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Designing a Knowledge Creation Model Using a Problem-based Learning Approach to Enhance Innovation in a High-technology Production Environment

By

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DECLARATION

I declare that the dissertation, *Designing a knowledge creation model using a problem-based learning approach to enhance innovation in a high-technology production environment,* which I hereby submit for the degree Magister Informatonis Scientiae at the University of Pretoria, is my own work and has not previously been submitted by me for a degree at this or any other tertiary institution.

The author, whose name appears on the title page of this dissertation, obtained the applicable research ethics approval to conduct the research described in this work. The author declares that she has observed the ethical standards required in terms of the University of Pretoria's code of ethics for researchers and the policy guidelines for responsible research.

26 October 2015

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ACKNOWLEDGMENT

Many colleagues and friends have provided valuable contributions to the results presented here. This study could not have been undertaken or completed without the help and support of my fellow members and the management of the organisation under study.

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ABSTRACT

Knowledge creation (KC) is a critical part of innovation. The researcher will demonstrate that knowledge creation is a learning process that is triggered by problems. The researcher will further show that KC depends on knowledge resources being available and will show that KC may lead to innovation. The researcher will then develop a KC model. This model builds on methodologies from the fields of innovation and learning to create a template for measuring and viewing the KC capability in a selected organisation. The model proposes a framework that may assist managers and executives to make each work-related problem an opportunity for learning and therefore KC. The model further aims to serve as a benchmark tool to analyse KC activities.

This dissertation will therefore aim to understand and identify the knowledge-creation processes and conditions that may lead to enhanced knowledge creation and innovation capability in the organisational environment. By means of a literature review the theory of innovation will be scrutinised in terms of the main drivers for innovation. The literature review will then establish the link between innovation and KC. Access to knowledge resources will be proven to form the foundation for learning that leads to KC. The literature review will further establish that problem-based learning is a cognitive approach that assists in solving problems by means of gradual processes. The research aims to show that the application of the principles of problem-based learning will enable KC in workplace environments. Based on the research gathered through the literature review a model will be created that will guide learning processes for KC activities.

The research will investigate the organisational learning domains in order to identify the learning mechanism that leads to KC and innovation. This will be done by both qualitative and quantitative measures.

Guided by the developed model, qualitative research will be completed to determine the existing KC landscape in the organisation under study. The aim of this research will thus be two fold to gather information about the organisation under study as well as to validate the KC model

Chapter 1 Introduction

Knowledge creation (KC) and innovation capability are critical questions in knowledge-intensive organisations today.

In this dissertation, the researcher will demonstrate that KC is a learning process that is triggered by problems. The researcher will further demonstrate that KC depends on knowledge resources being available and will show that KC may lead to innovation. Finally, a KC model will be created. This model builds on methodologies from the fields of innovation and learning to create a template for measuring and viewing the KC capability in an organisation. The model proposes a framework that may assist managers and executives to make each work-related problem an opportunity for learning and therefore KC. The model further aims to serve as a benchmark tool to analyse KC activities.

Drucker (1989: 30) describes innovation as "the specific instrument of entrepreneurship" and thus, among entrepreneurial firms, it may be the most critical success factor. Johannessen, Olsen and Lumpkin (2001: 20) confirmed Slappendel's (1996: 110) assertion that innovation is something more than mere change. They further state that it allows researchers to distinguish between changes that are simply alternatives or copies, and changes that are novel and original. Johannessen *et al.* (2001: 27) believe the focus on newness can be an indicator of the building blocks of sustainable competitive advantage. They also found that innovation is just as likely to come from an individual inventor as from an organisational initiative or a government-sponsored programme.

Based on the study done by Johannessen *et al.* (2001: 28), the following influences on innovation have been identified:

- External
  - Customer-supplier relations
  - Network studies
  - Market conditions
  - External knowledge infrastructures
- Internal
  - Cultural factors
  - Structural links, i.e. information, communication and learning processes
  - Internal competencies
  - The role of management information and communication technology
  - Maintenance of internal awareness of the importance of newness to innovation, which may aid an organisation's innovation efforts
  - Infusing knowledge sets with newness:
    - new ideas,
    - new skills,
    - new personnel, and
    - new forms of organising.

Innovation, therefore, according to Johannessen *et al.* (2001:20), equates to newness. Another dimension can be added to this aspect, namely context. The following example illustrate the concept of context. In general, getting access to the internet is not a new concept. However, if a community in rural Sudan decides to connect to the internet to manage health and educational queries, this is a new concept and, therefore, an innovative approach for this community. **Innovation can, therefore, be defined as new development in a specific context.** In essence this implies that what is new for one person is not necessarily new for someone else. Torjman and Leviten-Reid (2003: 16) confirm this statement by expanding the definition of innovation to include:

- the application of existing ideas in new ways or to new fields.

Aranda and Molina-Fernández (2002: 289) state that:

> *traditional innovation theories consider innovation as a radical act generated by the introduction of a new element or a new combination of already known elements in a determined product.*

Aranda and Molina-Fernández (2002: 289-290) identified the following innovation paradigms:

- **The technological-economic paradigm:** The innovation process emerges in the research and development department from a scientific basis.
- **The entrepreneurship paradigm:** This paradigm considers entrepreneurship as the main innovative process.
- **The strategic paradigm of innovation:** Business strategy is considered the main determinant of innovation.

Another important aspect when defining innovation is creativity. Majaro (1992: 27) defines creativity in relation to innovation as "the thinking process that helps us to generate ideas". This thinking process can be equated to the learning process, as indicated in Bloom's taxonomy, which will be discussed section 3. The creative thinking process may also be seen as a specific skill, as the researcher will illustrate in section 3.

According to Torjman and Leviten-Reid (2003: 14):

> *the concept of innovation used to be understood largely as a specific event, created by factors internal to a firm or organisation. It is now conceptualized as a process of solving problems and typically is the product of an interaction between a firm and an array of other actors. It is enhanced through social exchange and ongoing learning, searching and exploring.*

They further state that:

> *It is the capacity to learn continuously and adapt to rapidly changing conditions that determines the innovative performance of firms, regions and countries.*

Fenwick (2003: 123-132) confirms that innovation further involves a complex mix of tacit knowledge, implicit learning processes and intuition.

Deng (2008: 175) defines tacit knowledge as a personal mental model and insight in the complexity of the environment, which is usually characterised by personal beliefs, intuition or judgment, values and experiences. Explicit knowledge can be articulated as patterns of rules for problem-solving and is generally susceptible to codification and replication.

According to Torjman and Leviten-Reid (2003: 16):

> *Knowledge is crucial to the development of organisational competencies and learning is the process through which organisations harness and apply knowledge.*

However, to use knowledge, one needs to understand what knowledge is. The researcher will aim to develop a common vision of knowledge that incorporates the knowledge domains discussed in section 3.3.8.

Davenport and Prusak (2000: 5) define knowledge as:

> *Knowledge is a fluid mix of framed experience, values, contextual information, expert insight, and grounded intuition that provides an environment and framework for evaluating and incorporating new experiences and information. It originates and is applied in the mind of the knowers. In organisations it often becomes embedded not only in documents or repositories, but also in organisational routines, practices and norms.*

This definition fits well within the knowledge domains defined by Kratwohl (2002), as will be discussed in section 3.3.8, namely:

- Factual (refers to contextual information in the above definition)
- Conceptual (refers to values)
- Procedural (refers to experience)
- Metacognitive (refers to expert insight and grounded intuition).

Firestone (2003: 20) defines innovation as a knowledge process life cycle event that has been completed. The cycle begins with a problem that emerges, moves through KC processes and ends in the incorporation of knowledge structures (Du Toit, Van Staden and Steyn, 2011: 89). Afuah (1998) refers to innovation as new knowledge incorporated in products, processes and services.

Popaduik and Choo (2006: 312) found when studying the relationship between KC and innovation:

> *that knowledge creation is focused on the generation and application of knowledge that leads to new capabilities for the organisation. Innovation, on the other hand, is also concerned with how these new capabilities may be turned into products and services that have economic value in markets.*

They further state that knowledge about markets becomes a critical component of the innovation process and that it is this continuous interaction of technical knowledge and market knowledge that will define an organisation's capacity to innovate and therefore to prosper in an increasingly competitive environment. Based on the previous definitions of innovation, it is clear that the act of new KC is a pre-cursor to innovation.

The innovation process is essentially a learning process. Fenwick (2003: 124) confirms that all learning in work is to some extent innovative in that it introduces change. Organisational learning is further typically described in change terms, as for example in the following definition:

> *… changes in organisational practices … that are mediated through individual learning or problem-solving processes (Ellström, 2001: 422).*

The above statements all clearly indicate a direct link between learning and innovation.

The following different learning forms for innovative learning can be identified:

- Organisational learning
  - Organisational learning unfolds in different forms at individual, group and organisational levels. Crossan, Lane and White (1999: 530) suggest that four psychological and social processes of learning occur at these different levels:
    - intuiting
    - interpreting
    - integrating
    - institutionalising.
- Episodic learning (Leavy, 1998: 337).
  - For innovation, episodic learning may be the sudden break-through technologies that emerge at a clearly visible moment.
- Continuous learning (Leavy, 1998: 337)
  - Continuous learning is less visible and occurs through ongoing incremental improvements.
- Adaptive learning (Leavy, 1998: 337)
  - This form of learning involves small bounded change: adjustments to existing practices and structures.

- Generative learning sparks transformational change: novel solutions that challenge existing practices (Ellström, 2001: 423).

Learning for innovation/KC must therefore provide the opportunity to include all of the above learning forms. Innovation is a synergy between creativity and learning in a particular context. Innovation can thus be defined as new developments by means of various creative and learning processes executed in a given context. This context usually indicates the existence of a problem to be solved. Solving problems require access to knowledge and information, which is acquired in many ways. Every single bit of information that an individual internalises throughout his/her life will form the sum total of his/her knowledge base. Knowledge therefore establishes the foundation for innovation and/or KC. The end result of learning should therefore be unique and new knowledge. If this is the case, innovation may follow.

The researcher will throughout this dissertation refer to employees as knowledge workers. Gurteen (2006:1) defines the knowledge worker as:

> *"Those people who have taken responsibility for their work lives. According to Du Toit and Steyn (2009:2) these workers continually strive to understand the world about them and modify their work practices and behaviours to better meet their personal and organisational objectives."*

1.1 Background

The organisation under study is a small organisation situated in Stellenbosch, South Africa. The organisation functions in the high-end market of the communications technology industry. It develops and produces communication solutions that are both innovative and concrete to customer needs.

The next section provides the problem statement and the sub-problems to be developed for this dissertation. Through this dissertation the researcher will be looking at the fields of learning, organisational learning, innovation, KC and knowledge management and will establish the interrelationships between these areas. The specific link between information, knowledge, learning and innovation will be investigated in detail.

Taking cognizance of the fact that an organisation such as the organisation under study has up to now successfully delivered cutting edge innovative solutions to customers, it is envisaged that an analysis of the existing knowledge practices will provide valuable insight into the established innovation and KC processes. The same is true of the individuals in the organisation; their profiles in terms of learning and KC will provide critical research information.

1.2 Problem statement

This dissertation will aim to understand and identify the knowledge-creation processes and conditions that may lead to enhanced knowledge creation and innovation capability in the organisational environment. The purpose of this study will therefore *firstly* be to, understand the complexities of innovation and knowledge creation. The aim will be to identify the critical drivers for knowledge creation and innovation. *Secondly* the assumption that learning forms the basis of KC and therefore innovation will be constructed. *Thirdly* the identification and the nature of KC processes and conditions that enable innovation will be investigated. *Fourthly* the KC practices within teams as well as individuals in the organisational environment will be analysed, using a constructed model and measuring instrument. *Fifthly* the acquired insights into KC will be used to make recommendations that will enhance further innovation and KC in the organisation under study.

1.2.1 Sub-problem 1: Can a learning process trigger innovation?

The theory of innovation will be scrutinised in terms of the main drivers for innovation. The main assumption here is that learning will be one of the critical drivers.

Research question one: Can a learning process trigger innovation?

1.2.2 Sub-problem 2: What is the link between innovation and knowledge creation?

Innovation and KC are closely linked to one another.

- **Research question two:** What is the link between innovation and knowledge creation?

1.2.3 Sub-problem 3: Does access to knowledge enhance and contribute to the KC cycle?

Access to knowledge resources will be proven to form the foundation for learning that leads to KC. The research aims to identify the various information and knowledge products that exist to enhance learning in a particular context.

- **Research Question three:** Does access to knowledge enhance and contribute to the KC cycle?

1.2.4 Sub-problem 4: Will problem-based learning enhance knowledge creation?

Problem-based learning is a cognitive approach that assists in solving problems by means of gradual processes. The research aims to show that the application of the principles of problem-based learning will enable KC in workplace environments.

- **Research question four:** Will problem-based learning enhance knowledge creation?

1.2.5 Sub-problem 5: Can a knowledge creation model be developed that will ensure knowledge creation through learning processes?

Learning is a multivariate process with many dimensions. Learning methodologies exist that will improve KC in very specific environments. The research aims to create a model that will guide learning processes for KC activities.

- **Research question five:** Can a knowledge creation model be developed that will ensure knowledge creation through learning processes?

1.2.6 Sub-problem 6: What mechanisms for knowledge creation exist in the organisation's environment?

Accepting the fact that the organisation under study has proven abilities to innovate, it will be of extreme value to understand what mechanisms for KC exist in the organisation's environment. The research will investigate the organisational learning domains in order to identify the learning mechanism that leads to KC and innovation.

- **Research question six:** What mechanisms for knowledge creation exist in the organisation's environment?

1.2.7 Sub-problem 7: Which additional KC mechanisms will contribute to the innovation cycle at the organisation?

Identifying KC mechanisms and internal KC processes will enable the researcher to propose additional KC mechanisms to enhance the organisation's innovation capability.

- **Research question seven:** Which additional KC mechanisms will contribute to the innovation cycle at the organisation?

1.3 Outline of the study

The study will be completed in the framework of the following chapters.

1.3.1 Chapter 2 – Research methodology and design

This chapter describes the research design, the population, sampling, instruments and procedures for data collection and analysis. The validity and reliability of the research results will be addressed in this chapter. This chapter normally follow the literature review. In this dissertation it was decided however to place this chapter before the literature review because the literature review formed part of the exploratory process to substantiate the conceptual model.

1.3.2 Chapter 3 – Literature review

The literature review will establish the underlying principles of KC and innovation. The researcher will establish a link between innovation and KC and will subsequently demonstrate that KC is a learning process that is triggered by problems. This chapter will furthermore provide insight into attitudinal aspects required for KC and learning to take place and will establish the appropriate learning methodology that will assist the KC process. The literature review will therefore provide critical insights into the following aspects:

- Innovation
- KC
- Learning methodologies
- Problem-based learning.

The literature review will establish the underlying principles of a KC model that will be developed. This chapter will provide insight into the application of the model that will be developed. This chapter is part of the **exploratory phase,** and relies mainly on the literature review.

1.3.3 Chapter 4 – Research findings

The research findings will be presented in two sections. The first section is a description of the organisation based on **qualitative research** conducted through interviews with managers and consultation of organisational documentation. The second section is based on **quantitative research** results provided by the questionnaire.

1.3.4 Chapter 5 – Summary, conclusion and recommendations

This is the final chapter and the answers to the various research questions will be summarised in it. This chapter will further provide indications for further research to be done.

The next chapter will discuss the research methodology and design of this dissertation.

Chapter 2 Research methodology and design

This chapter describes the research design, the population, sampling, instruments and procedures for data collection and analysis. Criteria for establishing trustworthiness and ethical considerations will also be discussed. Mouton (1996:35) defines methodology as the means or methods of doing something. In this chapter methodology refers to how the research was done and its logical sequence.

2.1 Primary purpose of the study

The main objective of this dissertation will firstly be to review the relevant body of knowledge in the fields of innovation, learning and KC. The literature research is intended to inform and substantiate the development of a model that will clarify existing KC processes in the organisation. This model will then be tested in a case study by means of a questionnaire. The main aim of this questionnaire will be to act as an instrument that will provide insight into the existing KC mechanisms in the organisation. The results will be further supported by an overview of the organisation under study as presented in section 4.1. The researcher decided to situate the chapter on research and methodology before the literature review. This was done since the literature review was not done to explore the subject matter per se – but was done with the specific goal of substantiating and developing the conceptualised model. Therefore the research methodology has been known from the start of this research project.

2.2 Bounds and constraints to the field of study

Innovation as a field of study is complex and multivariate (Tepic, Kemp, Omta, Fortuin, 2013: 1). It is therefore advisable to focus on the KC aspects influencing innovation. This does not imply that general background sufficient to explain innovation will not be included as part of the study.

The field of study for learning is interdisciplinary, with inputs from many disciplines (Sawyer, 2015: 1), and will be narrowed to include a cognitive approach that will support problem-solving. The application of the model is constrained by the fact that it will be used once only. Results will therefore be interpreted based on feedback received at a specific point in time only.

The researcher is intimately involved in the organisation under study and will provide own observations and knowledge as gathered from discussions and information shared within the organisation. The following sections were specifically formulated and observed by the researcher:

- 4.1.2.1.2
- 4.1.2.1.3
- 4.1.4

The following listed sections were confirmed by means of discussions with senior management in these cases the drafted information were shared and approved by the CEO of the organisation.

- Specific sections of section 4.1.

2.3 Research Ethics Approval

Prior to conducting this research, authorization was obtained from the EBIT Ethics Committee (University of Pretoria). To maintain confidentiality, the researcher undertook not to disclose the respondents' personal details, including names, addresses, telephone numbers and any commercial plans or confidential business activities. All data were summarised in the dissertation.

2.4 Research design

The research philosophy employed in this dissertation may be defined as an *action research* – *case study* combination with a qualitative and explorative approach. The research will further be supported by quantitative research in the form of a questionnaire.

Argyris (1985: 4) describes action research as:

> *Action science is an inquiry into how human beings design and implement action in relation to one another. Hence it is a science of practice* …

Denscombe (2010:6) writes that an action research strategy's purpose is to solve a particular problem and to produce guidelines for best practice. The action researcher is not an independent observer, but becomes a participant, and the process of change becomes the subject of research (Benbasat, Goldstein and Mead, 1987: 371).

This is true of the approach envisaged for this dissertation, as the main focus will be to analyse critically how subjects engage with the knowledge to enable KC. Secondly, the outputs of this study will inevitably provide input for the enhancement or support of existing KC practices. The researcher is further intimately involved with the KC practices in the organisation.

The research requires a case study approach, as defined by Benbasat *et al.* (1987: 370):

> *A case study examines a phenomenon in its natural setting, employing multiple methods of data collection to gather information from one or a few entities (people, groups, or organizations). The boundaries of the phenomena are not clearly evident at the outset of the research and no experimental control or manipulation is used.*

Exploratory research is defined as research that looks for patterns, ideas or hypotheses, rather than research that tries to test or confirm hypotheses (Exploratory Research, 2005). The researcher has over the research period conducted intensive literature surveys. The aim of these investigations was to find applicable information that would substantiate a model for KC. A model (Figure 3-113.4) was developed by means of this exploratory research process.

To clarify the process it is critical to understand that the researcher has extensive work-experience and that the model has been applied in a conceptual format by the researcher in a variety of work-based scenarios. The main aim of the exploratory research phase and thus the literature review was therefore to substantiate and elaborate the model.

The model has undergone various transformations in response to increased understanding of the literature surveyed. A model is defined (Modelling, 2005) as:

> *A representation or description of something (a phenomenon or set of relationships) that aids in understanding or studying it.*

Research question five asked whether a KC model can be developed that will ensure KC through learning processes. With the exploratory process described above, the researcher was able to create a model (Figure 3-11) that would ensure KC through learning processes.

2.4.1 Qualitative research

For the purpose of this dissertation, qualitative research will be defined as follows:

> *Qualitative research is a situated activity that locates the observer in the world. It consists of a set of interpretive, material practices that makes the world visible. Qualitative research involves an interpretive, naturalistic approach to the world. This means that qualitative researchers study things in their natural settings, attempting to make sense of, or to interpret, phenomena in terms of the meanings people bring to them" (Denzin and Lincoln, 2005:3).*

Some elements of qualitative research are present in this dissertation when the researcher as an employee of the organisation under study makes interpretations and deductions about the organisation. Specific reference needs to be made to section 4.1.

2.4.2 Quantitative Research

The model was then used to design an instrument that could serve as a tool to benchmark the knowledge creation capability of the organisation. The data collected through this process was quantitative in nature, and was collected to understand and view the type of data that the instrument will provide.

2.4.2.1 Data collection

Data was collected using an own designed questionnaire which included both open and closed questions. It was necessary to employ the use of questionnaires since it was impossible to interview every respondent (McClure, 2002: 6).

2.4.2.1.1Instrumentation

The various domains that impact on knowledge creation were identified in this study. A research instrument was developed that will provide results that was used to interpret the organisation under study, based on the KC model developed in section 3.4. The instrument was drawn up to reflect these domains by using statements and questions that test the model against real-world scenarios. These statements and questions were derived from the theoretical framework as discussed in the literature review.

Because of the high mobility and tight schedules of the knowledge workers at the organisation, it was decided that a standard questionnaire with closed-ended questions would be developed to gather the desired information. Closed-ended questions force a response, score quickly and are easy to evaluate (McClure, 2002: 6).

The questionnaire was piloted once and two respondents were used. All questionnaires were completed anonymously. This enabled respondents to provide honest feedback, specifically where it was deemed sensitive. The response rate of the questionnaires was forced by the researcher's availability to assist and collect completed questionnaires.

The instrument consisted of the following sections:

2.4.2.1.1.1 Demographics

The questionnaire began with individual background variables, namely:

- Division of work in organisation
- Educational level
- The length of work experience at the organisation.

In all cases the respondents were asked to select the relevant option among specified alternatives.

2.4.2.1.1.2 Problem-solving domain

This section, consisting of three questions, was aimed at measuring the problem-solving domain as described in the KC model.

The first question aimed to establish the level of agreement in the organisation for the statement "to solve customer problems is seen as one of the significant drivers of innovation". This statement was supported when it was shown that problems are critical drivers for innovation in section 3.3.

The second question firstly equated customer requirements to customer problems and secondly aimed to establish the extent to which requirements are made available in a clear and precise manner by respondents. This question proved to be a problem, since not all respondents were involved in the process of establishing customer requirements.

The third question contained three classifications namely understand, explore and resolve (these are the problem-solving phases as discussed in section 3.3.2). The aim here was to establish a pattern of time spent by respondents, on each stage. A feedback scale of 0% – 100% was used. The results were interpreted using trend lines to indicate where the bulk of time are being spent (see section 4.2.2.3).

2.4.2.1.1.3 Skills domain

This section aimed to measure the skills domain as described in the KC model and specifically those identified as critical skills in sections 3.3.9 and 3.4.5. The following generic skills were measured:

- Creativity
- Learnability
- Critical thinking
- Communication
- Collaboration
- Problem solving

A scale of three variables was used. The scale included the following variables:

- Beginner
- Intermediate
- Advanced.

Results from this section of the questionnaire indicated which skills may be enhanced by means of targeted learning programs. The researcher selected only the generic skills (Figure 3-10) to be measured. Complexity management was omitted due to the view that it would form part of problem-solving. Communication was added since the researcher knows that this is a problem in the organisation.

2.4.2.1.1.4 Cognitive domain

The cognitive domain were constructed from action verbs derived from Kratwohl's (2002: 215) revised Bloom model. This section consisted of 40 action verbs that were measured. Five response options were used:

- Not at all
- Very little
- Somewhat
- Great extent
- Very great extent.

The above scale aimed to measure the level of activity of respondents for each of the action verbs.

The action verbs were provided as a list of terms. These verbs were then linked to the cognitive categories as described in the KC model (Figure 3-11). The objective was to derive a cognitive map of actions in the organisation, as specified by the respondents. The action verbs were further defined in a vocabulary list provided for the respondents (see Appendix 1).

2.4.2.1.1.5 Affective domain

This section measured the affective domain of the model and consisted of seven statements. The affective domain was discussed in sections 3.2.3 and 3.3.7. These statements were selected based on the impact that they have on knowledge creation as shown in the mentioned sections. These statements were measured against a Likert scale of five items. The Likert scale consisted of the following options:

- Strongly disagree
- Disagree
- Neutral
- Agree
- Strongly agree.

The literature review has clearly shown that specific attitudes are better suited and may enhance knowledge creation. This section of the questionnaire aimed to establish whether the attitude levels in the organisation was conducive to knowledge creation.

2.4.2.1.1.6 Knowledge domain

This section consisted of two questions, which were both measured against a Likert scale of five items. The Likert scale consisted of the following options:

- Strongly disagree
- Disagree
- Neutral
- Agree
- Strongly agree.

The literature review established that access to knowledge is a critical driver for knowledge creation (see sections 3.3.6 and 3.3.8). The first of the two questions, consisted of eight statements that measured mainly the value of knowledge for respondents, as well as, access to knowledge in the organisation. Question 6.2 consisted of three statements that measured mainly the attitude to the impact of knowledge on innovation and KC.

2.4.2.1.2Informed consent

Consent to conduct research was received from the Business services division of the organisation. Written consent was also obtained from the respondents.

2.4.2.1.3Anonymity and confidentiality

The informants were assured that the information they supplied would neither be made public nor lead to the disclosure of their identities.

2.4.2.1.4Results

A survey was conducted to gather data that contribute towards the validation of the model.

2.4.2.1.4.1 Sampling

The population for the study included all knowledge workers (119) at the organisation under study, at the time of the survey.

The first phase of the case study analysis consisted of interviews with management of the organisation. A discussion document was developed and this was refined by a final discussion session with the CEO of the organisation to verify the findings.

Proportional samples from the three innovation spheres (Section 4.1.1) were then selected based on the availability of respondents, at the time of the survey. These samples are presented in Table 2-1 below.

Table 2-1: Number of respondents per innovation sphere

Innovation sphere	Population		Sample			
	n	% of population	n	% of total sample	Average of Total population	% of population
Project	75	63%	16	57%		21%
Product	33	28%	9	32%		27%
Other	11	9%	3	11%		27%
Total	**119**	**100%**	**28**	**100%**		**24%**

2.4.2.1.4.2 Reliability of results

McDaniel and Gates (2012: 288) state that internal consistency reliability, assesses the ability to produce similar survey results, using different samples to measure a phenomenon during the same time period, this in essence also addresses data stability. In other words, the findings can be said to be reliable if the study is replicated and the same results are obtained.

In order to establish internal consistency of the quantitative data gathered the original sample (n = 28) was split into two random sub-samples of equal size (n = 14). The random sample selection-function of SPSS for Windows was used to perform a randomised split of the database. SPSS Exact Tests were used to analysing the data by exact methods.

Due to the small sample Metha and Patel (2012: 1) advise that Exact and Monte Carlo Test methods be used. These new methods provide a powerful means for obtaining accurate results when data sets are small, tables are sparse or unbalanced, the data are not normally distributed, or the data fail to meet any of the underlying assumptions necessary for reliable results using the standard asymptotic method (Metha & Patel, 2012: iii), as in the case of this sample.

Table 2-2 below shows the results. The results showed that in none of the tests, the null hypothesis could be dismissed, based on the significance value that is more than 0.05. Therefore due to the equivalence of the split samples the notion of internal consistency or stability of the data is supported, suggesting internal consistency of the data. Failure to reject the null-hypothesis, therefore suggested that the two sub-samples yielded similar results. The tests therefore proved that random splitting of the sample produced equivalent results which demonstrates internal consistency between the split samples. The above-stated tests confirm that there is a high level of confidence in internal consistency which implies that if another research is conducted using the same sample and methodology it will yield the similar results. Based on these findings the possibility of generalisation or extrapolation exists.

Table 2-2: Internal Consistency Reliability

Test Statistics						
		v5.1.2	v5.1.4		v5.1.6	v5.1.7
Exact Sig. [2*(1-tailed Sig.)]		.352[b]	.329[b]		.571[b]	.541[b]
Monte Carlo Sig. (2-tailed)	Sig.	.364[c]	.315[c]		.583[c]	.565[c]
	99% Confidence Interval	Lower Bound	.352	.303	.570	.552
		Upper Bound	.377	.327	.595	.578
Monte Carlo Sig. (1-tailed)	Sig.	.180[c]	.156[c]		.292[c]	.282[c]
	99% Confidence Interval	Lower Bound	.170	.147	.281	.271
		Upper Bound	.189	.165	.304	.294
a. Grouping Variable: Sample						
b. Not corrected for ties.						
c. Based on 10000 sampled tables with starting seed 403768731.						

2.4.2.1.4.3 Validity of results

Validity refers to the degree to which a question, scale or test assesses that which was intended to be measured. There are different forms of validity. For this study, content validity would be significant. Content validity refers to the extent to which a measuring instrument adequately covers the research query (Cooper and Schindler, 2014: 257; Rubio, Berg-

Weger, Tebb, Lee and Rauch, 2003: 94). Section 2.4.2.1.1 demonstrated how each item of the instrument was constructed as well as references to the underlying theory that supports the items. The validation of the results is therefore found in the manner in which they represent the theoretical framework developed to substantiate the existence of the model.

2.5 Summary

A description of the research design, data collection, sample selection and statistical analysis were provided in this chapter.

The population of the research consisted of the knowledge workers in the organisation under study.

The literature provided in Chapter three will provide a detailed analysis of literature to substantiate the model that will then be developed in Chapter three. Chapter 4 will provide a detailed description of the research findings.

Chapter 3 Literature review

The literature review will establish the underlying principles of KC and innovation. The researcher will establish a link between innovation and KC and will then demonstrate that KC is a learning process that is triggered by problems. This chapter further provides insight into attitudinal aspects that are necessary for KC and learning to take place.

Chapter 3 establishes the appropriate learning methodology that will assist the KC process. The literature review will, therefore, provide critical insights into the following aspects:

- Innovation
- Knowledge creation
- Learning methodologies
- Problem-based learning.

This chapter addresses **Research question one** and will demonstrate that learning may trigger innovation. **Research question two** will be addressed when the researcher shows that innovation and KC are closely linked and supportive of one another.

This chapter further demonstrates that access to knowledge enhances and contributes to the KC cycle, thereby addressing **Research question three**. **Research question four** will be addressed when the researcher shows that problem-based learning enhances KC.

A KC model will then be developed that will ensure KC through learning processes, this aspect addresses **Research question five**.

3.1 Overview

The origin of the word innovation dates back to the mid-16th century. The word is derived from the Latin word innovat, which means 'renewed or altered' and from the verb innovare, meaning in- 'into' + novare 'make new' (Concise Oxford dictionary of English etymology, 2015).

Godin (2008: 23) explains that novation is a term that first appeared in law in the 13th century. It meant renewing an obligation by changing a contract for a new debtor. In 1513 Machiavelli and Bacon in 1625 were among the very first individuals using the term innovation.

Innovation has been well studied and discussed in the literature, and there are many paths to take when one embarks on a discussion of innovation. For the purpose of this chapter, the researcher would like to argue that innovation is mainly driven by acquired knowledge, access to new knowledge, exchange of knowledge, barriers to overcome and failures to embrace.

The concept of innovation is an integral part of human development. As a matter of fact, it is a central part of what humans have achieved and what may be achieved in future. According to Seelig, it is nearly as common as taking a breath. She explains:

> *Every sentence we craft is unique, each interaction we have is distinctive, and every decision we make is done with our own free will. That we have the ability to come up with an endless set of novel responses to the world around us is a constant reminder that we are born to be inventive (*Seelig, 2012: 8).

When looking at the development of stone tools through the eons, it is clear that a gradual process of innovation was at play. The first stone tools were rudely crafted and used mainly for chopping, as seen in the tools of about 2 million years ago. The Acheulian (1.8 million years ago) tools were much better crafted and showed reworking of the flakes from the core to create rudimentary cutting devices. The Acheulian tools were created by Homo habilis, a more advanced early hominid, and this explains the development of the technology. The Acheulian technology spread throughout Africa and Asia, as demonstrated by archaeological records. Regional specialisations were then seen and these were attributed to a variety of factors, including environment, availability of resources, preferences and group dynamics (Phillipson, 2005: 91). In later archaeological records it is evident that technologies spread through contact. The contact, in some cases hostile (barriers), such as wars, exposed people to more advanced technologies. The critical mass of contact with diverse people and barriers to overcome consequently started to drive innovative ideas and technologies in an ever increasing tempo of discovery. The previous statements are supported by various researchers in die field of cultural exchange and diffusion. Alderman has written a chapter on the spreading of ideas and technologies in *Cultural Change and Diffusion* (Alderman, 2012: 123-134).

The following sections of this chapter will unpack innovation, describe problems as KC triggers, provide a cognitive learning approach to solve-problems, analyse the affective factors influencing KC, define required skills for KC and then describe the knowledge domain in more detail. These sections form the foundation of the KC model that were developed in section 3-8.

3.2 Seelig's innovation engine

In her book, *inGenius,* Seelig (2012: 13) discusses the innovation engine, conceptualised through years of teaching creativity and innovation. Seelig explains that creativity is generated internally and can be stimulated by mastering skills such as reframing problems, challenging assumptions and connecting and combining ideas. Seelig confirms that the following factors influence creativity:

- Intrinsic knowledge
- Environments of work
- Synergy between colleagues
- The rules, rewards, and constraints in the environment.
- People’s own attitude
- The culture of the community.

The innovation engine illustrates how all the above factors work together to enhance creativity. The engine is illustrated in Figure 3-21. The engine consists mainly of an internal part that is made up of knowledge, imagination and attitude. The external factors are resources, habitat and culture. Seelig (2012: 184) explains that the internal section of the engine was inspired by Bloom's original work in the

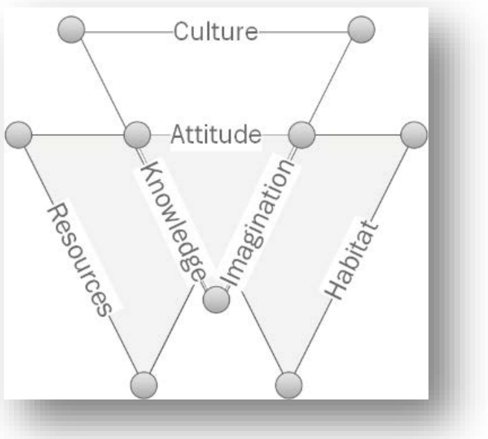

Figure 3-1: The innovation engine of Seelig (2012: 14)

1950s on learning. He focused on **what you know**, **what you do**, and **how you feel**, which are generally known as **knowledge**, **skills** and **attitude**. Bloom's impact on KC processes will be discussed in more detail in this chapter. Seelig adapted Bloom's skills category to imagination, as imagination refers to the specific skills needed for creativity.

3.2.1 Knowledge

Seelig (2012: 185) states that knowledge is the fuel of imagination. The more knowledge. Seelig further explains that in order to succeed, does not necessarily imply that one has to be an expert in the field where innovation is required. Lack of knowledge, combined with the correct attitude and access to required resources, may very well lead to fresh innovations. However, acquired knowledge is a first step on the ladder to innovation.

3.2.2 Imagination

Seelig (2012: 186-187) explains that imagination is the catalyst required for creative combustion. She refers to the work of Szpunar and McDermott (2008: 119 - 129) in which the authors cited a broad range of psychology and neuroscience research that reinforces the hypothesis that the same parts of one's brain are invoked when one remembers and when one imagines, including evidence that those who do not have the ability to remember the past are unable to conjure up a vision of the future. Imagination is therefore fuelled by knowledge or memories. This implies that the bigger the well of knowledge and memories, the greater the possibility of fresh innovation.

3.2.3 Attitude

If knowledge exists and the imagination is triggered by a fresh idea, attitude will determine if the idea becomes a feasible innovation. Seelig (2012: 188) explains that attitude is the spark that jump-starts creativity. Attitude is a complex neurological process and in the field of psychology various studies have been done in this regard. Some attitudes, it seems, are better suited to drive innovation processes, as seen in the study done by Moser, Schroder, Heeter, Moran and Lee (2011: 1484 - 1489). The study found that individuals who believe that intelligence develops through effort, usually see mistakes as opportunities to learn and improve. These individuals show stronger resilience to bounce back from mistakes, whereas for individuals who believe that intelligence is a given and mistakes reflect a lack of ability, recovering from mistakes is harder. The next section, on the value of failure, will discuss this attitude in further detail.

3.2.3.1 The value of failure

Learning through mistakes is a well-known fact, but at some point in life mistakes become failures best forgotten and not dwelled on too often. Research and modern thoughts on education and innovation suggest that failures are a critical part of the learning and therefore innovation process. Seelig refers to Edison when she explains the value of failure in the following excerpt from her book (Seelig, 2012: 151):

> *Thomas Edison tried thousands of different materials for the glowing filament inside a light bulb before finding one that worked. He famously said, "I have not failed. I've just found ten thousand ways that won't work." He knew that* ***every failure reveals a truth about the world and that unexpected results are***

> ***often the most interesting in that they uncover brand-new— and sometimes breakthrough — findings.*** *Unexpected observations have led to a wealth of important discoveries, such as radioactivity, penicillin, and blackbody radiation in the universe. Max Planck, the famous physicist, said, "An experiment is a question which science poses to Nature, and a measurement is a recording of Nature's answer.*

Herein lies an immense truth. Every obstacle or problem has thousands of possible solutions. The probability that only one of these paths will lead to success can only be tested through experimentation and subsequent failure. Therefore failures can be seen as the end results of learning processes. It is critical, however, that the failures prompt new pathways to investigate solutions. The failure must never become the reason for abandoning any idea. Seelig (2012: 154) further states that:

> *Genius is the ability to make the most mistakes in the shortest period of time. Each of those mistakes provides experimental data and an opportunity to learn something new. Like scientists, we need to stop looking at unexpected results as failures. By changing our vocabulary, by looking at "failures" as "data," we enhance everyone's willingness to experiment.* ***This is a big idea!***

The above provides an unyielding argument to embrace failures as part of the innovation process. But undocumented failures become null and void. It is therefore important that the failures be carefully documented to ensure that the knowledge gained from these experiments becomes evident. Quite often in the workplace situations will arise where one is working furiously to solve a problem, trying and discarding many approaches or ideas, yet very seldom pausing to document those discarded ideas, as well as the reasons for discarding them. If these were documented, it is entirely possible that this might save time in future when someone else embarks on a similar project. Documenting failed experiments is a critical part of the scientific method. The data gathered in the process are as valuable as the ultimate solution.

A further result of paying close attention to failures is the unexpected outcomes, as explained by Seelig (2012: 158) in referring to a statement made by Imran,

> *"Failure is a constant companion, and success is an occasional visitor."*

She mentions further that Imran appreciates failures:

> *because each one teaches him something important on the road to a breakthrough idea. He believes it is up to each of us* ***to mine our failures for valuable information and insights****. Failure and success are closely intertwined, and for him every failure follows a series of successes, and every success follows a series of failures. The key is seeing the process of trial and error on the way to a success as a series of experiments. If you look at your failures in this light, they take on brand-new meaning. This is true in all of life's ventures and adventures, large and small.*

One must keep in mind though that some failures might have catastrophic results. It is therefore important to understand the impact that a failure might have when embarking on any project. Failures in aircraft innovation, for instance, have cost lives. Some rules are therefore required to govern failures. Lanks (2011) mentions that the *"Fail early and fail often",* approach borrowed from the world of computer programming, expresses the urgency of getting iterations out into the world early in the process so that they can be tested, debugged, redesigned and refined. The sooner in the process one does it, the more likely it is that one can make meaningful adjustments into the final product. This approach fits perfectly in the agile environment. One of the characteristics of agile processes is the small iteration phases and these support the early failure methodology.

Lanks (2011) raises definite concern that while embracing failure is a required approach, the kind of failures that are allowed need to be defined and managed. One must at all costs aim to limit failure to the development phases and not to the delivery phase. Failures during delivery might cost lives, money and esteem.

To distinguish these conflicting kinds of failure better, Lanks (2011) defined a failure spectrum (see Figure 3-2) - from devastating to productive - that allows for differentiating among these different modalities.

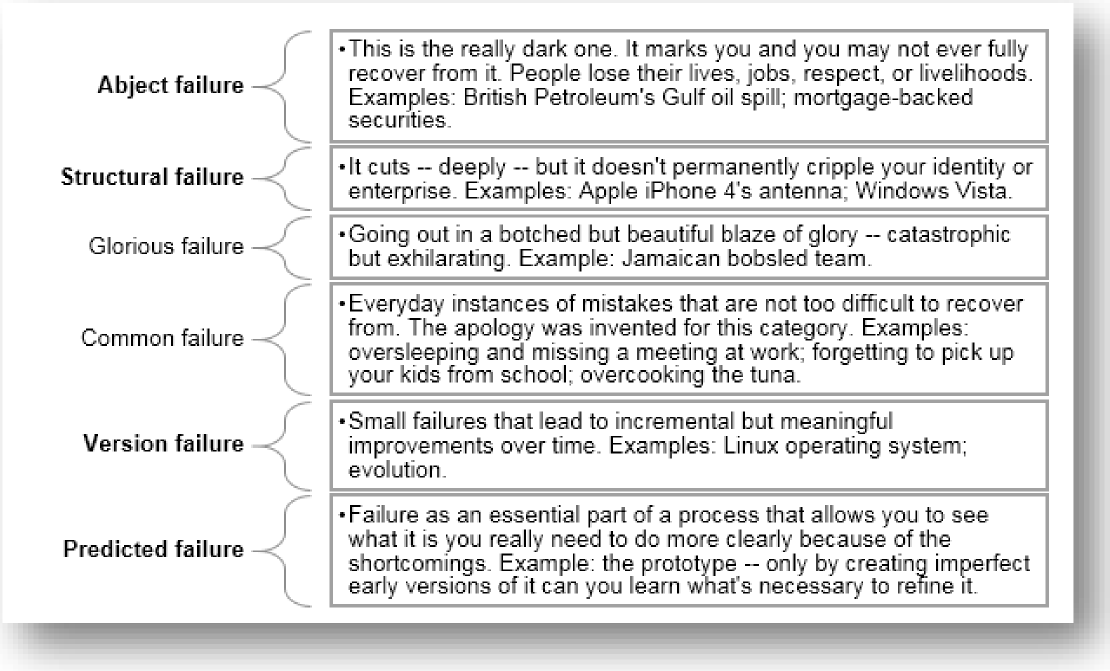

Figure 3-2: Lanks's failure spectrum (Lanks, 2011)

Failing to succeed is therefore a valuable culture to nurture in an organisation that aims to be innovative by nature. It is important therefore to decide in which manner one recognises failure as part of the successful innovation process. Similarly, it is critical to define those failures that are not acceptable and should be limited as far as possible.

When developing any learning programme, one of the guiding principles is to develop it in such a way that it is safe to fail. For example: before writing examinations, one may incorporate a mock examination in order to prepare for the real examination.

This also applies to the workplace; all development that leads to a deliverable needs to take place in an environment where it is safe to fail. Failing safely and frequently might just be what is needed to reach innovative solutions that really do work.

A failure thus only becomes valuable when one manages to take the failure, tweak the outcomes and find a better solution. This is something that needs to happen over and over again. True grit is required of those people who will find the best solutions.

3.2.4 Resources

If as stated above, making mistakes and then realising the need to learn more is important to spark innovation, then access to resources becomes a critical driver for innovation. Seelig (2012: 190-191) includes the following as resources:

- Funds that can be invested in new companies
- Natural resources
- Individuals with knowledge and expertise
- Organisations such as universities and local firms that foster innovation.

This list can go on and on; think about books, access to the internet and access to journals. Seelig explains that the broader one's knowledge base, the more resources can be mobilized. Knowledge and resources are closely linked to each other and one drives the other in an ever expanding wealth of more knowledge. Therefore the available resources influence knowledge, and existing knowledge (know-how and know-where) assists in accessing more resources.

3.2.5 Habitat

Habitat is known as working and living spaces. The importance of habitat is comprehensively discussed by Seelig (2012: 91-98). The work done by

McIntosh (2010) on his seven spaces for creative environments is a splendid indication of how these creative learning spaces can be applied. McIntosh (2010) describes seven different types of spaces optimised for innovation that can exist in both the physical and the online world:

- Private/secret spaces are places where people can be alone.
- Group spaces are places where small teams of people can work together. Group spaces provide the opportunity for intense collaboration.
- Publishing spaces are designed to showcase what is going on.
- Performing spaces are those where people can either share ideas or act them out.
- Participation spaces are places that allow personal engagement with what is going on.
- A data space is similar to a library or database, where information is archived/stored.
- Watching spaces allows for passive observation of what is happening.

Seelig (2012: 101) states that creative spaces lead to creative work. Seelig describes examples of how Pixar and Scribd have used space design to drive innovation. What comes to mind in both these examples is the element of play. Perhaps McIntosh's spaces can be expanded to include space for playing.

3.2.6 Culture

The last component of the innovation engine is culture. Seelig (2012: 193) defines culture as the way in which groups of people perceive, interpret and understand the world around them. Culture can be defined and influenced to change. A small group of persons with modified attitudes and behaviours may have a definite impact on a wave of change. As Seelig (2012: 193) explains:

> *Over time these ideas became contagious and were eventually supported by laws that reinforce those collective attitudes.*

If an organisation chooses to be creative and innovative, the culture of the organisation must be clearly defined as such and the behaviours that support creativeness must be encouraged. This encouragement is done by enthusiastic knowledge workers that take the lead, but also by policies that are written in support.

3.2.7 The value of diversity

This section will demonstrate how diversity can be seen as one of the main drivers of innovation. If the innovation engine is driven by knowledge, then it makes sense to say that the more diverse knowledge sources are, the better the chances are for innovative new solutions; refer to Chapter 1 and the statement by Johannessen *et al.* (2001: 28) on infusing newness. Nonaka and Takeuchi (1995: 115) confirm that the primary source of the KC process is the diversity of individuals' knowledge and experience.

In a report on diversity and innovation by the European Community Programme for Employment and Social Responsibility (2007: 7) it was found that diversity does indeed drive innovation. This report on innovation and diversity defines diversity as demographic traits, namely gender, age, race and ethnicity, sexual orientation, religion and beliefs, as well as disability. The report further defines diversity by acknowledging differences in learning styles and attributes of individuals, knowledge acquisition processes, communication styles, educational history, personal skills, professional abilities and functional expertise.

The link between innovation and diversity is well established and proven in the following set of examples from a literature review:

3.2.7.1.1 Hewlett Packard: latex printing technology

The organisation Hewlett Packard's latex printing technology was the product of innovation driven by diversity. The innovation was the end result of consciously assembling a diverse team of 120 engineers across four different countries. Issues of cultural and other forms of diversity were effectively managed in order to release the creative potential of different individuals (European Community Programme for Employment and Social Responsibility, 2007: 9).

3.2.7.1.2 Higher levels of innovation in German regions with higher diversity levels

Niebuhr (2010: 563) has analysed the impact of cultural diversity in research and development employment on innovation for a cross-section of German regions. This is what Niebuhr found:

> *The results indicate that cultural diversity might indeed matter for innovation activity. The evidence points to differences in knowledge and capabilities of workers from diverse cultural backgrounds that may enhance performance of regional Research and Development sectors. The positive impact of diversity on innovation seems to outweigh negative effects.*

3.2.7.1.3 Twitter

Seelig (2012: 42) provides the example of Twitter when stating that innovative companies know how important this type of cross-pollination is to creativity in their businesses. In this example, she explains that Twitter's knowledge of diversity as a driver for innovation affects the decision to hire people with diverse and unusual skill sets. She mentions as an example, that at Twitter, one might find the following diverse characters:

- Former rock stars
- A Rubik's cube champion
- A world-class cyclist
- A professional juggler.

These unrelated traits are normally the catalyst for new ideas and different viewpoints on old ideas. However, she does emphasize that the hiring practices at Twitter guarantee that all knowledge workers are skilled at their jobs.

3.2.7.1.4 Cultural diversity, innovation, and entrepreneurship: firm-level evidence from London

Nathan and Lee (2013) investigated a unique sample of 7 600 firms to establish links among cultural diversity, innovation, entrepreneurship and sales strategies in London businesses between 2005 and 2007. The findings of this study showed that:

- Organisations with diverse management are more likely to introduce new product innovations than are those with homogeneous 'top teams.'

- Diversity is particularly important for reaching international markets and serving London's cosmopolitan population.

- Migrant status has positive links to entrepreneurship.

3.2.7.1.5 Diversity: the art of innovation

Etuka (2009: 54 - 57) describes how a more diverse workforce will contribute to a firm's ability to innovate. This article reviews why firms may view diversity as a problem to be resolved rather than a resource for the organisation. The findings suggest that managers need to be re-educated about diversity and the contribution it can make to the business and that organisations need to rethink how they source, identify and develop talent. The results of this research confirm that diversity is enhanced by concentrating on varied skills and different abilities of future knowledge workers instead of only socio-cultural diversity.

3.2.7.1.6 The effects of national culture and ethno-linguistic diversity on innovativeness

Puia and Ofori-Dankwa (2013: 349 - 371) demonstrated that culture and ethno-linguistic diversity are positively associated with national innovation and show significantly greater variance in levels of national innovation than national culture alone when measured independently. This source therefore supports the value of diversity for innovation.

Diversity is one of the ingredients required when an organisation wishes to set the foundations for innovation. Diversity contributes to the innovation engine by adding value to the culture, resources and knowledge bases of the innovation engine.

3.2.8 Summary

This section demonstrated the value of the innovation machine. Each of the components was briefly described. The innovation engine contributes to this research by firmly establishing the following three domains as critical for innovation to follow, namely: knowledge, imagination/skills and attitude. These three domains will similarly form the core of the KC model that will be developed.

This section has further shown that diversity is a contributing factor to innovation. It was also shown that failing to succeed is a valuable attitude that drives the continuous cycle of innovation. The innovation engine will serve as a core element of the KC model that will be developed.

3.3 Core principles underpinning the KC model

The following section will discuss the core principles that will under pin the KC model to be developed.

3.3.1 Harnessing problems

Section 3.2.3.1 described the value of failures. If the attitude to accept failures as part of the development/learning process is in place, then problems may become valuable sources for innovation. A problem is defined by Baer, Dirks, and Nickerson (2013: 5) as:

> *A deviation from a desired set of specific or a range of acceptable conditions resulting in a symptom or a web of symptoms recognized as needing to be addressed.*

Trellinger, Selby and Isaksen (2008: 390) describe problems as questions for inquiry. A problem represents a gap between where one is or what one has, and a desired location or outcome as defined by Johnson (1972: 133).

This statement clearly shows that problems are opportunities, when referring to the desired outcome.

In this section the researcher would like to demonstrate that problems can be significant drivers of innovation. Nonaka and Takeuchi (1995: 56) see problem-solving as the source of continuous innovation and continuous innovation as the source of sustained competitive advantage.

> *When organizations innovate, they do not simply process information, from the outside in, in order to solve existing problems and adapt to a changing environment. They actually create new knowledge and information, from the inside out, in order to redefine both problems and solutions and, in the process, to re-create their environment.*

From this statement follows that problems are central to continuous innovation. In other words, problems presented by customers and markets may lead to innovation. Similarly, the daily problems that knowledge workers experience may result in innovative solutions and new knowledge or know-how from within the organisation. Nonetheless, problems must be solved in order to create something new.

Hsieh, Nickersen and Zenger (2007: 1258) highlight the relationships between opportunity, problems and value creation when they state that the association between opportunity discovery and problem-solving is not new. Their research has shown that both opportunity discovery and problem-solving relate to similar 'value creation' in the literature.

Section 3.2 on innovation and KC substantiated the fact that KC is a learning process. Hsieh, Nickersen and Zenger (2007: 1273) concluded that as the complexity of a problem increases, experiential search via trial and error provides fewer benefits and cognitive search via theorising becomes more useful. Therefore the author proposes that since KC is in essence a learning process, a cognitive learning approach may enhance the problem-solving process in the workplace.

3.3.2 Learning to solve problems

Complex problems require a problem-solving process that will attain the level of complexity and depth needed to solve these problems. Kaplan (2014: 115) defines complexity:

> *as the means by which knowledge is extended or broadened.*

Trellinger, Selby and Isaksen (2008) state that problem-solving is:

> *the thinking and behaviour we engage in to obtain the desired outcome we seek and that the outcome could be attaining a certain goal or finding a satisfactory answer to our question.*

These definitions show that problem-solving is a cognitive learning process that enables one to broaden one's knowledge base. Research has furthermore shown that experts have acquired extensive knowledge that affects what they notice and how they organise, represent and interpret information in their environment. This, in turn, affects their abilities to remember, reason and solve problems (Bransford, Brown and Cocking: 2000: 31). Problem-solving is an essential skill required for critical thinking as defined by Angelo (1995, p.6):

> *Most formal definitions characterize critical thinking as the intentional application of rational, higher order thinking skills, such as analysis, synthesis, problem recognition and problem solving, inference, and evaluation.*

Moore (2006: 2) defines critical thinking as:

> *Critical thinking is a deliberate metacognitive (thinking about thinking) and cognitive (thinking) act whereby a person reflects on the quality of the reasoning process simultaneously while reasoning to a conclusion. The thinker has two equally important goals: coming to a solution and improving the way she or he reasons.*

Research has shown that critical thinking is a skill that is not widely adopted and implemented. Paul (2005: 27) cites a series of studies demonstrating that:

- *most college faculty at all levels lack a substantive concept of critical thinking;*
- *most faculty don't realize they lack a substantive concept and instead believe they understand critical thinking sufficiently and are already successfully teaching it within their discipline;*
- *despite "reform" efforts, lecture, rote memorization, and (largely ineffective) short-term study strategies are still the norm in college instruction and learning today.*

Research conducted by Lombard and Grosser (2008: 1) provides further evidence that South African first-year students do not show proof of having acquired the relevant critical thinking and problem-solving skills. Pieterse (2013: 111) conducted research to indicate the ability of third-year students to apply critical thinking and concluded that these students also lacked these skills. This is a challenging state that needs to be solved by introducing a learning approach in workplaces that will allow knowledge workers to become experts that can solve complex problems.

Knowledge-intensive organisations are essentially creating new knowledge in order to solve problems. The problem-solving ability of the organisation therefore has a direct impact on its value proposition. It therefore makes sense that these organisations must endeavour to create knowledge workers with the necessary critical thinking skills that will enhance problem-solving. The research by Lombard and Grossner (2008), Paul (2005) and Pieterse (2013) discussed in previous paragraphs clearly shows that these skills might possibly be lacking in knowledge workers.

Problem-based learning has been applied successfully in learning institutions over the past few decades, as demonstrated in the research of Galecki and Rebala (2014). Based on these findings, these methods have been proven to have had a successful impact on specifically the fields of learning where higher-order thinking skills are required and nurtured. Engineering environments in general are places where complex problems are solved. Taking into consideration that innovative engineering firms are constantly working within the problem-solving domain, it makes sense to propose that a cognitive model is used to drive KC in these workplaces.

This might be a valuable approach especially where an organisation is rapidly growing and new knowledge workers are required to up-skill themselves on product knowledge, organisational processes, customer needs and market requirements.

Problem-based learning is a learning methodology that provides a problem to be solved. These problems are solved by using existing knowledge to find more knowledge that leads to a solution. If the problem never existed, no action would have been required. This is also true of the innovation process – is it really human nature to find solutions to problems that do not exist? Lyles (2014: 134) states that the simplification of problems is typical in many organisations that try to reduce problems to ones that can be defined so that the solution or innovation needed appears to be simple. Lyles mentions that research clearly indicates that managers may actually be misperceiving a more complex situation. According to Lyle, complex problems often need new innovative solutions and a process of creating new organisational knowledge, which equals a learning process.

Problem-based learning is a methodology with roots in the constructivist approach to learning.

> *Constructivism is a teaching philosophy based on the concept that learning (cognition) is the result of 'mental construction'. Students constructs their own understanding by reflecting on their personal experiences, and by relating the new knowledge with what they already know. Each student creates his or her own 'schemas' or mental-models to make sense of the world, and accommodates the new knowledge (learns) by adjusting them. One of its main principles is that learning is search for meaning, therefore, to be effective, a teacher must help the student in discovering his or her own meaning. Although based on cognitive psychology research, its history goes back to the ancient Greece, the Socratic method. (Constructivism, 2016)*

Barrows (1996: 5-6) defines the problem-based learning model as having the following characteristics:

- It is student centred learning.
- Learning is done in small focus groups, ideally six to ten people.
- Facilitators guide the students rather than teach.
- A problem forms the basis for the organised focus of the group, and stimulates learning.
- The problem is a vehicle for the development of problem-solving skills. It stimulates the cognitive process.
- New knowledge is obtained through self-directed learning.

All learning involves knowledge construction in one form or another; it is therefore a constructivist process (Hmelo-Silver, Duncan and Chinn, 2007: 99)

Janson, Ramachandran and Schmalzel (2010: 3) confirmed that agile learning environments, created to graduate engineers who can be rapidly productive in the professional and research worlds, are enhanced by project-based learning experiences in the Electrical and Computer Engineering (ECE) curriculum. They found that:

> *... student motivation increases in these settings, and their confidence in problem definition, integrative thinking, option development, and solution grows. The project structure of an engineering clinic within an ECE program is one that requires students to operate at higher orders of abstraction earlier in their education while still requiring a concrete hands-on, minds-on engineering solution to the real-world problem at hand.*

The problem-based learning process is described by the following model, as developed by the Illinois Mathematics and Science Academy:

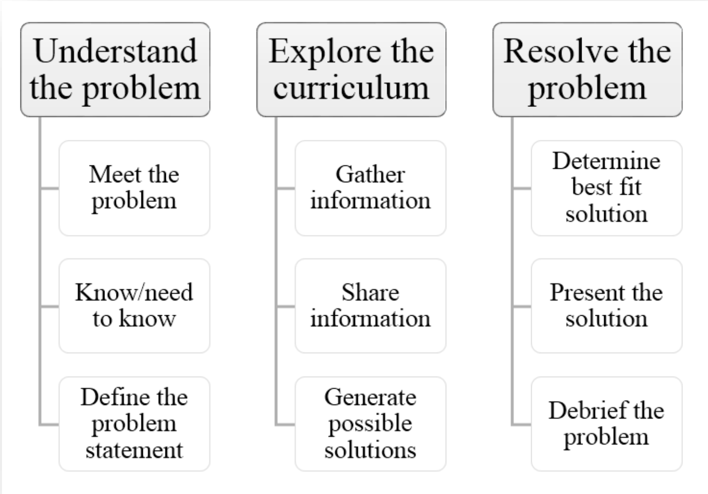

Figure 3-3: IMSA PBL Model (Illinois Mathematics and Science Academy)

This model may be adapted to function in the workplace as per the demonstration below:

Understand the problem	Meet the problem:	Employees encounter a problem that engages their interest and compels them to know more.	
	Identify knowledge and need to know more:	The group generates lists:	What we know What we need to know What we need to do
	Define the problem	Employees list the tasks to be completed and the factors for successful completion	
Explore the knowledge base(curriculum)	Gather information	Employees plan how to gather information from multiple and varied resources	
	Share information	Employees share information they have gathered with theit=r group and discuss its relevance to the problem.	
	Generate Possible Solutions	Employees synthesize information to gather several possible solutions.	
Resolve the problem	Determine best fit solution	Employees develop a blueprint to demonstrate a solution which fits the factors in their problem statement.	
	Present the solution	Employees present their solution and get feedback from a real world stakeholder in the problem.	
	Debrief the problem	Employees debrief the presentation to emphasize learning from other groups presentations.	

Figure 3-4: Example of problem-based learning in the workplace (Illinois Mathematics and Science Academy)

Figure 3-4 above presents a very clear framework for solving problems. It divides the problem-solving process into small executables with clear outcomes. Because of the nature of problem-based learning, the researcher argues that, by adopting this kind of framework, innovative solutions to complex problems may follow.

Through this process one takes a problem/barrier and solves/removes it by means of a clearly constructed method with the aim of creating new knowledge and ultimately solving the problem.

If user requirements are seen as problems to be solved, it will make sense to use a similar process to create a solution that fits the problem. This method of learning fits well within the agile framework where user requirements are seen as problems to be solved, as demonstrated by Figure 3-5 that show the importance of goal-driven development and scope analysis.

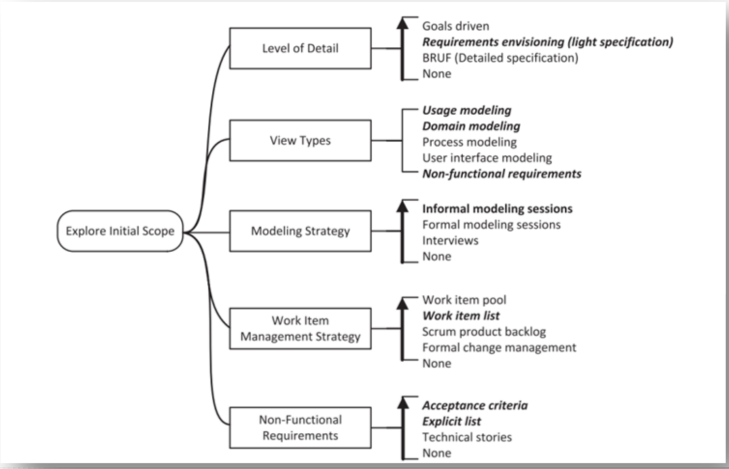

Figure 3-5: Ambler's process goal diagram: explore initial scope (Ambler, 2005)

The IMSA model provides a method for problem-solving. To enhance this process, Paul and Elder (2006: 21) provide a critical thinking model that includes standards, elements and traits. This model aims to provide a vocabulary that will guide the critical thinking process in engineering environments (Figure 3-6).

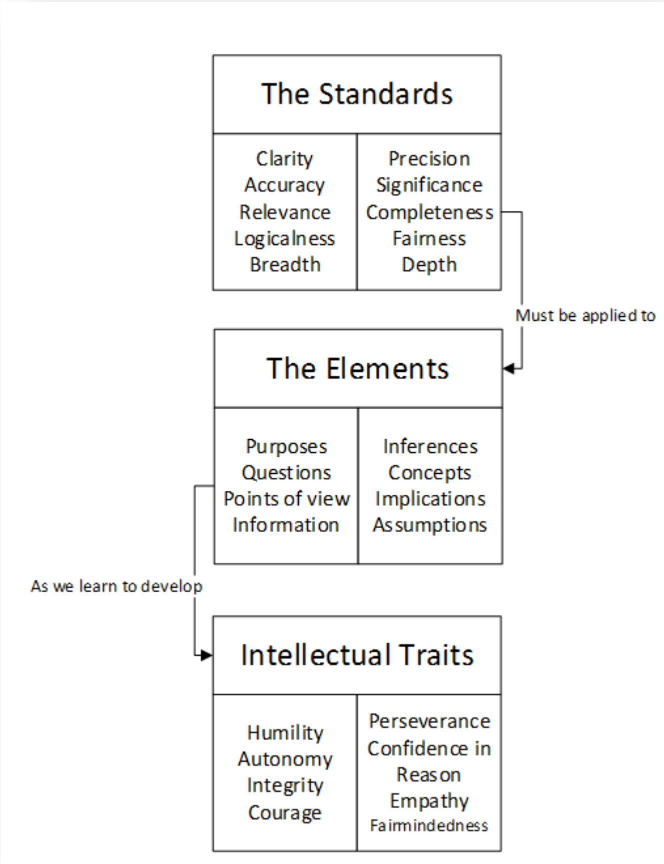

Figure 3-6: Paul's critical thinking example (Paul, 2005: 71)

Standards and elements are cognitive skills that can be learned. Intellectual traits form part of the affective domain and these might be difficult to acquire. This section has shown that critical thinking is necessary for problem-solving. The problem-based learning approach is seen as a cognitive constructivist learning methodology that assists in higher-order thinking skills. The next section will discuss learning methodologies in more depth by looking at the cognitive domain and specific measures to activate this domain.

3.3.3 Solving problems with a cognitive learning approach

The cognitive domain can be described as the place of learning. The cognitive domain may be enhanced by using specific learning methodologies to stimulate creative learning. As seen in the previous section on problems, complex problems require a cognitive approach and critical thinking is a valuable skill. Bloom's taxonomy of learning is widely used and seen as a method to stimulate creative learning through critical thinking.

3.3.4 Bloom's taxonomy of learning

The discussion of problem-solving and critical thinking in the previous section leads to the question of whether a particular cognitive learning approach may enhance the ability of learners to think critically. Bloom's taxonomy of learning (1979) has been identified as such a method. Bloom (1979: 38) believed that learning must focus on the promotion of higher forms of thinking, rather than simply transferring facts.

Bloom's taxonomy model consist of three domains, namely:

- Cognitive (intellectual capability, i.e., knowledge, or 'think')
- Affective (feelings, emotions and behaviour, i.e., attitude, or 'feel')
- Psychomotor (manual and physical skills, i.e., skills, or 'do').

Bloom defined various categories within each domain. Bloom's taxonomy is based on the premise that the categories are ordered according to the degree of difficulty; each category has to be mastered before the next category can be negotiated. For effective learning to take place, all three domains have to be in place and all categories must be negotiated successfully.

Life-long learning has been defined in Section 3.3.5 as "the acknowledgement (think) and passionate (feel) acceptance of the need to know more in order to (do) better and therefore stimulating the willingness (do) to learn". The link between Bloom's (1979) taxonomy model and life-long learning is established by the key principles, namely think, feel and do. This can also be translated as the what (cognitive), how (psychomotor) and why (affective) questions of learning. The questions of what, how and why one should learn, are a basic prerequisite for any learning to occur. In practical reality the question can be explained by the following (Figure 3-7):

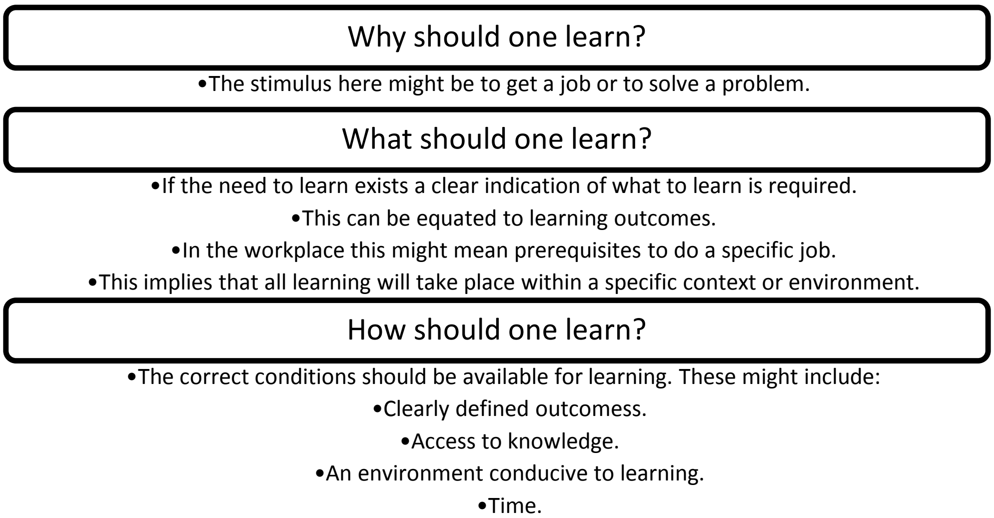

Figure 3-7: Example of three learning questions (researcher's own example)

Fields, Baxter and Seawright (2006: 1) state that constructivism in instructional design originated from the work of Bloom and others. This methodology supports the constructivist approach to problem-based learning, as discussed in section 3.3.

The cognitive process dimension represents a continuum of increasing cognitive complexity — from lower-order thinking skills to higher-order thinking skills. Kratwohl (2002: 215) identifies 19 specific cognitive processes that clarify the scope of the original six categories.

Table 3-1: The cognitive domain (Kratwohl, 2002: 215)

Lower-order thinking skills--->Higher-order thinking skills						
Remember	**Understand**		**Apply**	**Analyse**	**Evaluate**	**Create**
Recognising Identifying Recalling Retrieving	interpreting clarifying paraphrasing representing translating exemplifying illustrating instantiating classifying categorising subsuming summarising abstracting generalising	inferring concluding extrapolating interpolating predicting comparing contrasting mapping matching explaining constructing models	executing carrying out implementing using	differentiating discriminating distinguishing focusing selecting organising finding coherence integrating outlining parsing structuring attributing deconstructing	checking coordinating detecting monitoring testing critiquing judging	generating hypothesising planning designing producing constructing

The differentiation between this model and the original model of Bloom is found in the following explanation by Kratwohl (2002: 214):

> *The original number of categories, six, was retained, but with important changes. Three categories were renamed, the order of two was interchanged, and those category names retained were changed to verb form to fit the way they are used in objectives. The verb aspect of the original Knowledge category was kept as the first of the six major categories, but was renamed Remember.*
>
> *Comprehension was renamed because one criterion for selecting category labels was the use of terms that teachers use in talking about their work. Because understand is a commonly used term in objectives, its lack of inclusion was a frequent criticism of the original taxonomy. Indeed, the original group considered using it, but dropped the idea after further consideration showed that when teachers say they want the student to "really" understand, they mean anything from Comprehension to Synthesis. But, to the revising authors there seemed to be popular usage in which understand was a widespread synonym for comprehending. So, Comprehension, the second of the original categories, was renamed Understand.*
>
> *Application, Analysis, and Evaluation were retained, but in their verb forms as Apply, Analyse and Evaluate.* ***Synthesis changed places with Evaluation and was renamed Create.*** *All the original*

sub-categories were replaced with gerunds, and called "cognitive processes.

The revised model has a very clear place in the innovation/KC process because the ultimate higher order skill is create and KC is equivalent or a precursor to innovation. This model provides the tool that will allow managers to structure knowledge workers' expected outcomes so that new knowledge will be created and innovation may follow (see Appendix I).

3.3.5 The role of life-long learning in the innovation growth cycle

Schoenfield (1999: 6) defines learning as "… coming to understand things and developing increased capacities to do what one wants or needs to do …"

Hager (2004: 24) states that Dewey realised the importance for workers to link the social and political point of their work and the ideas that underpin this work to ensure maximisation of educative potential. Both Hager and Dewey therefore agree that work must be rooted in real-life passions and belief systems to have educational potential. Therefore, if one combines Schoenfield's definition of learning and Hager and Dewey's view of work, life-long learning can be defined as follows:

Life-long learning is the acknowledgement and passionate acceptance of the ***need to know more in order to do better*** *and therefore stimulating the willingness to learn.*

Life-long learning implies a birth-death cycle and it is therefore critical to apply learning methodologies that will enhance the stimulus for life-long learning throughout this cycle. The aim of this section is not to compare learning methodologies, but rather to look at specific learning methodologies that will allow for life-long learning. All problems experienced in the workplace can become learning opportunities if one has the attitude to pursue life-long learning.

Francis (1997: 169) explains that the concept of deutero-learning is imperative for successful learning to take place. Deutero-learning is described as the capacity to learn and how to learn. According to Francis this capability can be seen as the most critical ability in individuals preceding effective learning. Learning to learn is therefore the very first step towards innovation. This ability should be included in an individual's learning portfolio from the very first stages of learning.

Francis (1997: 169) states further that deutero-learning is the mechanism that forces learning to become explicit and thus leverages life-long learning and KC.

3.3.6 Link between information, knowledge and learning

As stated before, Davenport and Prusak (2000: 5) define knowledge as

> *"a fluid mix of framed experience, values, contextual information, expert insight and grounded intuition that provides an environment and framework for evaluating and incorporating new experiences and **information**. It originates and is applied in the mind of knowers. It often becomes embedded in documents, repositories, processes, routines, practices and norms."*

Analysis of the above definition indicates that knowledge consists of various learning (e.g. framed experience, values, contextual information, expert insight and grounded intuition) and information-gathering (e.g. incorporating new experiences and information) activities.

Data, on the other hand, are a set of discrete, objective facts about events as structured records of transactions, whereas information is data that make a difference (Davenport and Prusak, 2000:2-3).

This definition indicates that knowledge includes both learning and information; in other words, to become a knower and to create new knowledge one has to use information and data in order to learn. One can know information as part of knowledge but one has to learn to create new knowledge. The end result of learning should therefore be distinctive and new knowledge that incorporates, on the one hand, information and on the other ones' own values and experiences (see Figure 3.8).

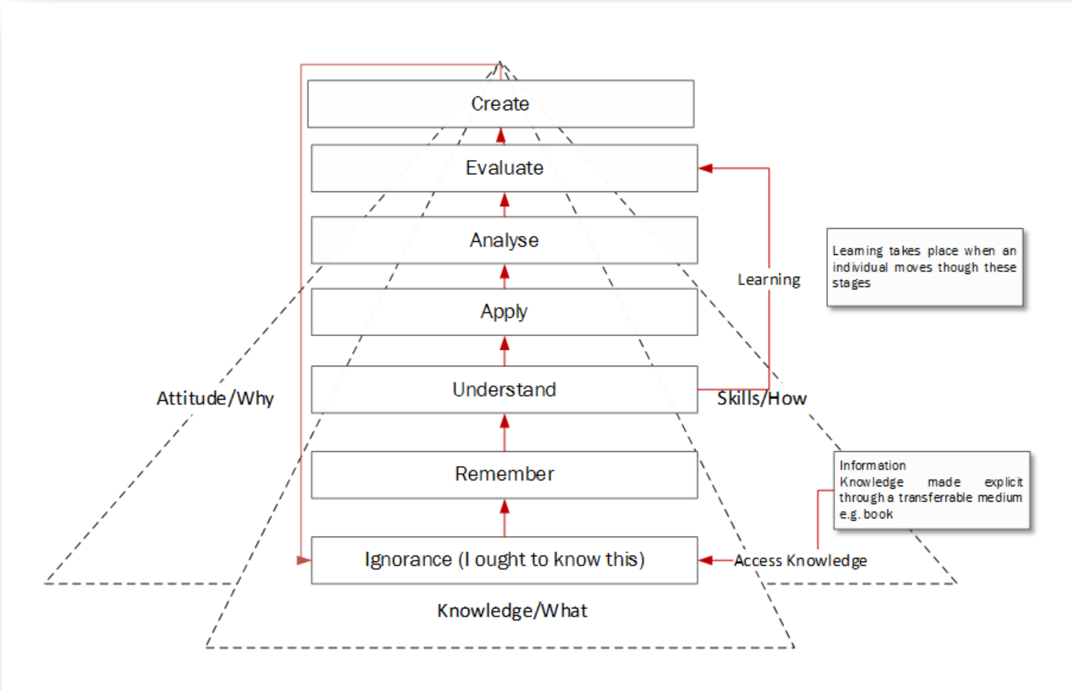

Figure 3-8: Combining the models of revised Bloom (Kratwohl, 2002: 215) and Seelig (2012).

Figure 3-8 demonstrates that KC depends on information being available, as well as the critical learning activities that should take place for knowledge to be created. The ability of a person to remember, understand, apply, analyse, evaluate and create is the sum total of that individual's KC ability.

The critical elements, according to Bloom (1979), that need to be available to ensure successful learning are:

- Information or knowledge (knowledge)
- Passion (attitude)

- The ability to learn (skills).

If these three elements are in place, effective learning will take place. Figure 3.8 further incorporates Seelig's (2012) innovation engine by adding the learning process inside the internal triangle of the innovation engine, as discussed in Section 3.2.

Bloom's taxonomy (1979), by the very nature of the levels and related questions for each level, would stimulate innovative learning. If these questions are applied in a work-based environment when defining tasks, innovative learning should automatically take place if all knowledge resources are in place (See Section 3.3.8). By using the various action verbs (Table 3-1), this learning curve can be attained and KC may be the result.

3.3.7 Defining the affective domain

Attitude has been included as one of the critical drivers for innovation in the innovation engine (Figure 3-1). Similarly the "stages of learning model" as described by Buckler (1996:33) indicates that the 'why' of learning is mainly a motivational aspect. According to Buckler (1996:34), motivation theory suggests that individuals will be intrinsically motivated to move through the model and the strength of this motivation will vary from individual to individual. Buckler (1996:34) further states:

> *that individuals will be prevented from moving through the model by inbuilt attitudes, values, beliefs and responses, of which they are often not aware. These responses may be the direct result of conditioning, by the organisation, or "taught" learning systems in general. An individual will only move through the model while the*

driving forces exceed the restraining forces, and will become "stuck" when the forces are exactly matched. Typical expressions which describe the driving and restraining forces at each stage of the process are shown on the model, but it is important to understand that these will be unique to each individual.

Buckler's model confirms the importance of attitude/affective knowledge in the innovation process. The most significant stimulus is the acknowledgement of ignorance. This acceptance of not knowing is what will drive the knowledge worker through the learning process. This is demonstrated in the model in Figure 3-9.

By combining the theory from Buckler's models, Seelig's (2012) innovation engine and the theory from Bloom's (1979) taxonomy, a model that will allow innovative learning to take place can now be presented, as shown in Figure 3-9.

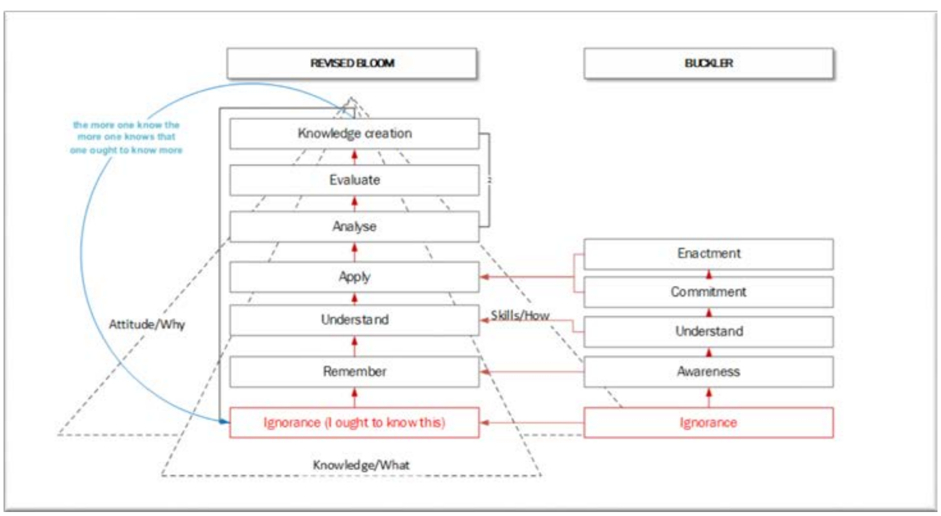

Figure 3-9: Combination of the model in Figure 3-8 and Buckler's model (1996: 33)

Figure 3-9 shows the Buckler model adjacent to the KC process. This model integrates the first level of Buckler's model, namely ignorance, into the existing KC process to create a learning for innovation model.

The statement, **'I ought to know this'**, appears to be the first level of learning for innovation. If one can admit that one ought to know about something the stimulus/motivation for innovative learning is in place. The learning for a KC model also incorporates the Socratic view of **the more one knows, the more one knows that one ought to know more**. These two questions form the basis for the creation of a continuous cycle of improvement or innovation.

As an example one might look at the process of designing a specific machine. One can assume that the design process has been successful, since this machine has been in production for a couple of years. If the designer, however, realises that no design is optimal and improvements can always be made, the cycle for improvement is stimulated and more research will take place. If the designer, however, has reached a comfort zone with regard to the design and the statement, 'I ought to know more', is not made, further development will not take place. The above approach in itself is a very motivational approach, since at no point will one reach a platform that tells one this cannot work. It provides the proverbial light at the end of the tunnel, indicating that there must be another approach.

Based on Buckler's model, it is clear that the right questions and attitude are the stimulus for innovative learning. The previous sections on attitude and failure (Section 3.2.3) confirm this approach. Affective learning forms a fundamental component of Bloom's revised taxonomy of learning. Affective learning is demonstrated by behaviours indicating attitudes of awareness, interest, attention, concern, responsibility and the ability to listen and respond in interactions with others. Paul in Niewoehner (2013) has similarly shown that affective traits are essential for critical thinking.

Table 3-2 below combines the affective traits from Bloom (1979), Seelig (2012) and Paul in Niewoehner (2013). These affective traits are important attributes of knowledge creators and critical thinkers alike.

Table 3-2: Affective traits

Name	Description	Author
Receiving	Refers to the student's willingness to attend to particular phenomena of stimuli.	Bloom
Responding	Refers to active participation on the part of the student.	Bloom
Valuing	Is concerned with the worth or value a student attaches to a particular object, phenomenon, or behaviour.	Bloom
Organisation	Is concerned with bringing together different values, resolving conflicts between them and beginning the building of an internally consistent value system.	Bloom
Value Set	The individual has a value system that has controlled his or her behaviour for a sufficiently long time for him or her to develop a characteristic "life-style."	Bloom
Intellectual Humility	Being conscious of the limits of one's knowledge, including sensitivity to circumstances in which one's native egocentrism is likely to function self-deceptively; ,,	Paul
Intellectual Courage	Being conscious of the need to face and fairly address ideas, beliefs or viewpoints about which one has strong negative emotions and to which one has not given serious thought. "	Paul
Intellectual Empathy	Being conscious of the need to put oneself imaginatively in the place of others in order genuinely to understand them, which requires consciousness of one's egocentric tendency to identify truth with one's immediate perceptions of long-standing thought or belief.	Paul

Name	Description	Author
Intellectual Autonomy	Having rational control over one's beliefs, values and inferences. '	Paul
Intellectual Integrity	Recognition of the need to be true to one's own thinking"'.	Paul
Intellectual Perseverance	Being conscious of the need to use intellectual insights and truths in spite of difficulties, obstacles and frustrations.	Paul
Confidence In Reason	Confidence that, in the long run, one's own higher interests and those of humankind at large will be best served by giving the freest play to reason, by encouraging people to come to their own conclusions by developing their own rational faculties; **faith that, with proper encouragement and cultivation, people can learn to think for themselves**, to form rational viewpoints, draw reasonable conclusions, think coherently and logically, persuade one another by reason and become reasonable persons, despite the deep-seated obstacles in the native character of the human mind and in society as we know it.	Paul
Fair-mindedness	Being conscious of the need to treat all viewpoints alike"".	Paul
Embrace failures	See section 3.2.3.1.	Seelig
Embrace diversity	See section 3.2.7	Seelig
Value problems	See section 3.3	

By combining the above affective traits it is possible to create a definition of the characteristics of the innovative employee that will have the ability to create new knowledge.

The typical innovative knowledge worker will therefore have the capacity to receive a stimulus for learning, to respond accordingly, in an organised manner guided by a set value system that includes the following qualities:

- Intellectual humility
- Intellectual courage
- Intellectual empathy
- Intellectual autonomy
- Intellectual integrity
- Intellectual perseverance
- Confidence in reason
- Fair-mindedness
- Embrace failures
- Value problems
- Embrace diversity.

3.3.8 Defining the knowledge domain

Without knowledge there can be no innovation. As stated before, Aranda and Moline-Fernandez (2002: 292) confirm the statement that knowledge is a source of competitive advantage. They further state that the importance of knowledge as a source of competitive advantage is even higher for those sectors where innovations are continually being developed (Decarolis and Deeds, 1999: 954; Pisano. 1994: 96).

The acquisition, transmission and integration, as well as application of knowledge, become the base for measuring an organisation's efficiency (Grant, 1996: 380; Nonaka and Takeuchi, 1995: 26; Spender, 1996: 49; Zander and Kogut, 1995: 77).

Aranda and Molina-Fernández (2002: 291) state that:

Flows of knowledge on customers' needs increase the firm's degree of innovation.

This hypothesis is confirmed in an article by Chen (2008) who states that the needs and experience of customers are one of the most important sources of innovation. This statement can be changed to the following: **flows of knowledge increase the organisation's degree of innovation.** The same can be said of the individual: flows of knowledge increase the individual's degree of innovation. Access to **multiple sources of knowledge** will therefore inevitably lead to faster cycles of innovation.

To enable the above-mentioned knowledge flows (Aranda and Molina-Fernández, 2002: 294), the organisation must ensure that knowledge is not obstructed by:

- Codifiability
- Complexity
- Teach ability
- Ability to observe knowledge when used
- Knowledge system-dependence.

Transforming tacit knowledge to explicit knowledge can also be seen as a form of innovation. However, there is also the loss of information during this process (Grant, 1996: 380). Aranda and Molina-Fernández (2002: 295) confirm that:

> ***Improved techniques for knowledge integration lead to higher innovation levels.***

Knowledge flows must therefore be stimulated by a variety of actions. Information and knowledge must be made accessible by means of logical and easy-to-use techniques. The search ability of explicit knowledge must be unlocked by means of classification, cataloguing and search tools. Critical knowledge needs to be pushed to ensure that the knowledge is disseminated. With regard to tacit knowledge, the manager must look at various options to allow for the transfer of this knowledge, e.g. knowledge fairs and communities of practice. The bottom line is that knowledge must be made accessible and a culture of sharing knowledge must be nurtured.

The concept of tacit and explicit knowledge as described by Taylor (2007: 61) will be explained. Taylor defines these concepts as follows:

> *"Implicit or tacit knowledge is knowledge that a person may be unaware of having, and that is difficult to articulate … In contrast, implicit learning occurs when a person acquires knowledge without the use of conscious strategies, and often without being aware of the knowledge gained.*
>
> *Explicit knowledge is knowledge a person can easily explain or describe … Explicit learning occurs in more formal teaching and learning settings or when conscious learning strategies are applied.*

Taylor states that implicit knowledge is not always acquired implicitly, nor is explicit knowledge always acquired explicitly.

Kratwohl (2002: 214) revised Bloom's taxonomy to demonstrate the intersection between knowledge and the cognitive domain. Kratwohl refined the model to include the knowledge dimension that classifies four types of knowledge that learners may be expected to acquire or construct, ranging from concrete to abstract. Table 3-3 shows the major types and subtypes in this knowledge domain.

Table 3-3: The knowledge domain (Kratwohl, 2002: 214)

Concrete knowledge --> Abstract knowledge			
Factual	**Conceptual**	**Procedural**	**Metacognitive**
• knowledge of terminology • knowledge of specific details and elements	• knowledge of classifications and categories • knowledge of principles and generalisations • knowledge of theories, models, and structures	• knowledge of subject-specific skills and algorithms • knowledge of subject-specific techniques and methods • knowledge of criteria for determining when to use appropriate procedures	• strategic knowledge • knowledge about cognitive tasks, including appropriate contextual and conditional knowledge • self-knowledge

Table 3-4 was designed to include the knowledge dimensions of Taylor (2007: 65 – 66). The researcher has further included a section that will demonstrate where the knowledge domains of Kratwohl (2002: 214) fit within this analysis of tacit and explicit knowledge (see section 3.3.4.).

Table 3-4: Taylor's (2007: 65 – 66) categories and subsets of knowledge combined with Kratwohl's (2002: 214) knowledge domains.

How learned	How held	How manifested, articulated, and transferred	Knowledge domain
Individual tacit knowledge			
Implicit	Implicit	• Manifested in outcomes or actions. Most likely skills-based. • Inarticulate. • Transferred by demonstration, observation, apprenticing, behaviour modelling, actual practice, or doing. • Transferred as above, and by mentoring, metaphor, analogy, storytelling, critical incident studies and prototype. • Most likely cognitively based, with mental models or exemplars. • Perhaps partially articulable, but attempts to explain may be inaccurate	Conceptual Metacognitive
Explicit	Implicit	• Manifested in common or shared understanding of technical foundations and abstract expressions of the expert area. • Explicit knowledge that has been "internalised." • Articulate. • Transferred by questioning to elicit or "surface" the underlying explicit knowledge base	Conceptual Metacognitive
Explicit	Explicit	• Manifested in individual's ability to explain items from the collective store of "hard data." • Readily articulated. • Transferred by formal learning procedures, for example schools, reading, formal training and so forth • Held in repositories such as libraries, books, formal data media, written rules, and procedures (or in verbally transmitted lore for oral societies). • The sum of explicit knowledge in a group, organisation, or society. • Readily articulated either verbally or in written form. • Transferred by formal learning procedures	Factual Procedural
Collective or social implicit knowledge			
Mainly implicit but can be explicit	Implicit	• Manifested in social interactions and shared an understanding of social norms and behaviours. • Maybe rule-driven, but cannot be fully articulated or explicated, as each application of the rule is dependent on the social context.	Conceptual Metacognitive Procedural

How learned	How held	How manifested, articulated, and transferred	Knowledge domain
		• Transferred mainly by "socialisation" - observation and informal behaviour modelling. • Can also be transferred by direct explanation of the rule in a particular context	
Explicit and implicit	Implicit	• Resides in systemic routines. • Manifested as "many individual kernels of tacit and explicit knowledge that jointly determine a … the system of facts, procedures, and routines." • Can be articulated in systems terms in the relationships between technologies, roles, (unwritten) formal procedures, and routines. • Transferred informally by observation and by on-the-job training of "the way we do things round here."	Conceptual Metacognitive Procedural

Table 3-4 shows that explicit knowledge is mainly factual and procedural, while tacit knowledge resides in the conceptual, metacognitive and sometimes procedural domains.

3.3.9 Defining the skills domain

OECD (2011: 41) states that different skills may be required for the various stages of innovation. These skills are shown in Figure 3-10.

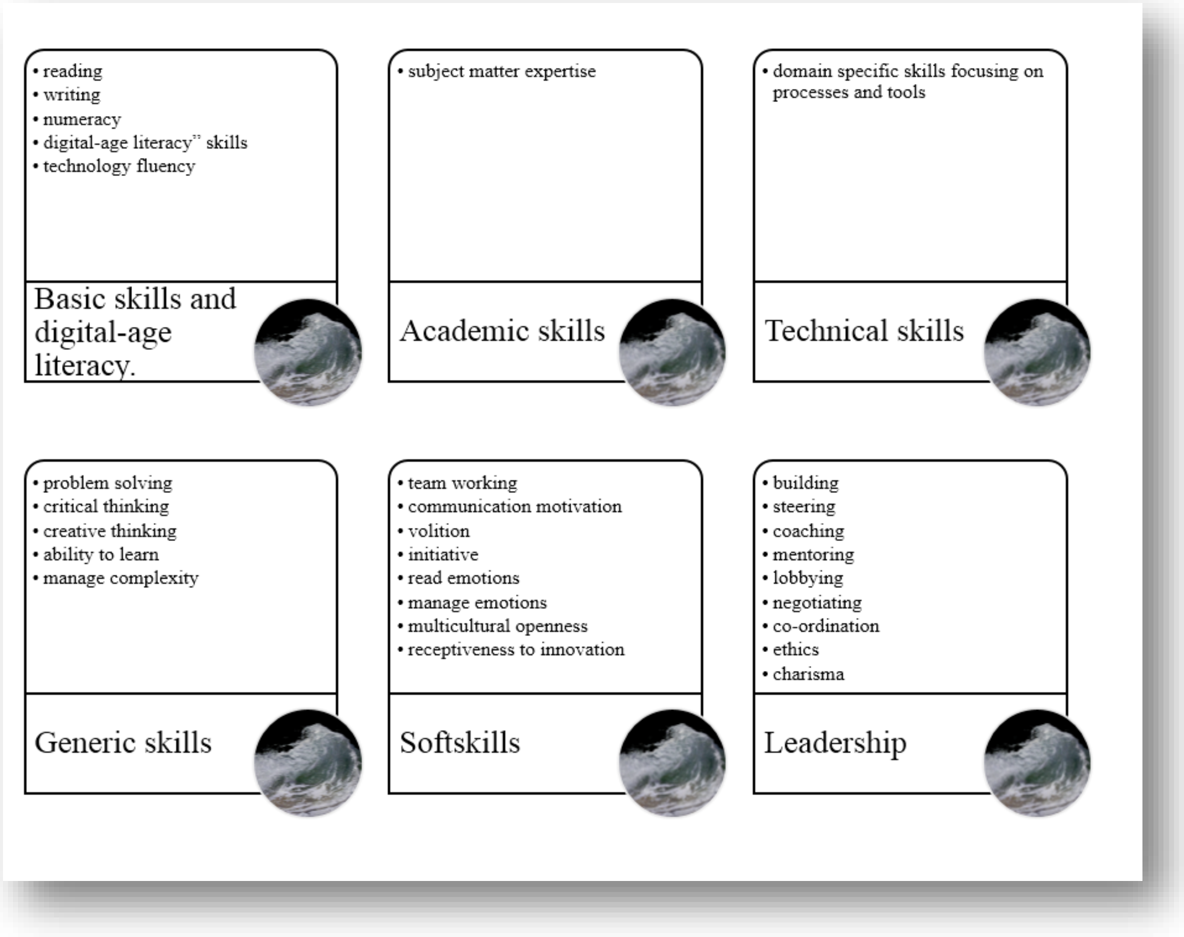

Figure 3-10: Skills for innovation (OECD, 2011:32-33)

The OECD (2011:47) report states that in rapidly changing environments, the skills required for innovation may evolve rapidly: so-called "soft skills" will be increasingly important and a greater premium may be placed on skills such as interpersonal communication, teamwork and problem-solving.

3.4 A proposed knowledge creation model

This section will describe a proposed model to manage KC. The KC model demonstrated in Figure 3-11 hinges on the following core principles: problems, skills, learning process, attitude and available knowledge and resources.

This model was developed by combining the following models and theories:

- Seelig's innovation engine (Seelig, 2012: 14)
- Bloom's revised model (Kratwohl, 2002: 214)
- Buckler's model (Buckler, 1996: 33)
- IMSA's problem-based learning model (Illinois Mathematics and Science Academy)
- Insights gained from the literature research into the fields of innovation, KC and learning.
- The researcher's own insights into how such a model can function.

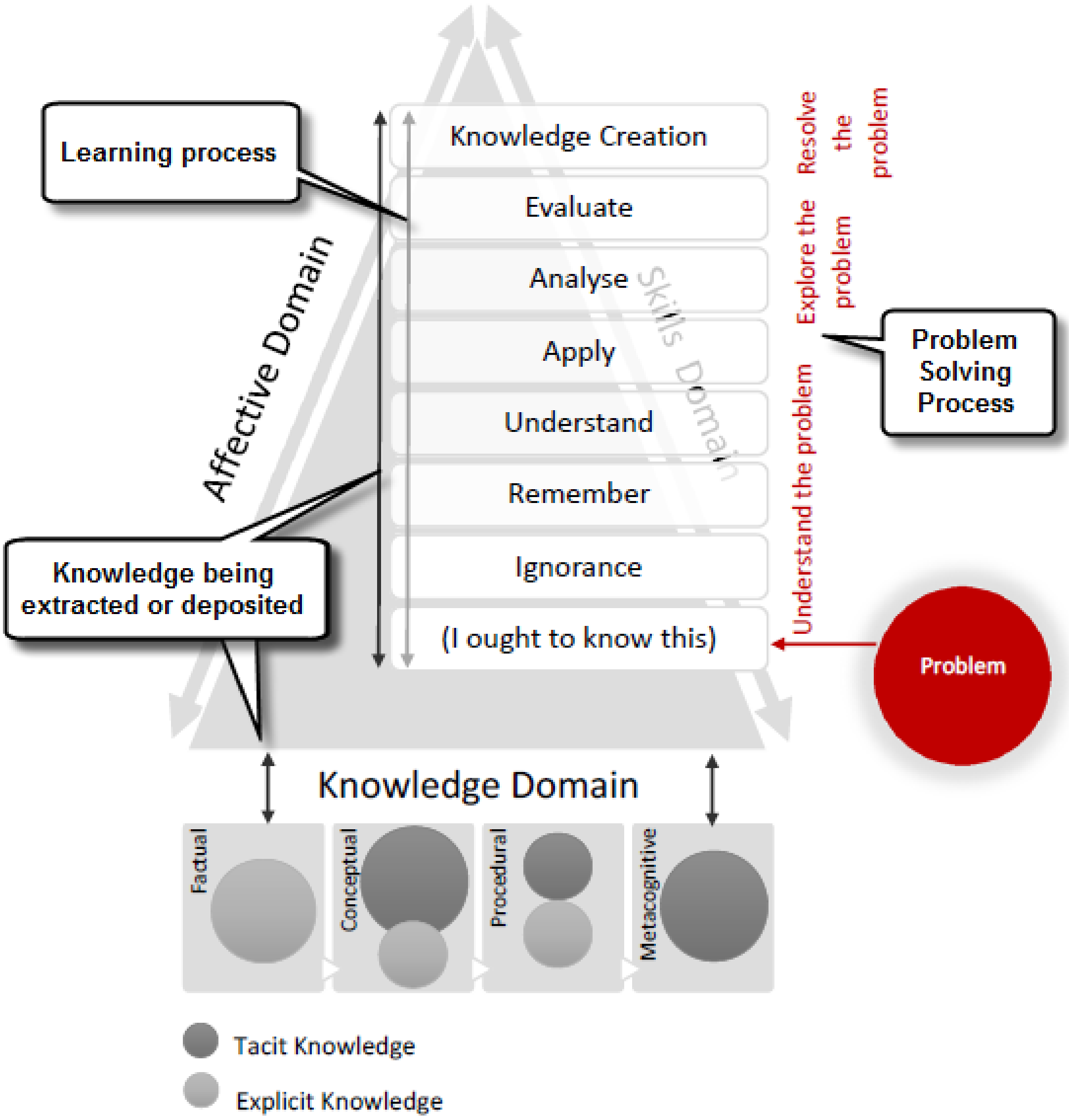

Figure 3-11: The knowledge creation model

The KC model will now be discussed in more detail. The KC model operates within the following domains:

3.4.1 The problem domain

As mentioned beforehand, problems are the main drivers of innovation today. The model in Figure 3-11 demonstrates how the problem, sometimes in the form of user requirements, stimulates the ignition of a problem-based learning process that might lead to new knowledge being created in order to solve a problem. In Section 3.3 a problem-based learning methodology was discussed. This section explained that poor problem-solving techniques are especially prevalent in organisations today. The IMSA PBL (See Figure 3-3) model fits well in the KC model, as demonstrated by the red text showing how the different PBL levels make use of the cognitive and knowledge domains to drive the KC process.

3.4.2 The cognitive domain

Knowledge creation depends on information being available, as well as the critical learning activities that should take place for knowledge to be created. An important stimulus for these activities to initiate is the acceptance of ignorance and the conviction that 'I ought to know this'. To solve a problem using this methodology implies that the worker gradually moves through the various learning phases. The knowledge worker will, however, at any given point be able to refer back to any of the lower-order categories as the need to know more becomes apparent (for example when reaching the applied category, the need to understand more might become clear). The KC model (Figure 3-11) now incorporates Bloom's revised model, as discussed in Section 3.3.4.

The cognitive domain can further be converted into actions by creating outcomes for tasks when using the action verbs provided in the phases (see Section 3.6 for an example).

3.4.3 The knowledge domain

Knowledge resources act as critical enablers for the innovation process. Figure 3-11 demonstrates that all aspects of the KC model hinge on the accessibility of data, information and knowledge, collectively named knowledge resources. The model demonstrates how the new knowledge created at the end of cycles will then contribute to the knowledge domain. If these aspects are not available, no new learning can take place. The KC model further supports the revised model of Kratwohl (2002: 214 - 215) when showing how information moves from knowledge through to KC and then becoming new knowledge to be embedded in documents, repositories, organisational routines, practices and norms.

Knowledge can be codified and deposited as explicit knowledge. Access to knowledge and the variety of users of specific items of knowledge are bound to create various new innovative developments. Therefore, to ensure continuous renewal in a particular environment, the most important aspect will be the ability of individuals to access a diversity of data, information and knowledge.

3.4.4 The affective domain

The affective domain is encapsulated in the attitude section of the model. Attitude is what drives the search for solutions. The 'why' question is important here, as is an attitude that demonstrates the principle of 'the more I know the more I know that I don't know.' Embracing failures is another important attitude that will enhance the cycle of KC, as shown in section 3.2.3.1. Essential affective traits have been listed in Table 3-2. These traits must be nurtured in organisations that wish to expand their KC capability.

3.4.5 The skills domain

In order to move through the learning process, specific skills are required. Skills may exist for the domain in which one is working, or they may include specific skills that are geared towards KC. (Refer to section 3.3.9 for more information about required skills.) By investing in the necessary skills, the organisation will ensure that the requirements for an innovative workforce are in place. Most of these skills can be enhanced through various learning programmes and workplace initiatives.

3.4.6 Summary

The KC model may assist researchers to analyse and manage KC capability. Section 3.6 will provide a sample of how to use the model to manage a complex problem. Section 4.2 will demonstrate how the model can be used to analyse the KC capability in an organisation.

3.5 Comparison of the KC model with the SECI model

Nonaka and Takeuchi (1995) developed the socialisation, externalisation, combination and internalisation (SECI) model in which they proposed four ways in which knowledge is converted, created and transferred to organisations.

The SECI model incorporates both tacit and explicit knowledge. The model describes the four processes, as shown in Figure 3-12.

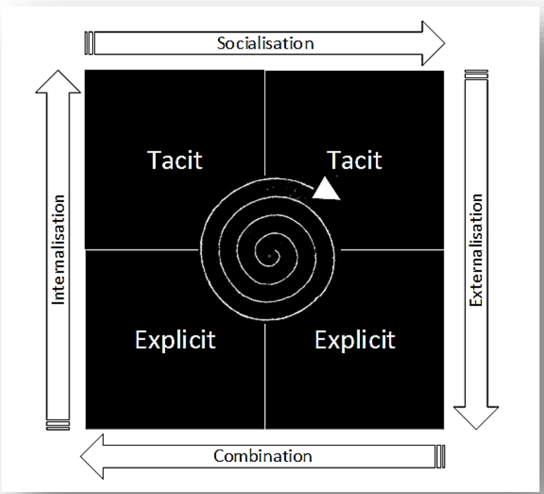

Figure 3-12: SECI model (Nonaka and Takeuchi, 1995: 62)

Nonaka, Umemeto, and Senoo (1996: 205) define **socialisation** as a process of creating common tacit knowledge through shared experiences. They explain that tacit knowledge has two dimensions, i.e. technical and cognitive. They provide the following two examples to explain the process for each dimension:

- Technical dimension skills are acquired through observation, imitation, and practice.
- The cognitive dimension of tacit knowledge can be acquired through informal meetings outside the workplace, thus creating common tacit knowledge (e.g. a worldview) as well as mutual trust.

Nonaka *et al.* (1996: 206) describe **externalisation** as a process of transferring tacit knowledge into such explicit knowledge as concepts and/or diagrams. They state that the creation of a new product concept can be seen as a good example of externalisation. They define **combination** as a process of assembling new and existing explicit knowledge into systemic knowledge such as a set of specifications for a prototype of the new product.

Internalisation is described by Nonaka *et al.* (1996: 208) as a process of embodying explicit knowledge into tacit, operational knowledge such as know-how. This mode is triggered by '**learning by doing or using**.'

The SECI model provides an explanation of how knowledge is created and transferred in the organisation. The KC model, on the other hand, provides the ability to measure the internalisation of knowledge and the subsequent outputs generated. In comparison to the SECI model, the KC model is essentially a model that explains the learning process. The learning/cognitive domain process is mainly encapsulated in the internalisation and socialisation phases of the SECI model. The externalisation and combination phases of the SECI model are visible in the codification section of the KC model.

3.6 Example of micro-application of the KC model on project level

To demonstrate the practical application of the KC model the researcher used a case example. Table 3-5 is a framework that is based on the components of the KC model. A manager can use this framework as a kick-off plan to solve a particular problem. The aim of this frame-work is to allow knowledge workers to solve problems by enabling outcomes that force them to move from lower-order thinking skills to higher-order thinking skills. The assumption is that when following this learning methodology during problem-solving a creative solution will result. The specific emphasis on codification will ensure that tacit and explicit knowledge will be codified for future use. The skills, knowledge and attitude (SKA) questions will allow the manager to foresee problem areas and create action plans to negotiate those areas.

In this example the problem is described as follows: **Various databases exist in an organisation. The organisation has decided to merge all data strategically into one database.** The manager must instruct a team of knowledge workers to solve this problem. Table 3-5 provide an example of the manager's analysis of tasks to be completed when solving the problem.

Table 3-5: A framework for the application of the learning for knowledge creation model

1 Learning Phase and Tasks		2 Outcomes derived from action verbs	3 Codification of knowledge	4 S Skills	5 K Knowledge	6 A Attitude
Understand the problem	Encounter the problem	Clarify the problem	In a work package	Yes	Yes	No
	Identify knowledge	Identify existing knowledge about the problem.	In a work package	Yes	Some	Yes
	Need to know more	Categorise what one needs to know.	In a work package	Yes	Yes	Yes
	Define the problem	Extrapolate tasks to be completed.	In a work package	Yes	Yes	Yes
		Identify successful completion criteria.	In a work package	Yes	Yes	Yes
Explore the knowledge base	Gather information	Summarise the aims of the various databases.	In a work package	Yes	Yes	Yes
		Map the detailed functions of each database.	In a work package	No	Yes	Yes
		Outline the functionality of each database in the work environment.	In a work package	No	Yes	Yes
		Construct models of existing databases.	In a work package	No	Yes	Yes
	Share information	Using the findings create a presentation	In a work package	Yes	Yes	Yes
	Generate possible solutions	Integrate the various functionalities of these databases into one proposed database structure.	In a work package	Yes	Yes	Yes
Resolve the problem	Determine best-fit solution	Construct a solution	In a work package	Yes	Yes	Yes
		Test the solution	In a work package	Yes	Yes	Yes
		Execute the solution	In a work package	Yes	Yes	Yes

Each column in the framework represents a specific area in the KC model. The following discussion will explain in more detail how each of these can be used to assist with the KC process.

3.6.1 Column 1: Learning Phase and Tasks

Column 1 makes use of the problem-based learning categories to provide the structure for the framework.

3.6.2 Column 2: Outcomes derived from action verbs

Column 2 provides detailed task descriptions derived from action verbs as described in Table 3-1. This is the critical part of the framework - it is advisable that the manager should incorporate all levels of the cognitive domain. All outcomes must progressively build upon one another to ensure that the higher orders of learning can be achieved. The example gradually moves the workers through the cognitive process, as seen below:

Table 3-6: Application of the revised Bloom model action verbs

Lower-order thinking skills-->Higher-order thinking skills					
Remember	Understand	Apply	Analyse	Evaluate	Create
Recognising Identifying	interpreting clarifying classifying categorising summarising inferring extrapolating comparing mapping explaining constructing models	implementing using	organising finding coherence integrating outlining	checking testing	producing constructing

3.6.3 Column 3: Codification of knowledge

Column 3 allow the user to specify the codification format for the knowledge derived from the outcomes. This step allows a definite decision to be made with regard to codification, thus forcing tacit knowledge to become explicit and therefore part of the shareable knowledge domain.

3.6.4 Column 4: Skills

Column 4 allow the user to contemplate the availability of skills when assigning the outcome to an employee. If the answer indicates that the skills are not available, the manager may mitigate the situation by either sourcing the skills or up-skilling knowledge workers.

3.6.5 Column 5: Knowledge

Column 5 allow the user of the model to consider whether the knowledge required for the outcome is readily available. If the knowledge is not available or is difficult to access (tacit knowledge), the manager once again has the opportunity to mitigate the issue.

3.6.6 Column 6: Attitude

Column 6 allow the manager an opportunity to reflect on any attitude problems that might arise. A typical attitude issue might be that the team that needs to solve the given problem does not recognise the problem as such. Once again, the manager can timeously mitigate the situation to assist the knowledge workers and correct any attitude problems, if possible.

3.7 Summary

This chapter started off by defining innovation. The following was clearly shown to be the main drivers of innovation:

- Innovation is driven by knowledge.
- Innovation is driven by imagination.
- Innovation is driven by attitude.
- Innovation depends on one's habitat.
- Innovation is influenced by culture.

- Innovation relies on access to resources.
- Innovation is enhanced by diversity.
- Innovation can be triggered by failing.
- Innovation is prompted by problems/barriers.

Innovation is as natural to human beings as existence is, but like life, innovation requires certain ingredients to be available. The literature review demonstrated that a structured learning process will drive innovation and KC. **Research question one** (Can a learning process trigger innovation?) was therefore addressed.

Research question two was addressed when the researcher showed that innovation and KC are closely linked and supportive of one another (section 3.2).

This chapter demonstrated and incorporated the fact that access to knowledge forms the foundation of KC and therefore knowledge resources that were shown to be the foundation in the KC model, thereby addressing **Research Question three** (Does access to knowledge enhance and contribute to the knowledge creation cycle?)

The clear link between problem-based learning and KC was further advanced. This chapter has demonstrated that learning is the action that promotes new solutions for problems. Leveraging the power of problems by using a cognitive constructivist approach in the form of action verbs makes it possible to structure the problem-solving process in such a manner that KC is the end result. **Research question four** (Will problem-based learning enhance knowledge creation?) has thus been answered by showing that problem-based learning leads to problem-solving and therefore enhances KC.

In this chapter the researcher developed a model that can be used to ensure a gradual learning process that will support KC (see Table 3-11). The model is in essence based on critical questions that will allow users to identify and determine progress and actions towards KC during any type of learning/development process. This model addressed **Research question five** (Can a knowledge creation model be developed that will ensure knowledge creation through learning processes?)

By integrating the life-long learning aspects into the KC model and combining them with KC theory, it becomes possible for individuals to contribute to new developments throughout their working lives. Combining Seelig's (2012:13) innovation engine in this model enables innovation to be embedded in the KC process as well. The KC model supports the theory of Torjman and Leviten-Reid (2003:16) mentioned previously, namely that:

> *knowledge is crucial to the development of organisational competencies and learning is the process through which organisations harness and apply knowledge.*

The researcher has further shown that a framework can be developed based on the KC model. By following the framework proposed in section 3.6 to create solutions to real-life work problems, the manager accomplishes the following:

- Define the problem-solving process.
- Move the workers through the different levels of learning to ensure higher-order learning is achieved.
- In doing this, create the possibility for innovation to take place.
- Define a codification strategy

- Create an environment conducive to learning and KC by ensuring that the following is in place: skills, knowledge and the correct attitude.

The next step in the research will be to apply the KC model. Application of the KC model will be demonstrated at the following levels:

- Macro: a questionnaire or instrument will be used to determine the KC capability of the organisation under study. The KC model will be used to interpret the organisation as a whole.
- Micro: a questionnaire or instrument will be used to determine the KC capability of individuals in the organisation under study. The KC model will be used to compare individuals.

The KC model will therefore be used as a benchmarking instrument to understand the organisation under study's KC capability better.

Chapter 4 Research findings

The research findings will be presented in this chapter in two sections. The first section is a description of the organisation based on qualitative research conducted through interviews with managers and consultation of organisational documentation. The second section is based on research results provided by the questionnaire (Appendix I).

These findings will be used to validate the application of the developed KC model (Figure 3-11: The knowledge creation model .

This chapter will aim to establish the context for the case study by investigating the specific processes that enable the KC processes of the organisation. This chapter will contribute to answering **Research question six**, namely, what mechanisms for KC exist in the organisation's environment? **Research question five** will be substantiated in this chapter when the research results demonstrate the functionality of the KC model. Based on the findings, additional mechanisms might be suggested in the final chapter of this dissertation. This will enable the researcher to address **research question seven**.

4.1 The case study description

The organisation under study defines innovation as the process of taking new concepts to market. Two main spheres for innovation exist within the organisation (Figure 4-1). The innovation spheres are stimulated by innovation triggers, usually in the form of needs, opportunities and technology. The product side of the chart is directed by market trends and requirements and the project side is directed by existing customer needs and existing technology and products. Therefore both spheres are in the business of creating innovative solutions; the only difference is the drivers. The two input spheres exert constant pressure on each other and this is indicated by the diagonal line in Figure 4-1. The line represents a balancing act that ensures that the organisation only sells what exists. Each of the spheres may contribute, support or enhance the other spheres of innovation in the organisation.

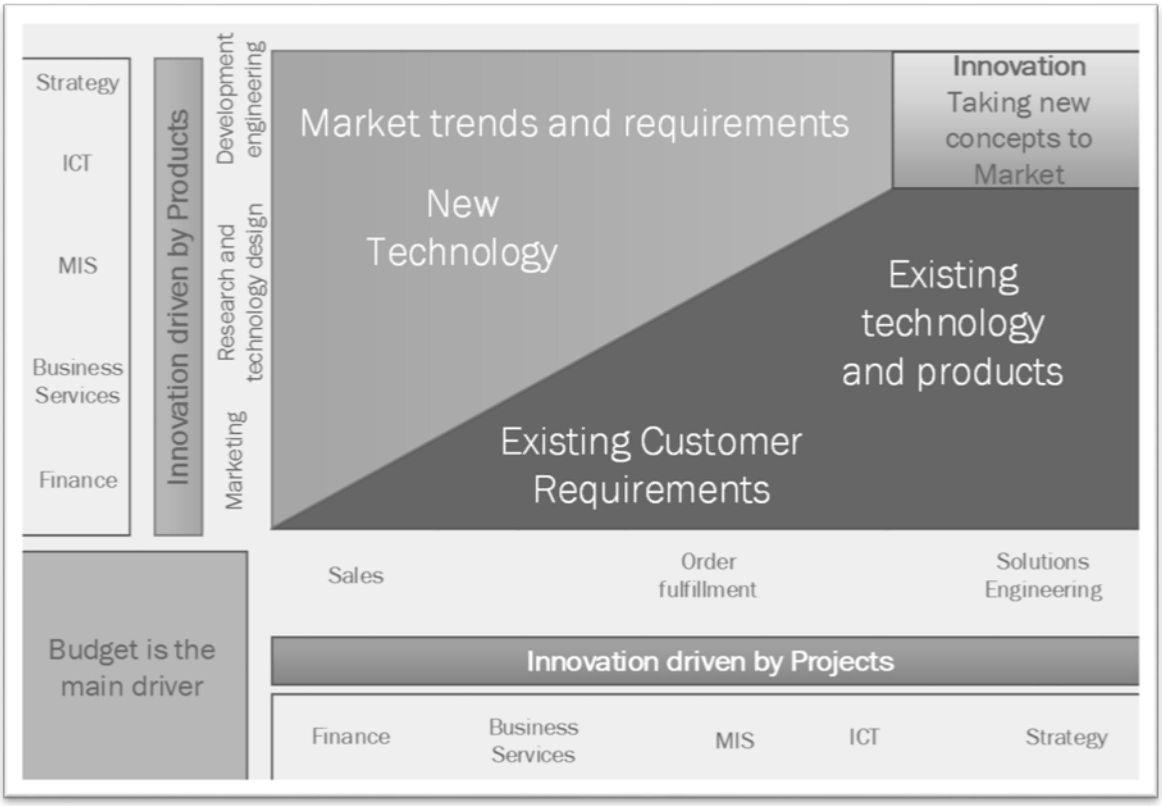

Figure 4-1: Innovation spheres of the organisation under study. (Input provided by the CEO of the organisation.)

The organisation under study clearly reflects the views on innovation as defined by Popaduik and Choo (2006: 312) by developing products and services that have economic value in markets. The organisation acknowledges the role that knowledge about markets plays in the innovation process. By embracing the continuous interaction of technical knowledge and market knowledge, the organisation is geared to prosper in an increasingly competitive environment. Figure 4-1 supports the view of Soni (2009: 79), namely:

> *When organisations innovate, they do not simply process information, from the outside in, in order to solve existing problems and adapt to a changing environment. They actually create new knowledge and information, from the inside out, in order to redefine both problems and solutions and, in the process, to re-create their environment.*

The organisation reflects the philosophy of Drucker (1989: 25-30) to some extent:

> *"Because the purpose of business is to create a customer, the business enterprise has two – and only two – basic functions: marketing and innovation. Marketing and innovation produce results; all the rest are costs. Marketing is the distinguishing, unique function of the business."*

The organisation differs from Drucker's philosophy in one aspect, namely the idea that everything else is viewed as costs. The CEO of the organisation refers to costs, as costs incurred to offer essential customer advantage. Figure 4-1 reflects this approach by indicating the value that all other functions provide in support of the product and project spheres.

Because of the exceptional growth of the organisation and its deliverables, it is currently in a challenging phase. Multiple new processes, products and knowledge workers have necessitated the restructuring of various existing structures.

4.1.1 Detailed description of the innovation spheres in the organisation

4.1.2 The product development sphere

The product development sphere consists of the development Engineering, marketing and research and technology design divisions. These three divisions drive the product development process.

4.1.2.1 Development engineering

The development engineering division produces and maintains products. This division has adopted a team-based iterative approach to development. The approach embraced by the organisation shows some similarities with agile engineering processes. Agile engineering is:

> *an iterative and incremental (evolutionary) approach to software development which is performed in a highly collaborative manner by self-organising teams within an effective governance framework with "just enough" ceremony that produces high-quality software in a cost effective and timely manner which meets the changing needs of its stakeholders (Ambler, 2005).*

Agile development is thus a process that allows and encourages constant change. The aim is to provide a better outcome or result in the shortest period (Ambler, 2005). The one aspect that is clearly visible throughout the agile methodologies mentioned is the focus on iterative development. The following section will specifically look at the agile manifesto.

4.1.2.1.1 The agile process adopted by the organisation under study

The organisation under study has moved towards the implementation of some aspects of a feature team approach. Larman and Vodde (2010: 2) describe the feature team as a 'long-lived cross-functional, cross-component team that completes many end-to-end customer features – one by one'. The characteristics of these teams, as defined by Larman and Vodde (2010: 2), are listed below:

- Feature team characteristics
- Long-lived
- Taking on new features over time
- Cross-functional and cross-component
- Ideally, co-located
- Working on a complete customer-centric feature, across all components and disciplines (analysis, programming, testing, etc.)
- Composed of generalising specialists
- In scrum, typically 7 ± 2 people.

One of the most notable features of these teams is the inherent ability to stimulate learning. Larman and Vodde (2010: 2) state that when requirements do not map to the skills of the team, learning is forced. Feature teams are therefore very well situated in the KC sphere.

4.1.2.1.2Learning support services

This is a relatively new department in the development engineering division. The aim of this department is to develop learning objects that demonstrate the functionalities of the systems. These modular learning objects are then packaged in terms of user requirements for learning programmes. This department aims to make all content relevant. Content will have relevance when it empowers users to use the organisation's products. Users will be empowered when they are shown how the organisation's products solve their problems – **this is problem-based learning.** Source content is developed using **modular and re-usable**

principles. Learning must further match the **target audience profile**, therefore the **ADDIE** [1] model of learning content development ensures that the above principles are achieved. ADDIE contains the following process steps:

- Analysis
- Design
- Development
- Implementation
- Evaluation.

The learning objects are developed using a variety of formats and modalities, which include:

- Videos
- Technical documents
- Quick reference cards
- Assessments.

These objects are then packaged using different publishing tools to serve different audiences and user requirements. For example:

- Technical documents might be published in book format.
- Objects might be packaged in a learning environment such as Moodle.[2]

[1] (ADDIE was developed by the Centre for Educational Technology at Florida State University for the U.S. Army.)

- [2] Acronym for Modular Object-Oriented Dynamic Learning Environment, which is a free software e-learning platform, also known as a Learning Management

This department uses a WIKI to collect and connect all content. This is a multi-authoring environment. This multi-authoring platform provides the opportunity to publish to multiple formats or channels, such as:

- Books
- PDF with video content
- WIKI to WIKI
- eBooks
- LMS (Learning Management System).

Figure 4-2 demonstrates the above principles, namely:

- Multi-authoring
- Reusable objects
- WIKI platform
- Multi-publishing channels.

System, or Virtual Learning Environment (VLE). (Moodle.com) which enables users to work through these objects systematically and then be assessed.

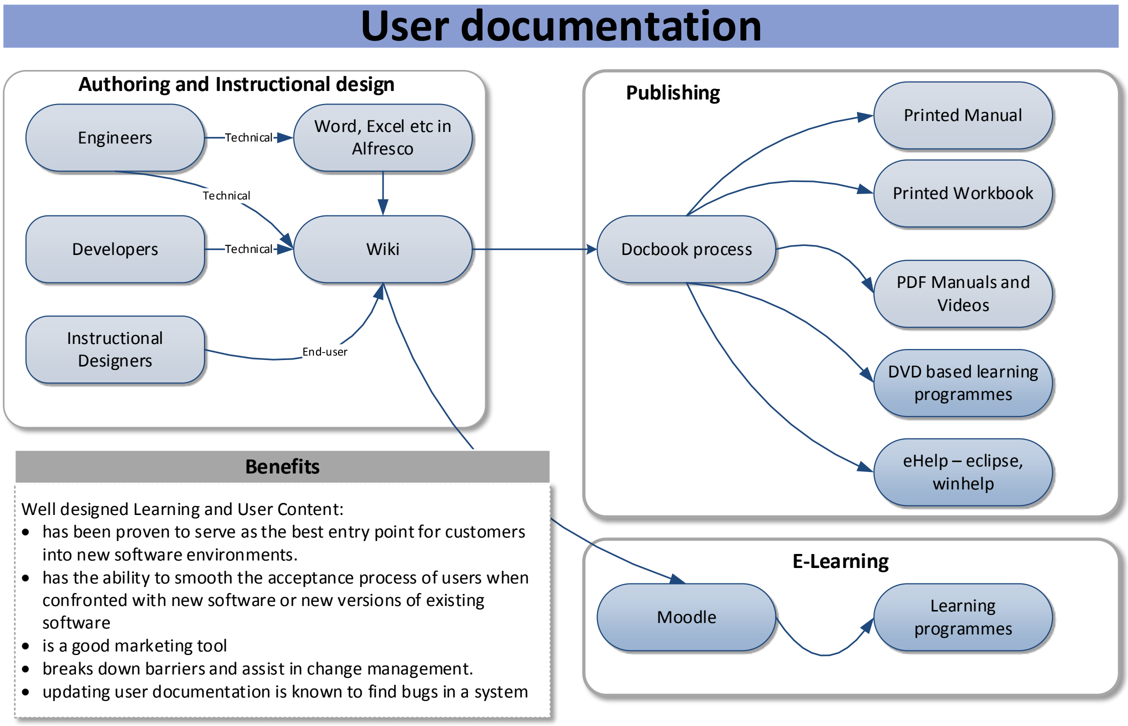

Figure 4-2: Re-usable, multi-authoring and multi-channel publishing model (developed by the researcher)

This department delivers a service to the following customers:

- Internal
    - Order fulfilment
    - Marketing
    - Sales
    - Development engineering
    - Solutions engineering
    - New knowledge workers
    - Existing knowledge workers.
- External
    - New customers
    - Potential customers
    - Existing customers.

4.1.2.1.3Summary

As stated by Dzamashvili-Fogelstrom, Gorschek, Svahnberg and Olsson (2010: 53), agile methods are attractive to software companies since they promise shorter time-to-market, as well as higher flexibility to accommodate changes in the requirements and thereby increased ability to react to changing customer (market) needs. Dzamashvili-Fogelstrom *et al*. (2010: 54) further analyse agile methodology as a method that makes use of small iterations to develop limited sets of the most important functionality at a given point in time. They also mention that the common property of agile methods is reactive rather than proactive tactics, encouraging quick adaptation to change rather than planning for it.

Agile development is thus a process that allows and encourages constant change. The aim is to provide a better outcome or result in the shortest period of time. Agile processes are by nature evolutionary and therefore innovation may follow. Agile processes further rely on small teams with good communication structures for knowledge sharing. **Agile methodology requires team members that are open to learning and willing to adapt to change**. As a matter of fact, the ability of agile teams to adapt to change is critical for the successful implementation of any agile project. The essence of innovation can be found in the human nature to adapt to difficult circumstances. Therefore adaptation is critical. **Because of the incremental development process triggered by change, innovation in this division happens in small leaps.** Agile methodologies fit well into the KC framework where KC is also seen as an iterative process for improvement.

4.1.2.2 Research and technology design division

The research and technology design division aims to identify and develop solutions that are ahead of the market. The goal is to ensure that the relevant solutions are in place by the time the future technologies are viable. The division develops solutions up to the point where conceptual solutions can be demonstrated. Knowledge workers in the division have regular discussions to transfer knowledge and often have to move to other divisions physically to enable transfer of technology and knowledge.

4.1.2.2.1 Technology forecast

Technological research is based on new protocols and standards that have been road-mapped internationally by the IEEE as future applications. The goal of the research division is to ensure that the relevant solutions are in place by the time the future technologies are viable. The technology forecast methodology suggested by Gerybadze (1994: 139) may be seen as similar to the processes followed by this division of the organisation under study. Gerybadze identifies three phases for technology forecasting:

- Screening intelligence: search and identify emerging technologies.
- Solution-finding intelligence: package the idea into a workable project.
- Implementation intelligence: transfer the idea into commercial application for the new technology.

The above-mentioned process is fairly straightforward, but does imply the application of a rigid research methodology. The basic principle of recording all results, whether they are viable or not, is strictly adhered to. The reasoning behind this is to enable confirmation that the right path has been decided on and that the alternatives have been sufficiently investigated and deemed not viable.

4.1.2.2.2Future forecasting

Forecasting the future trends for a market segment is a much more open process. The organisation under study makes use of a research team consisting of experts in their respective fields of study. This team is knowledgeable and reads across the spectrum. They meet regularly to discuss what they have seen or read. Proper research methodologies are once again followed and the following principles are adhered to:

- Peer-reviewed sources are used.
- Reputable sources are used.
- Cross-referencing of sources is applied.

To some extent this team is functioning in the realm of future forecasting. The principles of strategic thinking are implemented by this group of experts. Strategic thinking in terms of the future is very well demonstrated by Garland's (2006: 24) ecosystem for strategic decision-making. Figure 4-3 shows how future strategy depends on thinking about the world as a system. This model provides a clear picture of the different levels that strategic thinkers need to accommodate in their thinking processes. If the world is viewed as an interrelated system, it becomes much easier to spot the new trends. This is echoed by Garland's (2006: 25) statement:

Figure 4-3: Eco-system of a strategic decision (Garland, 2006: 25)

Understanding the larger system in which your organisation belongs is crucial to your success.

When applying strategic thinking in a research and development environment, the basic principles for research must be adhered to. According to Weathington, Cunningham and Pittenger (2012: 215), proper research is related to theory and hypotheses. This is demonstrated in Figure 4-4.

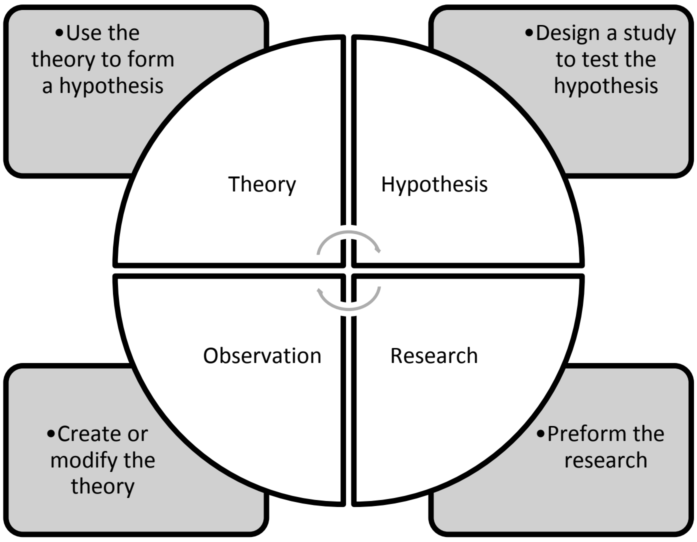

Figure 4-4: A diagram of the role of theory, hypothesis, and research (Weathington et al, 2012: 215)

As seen in the diagram, one outcome of research is that theories can be refuted. This is a critical part of business research and once again the reasons for refuting specific theories need to be well documented.

The research and technology design division of the organisation under study is pivotal for the future growth of the organisation. Management has made a definite decision to invest in research and development activities in the organisation.

This is in line with general trends, as seen in the following statement by Lamore (2013: 696):

> *In a study conducted by Booz, Allen, and Hamilton, they estimate that 35% of firm revenues are from products that did not exist five years ago.*

The link between marketing and research and development is further shown as an important aspect of research and innovation. In the article of Lamore (2013: 696) this is demonstrated as having positive effects on the product offerings, when these two functions collaborate and share knowledge. This interaction is well established in the organisation under study.

4.1.2.3 Marketing

The marketing division makes use of business intelligence about competitors, markets and customers to plan better, identify new opportunities and change accordingly. The division collects information from agents and trade shows and turns it into knowledge resources. This division further supports the philosophy of Drucker (1989: 25-30), as mentioned at the beginning of this section.

Wong (2013: 712) confirms that an organisation's ability to explore and exploit market opportunities is an essential core competence. Wong (2013: 712) further states that this competence, externalised as **marketing ideas, tactics and strategies**, is conceptualised and termed **"marketing innovation"** in innovation research. Marketing innovation is defined by the OECD (2005: 169) as the adoption of new marketing methods in exploring market opportunities and meeting these opportunities with a right product or service.

Marketing may essentially be seen as the provision of a product or service with value to a customer for profit. Many definitions exist for marketing, but the descriptions and definitions of Levitt (1960) remain an excellent, comprehensive and current definition of marketing:

> *Management must think of itself not as producing products, but as providing customer-creating value satisfactions' (Levitt 1960: 56).*

> *Selling focuses on the needs of the seller, marketing on the needs of the buyer. Selling is preoccupied with the seller's need to convert his product into cash; marketing with the idea of satisfying the needs of the customer by means of the product and the whole cluster of things associated with creating, delivering, and finally consuming it (Levitt 1960: 50).*

The marketing division's focus is directed at the needs of customers. Identifying these customers and their needs should thus be the primary function area for marketers. Marketing is a well-defined subject area with clearly defined processes that will enable marketers to reach their goals.

The marketing division is currently focusing on the following new KC actions:

- Customer analysis
    - Who are they?
    - What do they need?
    - What are their goals?
    - What do they value?
- Market analysis
- Competitive intelligence gathering.

It is therefore clear to see that the marketing division has laid the foundations for marketing innovation to take centre stage.

4.1.3 The project-focused sphere

The organisation has strategically agreed that user needs and opportunities are a critical if not the most important driver of development in the organisation. Sales, order fulfilment and solutions engineering therefore, present the front that leads the projects. This is the group that interfaces closely with existing customers.

4.1.3.1 Solutions engineering

The organisation has strategically agreed that user requirements are a critical if not the most important driver of development in the organisation. A new division, namely solutions engineering, was formed, with the specific goal to focus on analysing and defining customer requirements. Customer requirements will create the baseline for projects. This department will therefore define system architecture based on customer requirements as contractually agreed. Ill-defined user requirements normally lead to faulty design and in the end may result in serious revenue losses. This division is also closely involved with the writing of research proposals and in-depth knowledge of the products and systems of the organisation is required.

4.1.3.2 Sales

The sales team is required to exhibit intimate knowledge of the product offering. Customers are a valuable source of innovation. The sales team therefore build close customer relations in order to harness the knowledge that customers might bring to a product offering. By embracing the dynamic nature of customer needs, it is possible to make innovative changes to product offerings that might actually stimulate new market segments or customers. The sales team is concerned with existing customers and may take on board new customers that seem viable. Sales have been in existence for some time in the organisation. The sales team is in many cases the first interaction that potential customers might have with an organisation. Customer skills are therefore critical in this environment. The sales team's tasks include the following:

- Generate income and revenue.
- Increase brand awareness.
- Draw up proposals for tenders.
- Build trust with customers.
- Follow up on customer requests and requirements.
- Engage with new customers and teach them about the product.

Listening to customers and getting to know their needs are some of the most important KC actions that any business can take. Understanding the basics of customer service is essential when offering real value to customers.

The following statement made by Bohlmann, Spanjol, Qualls and Rosa (2013: 240) demonstrates the important role of the sales division related to customer needs:

> *The detection of customer needs seems to come primarily through personal relationships with customers, supplemented by other activities such as advertising or trade shows.*

By embracing the dynamic nature of customer needs, it is possible to make innovative changes to product offerings that might actually stimulate new market segments or customers. This approach is well supported by the agile methodology adopted by the engineering division.

4.1.3.3 Order fulfilment

Order fulfilment's primary functions are:

- Contract preparation
  - Assist with the costing of installation logistics and costs for new contracts.
  - Provide logistical input to new contracts.
- Contract execution
  - Provide project management functions.
  - Manage the logistics of installations.
  - Provide technical support with regard to installations.
  - Provide customer training.

Order Fulfilment knowledge workers are key experts when it comes to product logistics and installation of products. This knowledge is valuable and in most cases tacit knowledge gained through experience.

Order Fulfilment is one of the main customer interfacing functionalities in the organisation. This division is a valuable source of customer experience and knowledge. The discussion with regard to customer knowledge in section 4.1.3.2 is also applicable here. It is important to note that knowledge gained here must be analysed by Solutions Engineering to ensure that the application is valid and required.

4.1.3.4 Strategy, information and communication technology, management information systems, business services and finance

The business services division provides administrative and strategic support to the organisation. Though these services do not directly contribute to the innovation processes of the product offering, internal innovation of their processes may contribute to the success of the product offering. The division ensures that structures and practices are in place to support and encourage an innovative culture. The division initiates and facilitates appropriate team interventions to enhance the flow of knowledge and communication between team members. According to the manager of the division, the greatest asset of the organisation is the ideas of people, more specifically, the intellectual property and knowledge. The division has to nurture these assets and continuous learning is one of the keys to nurturing and develop knowledge resources and ideas for innovation.

Internal Support Services do not contribute to the product offering innovation, but can utilise innovative processes to enhance the success of the product offering. These services include information and communication technology (ICT) and management information systems (MIS) offerings.

The finance division forms the backbone and is a critical driver of the organisation, since the budget is the overall directive for all planned processes. The degree of innovative and agile abilities within these services will also contribute to the innovative culture in an organisation.

Ružičić and Kutlača (2011: 431) emphasise that organisations that create systems for the definition and development of innovative products and processes will not achieve success if their organisational context is not favourable. Their organisational structures and processes must encourage technological change. They specifically mention that organisational redesign means a change from traditional mechanistic bureaucracies to organic forms, which encourage flexibility and creativity. Wong (2013:

712) echoes the previous statements when he explains that organisational innovation can be further categorised into innovation in administrative systems (administrative innovation) and innovation in human capital (human capital innovation). Wong (2013: 712) defines administrative innovation as the introduction of new measures or practices to change the organisational structure or administrative procedures of an organisation, whereas:

> *Human Capital innovation refers to a firm's adoption of new practices and measures in the process of identifying and hiring of innovative personnel (Wong, 2013: 712).*

The management of the organisation under study recently decided to review the organisation structures strategically and came up with a structure geared towards innovation (Figure 4-1).

The ability of ICT and MIS to apply and utilise tools and technology required by business functions innovatively to enhance KC ability is a core point for growth in the organisation. This division supports the KC process as defined by Nonaka, Von Krogh and Voelpel (2006: 1179):

> *organisational knowledge creation as the process of making available and amplifying knowledge created by individuals, as well as crystallising and connecting it with an organisation's knowledge system.*

4.1.4 Existing learning domains in the organisation

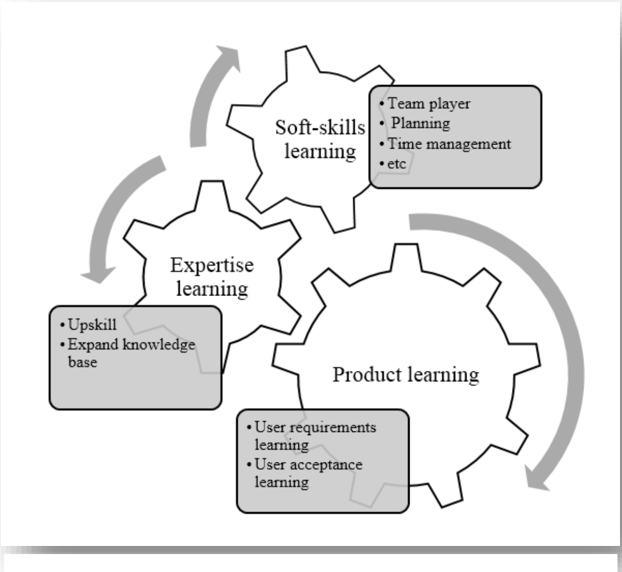

Figure 4-5: Learning domains of the organisation

Three main learning domains have been identified. These are shown in Figure 4-5.

The product learning domains implies all instances where knowledge workers and customers gain knowledge and insight into the products of the organisation. Learning in this domain can be formalised or may happen informally. The organisation has grown from a small to a medium-sized organisation in a relatively short period. Similarly, the product offerings have multiplied. Product learning was initially transferred informally because of a relatively low learner sample (employees and customers).

The rapid growth of the organisation necessitated the implementation of formal e-learning processes to enable product knowledge transfers. Product learning is produced and offered by the following teams in the organisation:

- Development engineering
- Learning support services
- Operational support teams
- Sales teams
- Marketing teams

- Solutions engineering teams.

4.1.4.1 User requirements learning

The initial step in crafting a solution for a customer is to understand the user requirements. Experience has shown that lack of user understanding of the products on offer leads to poor user requirement formulation. Potential customers must therefore gain a better understanding of possible solutions to ensure that the user requirements will be clear enough to lead to a solution of the intended problems.

User requirements learning is managed by the following teams:

- Solutions engineering
- Development engineering.

4.1.4.2 User acceptance learning

User acceptance learning happens when users are introduced to new products or features. All new features/product roll-outs need to be contractually accepted by users. In the organisation it is acknowledged that better understanding of the product results in better acceptance. User acceptance learning is therefore specific learning events that enable the user to understand new features/products contracted for delivery. This involves:

- Solutions engineering
- Development engineering
- Test engineering.

4.1.4.3 Expertise learning

4.1.4.4 Up-skilling

The development of solutions in the organisation depends on the ability of the workforce to learn new skills continuously. The organisation provides technical solutions that are based on the newest technological advances in the ICT field. It is therefore critical that knowledge workers have the ability and the means to up-skill themselves when required.

4.1.4.5 Expand knowledge base

Because of the organisation's vision to deliver cutting-edge solutions, a high premium is placed on the expansion of its knowledge base. This is done by learning that takes place in formal institutions, in-house learning programmes as well as learning through conferences and trade shows. The knowledge base is also expanded by investing in new knowledge workers.

4.1.4.6 Soft skills

Soft skills refer to all the skills required to assist knowledge workers in performing their jobs. These skills include management skills, planning skills, research skills, social skills and communication skills. Soft skills training is usually offered by the human resources department as formal training programmes.

4.1.5 Summary

The research findings in this section were based on discussions with management, as well as the researcher's own insight into the organisational processes. These insights were validated at management level. The aim was to provide a broad overview of the various divisions and their functions. This section further highlighted some methodologies applied in the different divisions. Throughout, the theme of KC and innovation was touched on. It became apparent that each division has a role to play in the innovation and KC cycle.

Through discussions in the organisation it was established that the foundations for innovative thinking and strategies had been laid in the various divisions. It is further clear that each division and every person in the organisation may play an important innovation role in their daily capacities. The innovation spheres model describes the organisation as an innovative organisation with a focused view on the management of the different innovation forces. Wong (2013: 724) confirms that the contribution of organisational innovation is more important than technical innovation, as organisational innovation creates the right environment and culture to nurture and stimulate technical and marketing innovations. The organisation under study is clearly moving in the right direction.

Research question six investigates what mechanisms for KC exist in the organisation's environment. The outcomes of this question are summarised below.

The engineering division has adopted the principles of agile development, though it is acknowledged that no specific agile methodology has been adopted, but rather a mixture of best practices that support the development objectives. Agile methodologies have been proven to assist and even drive KC, because of their nature of embracing and encouraging change. The emphasis on learning within agile teams is a further stimulant to KC. The firm focus on learning, specifically product learning, ensures that all consumers of the organisational products are well versed in its functionalities. These consumers refer to internal as well as external consumers. The value of empowered consumers will be discussed in Chapter five.

By placing user requirements centre stage the solutions engineering division will ensure that all development and design are done in line with user expectations. A user-centred development approach is therefore adopted and as will be shown later, this approach is well placed to lead to innovative designs.

The marketing division has made definite changes to tap into the KC abilities of both their markets. The fact that a particular drive exists in the marketing division to analyse markets, customers and competitors, demonstrates the emphasis that is placed on KC in this division.

The sales division, on the other hand, recognises that the customer is a core driver in tapping into new and innovative solutions. Customer requirements are a real source of KC.

The research and technology design division uses the mechanisms of technology forecast and future forecasting as indicators for new product deliverables. This division further supports KC by using scientific methods for research. This division places strong emphasis on knowledge transfer.

The business and financial division has made key decisions that will introduce processes that will support KC organisation wide. The business division has identified communication and learning as two key drivers for KC.

The order fulfilment division functions on two levels, namely customer and internal. Customer support recognises the critical role that customer feedback plays in KC. Support services are continuously improving processes and mechanisms to capture the feedback and translate it into new offerings.

The ICT and MIS divisions have made various new tools available that enhance KC abilities in the organisation. These include wikis, document management systems and case tracking tools.

4.2 Survey results

The survey was conducted at the premises of the organisation. A questionnaire was handed out and the researcher was available to offer assistance. The questionnaire was designed to interpret the organisation at the hand of the KC model (Figure 3-11). The questionnaire is available in Appendix I. The purpose of the survey was to analyse the KC capability of the organisation based on the principles of the KC model. This process served as validation for the KC model and its usability.

4.2.1 Demographics

The following demographic data were gathered:

- Sample distribution across innovation spheres
- Level of education of sample group
- Years of experience in the organisation of the sample group.

4.2.1.1 Question 1.1 in questionnaire – Sample distribution

Refer to section 2.4.2.1.4.1 for the sample determination discussion. The sample distribution was calculated by totalling the results of each division under the corresponding innovation sphere as indicated by Figure 4-1. The sample group was distributed across the product, project and other spheres, as defined in Figure 4-1. Most respondents (57% of sample/16) were from the product group, since this is the largest group in the organisation. The project group was represented at 32% of the sample (9) and the 'other' group was represented at 10.71% of the sample (3).

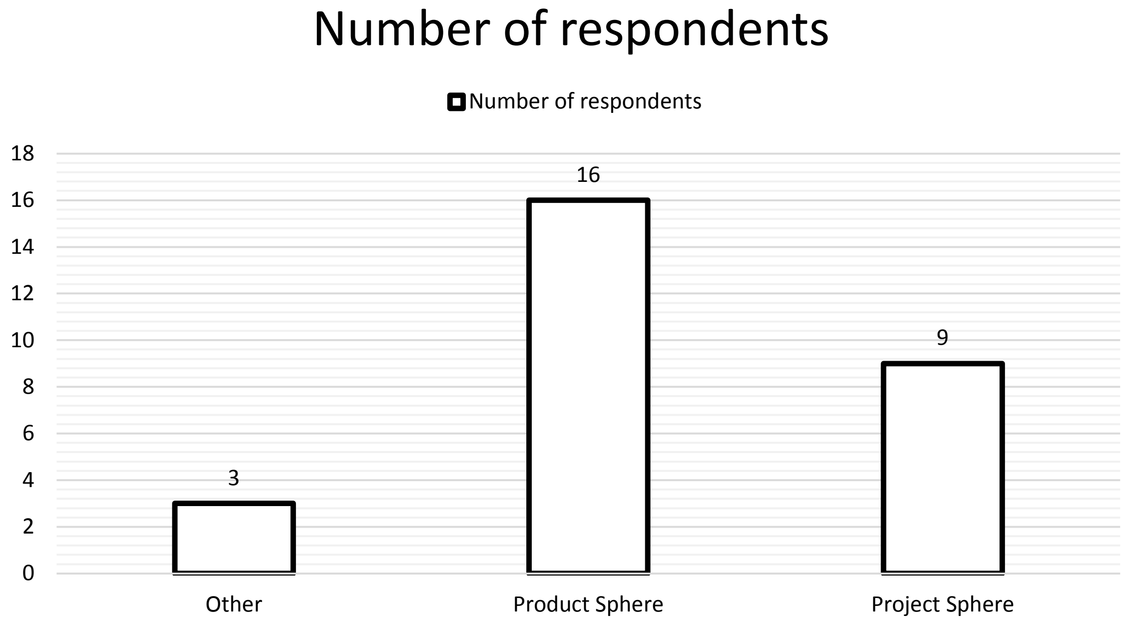

Figure 4-6: Sample distribution across the innovation spheres.

4.2.1.2 Question 1.2 in questionnaire – Educational level

The educational level of the sample group was high. The results showed that 82% (23) of the sample group held a qualification on Bachelor's degree level and higher. It is significant to note that 54% (15) of the respondents held a degree at master's level and 4% (1) at doctorate level (see Figure 4-7). The high education levels are indicative of a knowledge-intensive organisation, as defined by Deng (2008: 174): one whose primary workforce comprises well-educated, skilled knowledge workers who create market value through effective application of knowledge to provide a service for its clients. These results (Figure 4-7) indicate that the collective knowledge base of the organisation is strong and diverse, a fact that is reflected in its successful growth.

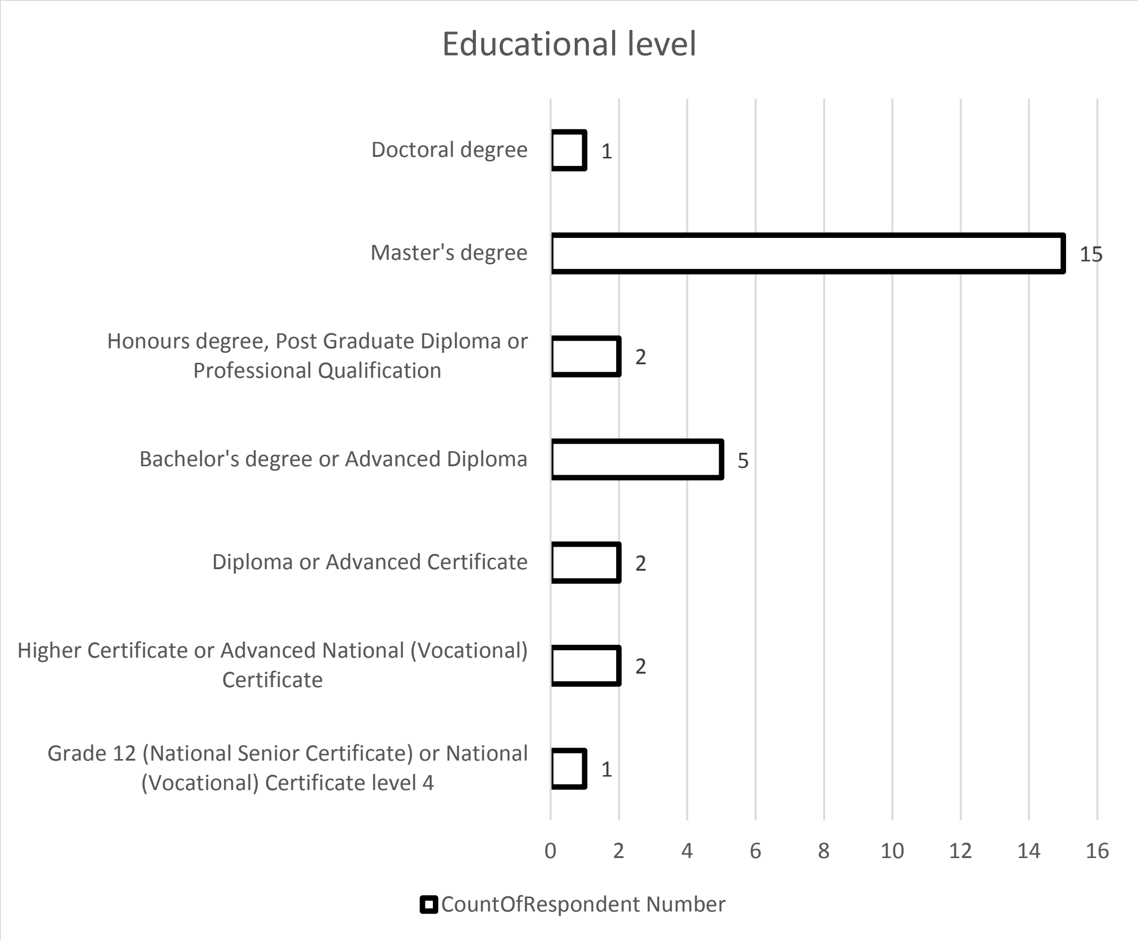

Figure 4-7: Educational level

4.2.1.3 Question 1.3 in questionnaire - Length of experience with organisation

The demographic results showed that the majority of respondents (68% see Figure 4-8) were new in the organisation and had less than five years' experience with the organisation. This supports the strategic view of the organisation that training and up-skilling must take priority, as mentioned in section 4.1.4.4.

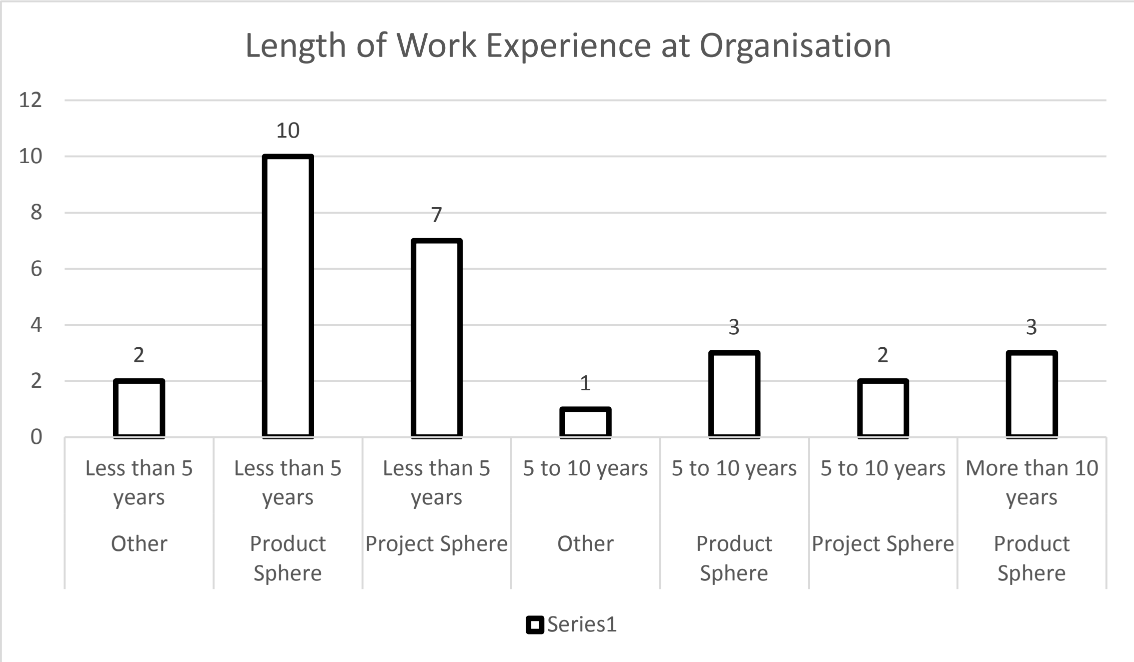

Figure 4-8: Length of experience at organisation

4.2.2 Problem-solving domain

This section of the results highlights the importance of problem-solving and the value that the correct attitude to problems has for the organisation.

4.2.2.1 Question 2.1 in questionnaire – Solving customer problems is seen as one of the big drivers of innovation

Almost 79% (22) of the respondents agreed to a very great extent or to a great extent with this statement. However, 4% (1) of the respondents (from the project sphere) differed significantly from this statement (see Table 4-1). This is a positive attitude to exhibit and supports the view of Hsieh, Nickersen and Zenger (2007: 1258), as discussed in section 3.3 when they highlight the relationships between opportunity, problems and value creation.

Table 4-1: Solving customer problems is seen as one of the big drivers of innovation (all respondents)

Do you agree with the statement that to solve customer problems is seen as one of the big drivers of innovation?	Very great extent	Great extent	Somewhat	Very little	Grand Total
Percentage of all respondents	32%	46%	18%	4%	100.00%
Numbers	9	13	5	1	28

In section 3.3 it was shown that problems and specifically customer problems were a major source for innovation.

Figure 4-9 demonstrates the difference in the views between the project and product spheres. The percentages were calculated as a percentage of the total number of respondents for each sphere (namely; project sphere = 9; product sphere = 16). The project sphere results show that approximately 66% of the respondents in the sphere agree with the statement to a great extent or more. The product sphere results show that approximately 81% of the respondents in the sphere agree with the declaration to a great extent or more. Since most of the customer interaction and therefore customer problems are managed within the project sphere, it is crucial that they understand the value of customer problems for innovative solutions.

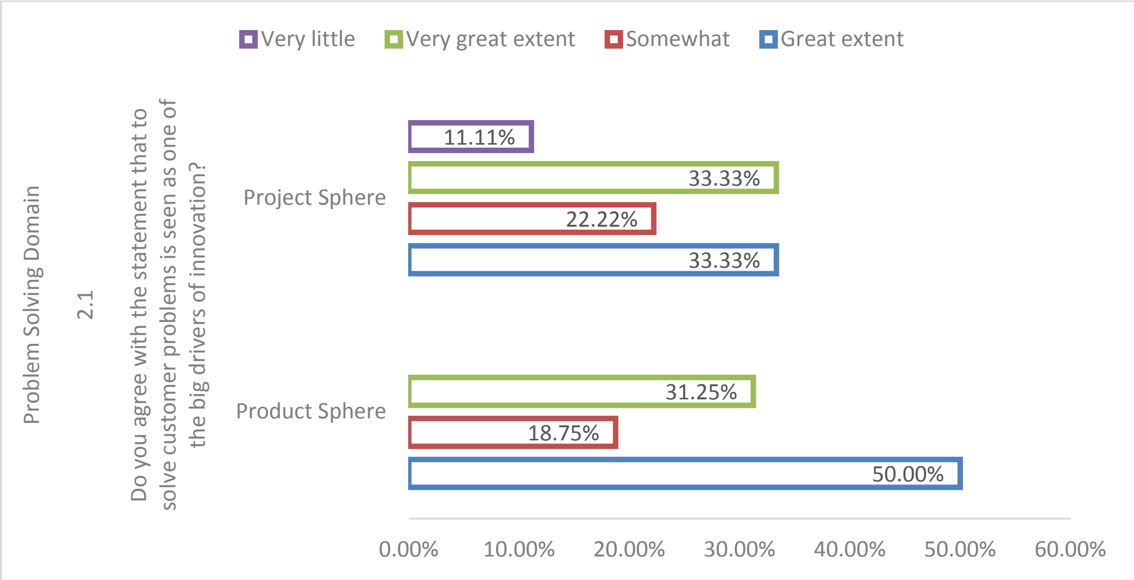

Figure 4-9: Comparison between the views of the project and product sphere for question 2.1

4.2.2.2 Question 2.2 in questionnaire – Customer problems are normally presented as customer requirements. Does your work process ensure that these requirements are clear and available?

This question was problematic in the sense that it did not add value to the problem-solving domain (see Figure 4-10). It is proposed that this question be changed in future to include the following three items:

- Statement: Customer problems are normally presented as customer requirements
    - This statement can be measured on a Likert scale.
    - This statement will provide information on the attitude of respondents toward customer problems.
- Does your work process ensure that these requirements are clear and available?

  - This question will then provide feedback on the percentage of respondents that are in the process of defining customer requirements.

- How regularly do you experience productivity problems due to ill-defined or unavailable requirements?

This will provide more substantial information on how well problems are defined, if at all.

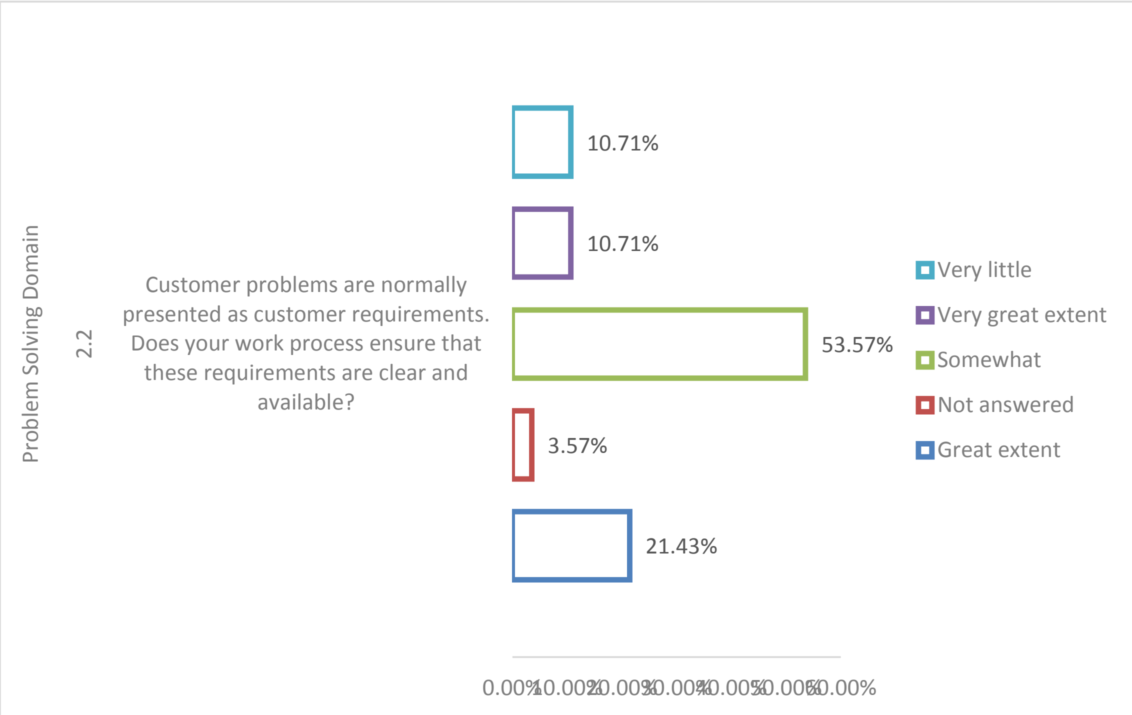

Figure 4-10: Customer problems are normally presented as customer requirements. Does your work process ensure that these requirements are clear and available? (Percentage of all respondents)

4.2.2.3 Question 2.3. Time spent on problem-solving phases

This section of the research may be extended to determine the expected time that should be spent on each phase. Figure 4-11, Figure 4-12, and Figure 4-13 provide an overview of the average time respondents spend on the various problem-solving phases. In all three charts a trend line indicates the time spent on the different phases. Both the project and product spheres have a downward trend, which indicates that most time is spent on the understanding and exploration phases. The other sphere has an upward trend, indicating that more time is spent on the resolution phase.

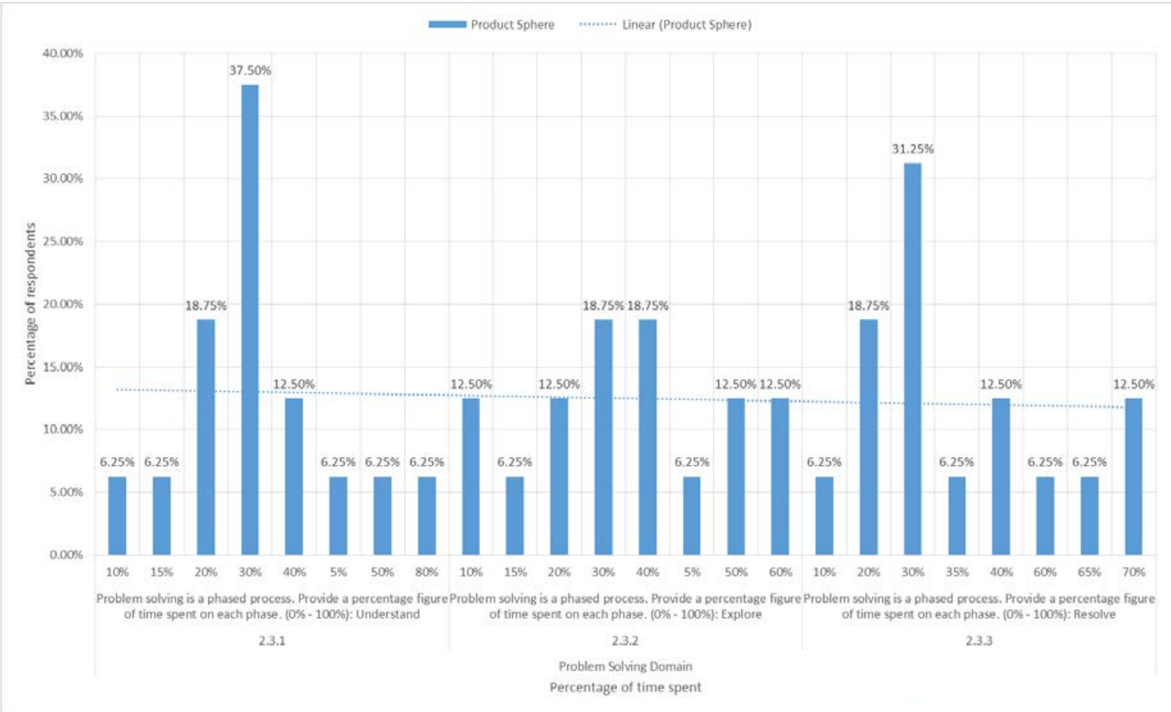

Figure 4-11: Time spent on solving problems – product sphere.

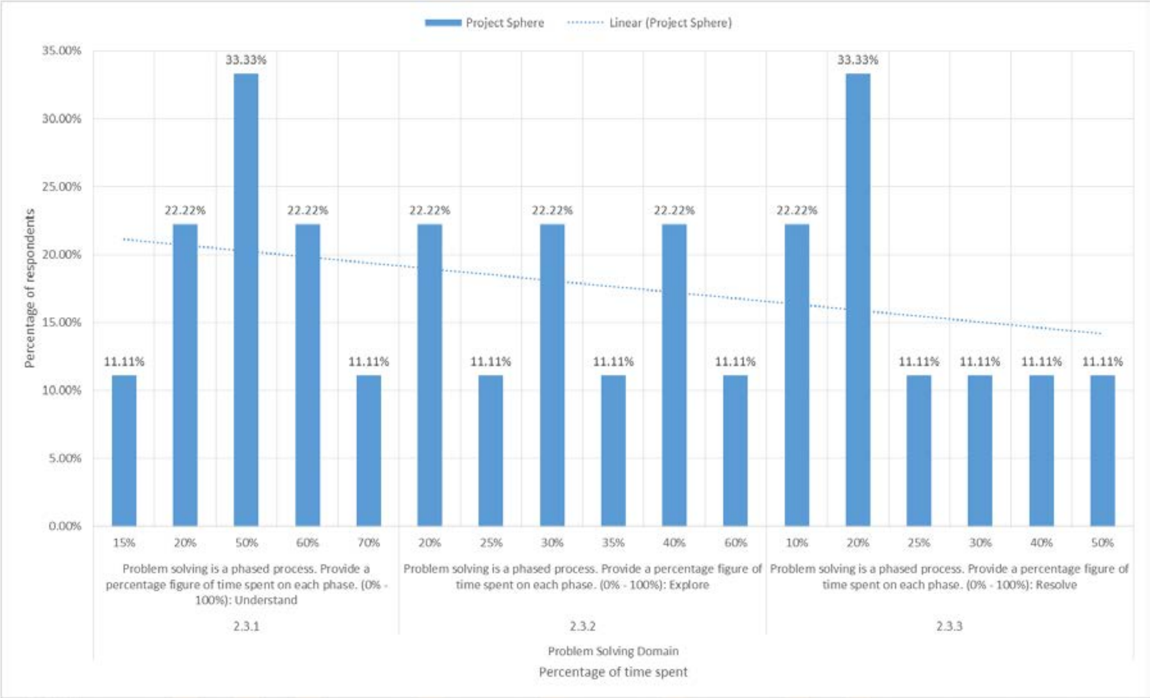

Figure 4-12: Time spent on solving problems – project sphere

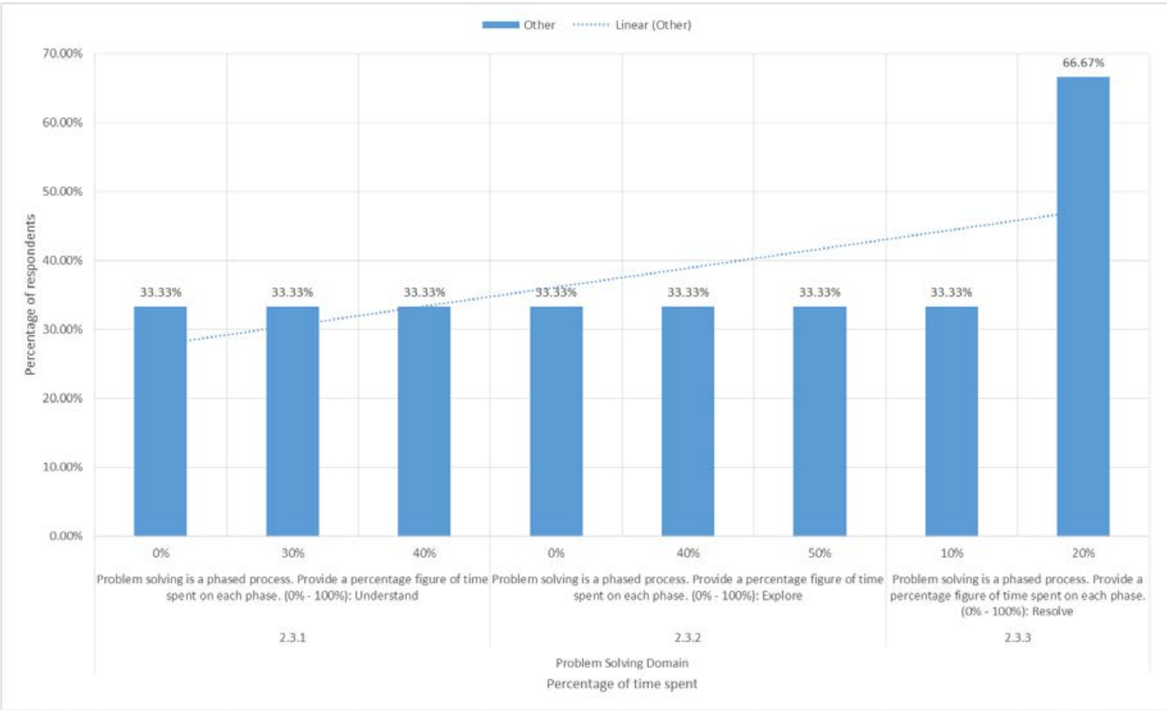

Figure 4-13: Time spent on solving problems – other sphere

4.2.3 Skills domain

The skills domain of the KC model is the enablers that allow knowledge workers to leverage knowledge and learning processes. Reinhardt, Schmidt, Sloep and Drachsler (2011:150) state that the main feature differentiating knowledge work from other conventional work is that the basic task of knowledge work is thinking. They say that although all types of jobs entail a mix of physical, social and mental work, it is the perennial processing of non-routine problems that requires non-linear and creative thinking that characterises knowledge work. In the OECD (2011: 10) report it is mentioned that a broad range of skills contribute to innovation and "soft skills" may be increasingly important. The organisation under study is a good example of a knowledge-intensive organisation where knowledge workers are required to think creatively about customer problems in order to craft the correct solutions.

The soft skills that were included in the questionnaire are demonstrated in Table 4-2 Soft-skills levels. With regard to problem-solving skills, 50% (14) of the respondents see themselves on an advanced level, while 50% (14) see themselves on an intermediate level. With regard to learnability, 46% (12) of the respondents see themselves on an advanced level, while 54% (15) of the respondents see themselves on an intermediate level. Most of the respondents (11% (3) who regard themselves as on a beginner level do so with regard to creativity, although 25% (7) of the respondents see themselves as on an advanced level with regard to creativity.

The organisation may want to focus future learning endeavours to enhance these soft skills to ensure that knowledge workers are well-equipped for the innovative and knowledge-intensive work environment in which they find themselves.

Table 4-2 Soft-skills levels

Skills	Advanced	Beginner	Intermediate
Collaboration	32%	7%	61%
Communication	36%	4%	61%
Creativity	25%	11%	64%
Critical Thinking	46%	4%	50%
Learnability	46%	0%	54%
Problem-solving	50%	0%	50.00%

4.2.4 Cognitive domain

Results retrieved from the cognitive domain section of the questionnaire provide an in-depth view of the typical actions that workers in the organisation undertake on a daily basis. These results can be utilised on macro- and micro-level. The cognitive domain results have various application possibilities, some of which will be demonstrated. On a macro-scale, strategic insights can be gathered when looking at the distribution of actions throughout the organisation, as shown in Figure 4-14. An immediate outlier is 16 respondents using the clarifying action to a great extent in order to gain understanding. It is not clear why this amount of time is being spent to clarify issues. This might be indicative of a possible problem, or a specific phase in the organisation. Another outlier is 14 respondents who are implementing solutions, projects and plans to a very great extent.

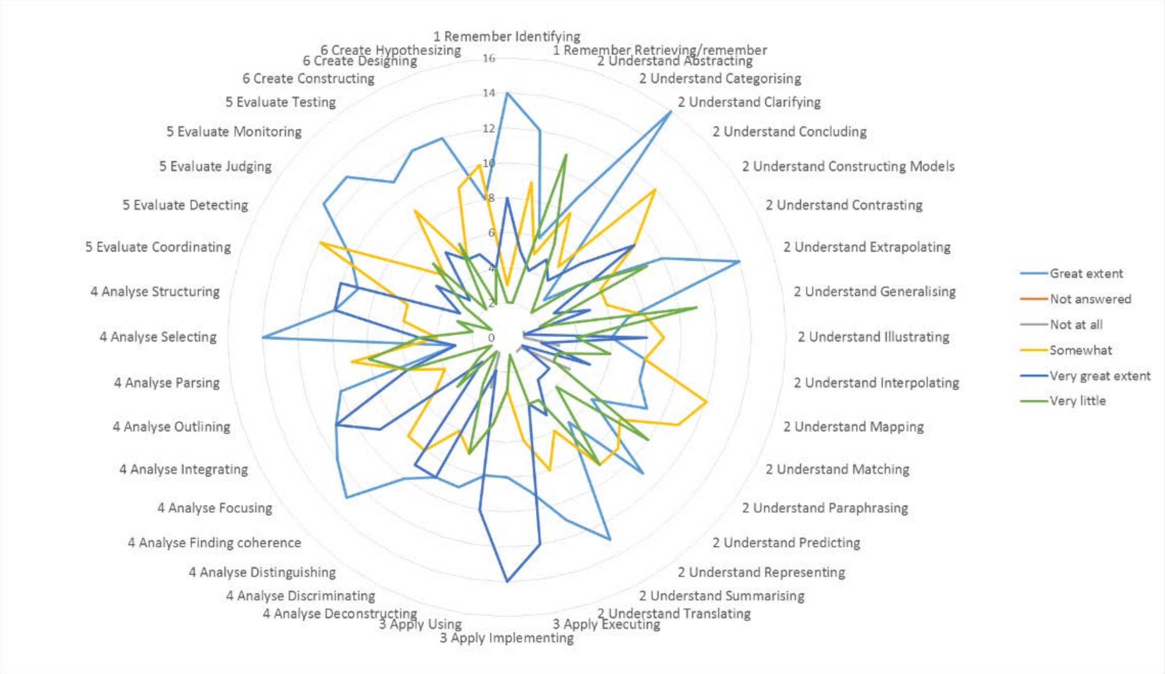

Figure 4-14: Cognitive map of all respondents

Figure 4-15, Figure 4-16 and Figure 4-17 demonstrate the differences in the cognitive maps of the various spheres. For the purpose of this comparison the researcher refers to those actions that are executed to a great or very great extent. The majority of the project sphere respondents are constructing, concluding, predicting, contrasting and implementing. The majority of the product sphere respondents are testing, retrieving, executing, selecting, summarising and contrasting. The majority of the 'other' sphere respondents are retrieving, selecting and focusing.

Figure 4-15: Cognitive map of the project sphere

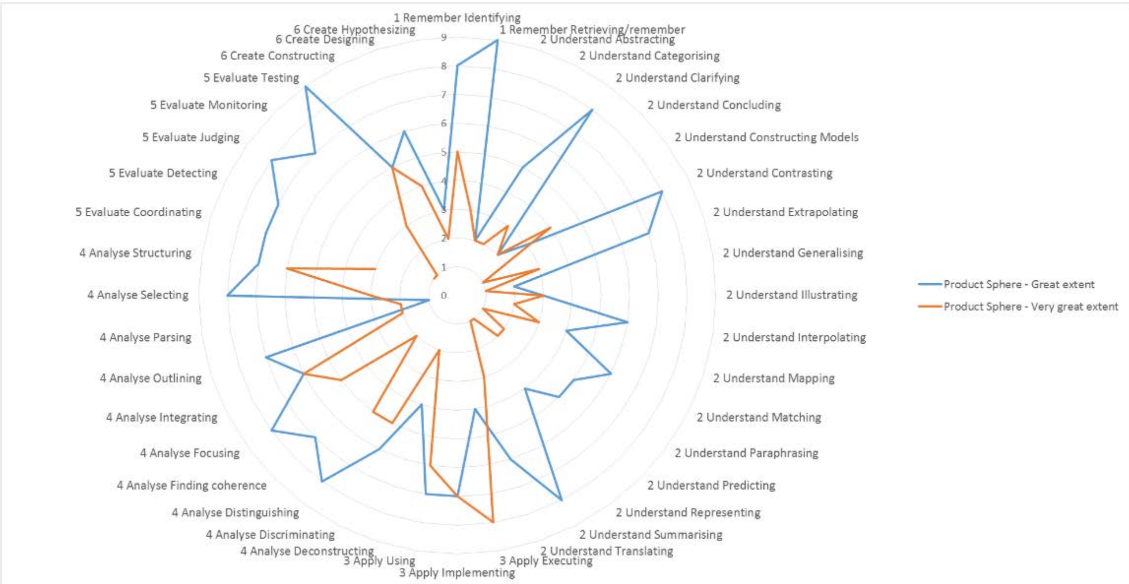

Figure 4-16: Cognitive map of the product sphere

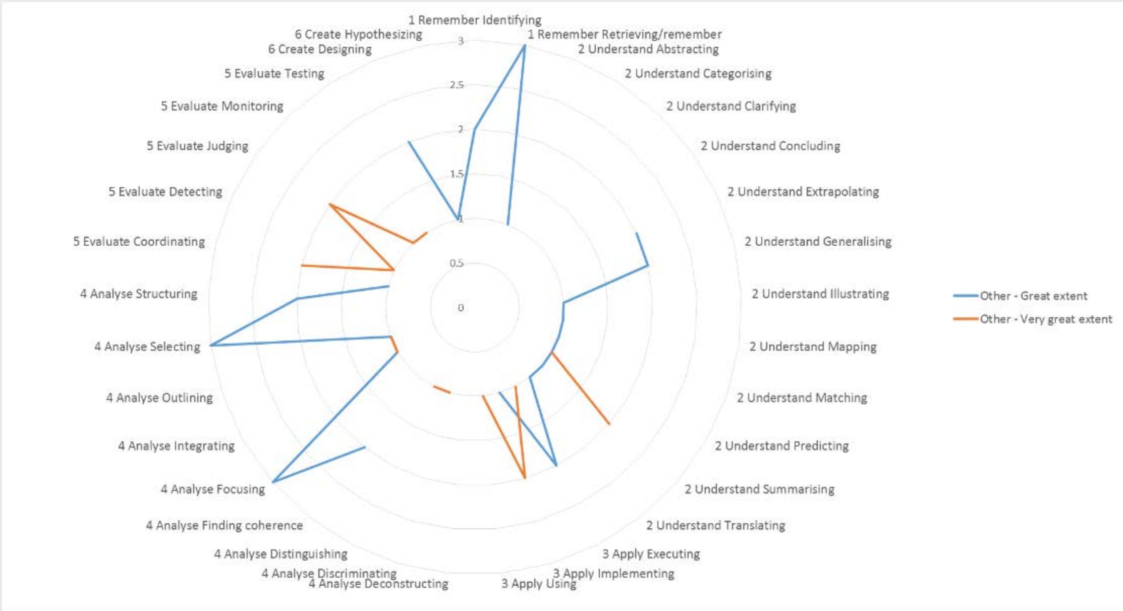

Figure 4-17: Cognitive map of the other sphere

To delve into the clarifying outlier one can, for instance, make a comparison between divisions to see where the actions are taking place.

Table 4-3 indicates that 100% of respondents from the business services, finance and marketing division are spending a great deal of time clarifying issues; 77% of respondents from Development Engineering are also spending more than a great deal of their time on clarifying issues. The questions to be asked in this case will be whether the fact that so much time is spent on clarifying issues is indicative of a problem or whether it is a normal part of the job set.

Table 4-3: Clarifying action

Values	Business Services	Development Engineering	Finance	Marketing	Order fulfilment	Research and Technology Design	Sales	Solutions Engineering
Great extent	100.00%	61.54%	100.00%	100.00%	50.00%			50.00%
Somewhat		7.69%			25.00%		100.00%	50.00%
Very great extent		15.38%			25.00%	50.00%		
Very little		15.38%				50.00%		

Figure 4-18: The Create phase in all demonstrates the create phase and its application in the various innovation spheres. Respondents in the project sphere spend most of their time on constructing (seven knowledge workers are spending time on constructing to a great extent). Those in the product sphere spend most of their time on constructing and designing, whereas those in the 'other' sphere spend most of their time on hypothesising and designing. These are valuable results for any organisation that wishes to understand where creation activities are taking place and to what extent this is happening.

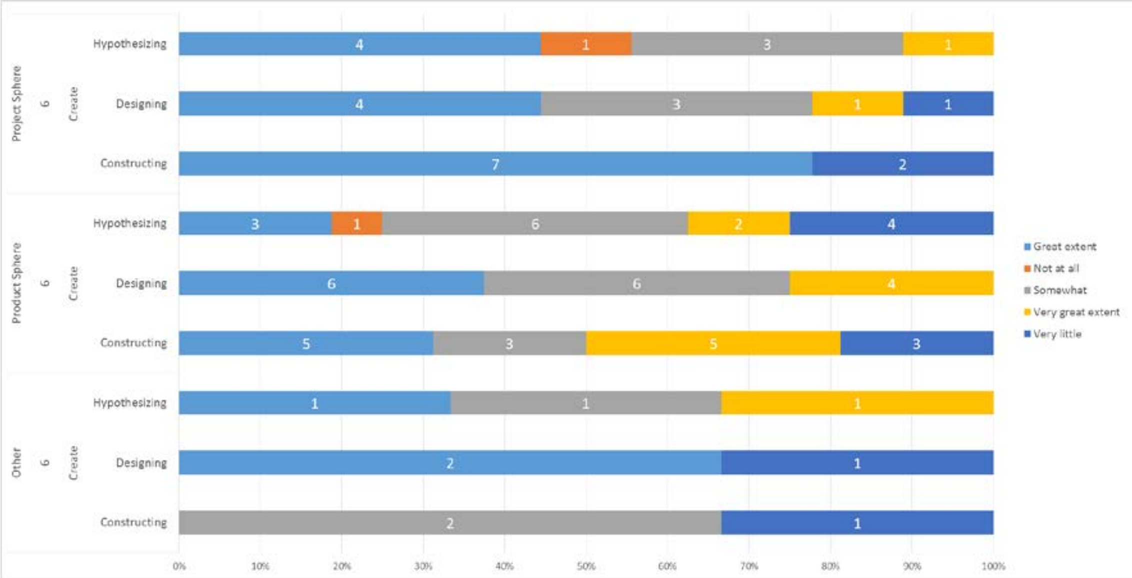

Figure 4-18: The Create phase in all spheres

Figure 4-19 (Knowledge worker 1) and Figure 4-20 (Knowledge worker 2) demonstrate the value of the cognitive domain action verbs on a micro-level. Profiles of individuals can be drawn. These profiles can be used to gain insight into the typical activities of a worker or these actions could be linked with performance management processes. Note the differences between the two knowledge workers' cognitive maps. Knowledge worker 1 is working to a great extent in the understand category. Knowledge worker 2 is clearly working at higher cognitive levels, namely apply and analyse, as well as to a great extent in the evaluate and create categories. These maps provide a very quick view into the actions that differentiate knowledge workers from one another.

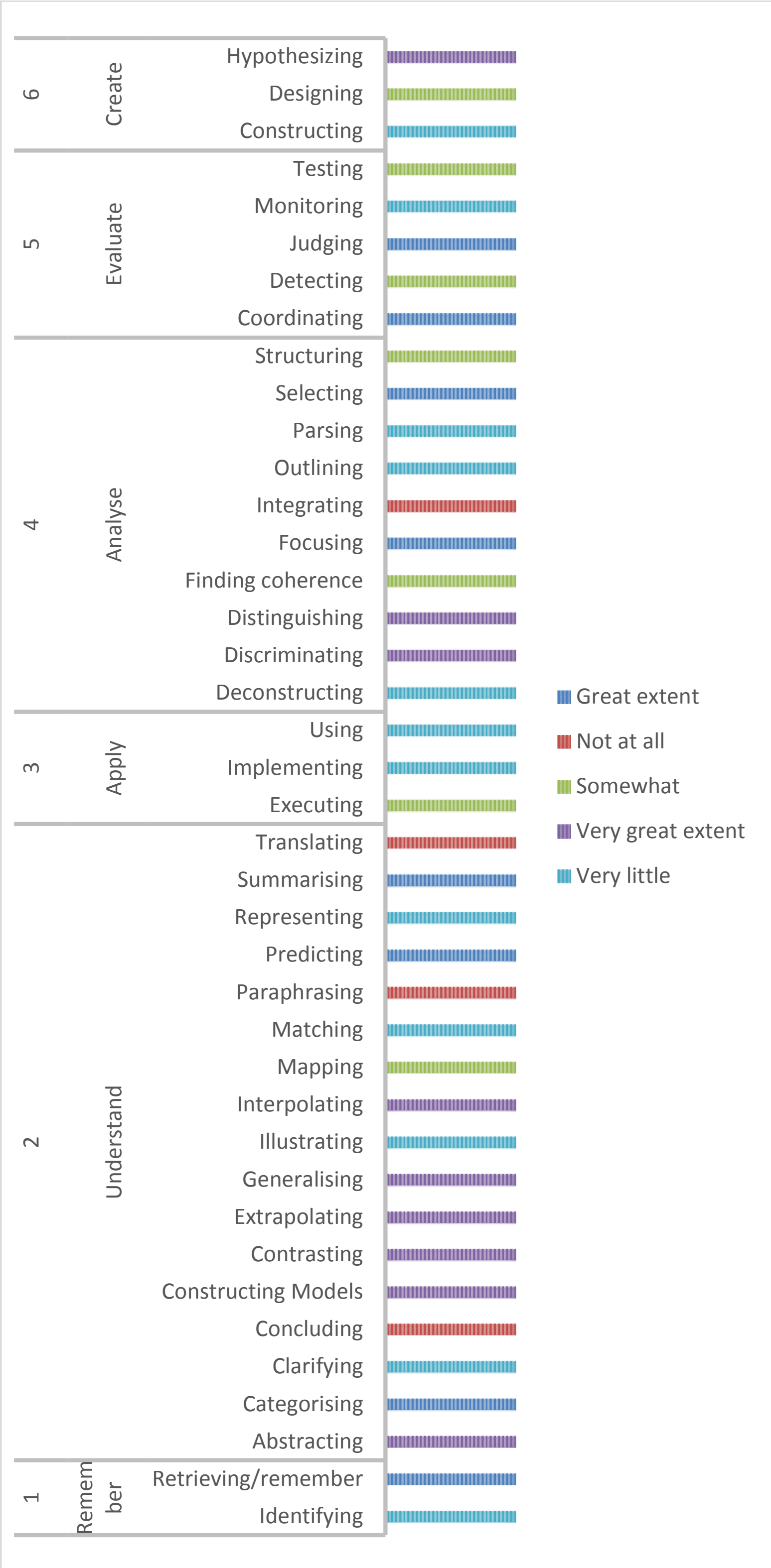

Figure 4-19: Cognitive map of knowledge worker 1

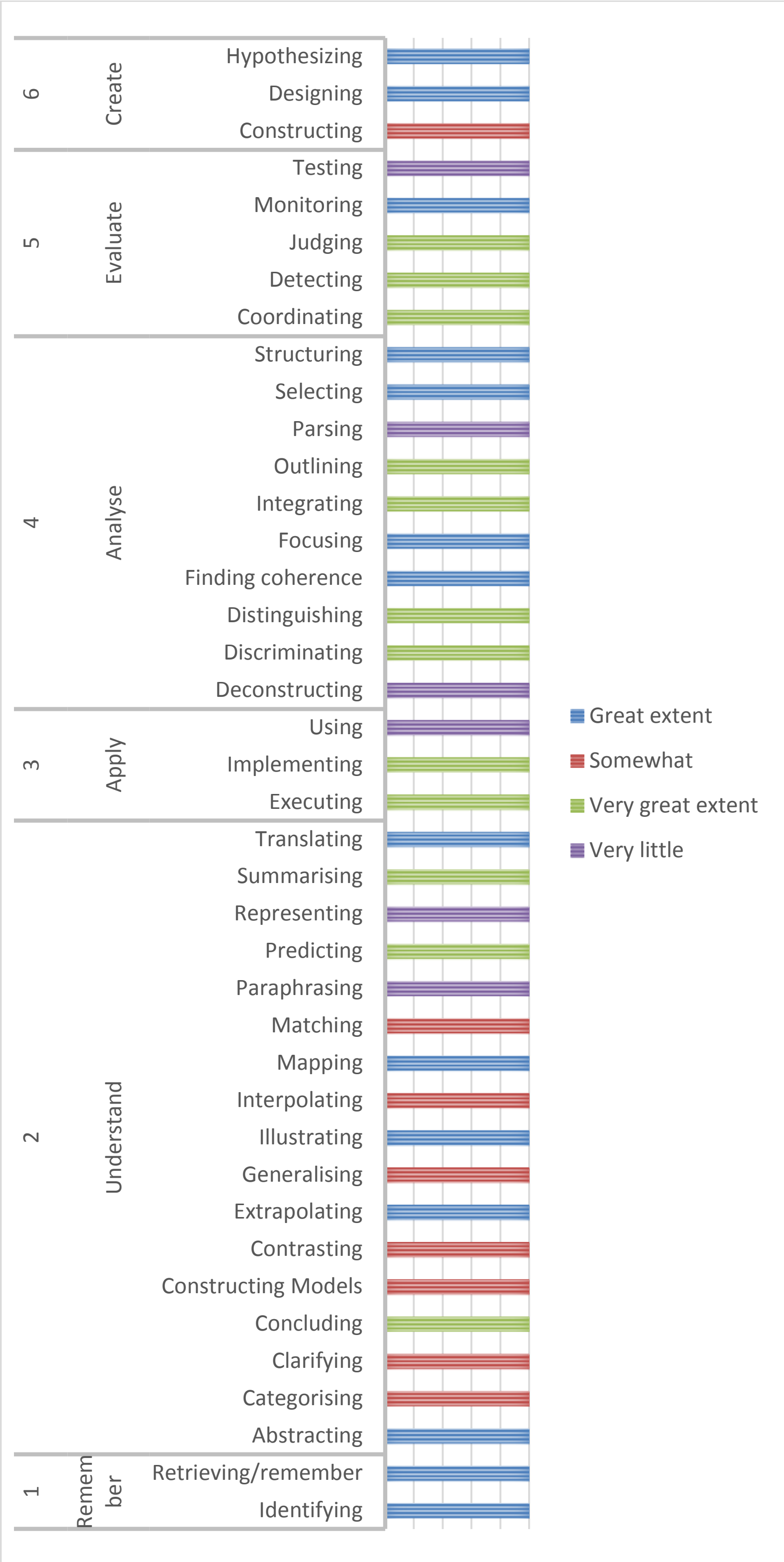

Figure 4-20: Cognitive map of knowledge worker 2

4.2.5 The affective domain

The affective domain was addressed in the questionnaire by a series of questions that support a positive attitude to learning and KC.

The questions were formulated based on the discussions in sections 3.3.7, 3.2.7 and 3.2.3.

The results were overwhelmingly positive, showing that the attitude to innovation and KC is positive (See Figure 4-21).

Seventeen respondents viewed problems as good for business and growth (see Figure 4-21).

The majority of the respondents agreed with the statement that "learning more generally makes me realise that I have a lot more to learn" (26). This is an important view to exhibit, as shown in section 3.4.4 (see also Figure 4-21).

Similarly, most respondents (23) viewed failing as good for success. The value of this attitude has been discussed in section 3.2.3.1. Acknowledging failure as part of successful development is an important stimulus for innovation. A large number of respondents (6) were, however, neutral on this topic. The value of failure is something that must be made clear in the organisation (see Figure 4-21).

The idea that diversity of opinions and ideas leads to innovative solutions also received overwhelming support from 23 respondents (see Figure 4-21). The importance of diversity for KC was discussed in section 3.2.7. This attitude is supported by the majority of respondents (27) that view mistakes as learning opportunities (see Figure 4-21).

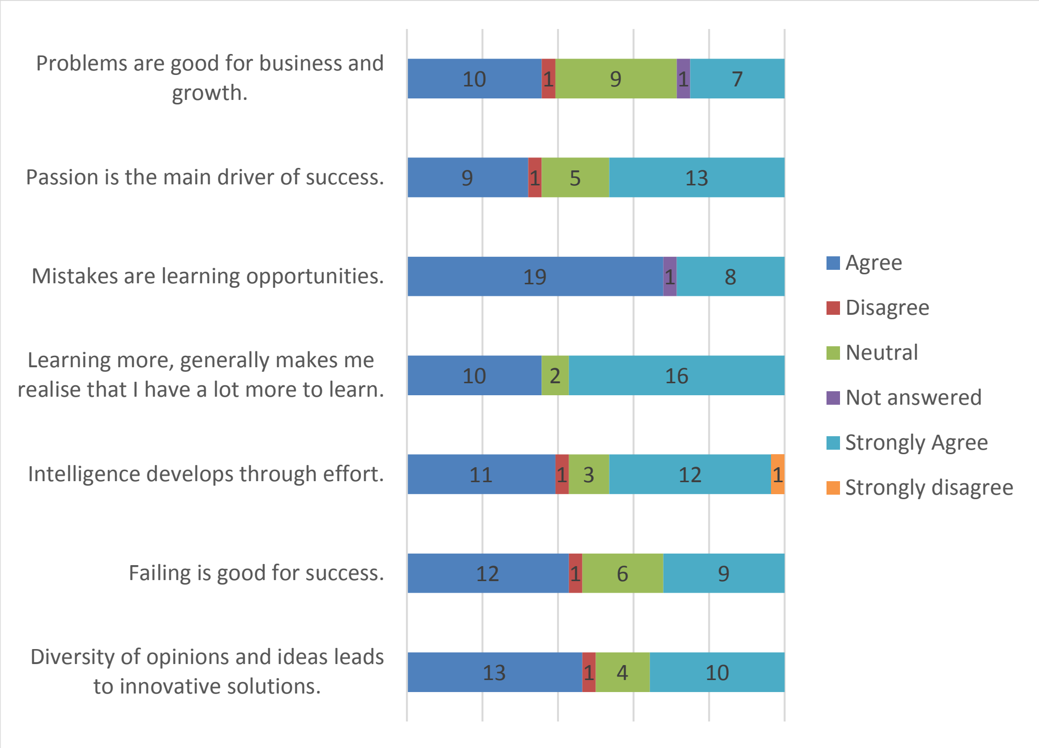

Figure 4-21: The Affective domain

Figure 4-22 demonstrates the difference in the affective domain between the project and product spheres.

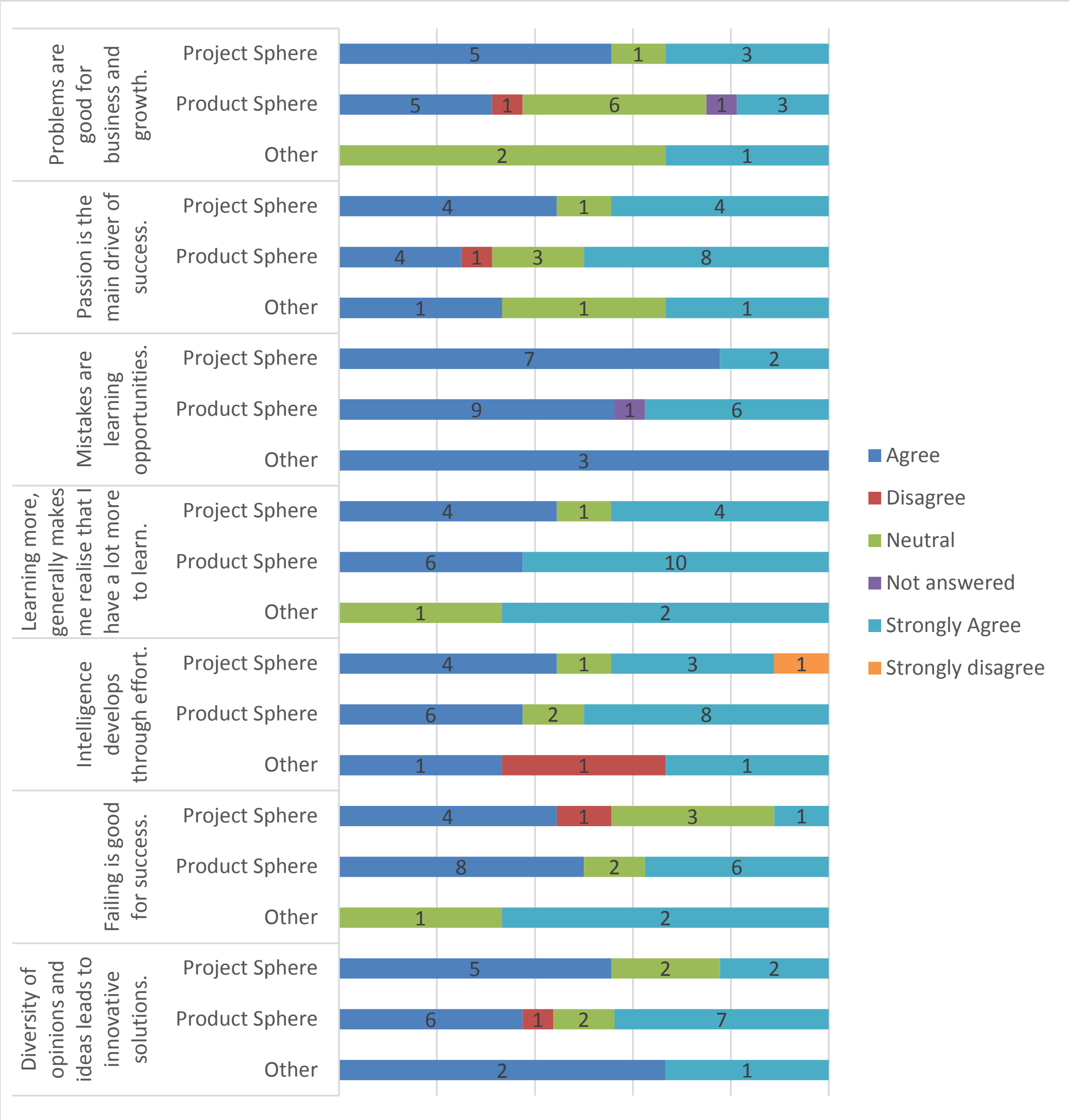

Figure 4-22: The affective domain: a comparison between the project and product spheres

4.2.6 The knowledge domain

This domain is represented in Figure 4-23. Ninety-two percent (26) of respondents confirmed that access to knowledge is critical for their jobs.

Nearly 78% (22) of respondents have experienced productivity problems due to inability to access explicit knowledge. More than 64% (18) have experienced some kind of productivity loss due to difficulty in accessing tacit knowledge. The majority of respondents indicated that most of the knowledge gathered through work processes is not codified. This represents a very large knowledge gap and may explain the productivity losses due to the amount of knowledge in tacit form. Combined with the statistic of 71% (19) of respondents being unable to access explicit knowledge, this is indicative of a major stumbling block for the organisation's KC capability.

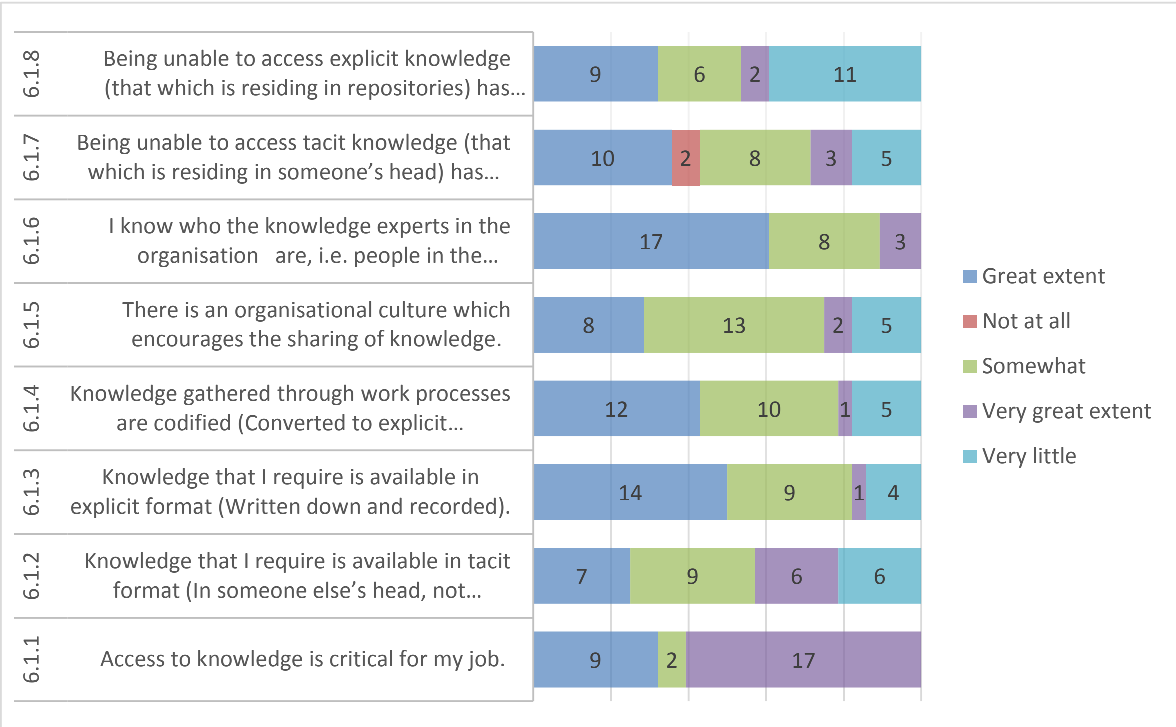

Figure 4-23: The knowledge domain

4.3 Summary

This section described the results gathered from the research instrument that was distributed in the organisation under study (see Appendix I). The results are summarised below:

- Demographics:
    - The majority of respondents are highly qualified at master's degree level.
    - The majority of the respondents are new to the organisation.
- The problem-solving domain:
    - Most of the knowledge workers view problems as opportunities.
    - The trend line indicated that knowledge workers in the product and project spheres spent most of their time understanding and exploring problems, whereas those in the 'other' sphere spent more time on the resolving phase.
- The skills domain:
    - The critical skills identified are represented mostly at an intermediate level.
- The cognitive domain:
    - This domain contained a wealth of information. The cognitive map showed immediate outliers that indicated that the organisation was functioning mainly at the 'understand' and 'apply' level at the moment. This section demonstrated the

value of the model and instrument in terms of team and individual cognitive task analysis.

- The affective domain
  - This domain was represented by attitudes that are valuable for KC. The majority of respondents demonstrated a positive attitude in this regard.
- The knowledge domain:
  - This section clearly showed that knowledge workers were experiencing problems to access both tacit and explicit knowledge in the organisation.

The overall conclusion is that the questionnaire did provide insight into the KC capabilities and mechanisms of the organisation under study, thus addressing **Research question six.** The information extracted from the survey further validated the value of the KC model in the sense that a picture of the organisation emerged that provided insight into the KC capability of the organisation. The instrument is not without limitations though and recommendations to enhance the research tool will be provided in the next chapter.

Chapter 5 Summary, conclusion and recommendations

5.1 Summary

The problem statement in chapter one of this dissertation defined the objective of the research as follows:

- To understand and identify the knowledge-creation processes and conditions that may lead to enhanced knowledge creation and innovation capability in the organisational environment.

The purpose of this study were to, understand the complexities of innovation and knowledge creation. The aim was to identify the critical drivers for knowledge creation and innovation. *Secondly* the assumption that learning forms the basis of KC and therefore innovation were constructed. The literature review of relevant research conclusively showed that KC is a learning process that is triggered by problems (**Research question one**).

The identification and the nature of KC processes and conditions that enable innovation were investigated. It was exposed that KC depends on knowledge resources to be available. Without knowledge, no new knowledge can be created.

The link between KC and innovation was established by Popaduik and Choo (2006: 312), as discussed in Chapter 1, when they defined the relationship between KC (creating new capabilities) and innovation (taking these capabilities to market). The organisation adheres to this vision of KC and innovation in its definition of innovation as the process of taking new concepts to market. The research therefore clearly shows the link between innovation and KC, as required by **Research question two**.

The literature that was reviewed provided substantial guidance to develop the KC model that was based on prior research as well as own insights. The model demonstrates the fact that the knowledge domain forms the foundation for KC.

The cognitive domain of the model was based on Kratwohl's (2002: 214) revised Bloom's taxonomy of learning. The cognitive approach in learning was selected as an appropriate methodology, based on the research done by Hsieh, Nickersen and Zenger (2007: 1273), who concluded that as the complexity of a problem increases, experiential search via trial and error provides fewer benefits and cognitive search via theorising becomes more useful.

Section 3.3.8 demonstrated the importance of existing knowledge as the foundation for KC. Knowledge cannot be created if access to existing knowledge is limited. If this is true, then it is also true that innovation will not follow. **Research question three** was therefore substantiated when it was shown that access to knowledge is a critical part of the KC cycle. Section 3.3 discussed the value of problems and demonstrated how problem-based learning will enhance KC, thus addressing (**Research question four).**

The KC model provides an opportunity to managers of knowledge-intensive organisations to intervene specifically in the various domains that might have an impact on KC and therefore one can assume that innovation will follow, as defined by Popaduik and Choo (2006:312). The

KC model addresses **research question five** by developing a KC model that will ensure KC through learning processes.

The KC model provides a solution to problem-solving. The very first step in the KC model is the acknowledgement of ignorance, which normally poses a problem. Using the cognitive domains of the revised Bloom model of Kratwohl (2002), it is possible to guide learners/workers through the learning cycle by means of action verbs. If this iterative approach of gradually moving higher into the cognitive domain is used, it is possible that new knowledge will be created. Innovation might follow, but new knowledge will definitely be created.

Research question six was addressed in section 4.1. This section provided a detailed overview of the various KC mechanisms employed in the organisation. These included, for example:

- Strategic decisions to manage innovation by restructuring the organisation into three distinct spheres (Section 4.1.1)
- Adopting a team based agile approach to development to ensure knowledge sharing (section 4.1.2.1.1)
- Establishing a learning support service that aims to codify and make accessible product knowledge (Section 4.1.2.1.2)
- Specific emphasis on transferring acquired knowledge as seen in section 4.1.2.2
- The organisation has strategically agreed that user needs and opportunities are a critical if not the most important driver of development in the organisation.

- Establishing infrastructure to support KC and learning (Sections 4.1.3.4 and 4.1.4)
- Appointing highly qualified knowledge workers.

Research question seven was addressed throughout section 4.1.5 and 4.2. A summary of the most important contributions that can be made to enhance the KC capability of the organisation include the following:

- Use a problem-solving methodology (see section 3.6).
- Incorporate action verbs to drive knowledge creation in the organisation (see section 3.6).
- Codify knowledge (see sections 3.6 and 4.2.5.1).
- Ensure access to explicit knowledge (see section 3.6 and 4.2.5.1).
- Start communities of practice using experts as mentors to share tacit knowledge.
- Upgrade required skills (see sections 3.3.9 and 4.2.3).
- Embark on value training that will enhance the affective traits required for KC (see section 4.2.5).

5.2 Conclusion

> *"After 40 years of intensive research on school learning in the United States as well as abroad, my major conclusion is: What any person in the world can learn, almost all persons can learn, if provided with the appropriate prior and current conditions of learning."* ***(Bloom, 1985:4).***

It is therefore possible to state the following:

If problem-solving at work equals a learning process and the appropriate prior and current conditions of learning are present, knowledge creation and innovation may follow. This dissertation has highlighted the appropriate conditions by developing a model and thereby defining the different domains required for knowledge creation. The organisation under study has been analysed based on the model and the findings elucidated the current conditions that are in place and those that still need to be developed or enhanced.

The survey results showed that lack of access to knowledge has led to productivity problems in the organisation under study. These problems experienced by the knowledge workers of the organisation will ultimately lead to lower productivity levels and may consequently have a severe impact on the KC and innovation capability of the organisation. The results from this survey provided insight into the current status of the organisation. Feedback was received for the following domains of the KC model:

- The problem domain
- The cognitive domain
- The knowledge domain
- The affective domain
- The skills domain.

The KC model has been tested by developing a research instrument with questions and statements that support the various domains of the model. The survey results indicate the value of the model and instrument. The instrument was shown to be reliable as well as valid in section 2.4.2.1.4.2.

The results confirmed the ability of the model to provide a tool for the benchmarking and possible management of KC processes in knowledge organisations.

Section 3.3 presented a substantial argument to confirm the value of problems as a driver for KC. The survey results has, shown that problems are viewed as opportunities and that a definite trend line is visible during the problem-solving phases. (See section 4.2.2).

The survey demonstrated that the skills domain of the organisation might benefit from specific training interventions to address skills gaps (See section 4.2.3).

The cognitive domain presented specific results that provided some insight into the type of work being undertaken by the majority of the knowledge workers (see section 4.2.4). Two outliers were identified, namely;

- Clarifying
- Implementing.

It is significant to note that clarifying was identified as one action that was used most often at the time of the study. Because of the volume of newness in the organisation, it is possibly expected that more time will be spent on clarifying information, processes and knowledge. This is a further validation of the value of the KC model. The other outlier, namely implementation, is substantiated by the fact that the organisation is currently in a delivery phase and therefore implementation is an important activity.

The overall conclusion was that the affective domain was positive and that the majority of respondents agreed with the statements (see section 4.2.5).

It can also be deducted that this positive attitude explains to some extent the ability of the organisation to consistently produce innovative solutions.

The knowledge domain feedback from the instrument was invaluable in terms of the knowledge management in the organisation (see section 4.2.5.1). This section clearly demonstrates a gap, in terms of, access to both tacit and explicit knowledge. This gap has also lead to productivity problems. The knowledge domain is therefore identified as one of the major problem areas of the organisation under study.

The research findings in chapter 4 demonstrated the value of the KC model to serve as a benchmarking tool for knowledge creation. The cognitive map was especially insightful. Section 3.10 demonstrated a case example of how to use the KC model as a planning tool that may assist in driving problems through a learning process that may lead to innovative solutions. The KC model has a clear role to play in today's management of knowledge creation in organisations.

5.3 Recommendations

The following section highlights specific recommendations that will enhance the KC capabilities of the organisation.

The skills domain survey results showed that the organisation may benefit from embarking on training courses that will enhance the following skills of knowledge workers:

- Collaboration
- Communication
- Creativity

- Critical thinking
- Learnability
- Problem-solving.

These are essential skills required, to allow knowledge workers to move gradually through the cognitive domains of the model.

The instrument or survey can then be used at a later stage to verify the impact of the application on this domain.

The KC model as such has not been applied in the organisation. Applying the model will entail the manager's action in various domains. The cognitive domain may be used to create interventions at task level in the organisation to drive specific outcomes.

The knowledge domain clearly showed that access to knowledge, either explicit or tacit, is a real concern in the organisation. The knowledge domain can be enhanced by embarking on a process to codify more tacit knowledge and to ensure that explicit knowledge is accessible (see section 3.3.8).

The skills domain can be enhanced by embarking on learning programmes that will improve the required skills (see section 3.3.9).

The affective domain can be addressed by instilling a set of values that will contribute to KC (see sections 3.2.3 and 3.3.7). Specific emphasis may be placed on the value of failures and diversity. Critical thinking skills will further contribute to the affective domain as well.

5.4 Areas for future research

Further research would include a bigger sample to get a clearer picture of the organisation. This will also serve as a further validation of the reliability of the research results. If the bigger sample reflects the validity of the current smaller sample, the implication will be that the research instrument may be rolled out to bigger organisations and that a sample of those organisations should provide reliable results.

The recommendations made in section 5.3 may be applied and then the KC capability should be measured again in the organisation to see which interventions worked.

It would further be significant to compare results of different organisations to one another to review the KC model's applicability in benchmarking KC in organisations.

It has been demonstrated that the KC model has various applications on macro- as well as micro-level. The researcher proposes the ensuing research to define these applications in more detail:

- Refining the research instrument to include deeper analysis of the problem-solving domain, skills domain and affective domain, as well as the knowledge domain.
- Testing the use of the KC model as a tool to assist in problem-solving, as demonstrated in section 3.6.
- Distributing the research instrument to a wider audience, including different organisations to test the benchmarking ability of the model.
- Investigating the possibility of using the cognitive domain in a performance measurement environment.

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Questionnaire

Extrapolating the knowledge creation ability of an organisation based on the Learning for Knowledge Creation model developed by JG Ippel

Questionnaire: Researcher: JG Ippel

1 Background Information

Question 1.1

Indicate your division of work below.

Development Engineering	Sales and Marketing	Operations and Planning	Solutions Engineering	Research and Technology Development

Question 1.2

Please indicate your highest academic qualification completed (mark one)

Levels	Designation	
1.2.1	Grade 9	
1.2.2	Grade 10 or National (Vocational) Certificate level 2	
1.2.3	Grade 11 or National (Vocational) Certificate level 3	
1.2.4	Grade 12 (National Senior Certificate) or National (Vocational) Certificate level 4	
1.2.5	Higher Certificate or Advanced National (Vocational) Certificate	
1.2.6	Diploma or Advanced Certificate	
1.2.7	Bachelor's degree or Advanced Diploma	
1.2.8	Honours degree, postgraduate diploma or professional qualification	
1.2.9	Master's degree	
1.2.10	Doctoral degree	

Question 1.3

Please indicate length of work experience at this organisation (mark one)

Less than 5 years	
5 to 10 years	
More than 10 years	

2 Problem-solving Domain

Question 2.1

	1	2	3	4	5
	Not at all	Very little	Somewhat	Great extent	Very great extent
Do you agree with the statement that solving customer problems is seen as one of the big drivers of innovation?					

Question 2.2

	1	2	3	4	5
	Not at all	Very little	Somewhat	Great extent	Very great extent
Customer problems are normally presented as customer requirements. Does your work process ensure that these requirements are clear and available?					

Question 2.3

Problem-solving is a phased process. Provide a percentage figure of time spent on each phase (0% - 100%. Total should be 100%)	
Understand	
Explore	
Resolve	

3 Skills Domain

Question 3.1

Rate your skills levels for the following:		1 Beginner	2 Intermediate	3 Advanced
3.1.1	Creativity			
3.1.2	Learnability			
3.1.3	Critical thinking			
3.1.4	Communication			
3.1.5	Collaboration			
3.1.6	Problem-solving			

4 Cognitive Level

Question 4.1

Work implies actions; the following action verbs demonstrate typical daily cognitive tasks that are required of workers. Indicate the level of usage for each action verb listed in the table below.

Examples:

- You create diagrams that show the hierarchical links in software – this is a typical outlining action.
- You need to make or constitute a distinction in or between things – this is a typical discriminating action.

*See the Appendix for definitions.		1 Not at all	2 Very little	3 Somewhat	4 Great extent	5 Very great extent
4.1.1	Identifying					

*See the Appendix for definitions.		1	2	3	4	5
		Not at all	Very little	Somewhat	Great extent	Very great extent
4.1.2	Retrieving/remembering					
4.1.3	Clarifying					
4.1.4	Paraphrasing					
4.1.5	Representing					
4.1.6	Translating					
4.1.7	Illustrating					
4.1.8	Categorising					
4.1.9	Summarising					
4.1.10	Concluding					
4.1.11	Abstracting					
4.1.12	Generalising					
4.1.13	Extrapolating					
4.1.14	Interpolating					
4.1.15	Predicting					
4.1.16	Contrasting					
4.1.17	Mapping					
4.1.18	Constructing Models					
4.1.19	Matching					
4.1.20	Executing					
4.1.21	Implementing					
4.1.22	Using					
4.1.23	Discriminating					
4.1.24	Distinguishing					
4.1.25	Focusing					
4.1.26	Selecting					
4.1.27	Finding coherence					
4.1.28	Integrating					
4.1.29	Outlining					
4.1.30	Parsing					
4.1.31	Structuring					
4.1.32	Deconstructing					
4.1.33	Coordinating					
4.1.34	Detecting					

*See the Appendix for definitions.		1	2	3	4	5
		Not at all	Very little	Somewhat	Great extent	Very great extent
4.1.35	Monitoring					
4.1.36	Testing					
4.1.37	Judging					
4.1.38	Hypothesising					
4.1.39	Designing					
4.1.40	Constructing					

5 Affective Domain

Question 5.1

Attitude is an important part of the ability to achieve, create and innovate.

Indicate to what extent each of the following applies to your view of the statements

		1	2	3	4	5
.		Strongly disagree	Disagree	Neutral	Agree	Strongly agree
5.1.1	Learning more generally makes me realise that I have a lot more to learn.					
5.1.2	Failing is good for success.					
5.1.3	Diversity of opinions and ideas leads to innovative solutions.					
5.1.4	Intelligence develops through effort.					
5.1.5	Mistakes are learning opportunities.					
5.1.6	Problems are good for business and growth.					
5.1.7	Passion is the main driver of success.					

6 Knowledge Domain

Question 6.1

Access to knowledge is critical to performance. Indicate to what extent each of the following is applied in your current work situation (rate them all)

		1	2	3	4	5
		Not at all	Very little	Somewhat	Great extent	Very great extent
6.1.1	Access to knowledge is critical for my job.					
6.1.2	Knowledge that I require is available in tacit format (in someone else's head, not written down or recorded).					
6.1.3	Knowledge that I require is available in explicit format (written down and recorded).					
6.1.4	Knowledge gathered through work processes are codified (converted to explicit knowledge in documents or wiki's).					
6.1.5	There is an organisational culture that encourages the sharing of knowledge.					
6.1.6	I know who the knowledge experts in the organisation are, i.e. people in the organisation with special skills and knowledge in a certain subject.					
6.1.7	Being unable to access tacit knowledge (that which is residing in someone's head) has caused productivity problems.					
6.1.8	Being unable to access explicit knowledge (that which is residing in repositories) has caused productivity problems.					

Question 6.2

Access to knowledge is critical to performance. Indicate to what extent you agree with the statements below (rate them all)

		1	2	3	4	5
		Strongly disagree	Disagree	Neutral	Agree	Strongly agree
6.2.1	Access to knowledge will enhance innovation capability.					
6.2.2	Lack of knowledge resources will lead to lower levels of creation and innovation.					
6.2.3	My knowledge creation capability is the sum total of my ability to access tacit and explicit knowledge resources.					

Thank you for your time!

7 Appendix 1: Action Verb Definitions

The definitions below were obtained from the British English Cambridge dictionary available online:

Identifying	To recognise a problem, need, fact, etc. and to show that it exists
Retrieving/remem ber	To find and bring back something
Clarifying	To make something clear or easier to understand by giving more details or a simpler explanation
Paraphrasing	To repeat something written or spoken using different words, often in a humorous form or in a simpler and shorter form that makes the original meaning clearer
Representing	To express or complain about something, to a person in authority
Translating	To change something into a new form, especially to turn a plan into something real
Illustrating	To show the meaning or truth of something more clearly, especially by giving examples
Categorising	To put people or things into groups with the same features
Summarising	To express the most important facts or ideas about something or someone in a short and clear form
Concluding	To complete an official agreement or task, or arrange a business deal
Abstracting	An abstract argument or discussion is general and not based on particular examples
Generalising	To say or write something very basic, based on limited facts, that is partly or sometimes true, but not always
Extrapolating	To guess or think about what might happen using information that is already known. To add words to a text.
Interpolating	In the mathematical field of numerical analysis, interpolation is a method of constructing new data points within the range of a discrete set of known data points.
Predicting	To say that an event or action will happen in the future, especially as a result of knowledge or experience
Contrasting	To show an obvious difference between two or more things
Mapping	The activity or process of creating a picture or diagram that represents s omething
Constructing Models	To build something or put together different parts to form something whole
Matching	Having the same colour or pattern as something else
Executing	To do or perform something, especially in a planned way
Implementing	To start using a plan or system
Using	To put something such as a tool, skill, or building to a particular purpose
Discriminating	Able to know and act on the difference between good and bad
Distinguishing	To be able to see the difference between two things
Focusing	To notice or understand the difference between two things
Selecting	To give a lot of attention to one particular subject or thing

Finding coherence	To choose a small number of things, or to choose by making careful decisions
Integrating	The situation when the parts of something fit together in
Outlining	a natural or reasonable way
Parsing	To combine two or more things in order to become more effective
Structuring	A description of the main facts about something
Deconstructing	Parsing or syntactic analysis is the process of analysing a string of symbols, either in natural language or in computer languages, conforming to the rules of a formal grammar.
Coordinating	To plan, organise, or arrange the parts of something
Detecting	The act of breaking something down into its separate parts in order to understand its meaning,especially when this is different from how it was previously understood
Monitoring	To watch and check a situation carefully for a period of time in order to discover something about it
Testing	To do something in order to discover if something is safe, works correctly, etc., or if something is present
Judging	To form, give, or have as an opinion, or to decide about something or someone, especially after thinking carefully
Hypothesizing	To give a possible but not yet proved explanation for something
Designing	To make or draw plans for something, for example systems or hardware components
Constructing	To build something or put together different parts to form something whole