be empty. An understanding of simple economics would prompt us to acknowledge that something must change in order for the teaching institution to sustain its attraction. In this example there is one obvious variable and that is the time of the lessons. There are however other possibilities. The teaching method could be changed to one that accommodates learners to learn in their own time, possibly from explicit data. The direct interaction of teacher to learner is a tacit to tacit transfer, termed socialisation by Nonaka, Reinmoeller and Senoo (1998:674). Irrespective of the medium of transfer, a human learner is always required. This study investigates preferences in learning styles and their relevance to knowledge transfer amongst core human resources.

The reason for the need for another human to acquire the core domain knowledge is investigated, as it is argued that a replacement human resource would be required in the event of the prime human resource not being available to perform the key tasks. After all, stored explicit data would achieve nothing unless applied. Malhotra (2003:3) states that execution is everything, regardless of the level of access to the highest quality information. Patterson (2003:20) notes that researchers have developed learning metrics that don't simply evaluate whether employees have learned new skills but whether those skills have been applied for the organisations benefit. King, Fowler and Zeitham (2001:96) emphasise that tacit competencies are important for competitive advantage because they are context-specific. Resource and skills shortages often occur during annual leave breaks, sickness, an accident, overload from work commitments and even untimely death. It is during these periods that the benefits of having duplicate skills available for application to a task are realised. The problem, however, revolves primarily around creating a backup of tacit knowledge. To create a backup for this knowledge and skills the core competencies need to be identified.

2.7 *Identifying the core competencies*

A duplication of tacit knowledge results in the acquisition of depth of skills, where depth is defined as the number of human resources having the ability to perform similar tasks. The following statement is the key to the selection of the research topic: "*Strategists have argued that maintaining a competitive advantage usually derives from outstanding depth in selected human skills*" (Quinn, Doorley and Paquette, 1990:60). For this reason, selected human skills need to be identified and the depth of these skills across the organisation measured. According to Greer (2001:125), "*companies that fail to concentrate their resources across all product lines are at a disadvantage*". The study will therefore focus on the tacit knowledge of the human resources that are crucial for maintaining the key product lines.

2.7.1 The field of cryptography

In this study within the electronic payments industry in South Africa, the core knowledge stems from the general disciplines of electronic engineering, computer science and data security, the underlying science of which is cryptography.

The electronics payment industry relies on expertise in cryptography as the foundation on which to enter this market. What makes this science unique in the sense that experienced resources are extremely hard to come by? One reason is that cryptography is an interdisciplinary subject, drawing from several fields from information theory, to extensive use of mathematics, notably number theory and finite mathematics. It is also a branch of engineering but an unusual one, as it must deal with active, intelligent and malicious opposition (Wordiq, 2004a).

Cryptography provides a means of accomplishing two crucial functions: encryption and authentication. Encryption is the process of encoding the contents of any data, with an algorithm and a randomly selected variable associated with the algorithm known as a key. Only the intended recipient of the communication, who holds the key, can decrypt and access the information (Banisar, 1999:255).

2.7.2 Security engineering

Modern systems in the financial world span many areas of human experiences. Security engineers need to consider the mathematical and physical properties of systems as well as considering attacks on the people who use and form parts of those systems using social engineering attacks. Over and above technical attacks, secure systems also need to resist coercion, fraud and deception by confidence tricksters. So as well as physics, chemistry and mathematics, it involves aspects of social science, psychology and economics. This field can be loosely termed ‘security engineering’, whereas cryptography was previously restricted to military applications (Wordiq, 2004b).

One of the pioneers of security engineering as a formal field of study is Ross Anderson of Cambridge University in the UK, who is still at the forefront of this technology. When a pioneer of a field of study is still currently active in their role and, as such, still considered the global expert in the field, this indicates that the field of study is young and the implication is that the knowledge base is small. Anderson (2001:3) defines security engineering as building systems to remain dependable in the face of malice, error or mischance. Anderson (2001:3) further points out that security engineering requires cross-disciplinary expertise, ranging from cryptography and computer security through hardware tamper-resistance and formal methods to a knowledge of applied psychology, organisational and audit methods and the law.

2.7.3 Exclusivity of knowledge

This study requires a high probability that the skills pertaining to the core competencies have been learnt within the organisation. This paragraph reviews the exclusivity of the knowledge.

Banisar (1999:254) states that since the end of World War 2, the United States government has attempted to limit the development and availability of publicly available cryptography in order to preserve and enhance its ability to monitor communications anywhere in the world. He concludes that the efforts by the U.S. government over the last twenty years to stunt the widespread deployment of encryption, both inside and outside the Unites States, has been successful.

A further indication of the newness of the subject is the statement by Kilian (2001:2) who states that "*the past few decades of cryptography research has had amazing success in putting most classical cryptographic problems on complexity-theoretic foundations, however, there still remain important problems in cryptography about which theory has had little or nothing to say*".

Mao (2004:xii) indicates that many engineers assigned to solving cryptography-related problems may have little proper training in cryptography. He further notes that this is in spite of the observation that designing cryptographic systems and protocols is a difficult job even for an expert cryptographer.

2.8 Limitation of available expertise

The effect of the limitations of available cryptography knowledge on an organisation that relies on applied cryptography is marked, as the availability of specialist resources available in the market place is almost non-existent in developing countries such as South Africa. Wőcke and Klein (2002:441) state that "*In South Africa, a massive brain drain is occurring as academics and skilled personnel are lost by emigration.*" Some countries tap into foreign resources to rebuild their competencies, however, this is different from importing other production factors as human emotions are involved. It is becoming increasingly difficult for an organisation to obtain and retain skilled resources in South Africa. According to a study by the HSRC (as cited in Wőcke and Klein, 2002:443) the demand for professionals is on the increase. South Africa cannot afford the ongoing loss of skills, particularly as integration into world economy forces South African industries to become more competitive. Wyrick (2003:29) states that organisations learn by retaining knowledge from past practices or current events and then applying that knowledge to make decisions that help them perform better and become more competitive. Wyrick (2003:29) further notes that individual learning is a prerequisite for organisational learning.

With the advent of e-Commerce, the internet, and wireless banking, the exposure to fraud is more rife than ever. Banking institutions are demanding greater measures of security and the criminal mind is evolving at the same pace as those attempting to provide security. Communications of the ACM (2005:10) reports that: "*almost every online bank has been hit by phishing attacks and that phishing gangs were using increasingly sophisticated techniques to harvest useful data*". The task of providing a secure system is becoming increasingly difficult. The advances in technology, particularly computer processing power, are such that a data encryption standard (DES) deemed secure ten years ago is now possible to be cracked in less than a day.

In conclusion, with a shortage of readily available skills, it is necessary for an organisation to take note of its own skills requirements and develop these as required.

2.9 The learning organisation

King, Fowler and Zeitham (2001:95) note that managers who agree on their firms' core competencies are more likely to be consistent in their decisions to develop those competencies and developed a method whereby the characteristics of competencies are evaluated in three dimensions. The first is a measurement of tacitness, along a continuum from articulated to tacit. Articulated refers to the extent to which the knowledge or skill can be documented and repeated by another person, whereas tacit is all experience. An example of pure tacit experience is riding a bicycle.

The study approaches the research design from a localised perspective rather than looking at a large organisation in its entirety. This is based on the research by Desouza and Evaristo (2003:62-65) who recognised that in some organisations the vision and initiatives for knowledge management efforts came from the regional offices, indicating that local offices in a given region needed to exchange expertise on a frequent basis in order to operate efficiently. The study is therefore conducted at geographically separated business units.

As all human personalities are different, attempting to optimise or define an ideal learning environment that is conducive to all personality types is not possible. Honey and Mumford (2000:6) use the analogy that trainers too often assume that learners are empty buckets waiting to be filled by whatever training method the trainer favours. They note that the observation that the buckets are different shapes and sizes is conveniently overlooked. Similarly one personality profile does not fit all job situations (Kreitner & Kinicki, 2002:129). In the workplace, which in a learning organisation is a learning environment, it is possible that there could be a benefit from measuring an individual's learning style preference and then adapting the environment to that individual's preference for learning. Understanding how one processes information, and how others process information, will make one more effective (Wyrick, 2003:27).

In the context of this research the learning environment can be categorised as one of the following:

- Working in isolation, using primarily explicit data such as documents, Internet and written or recorded communications.
- Working with a mentor who is a specialist on the subject and is able to provide tacit to tacit knowledge transfer.
- Learning from observing others from a distance.

A database of information is not effective if new data supersedes the existing data at a faster rate than it can be absorbed and used effectively. This accumulation of information is of no use if it cannot be absorbed and applied by the intended recipient. It is, therefore, evident that a medium for an effective database is a human resource.

2.10 Human resources – A medium for knowledge backup

Tacit knowledge can only reside within human beings, whereas articulated knowledge, or data, may be copied and backed up using a multitude of media. Unlike articulated data that can be packaged and stored, whether it is in the form of a book or a magnetic file, for example, tacit knowledge is far more elusive to pin down.

The tendency is for a more formal approach to be used and deemed successful in large organisations, yet in small groups where people are co-located, knowledge transfer tends to happen as a matter of course, which can result in the abandonment of formal approaches to constructing an experience repository (Dingsoyr & Conradi, 2002:405).

"*The introduction of self-directed work teams, re-engineering processes and multi-skilling of the staff are examples of the contemporary need for flexibility in the innovative firm*" (Van der Klink & Boon, 2002:411). They go on to state that: "*diminishing job security requires that employees bear larger responsibilities for their own careers*". This means that they need a clear insight into their competencies and into the possibilities of maintaining or improving their professional competencies. In light of this it is not only the organisation that benefits but also the individual.

2.11 Development of skills

Barnett (as cited in Van der Klink & Boon, 2002:413) stresses the need to pay more attention to the development of critical abilities that are not linked directly to specific jobs and tasks. The indications are that the ability to learn and adapt is of more importance than the skills and experience already acquired. A further attribute that has been noted as a result of this research is the requirement of the ability to problem solve at an in-depth technical level. This would require an analytical mind, possibly people with strengths in the theorist and reflector learning style preferences. Wyrick (2003:27) states that engineers are convergers, preferring to design first and build second. Kolb (1976) developed a four stage learning cycle, which was based on Jung's 1926 model of cognitive styles. The Honey and Mumford (2000) learning style questionnaire is based on Kolb's model. Convergers are Kolb's equivalent of the diagonal between Honey and Mumford's Theorist and Activist. According to Honey & Mumford (2000:61) Kolb has now published a revised version of the LSI. No comparisons of results with this version are known.

According to Patterson (2003:20) Kirkpatrick's model is one of the most widely used models for evaluation of training. This model also uses four levels of measurement: Reactions, Behaviour, Learning, and Results. These are closely associated with the styles of Kolb, who used the terms Divergers, Assimilators, Convergers and Accommodators. Honey and Mumford (2000:13) use the terms Activist, Reflector, Theorist and Pragmatist. These three tools are all based on earlier works done by Jung in 1926 on cognitive behaviour. Jung's dimensions include Sensing-Intuition (S-N), Thinking-Feeling (T-F), Extroversion-Introversion (E-I) and Judging-Perceiving (J-P) (Kreitner & Kinicki, 2002:138).

2.12 Conclusion

The one common element arising from this review of the literature is that irrespective of method or measurement tool the process of acquiring knowledge is always dependent on an available resource. To measure the level of a skill requires the evaluation of the application of the skill. In applying this to the research the questionnaire emphasises hands-on experience.

A person experienced in a particular field is less likely to ascend new learning curves if they are retained in their current position and draw on experience already acquired. If they work in isolation they are unlikely to transfer knowledge to others efficiently. Those ascending learning curves at the most rapid rate are those that have the appropriate base skill and a mentor to guide them through the obstacles. Hampton and Grudnitski (1996:5) report that cooperative learning may be particularly valuable in helping low achievers succeed. Wyrick (2003:28) states that: "*learning is maximised when all four stages of the learning cycle are used*". It can therefore be concluded that the organisation adopting training methods whereby the migration through all four learning stages is managed efficiently, will develop as a learning organisation at a faster rate than could otherwise be achieved.

The next chapter provides an insight into the research methodology used to determine the depth and level of skills and the preferred learning styles of specialists.

Chapter Three: Research design

3.1 Introduction

The research design had two distinct phases: The first was to identify and define the domains of competency within a business unit of an organisation so that a questionnaire could be compiled. The questionnaire listed the defined competencies. The levels of proficiency were defined so that respondents could categorise themselves as being unqualified, qualified but not experience, had general skills, had specialist skills or was an exclusive specialist. The resultant questionnaire is termed the 'Skills Level Questionnaire' within this study and is a product of this chapter.

The second phase entailed the collection and evaluation of data from the respondents. A second questionnaire, the Honey and Mumford Learning Styles Questionnaire (LSQ), was purchased and distributed together with the Skills Level Questionnaire. The purpose of the two questionnaires was to determine whether there was a preferred learning style amongst the specialists. The measurement method was by a measure of association using Goodman and Kruskal's gamma.

The aim of this study is to manage tacit knowledge, which is ultimately to duplicate human resource skills within the organisation. For a cross-sectional analysis the core competence domains and the learning environment are deemed to be constant. The variables come mainly from the human resources within the organisation and the analysis of their learning styles may provide insight into methods to improve learning through the transfer of knowledge. This may entail changing the work environment or establishing training courses. These are discussed in chapter 6.

3.2 Focus group study

The aim of the focus group was to identify the domains of core competencies within the business unit. This constituted a descriptive study from a focus group consisting of representatives from management and senior development. A questionnaire was developed to establish the domains of expertise that are considered vital to the business unit's strategies. The focus group session was conducted with the managing director, technical manager, product manager and a senior developer. The managing director has a master's degree in engineering management and a Phd in cryptographic engineering. The technical manager has an MSc degree in electronic engineering. The product manager has a BSc in electronic engineering and the senior developer has a bachelor's degree in computer science.

A listing of products and solutions currently on offer by the business unit and the relevant industry specifications was obtained from the organisation's corporate profile brochure. This product and solutions listing was reviewed during a preliminary video recorded interview with the organisation's head of engineering and was presented at the focus group to be used as a guideline for the discussion. In this particular industry an electronic product has a niché market category, hardware type, software type and development environment categories, each of which requires specialist domain knowledge. A letter of consent for the interview to be recorded to videotape was signed and dated 26 January 2005 - refer to annexure A.

3.3 Collation of data from the focus group session

Five specific industry sectors were listed in the organisation's corporate profile brochure. The organisation has developed products, solutions and services that are focused on supporting trusted transactions within these five sectors, which were identified as:

- Telco (telecommunications)
- Banking and financial services

- Retail
- Oilco (oil petroleum companies and forecourt sales)
- Utilities (pre-paid electricity and account payments)

Eight core competence domains were defined by the Focus Group. The technologies and products that utilise crypto skills were listed for each industry sector. It is recorded that a unanimous agreement was reached that these particular competencies are important to the competitive advantage of the organisation.

The eight core competence domains defined by the group were:

- Key Management Applications and Systems
- Cryptographic Hardware Development and Applications
- Designing Application Programming Interfaces
- Smart Card Security
- Security Architecture and Protocols
- Payment Protocols and Industry Specific Knowledge
- Crypto Engineering
- Solution Developers

These eight competence domains are defined further in the following discussion. These definitions are all derived from the focus group session.

3.3.1 Key management applications and systems

Key management applications and systems include products designed to load key components and firmware into specific devices such as point of sale terminals, to associate them to a particular retail chain and region. The development of these products requires skills that may comprise of domain knowledge of the specific industry sector, product knowledge of terminals and cryptographic hardware, security knowledge and then the general programming and engineering skills.

3.3.2 Cryptographic hardware development and applications

The cryptographic hardware products are a range of transaction security modules developed by the organisation. These are branded as the Incognito product range. General skills required in the development of these products are hardware engineering skills, as would be familiar to an electrical engineering graduate or an electronic technician. It is taken for granted that a person with the appropriate tertiary qualification would have the general skills required for this domain.

The domain specific skills are those exclusive to the products developed by the organisation and there is commonality with similar products manufactured by competitors. There is no other organisation in Africa that develops and manufactures products is this line, as can be determined from the official NIST accreditation product lists, available online from the following website: http://csrc.nist.gov/cryptval/140-1. The technology is limited primarily to the USA, Germany, France, Australia, France and Finland. Recently China and South Africa have submitted products for certification.

The specific skills required experience in tamper mechanisms and boot-loaders that meet VISA PED and FIPS140-2 levels 1, 2, 3 & 4 requirements. The knowledge is acquired through hands-on experience, typically by going through the motions and processes involved in certifying a security product. Access to information for FIPS requires a confidentiality and non-disclosure agreement to be signed between the organisation and a certification laboratory. Information is only released once a contract has been signed for the laboratory to proceed with certification processes. The fees are high, typically in the tens of thousands of US dollars. This results in the containment of knowledge to a very small group of people and makes the knowledge very valuable due to the high expenditure that needs to be incurred to acquire it. It is predicted at this stage that this domain knowledge is limited to one person who can claim to be a specialist in this area.

3.3.3 Application programming interfaces (API)

Application programming interfaces (API) can be described as being a software engine that performs a set of cryptographic functions. Typical functions are the Triple DES (data encryption standard), amongst a host of other industry standards. To develop an API requires an understanding of the basic cryptographic functions, knowledge of the modes of operation of the system in which it is likely to be used and the implementation of the functions and modes within the system that it is to be implemented. An understanding of the basic cryptographic algorithms can be learnt from vast sources of explicit (documented) information. This is often taught in cryptography courses in certain tertiary degrees such as computer science. It is not the in-depth theoretical knowledge of these algorithms that is required in the industry, it is the application of them and the knowledge of when, where and how to use them that is important. Knowledge of the industry requirements and standards is crucial for this development. The final application requires a working knowledge of the industry in which the API is to be implemented. Different industries require different API's, which results in the developers tending to specialise in a specific industry.

3.3.4 Smart card security

Smart card security is a growing industry. The majority of banking cards are based on the magnetic stripe technology, which is open to abuse by fraudsters. Smart cards are used extensively in what is arguably the fastest growing industry at present, cellular phones. The organisation has two production sites that manufacture smart cards. The team responsible for development work is relatively small considering the revenue generated by these products. Profit margins on these products are currently low and this is reducing with the Asian market entering the development and manufacture of these devices. Survival in this sector requires a rapid turnaround time on development and innovative thinking is becoming increasingly important to keep ahead of the competition. The current trend is towards contact-less smart cards, which according to Don Davis, editor of Card Technology magazine, is the next big thing (Davis, 2005:4).

3.3.5 Security architecture and protocols

Security architecture and protocols is a domain that combines the theoretical knowledge of cryptography principles and industrial applications. This is an area in which there is an abundance of explicit information available. Literature on applied cryptography has become readily available in recent years. Industries that rely on cryptography for their payment and data systems tend to use generally accepted and published standards for their security architecture design. The implementation of these designs becomes product and vendor specific at the API level. Therefore a person skilled in this domain has both an understanding of the theory as well as the application level of API's.

3.3.6 Payment protocols and industry specific knowledge

Payment protocols and industry specific knowledge is an adaptation or extension of the security architecture and protocols described in the previous section. The knowledge and skills required by a person to be competent in this area is obtained from the systems already implemented in specific industries. It is effectively a working knowledge and understanding of an application. The Cryptographic theory on which the system is designed may not necessarily form a part of this skill set but it is rather the practical implementation that forms the core. This knowledge is very much obtained from practical experience and is poorly documented within the organisation and not documented at all in the public domain. It is therefore very tacit.

3.3.7 Cryptographic engineering

Cryptographic engineering is exclusively the theoretical element of cryptography. It is a mathematically based science with a limited following.

Knowledge is generally obtained from tertiary studies and, in particular, research at masters or doctorate level. For those learning informally there are published papers and theses available on the topic. This is not a field learnt from experience and observations. Like mathematics, it needs to be actively studied and practiced.

3.3.8 Solution developers

The competence required of solution developers is the ability to take documented APIs and architecture documents and apply them to a solution. This requires an understanding of the application of crypto algorithms. This involves understanding a customers security needs and applying existing 'building blocks' such as cryptographic modules and the APIs supported by them to meet the customer needs. A customer would know their needs at a very high level, for example an auditor from Mastercard or Visa may inform them that they need to comply to a certain security requirement. The solution developer would understand that requirement and be capable of proposing a suitable solution. Knowledge of the customer's environment or architecture and the auditor's security requirements need to be understood.

3.3.9 Summary of core competencies

The core competencies, as defined in the preceding section, are summarized in this section for inclusion into the skills level questionnaire. A note for the reader is that these summaries contain jargon that is specific to the industry and may not necessarily be decipherable by a layman. All knowledge relating to the special skills as defined for each core competence is deemed to be current, with experience acquired or applied within the past 24 months.

3.4 Skills level questionnaire

The definitions from the preceding section were summarised to the reduced form so that they could be compiled into a manageable questionnaire. The questionnaire is presented as annexure B.

3.4.1 Competence domains

The following discussion presents the summarised competence domains as they appear on the questionnaire. The source of the information is all from the focus group.

a) Key management application and systems

- Entry Requirements: BSc: Electronics, Computer Science, Information System or equivalent.
- General Skills: Programming C, C++, GUI experience, documentation skills.
- Special Skills: Have a working knowledge of Applied Cryptography relevant to payment systems.
- Be familiar with customer requirements documents, User manuals, VISA Audit Requirements.
- Have a working knowledge of the ANSI Specification.
- Have knowledge of APIs of Incognito products and of devices programmed by Trusted Centres.
- A specialist should have the required special skills with experience in having written specifications for customers such as ABSA, Pick ń Pay, Wetton (Service Trusted Centre), STS Association, Exxon Mobil and Shoprite. A specialist would have developed and implemented Trusted Centres and Key Management Systems in accordance with specifications.

b) Cryptographic hardware development and application

- Entry Requirements: BSc Electronics or Higher Diploma.
- General Skills: Software (C, VHDL) and hardware development skills.
- Special Skills: hardware development, high-speed digital and

analog.

- Firmware Development: embedded, VHDL.
- Device drivers and target operating systems.
- Tamper mechanism and boot-loaders to meet VISA PED and FIPS140-2 levels 1, 2, 3 & 4 requirements.
- Working knowledge of target operating systems.
- Knowledge of circuitry of Crypto Incognito products, TSM2xx, 3xx and 4xx.
- Ability to develop device drivers.
- Knowledge of Windows, Linux and Solaris operating systems at device driver level.
- Knowledge of industry and standards and specifications, for example: Microsoft WHQL, Stratus ft, SUN, PCI 2.1.
- ***A specialist must be capable of writing a specification in*** accordance with market requirements, and designing the module from schematic stages through to mass production.

c) *Designing application programming interfaces (APIs)*

- Entry Requirements: BSc: Information Systems with a security focus.
- General Skills: Programming C, C++.
- Special Skills: Triple DES algorithm, modes of operation and implementation thereof.
- EMV 4.1 specification.
- PIN Encryption, ANSI X9.8 specification, DUKPT.
- Focus on API security.
- Knowledge of access control, as per VISA Audit requirements.

- A specialist is to have implemented API changes and updates on at least one of the following APIs: MCM, STS, PRIMA and ICSF.
- These skills are generally obtained from learning from others, having read the design section of 'Code Complete' and relevant security papers. One should have a knowledge and awareness of potential weaknesses in APIs.

d) Smart card security

- Entry Requirements: BSc Electronics, BSc Computer Science.
- General Skills: Programming C, C++, Java, embedded hardware environment with high constraints.
- Special Skills: EMV, DUKPT, key management, EFT pin translate, ISO pin block formats, ANSI standards, knowledge of POS terminals and their operating systems, documentation, API implementation, knowledge of ID management, authentication and payment security.

e) Security architecture and protocols

- Entry Requirements: BSc Electronics or Computer Science.
- General Skills: Programming C, C++.
- Special Skills: Understanding of applied cryptography, eg: have read and understood books on applied cryptography.
- On the Job Learning of the architectures of Telco, Banking, Retail, Oilco and Utilities industries.
- Knowledge of the application of APIs, understanding of industry requirements and ability to apply new functions to existing APIs.
- Knowledge of MAC algorithm and key management techniques.
- A person with this skill will be able to select and utilise known APIs

for their implementation in a secure solution. Experience includes knowledge of system and industry standards such as ANSI X9 and ISO security standards.

f) *Payment protocols and industry specific knowledge*

- Entry Requirements: BSc Electronics, Computer Science or similar.
- General Skills: Programming C, C++.
- Special Skills: Key management, electronic payment systems, debit card, EMV and bill payments.
- Knowledge of industry specific systems such as Mobile, Phone, Retail and STS. Familiarity with industry standards.
- Hands-on development required to get familiar with products and history of various versions.
- Person-to-person knowledge transfer required, documentation is limited to product specification, STS specification and source code.
- Understanding legalities of firmware versions requires knowledge transfer from person-to-person.
- STS, Mobile, Phone and Retail.

g) *Crypto engineering*

- Entry Requirements: BSc Electronics, Computer Science or similar.
- General Skills: Software engineering.
- Special Skills: Security engineering.
- This competence requires the in-depth knowledge of books such as crypto engineering. Standards are ANSI and ISO.
- Knowledge of system evaluation as performed by laboratories such as T-systems and Infogard.

- Knowledge of the content of Ross Andersons book, Applied Cryptography and Crypto white papers.
- Knowledge of PIN blocks.

h) Solution developers

- Entry Requirements: BSc Engineering, Computer Science, Engineering Diploma or similar.
- General Skills: System engineering.
- Special Skills: This competence requires the ability to take documented APIs and architecture documents and apply them to a solution.
- Understanding of cryptographic algorithms.

3.4.2 Skills level scaling

The level of experience was measured on a combination of time and capability. This would typically be performance at a defined level over a specified time period. The scale format will be a 5-point Likert scale using an ordinal data type. The five levels on the Likert scale are:

- Exclusive Expert
- Specialist
- Generalist
- Inexperienced
- Unqualified

The five levels, as they appear in the questionnaire, are presented in the following discussion:

a) Exclusive expert

An exclusive expert is the prime developer of a technology in a domain and deemed by the Technical Group Manager (TGM) to be the person most competent in this field within the department. They are always asked to provide input for discussion on this topic and their views are usually those that determine the final outcome of decisions in this domain.

b) Specialist

A specialist has hands-on experience doing development in this domain within the past 12 months and is deemed by the TGM to be capable of responding reliably to senior management on the topic. They are always requested to provide input for discussion on this topic. They are aware of others in the department who have expertise in this domain.

c) Generalist

A generalist has hands-on experience developing in this domain within the past 24 months. The involvement is usually limited to helping out where a specialist is unavailable or working as part of a team. They would generally receive guidance from a specialist when working within this domain.

d) Inexperienced

An inexperienced person may have a suitable academic background to undertake development within this domain, however they have not performed hands-on within this domain in the past 24 months.

e) Unqualified

An unqualified person may require an unproductive training period prior to being deemed competent by their Technical Group Manager (TGM) within this domain.

The Skills Level Questionnaire for this phase was developed to incorporate questioning based on the Likert scale, multiple-choice single-response and multiple-choice multiple-response. The resultant data form the questionnaire is ordinal, that is, there is a progressive proficiency of skill from unqualified through to exclusive expert.

3.4.3 Skills level coding

The skills level questionnaire (SLQ) was coded to simplify the data analysis procedure. The coding technique differentiated the responses between the domains of core competency and the relative skill levels. The competence domains were numbered from 1 to 8. Domain 2 was divided into parts a, b and c. Domain 6 was divided into parts a, b, c, d and e. Domains 2 and 6 were considered too broad on their own and, therefore, were divided down to increase the resolution. The skills levels were coded from 5 down to 1 for ‘exclusive expert’, ‘specialist’, ‘generalist’, ‘inexperienced’ and ‘unqualified’ respectively.

3.4.4 Summary of the skills level questionnaire

The skills level questionnaire was drafted after the focus group session and consisted of eight major competence domains. The requirement of this questionnaire was to collect data that would represent the depth and level of skills of the respondents within the defined competency domains. The questionnaire was geared at a level appropriate to development engineers within the business unit. That is, they would typically be familiar with the acronyms and abbreviations used in the questionnaire. The skills level questionnaire was reviewed for structure and lines of questioning as part of the research proposal. The skills level grading was validated by senior developers and the technical group manager of the Crypto Business Unit.

3.5 Learning styles questionnaire

Honey and Mumford's (2000) learning styles questionnaire (LSQ) was purchased for the purposes of this study from Peter Honey's website [online: peterhoney.com] and was used to evaluate learning style preferences of the participants. The LSQ and its associated user guide were used to administer the questionnaires and analyse the data.

3.5.1 Learning styles scaling

The LSQ has four styles: Activist, Theorist, Pragmatist and Reflector. The questions are answered in binary format and the data type is ordinal. The construct validity and internal reliability have been validated with alphas of 0.59 and 0.74 respectively (Van Zwanenberg & Wilkinson, 2000:365).

The orders of learning style preference are scaled as follows:

- Very low preference
- Low preference
- Moderate preference
- High preference
- Very high preference

The LSQ has been reviewed and evaluated in other studies. Duff (2001:189) concluded that prior research found the scores produced by the LSQ as having moderate to satisfactory internal consistency reliability.

3.5.2 Learning styles coding

The LSQ coding is documented in The Learning Styles Helper's Guide™ (Honey and Mumford, 2000). This questionnaire has 80 questions that are binary coded and ordinal. There are no right and no wrong answers. If the respondents agree more than they disagree with a statement, they put a tick (√)

in the box. If they disagree more than they agree, they put a cross in the box. This is to prevent unanswered or skipped questions being recorded as incorrect. The questionnaire is presented as annexure C.

3.6 Sample size

The sample size for the ‘Skills Level’ and ‘Learning Styles’ questionnaires was fifteen (15). This comprised eight people from the development team in the crypto business unit in Kwa-Zulu Natal, four from Gauteng and three from Cape Town. The sample was selected from the organisations development staff who were deemed by the head of engineering to have experience in the field of cryptography. Note that though the sample size is small, comparisons are made with secondary data from the LSQ where the sample sizes are 3,500 for general norms and 173 for engineering/science graduates (Honey and Mumford, 2000:61).

3.7 Data collection

The second phase of the research design was the collection of data via the administered questionnaires as a once-off cross-sectional data collection process. The questionnaires were handed to participants in Durban and emailed to the respondents in Gauteng and Cape Town. The responses from Durban were collected by hand and those from the other regions were received via return email. The Honey and Mumford (2000) 80-question learning styles questionnaire was administered in accordance with the user guide purchased with the questionnaire.

3.8 Data analysis

The following discussion describes the methods used to manage the data.

3.8.1 Handling of data

Confidentiality has been retained between researcher and participant. The participants' names have been withheld and are referred to as respondent one through to respondent fifteen.

3.8.2 Presentation

For the presentation of the data a coding format was designed in order to simplify analysis by an end user. It is not desirable to burden senior managers with pages of data and statistics. It is preferable to have a visual representation that is simple to analyse at a glance. Graphical presentations are presented showing a cross section of total depth of skills across all the respondents. Both the SLQ and the LSQ data are presented in a table format.

3.8.3 Statistical analysis

Goodman and Kruskal's gamma was calculated using data from both the SLQ and LSQ to determine whether there was any measure of association between skills levels and learning styles. The measurement of gamma uses concordant pairs versus discordant pairs to predict association. The value of gamma is the proportional reduction of error when prediction is done using preponderance of evidence (Cooper & Schindler; 2001:559). The values of gamma range from -1.0 to +1.0. A strong negative association is indicated when gamma approaches minus one. A strong positive association is indicated when gamma approaches positive one. Values of gamma close to zero indicate little or no measure of association.

The concordant pairs are:

1. High skills level indicated as 'specialist' or 'exclusive expert' and
2. A strong or very strong learning style preference.

For example: If there are five specialists identified across the thirteen skills domains and of these five, four have a strong preference for the 'theorist' learning style, then:

Concordant pairs (P) = 4 – [indicated by the four with a strong preference for theorist]
Discordant pairs (Q) = 1 – [Indicated by the one specialist without the strong preference for theorist]
Gamma = (P-Q)/(P+Q) = (4 -1)/(4 +1) = 3/5 or 0.6

This example indicates a fairly high measure of association between ‘specialist’ and the ‘theorist’ learning style.

Gamma is calculated for all permutations of ‘learning styles’ (4-off) and ‘specialists and generalists’ (3-off). A total of four gammas are analysed.

3.8.4 Nature/Form of results

The results, though having been collected openly within the organisation throughout the data gathering process, are highly company confidential. This could expose strengths and weaknesses within the organisation that would not be desirable in the hands of the competitors.

3.8.5 Conclusion

Chapter three described the research methodology used for the study. It commenced with the focus group study that defined the domains that were used for the design of the skills level questionnaire (SLQ). The output from the focus group session achieved the first objective of the study, which was to determine the specific domains of core competence required within the cryptographic business unit. The SLQ was developed to enable the depth and level of core skills to be identified. An overview of the learning styles questionnaire was presented. Finally the methodology culminates with an analysis of a measure of association being done between data from the SLQ and the LSQ.

The next chapter presents the quantitative data as acquired from the two questionnaires, SLQ and LSQ.

Chapter Four: Presentation of data

4.1 Introduction

In this chapter, the data from the SLQ and LSQ questionnaires are presented. The second objective of the study was to determine the actual number of human resources in possession of the defined competencies (depth) and their relative experience within the defined domain (level). The third objective was to determine the preferred learning styles of the respondents.

4.2 Data acquisition

The second phase of the study was to acquire data from a team of developers within a single business unit, who are actively involved in the development environment and who are deemed to be knowledgeable in some or all of the domains as defined in chapter three.

The two questionnaires were distributed to the candidates and responses received over a 10-day period. These were the skills level questionnaire and the learning styles questionnaire. The candidates were from three geographical regions: Durban, Cape Town and Gauteng.

Durban is the centre for cryptographic development within the organisation and, as a result, eight of the fifteen candidates selected for participation were from this region. Four were from Gauteng and three from Cape Town. The eight respondents from Durban represent a census of the developers in this region within the organisation. Cape Town and Gauteng have other developers with general skills in the defined domains. A list was drawn up by the Head of Engineering, indicating all the people within the engineering team that have experience in crypto related development. Questionnaires were sent to all of these people, totalling twenty. Ten were sent to Gauteng and ten to Cape Town. Three responses were received from Cape Town and four from Gauteng. The response rates were, therefore, KZN: 100%, Cape: 33% and Gauteng: 40%.

The rationale behind this study is ultimately to have a means of effectively allocating human resources, with appropriate skills, to project teams. For the purposes of this study the abovementioned respondents are, at the time of the survey, deemed to be a very good representation of the set of human resources from which all crypto related projects are drawn. Each respondent completed both the skills level questionnaire and the learning styles questionnaire.

4.3 Skills level data

The skills level questionnaire contained the eight core competence domains as presented in the following discussion. Domains 2 and 6 have each been expanded into three and four skills respectively to gain better resolution. A total of thirteen skills are therefore defined.

4.3.1 Competence domains

- Domain 1:Key Management Application and Systems - Skill 1.
- Domain 2: Cryptographic Hardware Development and Application.
  - Hardware – Skill 2.
  - Firmware – Skill 3.
  - Drivers and Operating Systems – Skill 4.
- Domain 3: Designing Application Programming Interfaces (APIs) – Skill 5.
- Domain 4: Smart Card Security – Skill 6.
- Domain 5: Security Architecture and Protocols – Skill 7.
- Domain 6: Payment Protocols and Industry Specific Knowledge.
  - STS – Skill 8.
  - Mobile/Prepaid – Skill 9.
  - Sicrypts – Skill 10.

- Retail EPS/EMV) – Skill 11.

- Domain 7: Crypto Engineering – Skill 12.
- Domain 8: Solution Developers – Skill 13.

4.3.2 Presentation of skills levels data

The following discussion presents the skills and associated skill level for each of the fifteen respondents.

a) Respondent 1

Respondent one is inexperienced in skills 2, 3, 4, 5, 6, 8, 9, 10, 11 and is a generalist in skills 1, 7, 12 and 13. This respondent has two PhDs. The tabulated results are presented in Table 4-1.

Table 4-1: Skill levels of respondent 1

Respondent 1			
Skill		Skill Level	
Domain 1	Skill 1	3	Generalist
Domain 2	Skill 2	2	Inexperienced
	Skill 3	2	Inexperienced
	Skill 4	2	Inexperienced
Domain 3	Skill 5	2	Inexperienced
Domain 4	Skill 6	2	Inexperienced
Domain 5	Skill 7	3	Generalist
Domain 6	Skill 8	2	Inexperienced
	Skill 9	2	Inexperienced
	Skill 10	2	Inexperienced
	Skill 11	2	Inexperienced
Domain 7	Skill 12	3	Generalist
Domain 8	Skill 13	3	Generalist

b) Respondent 2

Respondent two is inexperienced in skills 2, 6 and 7, is a generalist in skills 1, 3, 5, 8, 9, 10,11, 12 and a specialist in skills 4 and 13. The tabulated results are presented in Table 4-2.

Table 4-2: Skill levels of respondent 2

Respondent 2			
Skill		**Skill Level**	
Domain 1	Skill 1	3	Generalist
Domain 2	Skill 2	2	Inexperienced
	Skill 3	3	Generalist
	Skill 4	4	Specialist
Domain 3	Skill 5	3	Generalist
Domain 4	Skill 6	2	Inexperienced
Domain 5	Skill 7	2	Inexperienced
Domain 6	Skill 8	3	Generalist
	Skill 9	3	Generalist
	Skill 10	3	Generalist
	Skill 11	3	Generalist
Domain 7	Skill 12	3	Generalist
Domain 8	Skill 13	4	Specialist

c) Respondent 3

Respondent three is unqualified in all thirteen skills. This respondent's skills lie in a domain that has not been identified as a core competence domain. The tabulated results are presented in Table 4-3.

Table 4-3: Skill levels of respondent 3

Respondent 3			
Skill		**Skill Level**	
Domain 1	Skill 1	1	Unqualified
Domain 2	Skill 2	1	Unqualified
	Skill 3	1	Unqualified
	Skill 4	1	Unqualified
Domain 3	Skill 5	1	Unqualified
Domain 4	Skill 6	1	Unqualified
Domain 5	Skill 7	1	Unqualified
Domain 6	Skill 8	1	Unqualified
	Skill 9	1	Unqualified
	Skill 10	1	Unqualified
	Skill 11	1	Unqualified
Domain 7	Skill 12	1	Unqualified
Domain 8	Skill 13	1	Unqualified

d) Respondent 4

Respondent four is inexperienced in skills 3, 4, 5, 8, 9 and 10 and is a generalist in skills 6, 7, 11, 12 and 13 and specialist in skill 1. The tabulated results are presented in Table 4-4.

Table 4-4: Skill levels of respondent 4

Respondent 4			
Skill		**Skill Level**	
Domain 1	Skill 1	4	Specialist
Domain 2	Skill 2	1	Unqualified
	Skill 3	2	Inexperienced
	Skill 4	2	Inexperienced
Domain 3	Skill 5	2	Inexperienced
Domain 4	Skill 6	3	Generalist
Domain 5	Skill 7	3	Generalist
Domain 6	Skill 8	2	Inexperienced
	Skill 9	2	Inexperienced
	Skill 10	2	Inexperienced
	Skill 11	3	Generalist
Domain 7	Skill 12	3	Generalist
Domain 8	Skill 13	3	Generalist

e) Respondent 5

Respondent five is inexperienced in skills 2, 4 and 10 and is a generalist in skills 3, 6, 7, 8, 9 and 12 and specialist in skills 1, 5, 11 and 13. The respondent has a BSc degree in electronic engineering. The tabulated results are presented in Table 4-5.

Table 4-5: Skill levels of respondent 5

Respondent 5			
Skill		**Skill Level**	
Domain 1	Skill 1	4	Specialist
Domain 2	Skill 2	2	Inexperienced
	Skill 3	3	Generalist
	Skill 4	2	Inexperienced
Domain 3	Skill 5	4	Specialist
Domain 4	Skill 6	3	Generalist
Domain 5	Skill 7	3	Generalist
Domain 6	Skill 8	3	Generalist
	Skill 9	3	Generalist
	Skill 10	2	Inexperienced
	Skill 11	4	Specialist
Domain 7	Skill 12	3	Generalist
Domain 8	Skill 13	4	Specialist

f) Respondent 6

Respondent six is inexperienced in skills 4, 6, 9 and 10, a generalist in skill 11 and a specialist in skills 1, 3, 5, 7, 8, 12 and 13. Respondent six is unqualified in skill 2. The respondent has an honours degree in computer science and studied cryptography at university level. The tabulated results are presented in Table 4-6.

Table 4-6: Skill levels of respondent 6

Respondent 6			
Skill		Skill Level	
Domain 1	Skill 1	4	Specialist
Domain 2	Skill 2	1	Unqualified
	Skill 3	4	Specialist
	Skill 4	2	Inexperienced
Domain 3	Skill 5	4	Specialist
Domain 4	Skill 6	2	Inexperienced
Domain 5	Skill 7	4	Specialist
Domain 6	Skill 8	5	Specialist
	Skill 9	2	Inexperienced
	Skill 10	2	Inexperienced
	Skill 11	3	Generalist
Domain 7	Skill 12	4	Specialist
Domain 8	Skill 13	4	Specialist

g) Respondent 7

Respondent seven is inexperienced in skills 4, 6 and 8, and is a generalist in skills 1, 3 and 9 and specialist in skills 5, 7, 11, 12 and 13. Respondent seven is unqualified in skills 2 and 10 and has a bachelor's degree in computer science. The tabulated results are presented in Table 4-7.

Table 4-7: Skill levels of respondent 7

Respondent 7			
Skill		**Skill Level**	
Domain 1	Skill 1	3	Generalist
Domain 2	Skill 2	1	Unqualified
	Skill 3	3	Generalist
	Skill 4	2	Inexperienced
Domain 3	Skill 5	4	Specialist
Domain 4	Skill 6	2	Inexperienced
Domain 5	Skill 7	4	Specialist
Domain 6	Skill 8	2	Inexperienced
	Skill 9	3	Generalist
	Skill 10	1	Unqualified
	Skill 11	4	Specialist
Domain 7	Skill 12	4	Specialist
Domain 8	Skill 13	4	Specialist

h) Respondent 8

Respondent eight is inexperienced in skills 2, 6, 9, 10 and 12, and is a generalist in skills 1, 8 and 11 and specialist in skills 3, 4, 5, 7 and 13. The respondent has a bachelor's degree in computer science. The tabulated results are presented in Table 4-8.

Table 4-8: Skill levels of respondent 8

Respondent 8			
Skill		**Skill Level**	
Domain 1	Skill 1	3	Generalist
Domain 2	Skill 2	2	Inexperienced
	Skill 3	4	Specialist
	Skill 4	5	Specialist
Domain 3	Skill 5	4	Specialist
Domain 4	Skill 6	2	Inexperienced
Domain 5	Skill 7	4	Specialist
Domain 6	Skill 8	3	Generalist
	Skill 9	2	Inexperienced
	Skill 10	2	Inexperienced
	Skill 11	3	Generalist
Domain 7	Skill 12	2	Inexperienced
Domain 8	Skill 13	4	Specialist

i) Respondent 9

Respondent nine is inexperienced in skills 5, 6, 8, 9, 10, 11 and 13, and is a generalist in skills 1, 4, 7 and 12, and specialist in skills 2 and 3. The respondent has a master's degree in electronic engineering. The tabulated results are presented in Table 4-9.

Table 4-9: Skill levels of respondent 9

Respondent 9			
Skill		**Skill Level**	
Domain 1	Skill 1	3	Generalist
Domain 2	Skill 2	5	Specialist
	Skill 3	4	Specialist
	Skill 4	3	Generalist
Domain 3	Skill 5	2	Inexperienced
Domain 4	Skill 6	2	Inexperienced
Domain 5	Skill 7	3	Generalist
Domain 6	Skill 8	2	Inexperienced
	Skill 9	2	Inexperienced
	Skill 10	2	Inexperienced
	Skill 11	2	Inexperienced
Domain 7	Skill 12	3	Generalist
Domain 8	Skill 13	2	Inexperienced

j) Respondent 10

Respondent ten is inexperienced in skills 4, 6, and 10, and is a generalist in skills 8 and 13 and a specialist in skills 1, 2, 3, 5, 7, 9, 11 and 12. The respondent has a master's degree in electronic engineering. The tabulated results are presented in Table 4-10.

Table 4-10: Skill levels of respondent 10

Respondent 10			
Skill		**Skill Level**	
Domain 1	Skill 1	4	Specialist
Domain 2	Skill 2	4	Specialist
	Skill 3	4	Specialist
	Skill 4	2	Inexperienced
Domain 3	Skill 5	4	Specialist
Domain 4	Skill 6	2	Inexperienced
Domain 5	Skill 7	4	Specialist
Domain 6	Skill 8	3	Generalist
	Skill 9	4	Specialist
	Skill 10	2	Inexperienced
	Skill 11	4	Specialist
Domain 7	Skill 12	4	Specialist
Domain 8	Skill 13	3	Generalist

k) Respondent 11

Respondent eleven is inexperienced in skills 5 and 6, and is a generalist in skills 1, 9, 12 and 13, and specialist in skills 7 and 10. Respondent eleven is unqualified in skills 2, 3, 4, 8 and 11. The tabulated results are presented in Table 4-11.

Table 4-11: Skill levels of respondent 11

Respondent 11			
Skill		**Skill Level**	
Domain 1	Skill 1	3	Generalist
Domain 2	Skill 2	1	Unqualified
	Skill 3	1	Unqualified
	Skill 4	1	Unqualified
Domain 3	Skill 5	2	Inexperienced
Domain 4	Skill 6	2	Inexperienced
Domain 5	Skill 7	4	Specialist
Domain 6	Skill 8	1	Unqualified
	Skill 9	3	Generalist
	Skill 10	4	Specialist
	Skill 11	1	Unqualified
Domain 7	Skill 12	3	Generalist
Domain 8	Skill 13	3	Generalist

l) Respondent 12

Respondent twelve is inexperienced in skills 1, 6, 7, 8 and 13, and is a generalist in skills 9, 11 and 12, and is unqualified in skills 2, 3, 4, 5 and 10. The tabulated results are presented in Table 4-12.

Table 4-12: Skill levels of respondent 12

Respondent 12			
Skill		**Skill Level**	
Domain 1	Skill 1	2	Inexperienced
Domain 2	Skill 2	1	Unqualified
	Skill 3	1	Unqualified
	Skill 4	1	Unqualified
Domain 3	Skill 5	1	Unqualified
Domain 4	Skill 6	2	Inexperienced
Domain 5	Skill 7	2	Inexperienced
Domain 6	Skill 8	2	Inexperienced
	Skill 9	3	Generalist
	Skill 10	1	Unqualified
	Skill 11	3	Generalist
Domain 7	Skill 12	3	Generalist
Domain 8	Skill 13	2	Inexperienced

m) Respondent 13

Respondent thirteen is unqualified in skills 1, 2, 3, 4, 5, 6, 7, 8, 9, 10 and 12, and is a generalist in skills 11 and 13. The tabulated results are presented in Table 4-13.

Table 4-13: Skill levels of respondent 13

Respondent 13			
Skill		**Skill Level**	
Domain 1	Skill 1	1	Unqualified
Domain 2	Skill 2	1	Unqualified
	Skill 3	1	Unqualified
	Skill 4	1	Unqualified
Domain 3	Skill 5	1	Unqualified
Domain 4	Skill 6	1	Unqualified
Domain 5	Skill 7	1	Unqualified
Domain 6	Skill 8	1	Unqualified
	Skill 9	1	Unqualified
	Skill 10	1	Unqualified
	Skill 11	3	Generalist
Domain 7	Skill 12	1	Unqualified
Domain 8	Skill 13	3	Generalist

n) *Respondent 14*

Respondent fourteen is inexperienced in skills 2, 8, 9 and 10, and is a generalist in skills 3, 4 and 12, and specialist in skills 1, 5, 6, 7, 11 and 13. The respondent has a master's degree in electronic engineering and an MBA. The tabulated results are presented in Table 4-14.

Table 4-14: Skill levels of respondent 14

Respondent 14			
Skill		**Skill Level**	
Domain 1	Skill 1	4	Specialist
Domain 2	Skill 2	2	Inexperienced
	Skill 3	3	Generalist
	Skill 4	3	Generalist
Domain 3	Skill 5	4	Specialist
Domain 4	Skill 6	4	Specialist
Domain 5	Skill 7	4	Specialist
Domain 6	Skill 8	2	Inexperienced
	Skill 9	2	Inexperienced
	Skill 10	2	Inexperienced
	Skill 11	5	Specialist
Domain 7	Skill 12	3	Generalist
Domain 8	Skill 13	4	Specialist

o) Respondent 15

Respondent fifteen is inexperienced in skills 2, 3, 4, 12 and 13, and is a generalist in skills 1, 5 and 7 and specialist in skills 6 and 11. Respondent fifteen is unqualified in skills 8, 9 and 10. The tabulated results are presented in Table 4-15.

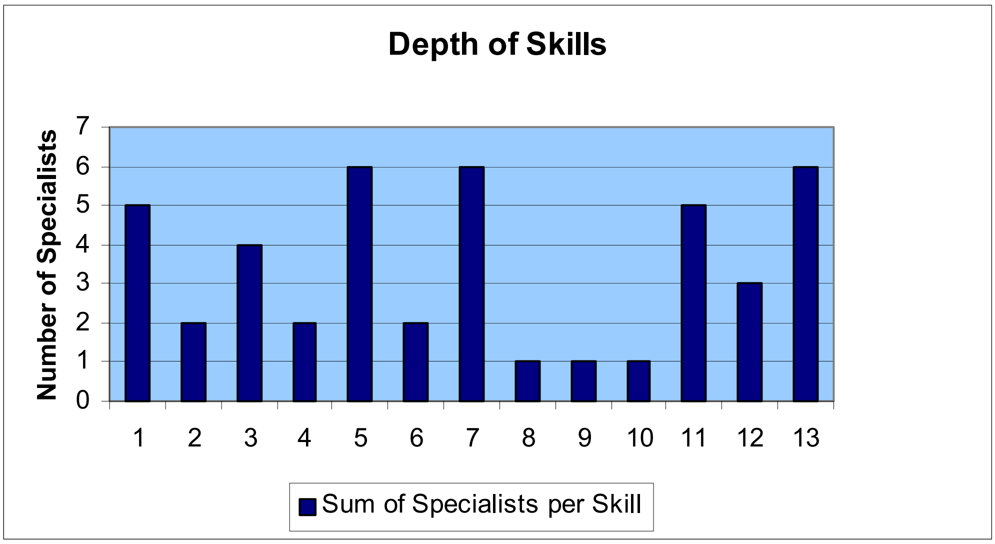
Table 4-15: Skill levels of respondent 15

Respondent 15			
Skill		**Skill Level**	
Domain 1	Skill 1	3	Generalist
Domain 2	Skill 2	2	Inexperienced
	Skill 3	2	Inexperienced
	Skill 4	2	Inexperienced
Domain 3	Skill 5	3	Generalist
Domain 4	Skill 6	4	Specialist
Domain 5	Skill 7	3	Generalist
Domain 6	Skill 8	1	Unqualified
	Skill 9	1	Unqualified
	Skill 10	1	Unqualified
	Skill 11	4	Specialist
Domain 7	Skill 12	2	Inexperienced
Domain 8	Skill 13	2	Inexperienced

4.3.3 Depth of skills

For the purposes of this study the depth of skills is defined as the number of human resources that possess an identified set of skills and experience at the level of a specialist, as defined in section 3.4.2. The maximum number of specialist for any one skill is six and this is for skills 5, 7 and 13. Skills 8, 9 and 10 have only one specialist each. The remaining skills have between two and five specialists per skill. The sum of the number of specialists for each of the thirteen skills is presented in Figure 4-1. A total of 44 instances of specialist skills are recorded across the 13 skills with an average of 3.38 specialists per skill. The maximum depth of skills is therefore 6, the minimum 1 and the average is 3.38.

Figure 4-1: Profile of the depth of skills across the domains



The skills level profile provides a snapshot view of the depth of skills across all the core competence domains. At a glance a human resource manager can determine the domains of strength and weakness within a business unit and determine general training needs.

4.4 Learning styles data

The third objective of the study was to determine the learning styles preferences of the respondents. The following discussion presents the data obtained from the LSQ.

The second questionnaire completed by the respondents is the 'Honey and Mumford Learning Styles Questionnaire'. The relevance of this questionnaire was to provide insight into this aspect of individuals and the team in order to assist in the development of skills. Honey and Mumford (2000) advise against using the tool as a selection tool. "*The questionnaire is solely designed to be an aid to self-assessment and self-managed learning*" (Honey & Mumford: 2000:22). In the context of this study an exploratory investigation was done to determine whether there is a relationship between learning styles and skills acquired within a learning environment.

Discussion in chapter two indicated that the specific skills required within this industry are not readily acquired from tertiary education but are most likely to be acquired from within the industry and its associated learning environment. It can be reasonably deduced that the respondents that have reached the specialist level of any skills type, as defined in chapter three, have acquired their domain knowledge from within the learning environment of the same organisation. The culture of the organisation can be deemed to be constant over the period relevant to this study. It is noted that the questionnaire specifically requested that the skills be current and the level of expertise be relevant to the past twenty-four months. This was to contain the results to a period over which the company culture, and hence learning environment, is unlikely to have changed significantly.

4.4.1 Presentation of LSQ data

The data for each of the fifteen respondents is presented in the following discussion. The data is presented in table format with three rows, the first showing the scores recorded for the respondent correlating to each of the four learning styles. The second indicates the averages for each of the learning styles as recorded by Honey and Mumford (2000) for a specific group of individuals that are classified as Engineering/Science graduates. The respondents all fit into this group. The third row is the averages for a general group of 3,500 respondents as recorded by Honey and Mumford (2000). The data in the cells corresponding to each of the learning styles, activist, reflector, theorist and pragmatist, is colour coded in terms of the level of the learning style preference in accordance with the reference in Table 4-16. Red indicates a very strong preference, orange a strong preference, yellow a moderate preference, blue a low preference and green a very low preference. The data range for each of the learning styles is indicated in Table 4-16 in the cells below the learning style. These ranges are in accordance with the Honey and Mumford User Guide (2000) for the category of general norms, taken from a sample of 3,500 people.

Table 4-16: General norms for learning styles

Reference (General Norms)	Activist	Reflector	Theorist	Pragmatist
Very strong preference	13-20	18-20	16-20	17-20
Strong preference	11-12	15-17	14-15	15-16
Moderate preference	7-10	12-14	11-13	12-14
Low preference	4-6	9-11	8-10	9-11
Very low preference	0-3	0-8	0-7	0-8

a) *Respondent 1*

Respondent one has a very strong preference for the activist learning style, strong preferences for reflector and theorist styles and a moderate preference for the pragmatist style. The respondent's data is recorded in Table 4-17.

Table 4-17: Learning style preferences for respondent 1

	Activist	Reflector	Theorist	Pragmatist
Respondent 1	15	16	14	14
Norm for Engineering/Science graduates	8.6	14.2	12.2	12.7
General norm	9.3	13.6	12.5	13.7

b) *Respondent 2*

Respondent two has a very low preference for the activist learning style, a strong preference for reflector and pragmatist styles and a very strong preference for the theorist style. The respondent's data is recorded in Table 4-19.

Table 4-18: Learning style preferences for respondent 2

	Activist	Reflector	Theorist	Pragmatist
Respondent 2	3	17	18	15
Norm for Engineering/Science graduates	8.6	14.2	12.2	12.7
General norm	9.3	13.6	12.5	13.7

c) *Respondent 3*

Respondent three has moderate preferences for the activist, reflector and theorist learning styles and a strong preference the pragmatist style. The respondent's data is recorded in Table 4-19.

Table 4-19: Learning style preferences for respondent 3

	Activist	Reflector	Theorist	Pragmatist
Respondent 3	7	14	13	15
Norm for Engineering/Science graduates	8.6	14.2	12.2	12.7
General norm	9.3	13.6	12.5	13.7

d) Respondent 4

Respondent four has a low preference for the activist learning style and strong preferences for reflector, theorist and pragmatist styles. The respondent's data is recorded in Table 4-20.

Table 4-20: Learning style preferences for respondent 4

	Activist	Reflector	Theorist	Pragmatist
Respondent 4	7	15	14	16
Norm for Engineering/Science graduates	8.6	14.2	12.2	12.7
General norm	9.3	13.6	12.5	13.7

e) Respondent 5

Respondent five has a low preference for the activist learning style and strong preferences for reflector, theorist and pragmatist styles. The respondent's data is recorded in Table 4-21.

Table 4-21: Learning style preferences for respondent 5

	Activist	Reflector	Theorist	Pragmatist
Respondent 5	6	15	14	15
Norm for Engineering/Science graduates	8.6	14.2	12.2	12.7
General norm	9.3	13.6	12.5	13.7

f) Respondent 6

Respondent six has a low preference for the activist learning style, a strong preference for reflector style and moderate preferences for the theorist and pragmatist styles. The respondent's data is recorded in Table 4-22.

Table 4-22: Learning style preferences for respondent 6

	Activist	Reflector	Theorist	Pragmatist
Respondent 6	6	16	12	14
Norm for Engineering/Science graduates	8.6	14.2	12.2	12.7
General norm	9.3	13.6	12.5	13.7

g) Respondent 7

Respondent seven has a low preference for the activist learning style, strong preferences for reflector and theorist, and a very strong preference for the pragmatist style. The respondent's data is recorded in Table 4-23.

Table 4-23: Learning style preferences for respondent 7

	Activist	Reflector	Theorist	Pragmatist
Respondent 7	6	15	14	17
Norm for Engineering/Science graduates	8.6	14.2	12.2	12.7
General norm	9.3	13.6	12.5	13.7

h) Respondent 8

Respondent eight has a very low preference for the activist learning style, a moderate preference for reflector style, a strong preference for the theorist style and a very strong preference for the pragmatist style. The respondent's data is recorded in Table 4-24.

Table 4-24: Learning style preferences for respondent 8

	Activist	Reflector	Theorist	Pragmatist
Respondent 8	2	12	14	18
Norm for Engineering/Science graduates	8.6	14.2	12.2	12.7
General norm	9.3	13.6	12.5	13.7

i) Respondent 9

Respondent nine has low preferences for the activist and theorist learning style, a very strong preference for reflector and a strong preference for the pragmatist learning style. The respondent's data is recorded in Table 4-25.

Table 4-25: Learning style preferences for respondent 9

	Activist	Reflector	Theorist	Pragmatist
Respondent 9	4	16	14	15
Norm for Engineering/Science graduates	8.6	14.2	12.2	12.7
General norm	9.3	13.6	12.5	13.7

j) Respondent 10

Respondent ten has a very low preference for the activist and pragmatist learning styles, a low preference for reflector and a moderate preference for the theorist learning style. The respondent's data is recorded in Table 4-26.

Table 4-26: Learning style preferences for respondent 10

	Activist	Reflector	Theorist	Pragmatist
Respondent 10	3	9	11	7
Norm for Engineering/Science graduates	8.6	14.2	12.2	12.7
General norm	9.3	13.6	12.5	13.7

k) Respondent 11

Respondent eleven has a moderate preference for the activist, theorist and pragmatist learning styles and a strong preference for reflector style. The respondent's data is recorded in Table 4-27.

Table 4-27: Learning style preferences for respondent 11

	Activist	Reflector	Theorist	Pragmatist
Respondent 11	9	15	11	12
Norm for Engineering/Science graduates	8.6	14.2	12.2	12.7
General norm	9.3	13.6	12.5	13.7

l) Respondent 12

Respondent twelve has a low preference for the activist learning style, strong preferences for reflector and pragmatist styles, and a moderate preference for the theorist style. The respondent's data is recorded in Table 4-28.

Table 4-28: Learning style preferences for respondent 12

	Activist	Reflector	Theorist	Pragmatist
Respondent 12	4	15	11	15
Norm for Engineering/Science graduates	8.6	14.2	12.2	12.7
General norm	9.3	13.6	12.5	13.7

m) Respondent 13

Respondent thirteen has moderate preferences for the activist and theorist learning styles and strong preferences for reflector and pragmatist styles. The respondent's data is recorded in Table 4-29.

Table 4-29: Learning style preferences for respondent 13

	Activist	Reflector	Theorist	Pragmatist
Respondent 13	9	16	12	16
Norm for Engineering/Science graduates	8.6	14.2	12.2	12.7
General norm	9.3	13.6	12.5	13.7

n) Respondent 14

Respondent fourteen has a low preference for the activist learning style, strong preferences for reflector and theorist styles, and a moderate preference for the pragmatist style. The respondent's data is recorded in Table 4-30.

Table 4-30: Learning style preferences for respondent 14

	Activist	Reflector	Theorist	Pragmatist
Respondent 14	6	16	15	12
Norm for Engineering/Science graduates	8.6	14.2	12.2	12.7
General norm	9.3	13.6	12.5	13.7

o) Respondent 15

Respondent fifteen has a low preference for the activist learning style, strong preferences for reflector and theorist styles, and a moderate preference for the pragmatist style. The respondent's data is recorded in Table 4-31.

Table 4-31: Learning style preferences for respondent 15

	Activist	Reflector	Theorist	Pragmatist
Respondent 15	5	15	14	13
Norm for Engineering/Science graduates	8.6	14.2	12.2	12.7
General norm	9.3	13.6	12.5	13.7

4.4.2 Summary of LSQ data

A summary of the data as recorded for each of the fifteen respondents is presented in Table 4-32.

Table 4-32: Summary of learning styles for the fifteen respondents

	Activist	Reflector	Theorist	Pragmatist
Respondent 1	15	16	14	14
Respondent 2	3	17	18	15
Respondent 3	7	14	13	15
Respondent 4	7	15	14	16
Respondent 5	6	15	14	15
Respondent 6	6	16	12	14
Respondent 7	6	15	14	17
Respondent 8	2	12	14	18
Respondent 9	4	16	14	15
Respondent 10	3	9	11	7
Respondent 11	9	15	11	12
Respondent 12	4	15	11	15
Respondent 13	9	16	12	16
Respondent 14	6	16	15	12
Respondent 15	5	15	14	13
Average for 15 respondents	6.1	14.8	13.4	14.3

4.4.3 Average for general norms

The average scores for activist, reflector, theorist and pragmatist are 6.1, 14.8, 13.4 and 14.3 respectively. The average scores for the general norm are 9.3, 13.6, 12.5 and 13.7 respectively for the four learning styles, activist, reflector, theorist and pragmatist. The averages, as recorded for the group and for the general norms, are presented in Table 4-33. The variances between the respondents' averages and the norm averages are –34.1%, 8.8%, 7.2% and 4.1% for the same respective styles.

Table 4-33: Average for 15 respondents versus general norms

	Activist	Reflector	Theorist	Pragmatist
Average for 15 respondents	6.1	14.8	13.4	14.3
Average for general norm	9.3	13.6	12.5	13.7
Percentage variance	-34.1%	8.8%	7.2%	4.1%

4.4.4 Norms for engineering/science graduates

Honey and Mumford (2000) present a set of value ranges that represent the norms for specific groups of people. The ranges for a group of engineering/science graduates are presented in Table 4-34.

Table 4-34: Learning style norms for engineering/science graduates

Reference (E/S Graduates)	Activist	Reflector	Theorist	Pragmatist
Very strong preference	13-20	18-20	16-20	16-20
Strong preference	11-12	16-17	14-15	14-15
Moderate preference	6-10	12-15	11-13	11-13
Low preference	4-5	9-11	8-10	9-10
Very low preference	0-3	0-8	0-7	0-8

4.4.5 Average for engineering/science graduates

The averages for the engineering/science graduates, as recorded by Honey and Mumford (2000), are 8.6, 14.2, 12.2 and 12.7 for activist, reflector, theorist and pragmatist respectively. The averages for the fifteen respondents are presented together with the Honey and Mumford averages in Table 4-35.

The variances between the respondents' averages and the norm are –34.1%, 8.8%, 7.2% and 4.1% for the four respective styles.

Table 4-35: Average for 15 respondents versus Eng/Sci norms

	Activist	Reflector	Theorist	Pragmatist
Average for 15 respondents	6.1	14.8	13.4	14.3
Average for Eng/Sci graduates	8.6	14.2	12.2	12.7
Percentage variance	-28.7%	4.2%	9.8%	12.3%

4.5 Summary

Chapter four presented the quantitative data as acquired from the SLQ and LSQ questionnaires. The data from the SLQ provides an indication of the level of the fifteen respondents across thirteen skills categories. The number of specialists per skill domain was extracted from the raw data and presented as the depth per skill type. This achieved the second objective of the study.

The data from the LSQ represents the preferred learning styles of each of the respondents. The average scores for the respondents were presented together with the norms for the categories of 'general' and 'engineering/science' graduates. This achieved the third objective of the study.

Chapter five presents an analysis of the data that has been presented in chapter four.

Chapter Five: Data interpretation

5.1 Introduction

The purpose of this chapter is to interpret the data that was presented in chapter four. The analysis has been structured to extract information that may be pertinent to the aim of the study, in particular towards achieving the fourth and final objective of the study. The fourth objective is to determine whether there is any relationship between levels of expertise and learning styles within this industry that would warrant change to be implemented to create a learning environment conducive to creating more specialists.

5.2 The baseline for analysis

Honey and Mumford (2000:61-67) identify normal profiles across various groups. Two groups are applicable to this study, general norms and engineering/science graduates. The latter group is representative of the respondents of this study. The general norms for a sample of 3,500 people indicate the means for activist, reflector, theorist and pragmatist as 9.3, 13.6, 12.5 and 13.7 respectively. For the group of engineering/science graduates, the means for activist, reflector, theorist and pragmatist are 8.6, 14.2, 12.2 and 12.7 respectively. The baseline data is presented in Table 5-1.

Table 5-1: Learning style baseline variances

	Activist	Reflector	Theorist	Pragmatist
Average for general norms	9.3	13.6	12.5	13.7
Average for Eng/Sci graduates	8.6	14.2	12.2	12.7
Percentage variance	-8.14%	4.23%	-2.46%	-7.87%

The norms within the Honey and Mumford (2000) LSQ User Guide have been based on research in countries other than South Africa. The survey includes the UK, France, Germany, Austria, Italy, Scandinavia, Switzerland, Ireland, USA, Australia and Greece, each of which differ slightly from the norm.

5.3 Variances in LSQ data

Chapter four presented the averages for the fifteen respondents to this study across the learning styles, activist, reflector, theorist and pragmatist as 6.1, 14.8, 13.4 and 14.3 respectively. The variance for the respondents versus the general norms is –34.1%, 8.8%, 7.2% and 4.1% across the four respective styles. These are presented in Table 5-2. The variances of the respondents compared to the general norm indicate that the preference for the activist learning style is particularly low, for reflector and theorist the preferences are strong and for pragmatist they are moderate. To draw conclusions from these results one first needs to identify possible contributing factors, constants and variables. The group of respondents are categorised as engineering/science graduates. Research by Kolb in 1976 and 1981 (as cited in Wyrick, 2003:31) indicates that people with particular learning style preferences are attracted to certain professions. It is likely that people attracted to this career and hence group, are accustomed to analysing data, understanding the content and drawing conclusions from such data. This correlates strongly to the characteristics of the reflector learning style preference. An average of 14.8 for the respondents compared to 13.6 for the general norms does indicate a strong preference for this learning style.

Table 5-2: Variances of respondents versus general norms

	Activist	Reflector	Theorist	Pragmatist
Average for 15 respondents	6.1	14.8	13.4	14.3
Average for general norm	9.3	13.6	12.5	13.7
Percentage variance	-34.1%	8.8%	7.2%	4.1%

5.3.1 Reflector variances

The average for an international group of engineering/science graduates is 14.2, and when compared with 13.6 for the international general norms, it can be expected that the respondents would tend towards the trend of the former. The results of the respondents indicate that this is the case. The respondents averaged 14.8, which is only a 4.2% deviation from the international group of engineering/science graduates. The data discussed in this section is presented in Table 5-3. Deductive reasoning indicates that the respondents are within the average window for their preference towards the reflector learning style. Compared to the general norm, it can therefore be stated that engineering/science graduates have a strong preference towards the reflector learning style.

Table 5-3: Variances of respondents versus Eng/Sci norms

	Activist	Reflector	Theorist	Pragmatist
Average for 15 respondents	6.1	14.8	13.4	14.3
Average for Eng/Sci graduates	8.6	14.2	12.2	12.7
Percentage variance	-28.7%	4.2%	9.8%	12.3%

5.3.2 Theorist variances

The average for the general norms for the theorist style are almost the same as those for the group of engineering/science graduates with averages of 12.5 and 12.2 respectively. The respondents averaged 13.4 for this style, which is 7.2% and 9.8% higher than the respective norms for the two above-mentioned groups. The preference level is moderate compared to both the general norms and the engineering/science graduates.

5.3.3 Pragmatist variances

The windows ranges for the pragmatist learning style differ between the categories of general norms and engineering/science graduates. The range limits for the two groups between moderate and high ratings are 14 and 13 respectively. The effect is that the average of 14.3 for the respondents is classified as a moderate preference compared to the general norms and a strong preference compared to the group of engineering/science graduates. The variance of the respondents compared to the other two groups is not large and can be deemed to be normal.

5.3.4 Activist variances

The baseline averages for the activist style between the general norms and the engineering/science graduates are 9.3 and 8.6 respectively, a variance of -8.14%. The respondents average for their preference for the activist style is only 6.1, a variance of –34.1% and –28.7% compared to the two abovementioned averages respectively. This variance is a substantial deviation from the two groups.

5.4 Discussion of LSQ data

The LSQ data and the results are discussed in the following section in context with the respondents and organisation’s background.

5.4.1 Contextual discussion of tertiary learning

The core competencies in this study are deemed to be outside the norms of general knowledge, even within the group of engineering science graduates. The need for acquiring knowledge is possibly greater in the field of cryptography than it is for the field of computer graphics or bridge building for example. Typically, graduates are able to apply knowledge acquired from tertiary studies directly to a problem, particularly where typical industry problems have found their way into the course syllabus and are used as examples. Specific domain knowledge of fields that are uncommon, such as cryptography, is generally new to engineering graduates. For example, seven of the eight respondents from KZN obtained their qualifications from the same institution. Only two had exposure to theoretical cryptography in the tertiary courses, which were electives on the Computer Science degree. The BSc electrical engineering course does not cover cryptography at all. It is noted here that the implementation of cryptographic solutions within the business is largely done on electronic hardware platforms, referred to in the industry as embedded platforms. Now the Computer Science degree does not include any foundation in electronics or embedded platforms.

5.4.2 Contextual discussion of organisational learning

The requirement to learn a new domain can be deemed to be abnormally high in this industry, for the fact that application of tertiary knowledge cannot be applied until a new field, foreign to the graduate, has been learnt. Deductive reasoning leads to the conclusion that, to become a specialist in this business unit, a person would need to acquire knowledge of an entirely new domain and succeed at it. The sources of knowledge would typically have two kinds of sources, explicit knowledge and tacit. The explicit knowledge would be acquired from text books, white papers etc. note that a strength in the 'theorist' learning style preference would be beneficial to this type of learning. The tacit knowledge would need to be acquired from another person or learnt firsthand. The former would be through observation or mediation. The learning style preferences of 'reflector' and 'pragmatist' would be beneficial for this learning experience. Reflector would learn from observing another specialist and pragmatists by applying what has been observed.

5.4.3 The low preference for the activist style

The nature of the development within this field is risk averse. The products and solutions are all related to high levels of security, where the consequences of a breach in security could have catastrophic results both for the customer and the organisation. The slogan for the organisation is 'Trusted Transactions'. An insecure or 'non trustworthy' transaction could harm the reputation of the organisation. Perhaps this is the reason for the specialists downplaying the 'activist' learning style. The risk could possibly outweigh the benefit. If the specialists LSQ results are separated from the non-specialists amongst the respondents, the preference for activist drops to a 5.2 and theorist rises to a 13.7. This is presented in Table 5-4.

Table 5-4: Variance of specialists versus Eng/Sci norms

	Activist	Reflector	Theorist	Pragmatist
Average for 11 specialists	5.2	14.6	13.7	14.0
Average for Eng/Sci graduates	8.6	14.2	12.2	12.7
Percentage variance	-39.7%	3.1%	12.5%	10.2%

Similarly, an analysis of the averages of the non-specialists reveals that the preference for activist rises to 8.8 and that for theorist drops to 12.5. These results are presented in Table 5-5. The changes in activist and theorist are of particular interest as they change from low preference to moderate preference and from strong preference to moderate preference respectively. This trend is analysed further by means of a measure of association in the ensuing discussions.

Table 5-5: Variance of non-specialists versus Eng/Sci norms

	Activist	Reflector	Theorist	Pragmatist
Average for 4 non specialists	8.8	15.3	12.5	15.0
Average for Eng/Sci graduates	8.6	14.2	12.2	12.7
Percentage variance	1.7%	7.4%	2.5%	18.1%

5.4.4 Comparison of results to other studies

In a similar study conducted by Wyrick (2003:30) the Learning Styles Inventory (LSI), developed by Kolb in 1976, presented similar results for a group that Kolb termed 'Divergers'. Wyrick's (2003) LSI study was done on a group of engineers in Sweden. The strongest learning style common to engineers in Wyrick's (2003) study was 'Convergers', the equivalent of the intersection between Honey and Mumford's Theorist and Pragmatist. The discussion in the preceding paragraph revealed that the specialists had a strong preference for theorist and pragmatist styles and the non-specialists had a strong preference for the pragmatist style. This is consistent with Wyrick's (2003) LSI findings.

Wyrick (2003:29) identified that results from a similar study were consistent over time for Swedish and American engineering students and states that *"it seems likely that the results are common for all engineers*". It seems this is also common to South African engineers. A rare fifth type of learner is the 'hub' learner, who is equally at home with all the four learning styles. They are very flexible and can tolerate different situations well. Respondent one scores high in all areas and is possibly a rare hub learner. This respondent is not identified as being a specialist in any domain field, only a generalist. It is of interest that this respondent has two PhDs, indicating that they are strong in all styles of learning.

5.5 Measure of association

The fourth and final objective of the study is to determine whether there is any relationship between levels of expertise and learning styles within this industry that would warrant change to be implemented to create a learning environment conducive to creating more specialists.

Goodman and Kruskal's Gamma (as cited in Cooper and Schindler, 2001:559) has been selected as a suitable measure to determine a relationship. Gamma shows the association between two variables. The two variables in this phase of the study are:

1. The number of respondents having a particular skill level and
2. The preferred learning style.

From this analysis it may be able to establish whether the specialists tend to prefer a certain learning style such as activist, reflector, theorist or pragmatic. If so, this may indicate that either a particular type of person is attracted to the organisation, or could it be that the environment is more suited to creating experts out of those with a particular learning style preference. The LSQ is a training analysis tool and ultimately the objective of the entire study is to find an effective means to manage tacit knowledge. This requires understanding and measuring what the tacit knowledge is, where it resides and how to produce 'copies' or backups of such knowledge. The solution is not to transcribe the knowledge into explicit format, as that is not deemed to be backing up tacit knowledge. The proposed solution is to expose more people to the experiences that result in tacit knowledge. This study merely provides a method to create a more effective management method of achieving this objective.

Goodman and Kruskal's gamma (Cooper and Schindler, 2001:559) is defined as:

$$\text{Gamma} = P\text{-}Q/P\text{+}Q$$

Where P is the number of instances of associations of the two variables and Q is the number of instances of disassociation of the variables.

The first variable is the number of instances of specialist skills level of 'specialist'. This implies that the count for 'P' will include 'specialists' and 'exclusive experts'.

The second variable is the preferred learning style. Respondents scoring a moderate, strong or very strong preference will be counted as an association. P will therefore be the number of instances that respondents that are at the skills level of a specialist are associated with a preference to a moderate, strong or very strong learning style. Q is the number of instances that respondents that are at the skills level of a specialist are associated with a low or very low preference to learning style. Respondents 1, 3, 12 and 13 will not produce scores for P or for Q as they do not have specialist skills in any of the defined domains.

5.5.1 Measure of association for activist

For the activist learning style there are a total of 2 instances of specialist skills associated with a moderate or higher learning style preference. These two instances are both associated with respondent 11. P therefore measures 2. There are a total of 39 instances of specialist skills associated with a low or very low learning style preference. These are associated with respondents 2, 4, 5, 6, 7, 8, 9, 10, 14 and 15. Q therefore measures 39.

$$\text{Gamma (Activist)} = (2 - 39) / (2 + 39) = -0.9$$

A measurement of gamma of –0.9 for the activist learning style is an indication of a very strong measure of disassociation between specialists and the activist learning style.

5.5.2 Measure of association for reflector

For the reflector learning style there are a total of 33 instances of specialist skills associated with a moderate or higher learning style preference. These instances are associated with respondents 2, 4, 5, 6, 7, 8, 9, 11, 14 and 15. P therefore measures 33. There are a total of 8 instances of specialist skills associated with a low or very low learning style preference. These are associated with respondent 10. Q therefore measures 8.

$$\text{Gamma (Reflector)} = (33 - 8) / (33 + 8) = +0.61$$

A measurement of gamma of +0.61 for the reflector learning style is an indication of a strong measure of association between specialists and the reflector learning style.

5.5.3 Measure of association for theorist

For the theorist learning style there are a total of 39 instances of specialist skills associated with a moderate or higher learning style preference. These instances are associated with respondents 2, 4, 5, 6, 7, 8, 10, 11, 14 and 15. P therefore measures 39. There are a total of 2 instances of specialist skills associated with a low or very low learning style preference. These are associated with respondent 9. Q therefore measures 2.

$$\text{Gamma (Theorist)} = (39 - 2) / (39 + 2) = +0.90$$

A measurement of gamma of +0.90 for the theorist learning style is an indication of a very strong measure of association between specialists and the theorist learning style.

5.5.4 Measure of association for pragmatist

For the pragmatist learning style there are a total of 33 instances of specialist skills associated with a moderate or higher learning style preference. These instances are associated with respondents 2, 4, 5, 6, 7, 8, 9, 11, 14 and 15. P therefore measures 33. There are a total of 8 instances of specialist skills associated with a low or very low learning style preference. These are associated with respondent 10. Q therefore measures 8.

Gamma (Pragmatist) = (33 - 8) / (33 + 8) = +0.61

A measurement of gamma of +0.61 for the pragmatist learning style is an indication of a strong measure of association between specialists and the pragmatist learning style.

5.5.5 Summary of measurement of association

The measurement of gamma for the four learning styles preferences are:

- Activist: Gamma = -0.90: Very strong measurement of disassociation.
- Reflector: Gamma = 0.61: Strong measure of association.
- Theorist: Gamma = 0.9: Very strong measure of association.
- Pragmatist: Gamma =0.61: Strong measure of association.

The results from the preceding discussion are presented in Table 5-6. This information is of particular importance for this study as it highlights the strengths of the specialist’s strength in the theorist style and their weakness in the activist style of learning.

Table 5-6: Summary table of concordant and discordant data

	Activist	Reflector	Theorist	Pragmatist	Specialist Skills	Activist P	Activist Q	Reflector P	Reflector Q	Theorist P	Theorist Q	Pragmatist P	Pragmatist Q
Res. 1	15	16	14	14	0								
Res. 2	3	17	18	15	2	0	2	2	0	2	0	2	0
Res. 3	7	14	13	15	0								
Res. 4	7	15	14	16	1	0	1	1	0	1	0	1	0
Res. 5	6	15	14	15	4	0	4	4	0	4	0	4	0
Res. 6	6	16	12	14	7	0	7	7	0	7	0	7	0
Res. 7	6	15	14	17	5	0	5	5	0	5	0	5	0
Res. 8	2	12	14	18	2	0	2	2	0	2	0	2	0
Res. 9	4	16	14	15	2	0	2	2	0	0	2	2	0
Res. 10	3	9	11	7	8	0	8	0	8	8	0	0	8
Res. 11	9	15	11	12	2	2	0	2	0	2	0	2	0
Res. 12	4	15	11	15	0								
Res. 13	9	16	12	16	0								
Res. 14	6	16	15	12	6	0	6	6	0	6	0	6	0
Res. 15	5	15	14	13	2	0	2	2	0	2	0	2	0
					Total	2	39	33	8	39	2	33	8
					Gamma	-0.90		0.61		0.90		0.61	

5.6 Conclusion

The high average for the preference for the theorist learning style amongst the specialists and the low preference for the activist style have been identified. This finding is not a preferred profile for specialists or potential specialists; it is more an indication of how these people became specialists. The learning process is a cycle that consists of all four phases or styles; some people just have preferences for certain phases. The aim of this study is identify a means to efficiently duplicate tacit knowledge through the learning cycle. If any skills need to be developed from a generalist level to a specialist level they are likely to be developed from the generalist level. The reason for trying to establish the preferred learning styles of specialist is to determine if the learning environment contributed in any way to them becoming specialists so that this could be applied to others such that they too could become specialists.

The relatively low scoring for the activist learning style is the predominant anomaly that is consistent throughout the measure of association and the comparison of norms for this sample of respondents. Honey and Mumford (2000:10) indicate that there are four processes to the learning cycle. Each of the four styles is dependent on the others and none is effective on their own. The time spent on each phase may vary considerably. Honey and Mumford (2000:11) refer to this imbalance as a distortion of the learning cycle. It is evident from the results that the learning cycle within the organisation in this study is distorted. Recommendations need to be made to rectify the imbalance within the learning environment such that the learning cycle is more balanced.

The next chapter draws conclusions from these results and presents recommendations based on the findings.

Chapter Six: Conclusions and recommendations

6.1 Introduction

This chapter presents the conclusions for the study and provides recommendations that may contribute towards the stated benefits of the study.

6.2 Review of objectives

The four stated objectives of this study were stages geared towards achieving an overriding aim. The aim of the study was to establish an effective means to transfer knowledge from one specialist to another, so creating depth of knowledge. This is stated in the title of the study: "*Managing Tacit Knowledge in a Hi-Tech Learning Organisation*".

6.3 Conclusions

The conclusions and recommendations are presented in the following discussions:

6.3.1 Managing tacit knowledge

An analogy to the transfer of core competence knowledge from one human resource to another is that of an organisation backing up its IT data by making a copy for storage. It is known that in the modern day most organisations actively save their data from their main repositories for safekeeping. The benefits of this effort are only realised when a skilled resource is lost to the organisation or a data backup system fails and data needs to be recovered. To grasp the importance of the need to manage data one needs to evaluate the consequences should a critical file or database be lost and deemed unrecoverable. The consequences are similar whether the data is explicit or tacit. It has become standard procedure for organisations to manage explicit data through a backup or failover system. However, taking active steps towards backing up tacit knowledge appears to be uncommon.

6.3.2 Identifying the knowledge to be managed

The field of cryptography was chosen as the knowledge domain for this study as it is a niche domain. The acquisition of knowledge that forms the measurement for the study was likely to be from within the business unit rather than being general knowledge. The measure of association between learning styles and core competencies are deemed to have more relevance if the competencies have been acquired from within this business unit. Some constants are required such that variables are minimised.

The core competence domains that have been identified may seem vague to persons not directly involved in development within the business unit, however, they are fully understood by those employed as developers in this facility. The self-assessment of skills levels is subjective, particularly with the ranking of 'exclusive specialist'. This ranking was ultimately for risk analysis purposes only and did not contribute to inaccurate analysis. The specialist and exclusive expert categories were combined as being the level of competence. Note that the exclusivity element was not used for analysis.

6.3.3 Backing up knowledge through learning

Learning styles are not the be all and end all of learning. They are merely one small aspect of all the processes and variables that contribute towards learning. These other variables may vary largely between one person and the next and may be not be consistent across a group. These variables include method of learning, past experience of learning, cognitive ability, culture, job opportunities, impact of facilitator amongst many others. To create a competitive advantage, the identification of the strengths and weaknesses both within the organisation and of competitors needs to be identified. The competitive advantage can only be realised when those weaknesses are removed or minimised and the strengths developed.

It is impractical to address the unique individual requirements of each person within a learning organisation and tailor the learning environment to meet the needs of each. However, when research produces results such as has been determined from chapter five, where there is a measure of commonality amongst the majority of people, then it is practical to change and adapt the environment to meet the learning needs accordingly.

Honey and Mumford (2000:11) state that the four stages of learning; experiencing, reviewing, concluding and planning are mutually supportive. They further state that none is fully effective as a learning procedure on its own and each stage plays an equally important part in the total process. People develop preferences for certain stages over others. For example, a preference for experiencing may result in an addiction for activities and the assumption that having experiences is synonymous with learning from them.

A preference for reviewing, results in people avoiding first-hand experiences. They postpone reaching conclusions for as long as possible while gathering more information. This is often referred to as an: 'analysis to paralysis' tendency.

A preference for concluding may result in a tendency to jump to conclusions without first reviewing the information. The review stage might be bypassed such that people have a compulsion to reach an answer quickly.

Preferences for embarking on an expedient course of action and implementing it with inadequate preparation results in a tendency to go for 'quick fixes' without considering consequences, alternatives or taking a planned approach.

6.3.4 Learning styles

Summaries of the four learning style preferences from the Honey and Mumford Learning Styles User Guide (Honey & Mumford, 2000:11–12) are presented in the following discussion.

6.3.4.1 Activists

Activists involve themselves fully and without bias in new experiences. They enjoy the here and now and are happy to be dominated by immediate experiences. They are open-minded, not sceptical, and this tends to make them enthusiastic about anything new. Their philosophy is *"I'll try anything once"*. They tend to act first and consider the consequences afterwards. Their days are filled with activity. They tackle problems by brainstorming. As soon as the excitement from one activity has died down they are busy looking for the next. They tend to thrive on the challenge of new experiences but are bored with implementation and longer-term consolidation. They are gregarious people constantly involving themselves with others but in doing so, they seek to centre all activities on themselves.

6.3.4.2 Reflectors

Reflectors like to stand back to ponder experiences and observe them from many different perspectives. They collect data, both first hand and from others, and prefer to think about it thoroughly before coming to any conclusion. The thorough collection and analysis of data about experiences and events is what counts, so they tend to postpone reaching definitive conclusions for as long as possible. Their philosophy is to be cautious. They are thoughtful people who like to consider all possible angles and implications before making a move. They prefer to take a back seat in meetings and discussions. They enjoy observing other people in action. They listen to others and get the drift of the discussion before making their own points. They tend to adopt a low profile and have a slightly distant, tolerant, unruffled air about them. When they act it is part of a wide picture that includes the past as well as the present and others' observations as well as their own.

6.3.4.3 Theorists

Theorists adapt and integrate observations into complex but logically sound theories. They think problems through in a vertical, step-by-step, logical way. They assimilate disparate facts into coherent theories. They tend to be perfectionists who won't rest easy until things are tidy and fit into a rational scheme. They like to analyse and synthesise. They are keen on basic assumptions, principles, theories, models and 'systems thinking'. Their philosophy prizes rationality and logic, "*If it's logical it's good*". Questions they frequently ask are "*Does it make sense?*", "*How does this fit with that?*", "*What are the basic assumptions?*" They tend to be detached, analytical and dedicated to rational objectivity rather than anything subjective or ambiguous. Their approach to problems is consistently logical. This is their 'mental set' and they rigidly reject anything that doesn't fit with it. They prefer to maximise certainty and feel uncomfortable with subjective judgements, lateral thinking and anything flippant.

6.3.4.4 Pragmatists

Pragmatists are keen on trying out ideas, theories and techniques to see if they work in practice. They positively search out new ideas and take the first opportunity to experiment with applications. They are the type of people who return from management courses brimming with new ideas that they want to try out in practice. They like to get on with things and act quickly and confidently on ideas that attract them. They tend to be impatient with ruminating and open-ended discussions. They are essentially practical, down-to-earth people who like making practical decisions and solving problems. They respond to problems and opportunities as a challenge. Their philosophy is "*There is always a better way"* and *"If it works it's good*".

6.4 Recommendations

Within the organisation under study, projects are planned and compiled at business unit level. The teams are allocated from the members within the business unit. There is generally more emphasis placed on ensuring that all the members allocated to a business unit are fully utilised, that is, they are fully allocated to projects and are therefore assumed to be busy and not idle. The supposed full utilisation of capacity results in unforeseen project overruns as business unit members attach themselves to a project as a means of finding a place to allocate their time. Allocating time to a project without contributing to the output of the project is an inefficient wastage of human resource capacity. Recommendations to the ‘full utilisation’ dilemma are presented in the ensuing discussion. It was recorded that the learning style preference for the pragmatist style was 12.3% higher than the norm for this group and for the activist learning style it was 28.7% below the norm. These indicate the significant strengths and weaknesses of the respondents with regard to the four stages of the learning style circle (Honey and Mumford, 2000:9). A gamma of 0.61 indicates a strong positive association between the pragmatist style and specialists. With the objective of the study being to promote learning and in particular the cross-pollination of tacit knowledge, it is recommended that the strength of the pragmatists be utilised predominantly within the learning environment. The activist style must at the same time be developed to accelerate the learning process. The group of respondents with specialist skills showed a very strong preference to the theorist learning style. A gamma of 0.9 was recorded for the specialists. The theorist style should be developed for those that need to elevate themselves to a level of specialist. The nature of the field of cryptography and the domains identified within the study as being core to the organisation indicate that a strong theoretical understanding of the subject would contribute towards an individual achieving the level of a specialist.

6.4.1 The work environment

The current work environment has independent offices for each developer. There is a common boardroom for communal gatherings, which is mostly used for formal meetings and a common library and tea area used for informal discussion. As the offices are small discussions are generally on a one to one basis. The situation sees one person at his or her desk in their own office environment whilst the second person is out of their personal office space and encroaching into someone else’s space. This could result in the ‘away from home’ person perceiving that they could be seen to be unproductive in these situations. This could be changed to include a common integration area that may promote the cross-pollination of knowledge. A common test environment that encourages participation and experimentation could utilise the pragmatist preference to try out ideas to see if they work, while at the same time developing the activist style by providing a platform to experiment yet without the normal risk associated with this style. This common area could bring together those from whom knowledge is required and pass it on to those that require development. The respondents have a 12.3% above average preference for the pragmatist style, indicating that the learning environment should include areas for practical experimentation and knowledge sharing. Common integration areas are therefore recommended.

6.4.2 Training programmes

A further recommendation is to develop training programmes for each of the core competence domains. It is proposed that the specialists prepare presentations and notes on topics relevant to the domain in which they are deemed to be specialists and present these to the other members in a practical environment. Similar training sessions have been conducted successfully in the past. These could be improved by the inclusion of a practical element to the environment rather than the formal boardroom environment that may favour the theorist. The respondents typically have a strong preference for the pragmatist learning style; therefore, the inclusion of a practical element could enhance the learning.

These training sessions obviously require time away from projects and at present is deemed to be unproductive time. The developers within the organisation are required to complete timesheets on a weekly basis, which account for every hour of their time during the week. Training time is currently deemed to be an addition to overhead expenses and developers tend to avoid its use for fear of being seen to be ‘idle’.

6.4.3 Project management

Within this organisation work is planned around projects and every resource is allocated to a number of projects. Senior management, such as the head of engineering and the directors, are presented resource allocation reports on a regular basis. These reports show primarily the percentage allocation of each resource to projects. This results in a tendency for developers to overestimate their time forecasts such that they are presented as being fully utilised. Project managers also tend to ‘pad’ the projects such that their allocated teams are fully utilised. This looks impressive in terms of the report, particularly when resources are allocated in excess of 100%. A resultant problem is that people expand the work to fill the available time. This results in unforeseen project overruns as business unit members attach themselves to a project as a means of finding a place to allocate their time. This is an inefficient wastage of capacity. Any project manager worthy of the title would know that when planning a project and allocating resources the process of resource levelling always results in certain resources being the bottlenecks, while others are only used for short or partial allocation to tasks. The probability of a business unit always having the exact match of workload to the available resources is pretty slim. This is currently how it is presented to senior management. A recommendation is to present the benefits of the transfer of knowledge to management and promote the allocation of time to transferring knowledge in core domains.

6.4.4 Performance management

Performance management within the organisation is currently done via means of key performance area measurement (KPAs). Performance is assessed by the performance of the individual on project tasks. There is little done towards the measurement of expanding their capabilities. A recommendation is to present the individuals with the matrix of skills level versus the thirteen skills domains. A performance requirement could be set for that person to develop their skills within a domain over the next assessment period. A prescribed amount of time should be allocated to the person for accomplishing this. It is up to that person to find his, or her, time over the assessment period during dips in their own workload. Some people may claim to be constantly overloaded. Their performance could be measured by how they offload tasks to and assist in training their colleagues. This ideally would free them up to achieve their own objectives to develop themselves. (Dingsoyr & Conradi, 2002:408) found that developers should actively participate in collecting and distributing knowledge. This would result in all the four objectives of this study being accomplished and is a proposed solution to managing tacit knowledge in a hi-tech leaning organisation.

6.5 Areas for further research

Further research could be undertaken by performing a longitudinal study of the competencies within a single organisation in order to track the learning progression. A longitudinal study is likely to indicate changes in the core competencies and the research could be of benefit to track whether the specialists maintain their levels of competence as the core competencies change.

A longitudinal study of the learning styles could be conducted to determine whether the learning style preferences change over time, particularly if there is an active programme implemented to develop weak learning styles.

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ANNEXURE A

ANNEXURE B

ANNEXURE C

46 Buckingham Place
Cowies Hill
Pinetown
3610
25 January 2005

Dear Participant,

LETTER OF INFORMATION AND CONSENT

“Managing Tacit Knowledge in a Hi-Tech Learning Organisation”

I am currently undertaking a research project that aims to determine the core competencies required within the industry and the expertise available to an organisation in the cryptographic industry.

Would you agree to be interviewed for the study and do you consent to the interview being video taped? The interview will take approximately 60 minutes. Participation is voluntary and you are free to withdraw from the study at any time. The information you give will only be used for research purposes, and your identity and individual answers will be kept totally confidential. Should you wish to discuss this further please feel free to contact me or my supervisor (Ms K Roodt, 082 4618002)

Your assistance will be much appreciated,
Yours faithfully,

……………………
S.D.C O’Neill
Cell: 083 2628802
Office: 031 2675508

……………………………………………………………………………………..

Please complete the following as confirmation of your willingness to participate in this research project:

I, …………………………………….. have adequately discussed the study with the researcher, understand that I may withdraw from it at any time without giving reasons, and voluntarily agree to participate by being interviewed and to complete the questionnaire.

Signature…………………………………………… Date ……………………

Name: ____________________

Core Competencies required for the Crypto Business Unit Development Team

For each of the 8 (eight) listed Competency Domains, rank yourself in accordance with the Ranking Scale provided on pg 6, by marking the appropriate box with an X.

Example: If you meet the criteria for '**Specialist**' as defined on page 6:

Example	Exclusive Expert	Specialist	Generalist	Inexperienced	Unqualified
	5	**X**	3	2	1

All knowledge must be current, with experience gained or applied within the last 24 months.

1. Key Management Application and Systems

Entry Requirements: BSc: Electronics, Computer Science, Information System or equivalent
General Skills: Programming C, C++, GUI experience. Documentation: Create user manuals and be able to transform user requirements into a system specification.
Special Skills: Have a working knowledge of Applied Cryptography relevant to payment systems.
Be familiar with customer requirements documents, User manuals, VISA Audit Requirements.
Knowledge of ANSI Standards. Knowledge of Application Programming Protocols (API's) of Incognito products and of devices programmed by Trusted Centres.
A specialist should have the required special skills, with experience in having written specifications for customers, developed and implemented Trusted Centres and Key Management systems in accordance with specifications.
ABSA, PnP, Wetton, STS, OPT, Shoprite~~, Delete~~ Other (specify by deleting those not applicable)

Domain 1	Exclusive Expert	Specialist	Generalist	Inexperienced	Unqualified
	5	4	3	2	1

2. Cryptographic Hardware Development and Application

Entry Requirements: BSc Electronics or Higher Diploma
General Skills: Software (C, VHDL) and Hardware Development skills
Special Skills: Hardware Development, High-speed digital and Analog. Firmware Development – embedded, VHDL. Device drivers And target operating systems. Tamper mechanism and Boot-loaders to meet VISA PED and FIPS140-2 levels 1,2,3, & 4 requirements
Working knowledge of target operating systems.
Knowledge of circuitry of Crypto Incognito products, TSM2xx, 3xx and 4xx. Ability to develop Device drivers. Knowledge of Windows, Linux, Solaris Operating systems at device driver level.
Knowledge of industry and standards and specifications eg Microsoft WHQL, Stratus ft, SUN, PCI 2.1.
A specialist must be capable of writing a specification in accordance with given requirements, and designing the module from schematic stages through to mass production.

Domain 2a Hardware	Exclusive Expert	Specialist	Generalist	Inexperienced	Unqualified
	5	4	3	2	1

Domain 2b Firmware	Exclusive Expert	Specialist	Generalist	Inexperienced	Unqualified
	5	4	3	2	1

Domain 2c Drivers & OS	Exclusive Expert	Specialist	Generalist	Inexperienced	Unqualified
	5	4	3	2	1

3. Designing Application Programming Interfaces (API's)

Entry Requirements: BSc: Information Systems with a Security focus
General Skills: Programming C, C++
Special Skills: Triple DES algorithm, modes of operation and implementation thereof.
EMV 4.1 specification.
PIN Encryption, ANSI X9.8 specification. DUKPT
Focus on API security. Access Control, as per VISA Audit requirements.
A specialist is to have implemented API changes and updates on the MCM, STS, PRIMA or ICSF API's. Please circle those applicable to your ranking.
These skills are generally obtained from learning from others, eg: having read the design section of 'Code Complete" and/or relevant security papers. One should have a knowledge and awareness of potential weaknesses in API's.

Domain 3	Exclusive Expert	Specialist	Generalist	Inexperienced	Unqualified
	5	4	3	2	1

4. Smart Card Security

Entry Requirements: BSc Electronics, BSc Computer Science.
General Skills: Programming C, C++, Java, embedded hardware environment with high constraints.
Special Skills: EMV, DUKPT, key management, EFT pin translate, ISO pin block formats, ANSI standards, Knowledge of POS Terminals and their operating systems. Documentation. API Implementation.
Knowledge of ID management, authentication, and payment security.

Domain 4	Exclusive Expert	Specialist	Generalist	Inexperienced	Unqualified
	5	4	3	2	1

5. Security Architecture and Protocols

Entry Requirements: BSc Electronics or Computer Science
General Skills: Programming C, C++
Special Skills: Understanding of Applied Cryptography, eg have read & understand literature on Applied Cryptography.
On the Job Learning of the architectures of Telco, Banking, Retail, Oilco and Utilities industries.
Knowledge of the application of API's, understanding of industry requirements and ability to apply new functions to existing API's.
Knowledge of MAC algorithm and key management techniques.
A person with this skill will be able to select and utilise known API's for their implementation in a secure solution. Experience includes knowledge of system and industry standards such as ANSI X9 and ISO security standards.

Domain 5	Exclusive Expert	Specialist	Generalist	Inexperienced	Unqualified
	5	4	3	2	1

6. Payment Protocols and Industry Specific Knowledge

Entry Requirements: BSc Electronics or Computer Science or similar
General Skills: Programming C, C++
Special Skills: Key Management, Electronic Payment Systems, Debit card, EMV, Bill payments.
Knowledge of Industry Specific systems such as Mobile, Phone, Retail (EPS/EMV), Utility (STS/Pre-Paid). Familiarity with Industry standards.
Hands on development required to get familiar with products and history of various versions.
Person to person knowledge transfer would have been required to obtain these skills, as available documentation is limited to product specifications and source code.
STS, Mobile, Phone, Retail, Other – specify. Other (specify by deleting those not applicable to your ranking.)

Domain 6a STS	Exclusive Expert	Specialist	Generalist	Inexperienced	Unqualified
	5	4	3	2	1

Domain 6b Mobile (Pre-paid/ Transaction)	Exclusive Expert	Specialist	Generalist	Inexperienced	Unqualified
	5	4	3	2	1

Domain 6c Phone (Sicrypts)	Exclusive Expert	Specialist	Generalist	Inexperienced	Unqualified
	5	4	3	2	1

Domain 6d Retail (EPS/EMV)	Exclusive Expert	Specialist	Generalist	Inexperienced	Unqualified
	5	4	3	2	1

Domain 6e Other: ____________	Exclusive Expert	Specialist	Generalist	Inexperienced	Unqualified
	5	4	3	2	1

7. Crypto Engineering.

Entry Requirements: BSc Electronics, Computer Science or similar.
General Skills: System Engineering, Computer and Network Security. Best Practices for design and implementation.
Special Skills: Security Engineering.
This competence requires the in-depth knowledge of books such as 'Security Engineering'. Applicable standards are ANSI and ISO. Knowledge of System evaluation as performed by laboratories such as T-systems and Infogard.
Knowledge of the content of Ross Andersons book, Applied Cryptography and Crypto white papers. Knowledge of PIN Blocks
Risk Management with regard to the design of a secure system and its implementation. A working knowledge of the risks an organisation could be exposed to as a result of the designed solution.

Domain 7	Exclusive Expert	Specialist	Generalist	Inexperienced	Unqualified
	5	4	3	2	1

8. Solution Developers.

Entry Requirements: Bsc Eng, Computer Science, Engineering Diploma or similar
General Skills: System Engineering, Software Engineering.
Special Skills:
This competence requires the ability to take documented API's and architecture documents and apply them to a solution.
Understanding of Crypto Algorithms.

Domain 8	Exclusive Expert	Specialist	Generalist	Inexperienced	Unqualified
	5	4	3	2	1

Ranking Definitions

Exclusive Expert – You are the prime developer of a technology in this domain and are deemed by your Technical Group Manager (TGM) to be the person most competent in this field within your department. You are always asked to provide input for discussion on this topic and your views are usually those that determine the final outcome of decisions in this domain.

Specialist – You have had hands on experience doing development in this domain within the past 12 months, and are deemed by your TGM to be capable of responding reliably to senior management on the topic. You are always requested to provide input for discussion on this topic. You are aware of others in the department who have expertise in this domain.

Generalist– You have had hands on experience developing in this domain within the past 24 months. Your involvement is usually limited to helping out where a specialist is unavailable, or workings as part of a team. You would generally receive guidance from a specialist when working within this domain.

Inexperienced – You may have a suitable academic background to undertake development within this domain, however, you have not performed hands on within this domain in the past 24 months.

Unqualified – You require an unproductive training period prior to being deemed competent by your TGM within this domain.

Learning Styles Questionnaire

		This questionnaire will help you discover your learning style preferences. We all develop learning 'habits' that make us happier to learn in some ways and less happy to learn in other, less familiar ways. Most people are only vaguely aware of their learning preferences. This questionnaire will clarify your preferred ways of learning so that you are in a better position to select experiences that suit and or broaden your scope by strengthening under-utilised styles. There is no time limit for the completion of this questionnaire. It will probably take you 10 to 15 minutes. The accuracy of the results depends on how honest you are. There are no right and no wrong answers. If you agree more than you disagree with a statement put a tick (√) in **column B**, if you disagree more than you agree with a statement put a cross (x) in **column B**.
	√	Eg

1		I have Strong beliefs about what is right and wrong, good and bad
2		I often act without considering the possible consequences
3		I tend to solve problems using a step-by-step approach
4		I believe that formal policies and procedures restrict people
5		I have a reputation for saying what I think, simply and directly
6		I often find that actions based on feelings are as sound as those based on careful thought and analysis
7		I like the sort of work where I have time for thought preparation and implementation
8		I regularly question people about their basic assumptions
9		What matters most is whether something works in practice
10		I actively seek out new experiences
11		When I hear about a new idea or approach I immediately start working out how to apply it in practice
12		I am keen on self-discipline such as watching my diet, taking regular exercise, sticking to a fixed routing, etc.
13		I take pride in doing a thorough job
14		I get on best with logical, analytical people, and less well with spontaneous, 'irrational'

		people.
15		I take care over the interpretation of data available to me and avoid jumping to conclusions
16		I like to reach a decision carefully after weighing up many alternatives.
17		I'm attracted more to novel, unusual ideas than to practical ones.
18		I don't like disorganised things and prefer to fit things into a coherent pattern
19		I accept and stick to laid down procedures and policies so long as I regard them as an efficient way of getting the job done.
20		I like to relate my actions to a general principle.
21		In discussions I like to get straight to the point.
22		I tend to have distant, rather formal relationships with people at work.
23		I thrive on the challenge of tackling something new and different.
24		I enjoy fun-loving, spontaneous people.
25		I pay meticulous attention to detail before coming to a conclusion.
26		I find it difficult to produce ideas on impulse.
27		I believe in coming to the point immediately.
28		I am careful not to jump to conclusions too quickly.
29		I prefer to have as many sources of information as possible - the more data to think over the better.
30		Flippant people who don't take things seriously usually irritate me.
31		I listen to other people's points of view before putting my own forward.
32		I tend to be open about how I'm feeling.
33		In discussions I enjoy watching the manoeuvrings of the other participants.
34		I prefer to respond to events on spontaneous, flexible basis rather than plan things out in advance.
35		I tend to be attracted to techniques such as network analysis, flow charts, branching programmes, contingency planning, etc.
36		It worries me if I have to rush out a piece of work to meet a tight deadline.

37		I tend to judge people's ideas on their practical merits.
38		Quiet, thoughtful people tend to make me feel uneasy.
39		I often get irritated by people who tend to rush things.
40		It is more important to enjoy the present moment than to think about the past or future.
41		I think that decisions based on a thorough analysis of all the information are sounder than those based on intuition.
42		I tend to be a perfectionist.
43		In discussions I usually produce lots of spontaneous ideas.
44		In meetings I put forward practical, realistic ideas.
45		More often than not, rules are there to be broken.
46		I prefer to stand back from a situation and consider all the perspectives.
47		I can often see inconsistencies and weaknesses in other peoples arguments
48		On balance I talk more than I listen.
49		I can often see better, more practical ways to get things done.
50		I think written reports should be short and to the point.
51		I believe that rational, logical thinking should win the day.
52		I tend to discuss specific things with people rather than engaging in social discussion.
53		I like people who approach things realistically rather than theoretically.
54		In discussion I get impatient with irrelevancies and digressions.
55		If I have a report to write I tend to produce lots of drafts before settling on the final version.
56		I am keen to try things out in practice.
57		I am keen to reach answers via a logical approach.
58		I enjoy being the one that talks a lot.
59		In discussions I often find I am the realist, keeping people to the point and avoiding wild speculations.

60		I like to ponder many alternatives before making up my mind.
61		In discussions with people I often find I am the most dispassionate and objective.
62		In discussions I'm more likely to adopt a 'low profile' than to take the lead and do most of the talking.
63		I like to be able to relate current actions to a longer term bigger picture.
64		When things go wrong I am happy to shrug it off and put it down to experience.
65		I tend to reject wild, spontaneous ideas as being impractical.
66		It's best to think carefully before taking action.
67		On balance I do listening rather than the talking.
68		I tend to be tough on people who find it difficult to adopt a logical approach.
69		Most times I believe the end justifies the means.
70		I don't mind hurting people's feelings so long as the job gets done.
71		I find the formality of having specific objectives and plans stifling.
72		I'm usually one of the people who puts life into a party.
73		I do whatever is expedient to get the job done.
74		I quickly get bored with methodical, detailed work.
75		I am keen on exploring the basic assumptions, principles and theories underpinning things and events.
76		I'm always interested to find out what people think.
77		I like meetings to be run on methodical lines, sticking to laid down agenda, etc.
78		I steer clear of subjective or ambiguous topics.
79		I enjoy the drama and excitement of a crisis situation.
80		People often find me insensitive to their feelings.