The role of social networks in consulting engineers' collaborative information behaviour

by

MADELY DU PREEZ

submitted in order with the requirements
for the degree of

DOCTOR OF LITERATURE AND PHILOSOPHY

In the subject

INFORMATION SCIENCE

at the

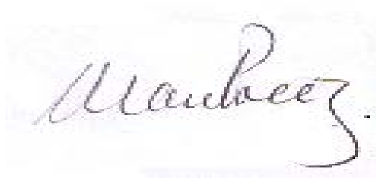
UNIVERSITY OF SOUTH AFRICA, PRETORIA

SUPERVISOR: PROF HESTER W.J. MEYER

SEPTEMBER 2015

DECLARATION

I, Madely du Preez, declare that “The role of social networks in consulting engineers’ collaborative information behaviour” is my own work and that all sources that I have used or quoted have been indicated and acknowledged by means of complete references.



29 October2015

Signature Date

ABSTRACT

The purpose of this qualitative study was to investigate the role of social networks in the information behaviour of consulting engineers. Wilson's (1999; 2000) encapsulating information behaviour definition, and the contribution other researchers made to it, was used to develop an information behaviour framework for the study. In an in depth literature review it was learnt that engineering work is about team work and that engineers rely on their personal knowledge and expertise, as well as the knowledge and expertise of other experts in the field. This was confirmed by the findings of the empirical study. Throughout the literature review it was shown that the interaction between elements in the context and the personal dimension gives rise to information needs, which in turn prompt certain information behaviour activities. Narrative inquiry, a relatively new information behaviour data collection and analysis technique, guided the study. Fifteen consulting engineers who are involved in building projects participated in the study. Two chapters were dedicated to data analysis where the engineers' stories of an engineering project were re-storied to learn more about the context of engineering work and how engineers operate. The findings revealed that the team members of projects involving consulting engineers come from different organisations. It was found that consulting engineers collaboratively seek, gather, use, communicate and share information. Interdependency emerged as a prominent element in the effective structures of consulting engineers' personal dimension and evidently plays an important role in collaborative information behaviour in consulting engineers' team work. It serves as a contributing factor in the natural forming of their social networks, which proved to be important sources of engineering information. The findings contributed to the refinement of the information behaviour framework developed for the purpose of this study. The framework graphically illustrates consulting engineers' information behaviour. This study contributes to an understanding of the important role social networks play in consulting engineers' successful accomplishment of engineering projects in everyday life.

Keywords: information behaviour; consulting engineers; social networks; social networking; narrative inquiry

ACKNOWLEDGEMENTS

Completing this study has been a long journey. During this journey new friendships were fostered and old ones strengthened. It also required lots of support from a number of people and there are not enough words to say thank you, and most probably some important persons might be missed. However, some persons played a vital role in the successful completion of this study. My thanks therefore go to Prof Hester Meyer for her guidance and patience. Thank you for the many hours we spent together talking about information behaviour. You were not only my study leader, you were also my mentor and I will always treasure the friendship that was forged throughout this journey. A thank you is also due to Prof Ina Fourie for her initial interest and guidance. It was Prof Fourie who introduced me to the idea of using narrative inquiry as a research method.

An empirical study cannot be completed without a group of respondents. A huge thank you goes to the fifteen consulting engineers who made some of their precious time available to discuss their engineering projects with me and share their experiences of information use. Without your time, energy and willingness I would never have been able to complete this journey.

Family members are often neglected when one is involved in a postgraduate study. Thank you Pieter, my dear and patient husband for supporting me in realising this dream. I realise the many evenings, weekends and often holidays spent alone, because I was working on this thesis, were not easy and yet you hardly ever complained. Thank you also goes to my children, Werna and Gary Oberholzer, Willem and Jenny du Preez and Francois du Preez and Michelle Steynberg. Your encouragement and silent support are truly valued.

I was privileged to have the support of my mother, Werna Schiel and that of my two brothers Reinhard and Carlie.

The contributions colleagues make in such a study is seldom valued. However, if it wasn't for your support and encouragement, I might have given up long before the journey was completed and might have rather focused on teaching alone. In addition to my colleagues, also thank you to Unisa who made funding available for the study and allowed for time away from the office to focus on my research. Without this time and financial support, this study would never have happened.

An editor's contribution to a thesis is seldom acknowledged. However, a big thank you is due to Christine and Susan Swanepoel who edited this thesis with great care. Your contribution to the final preparation of this document is appreciated.

In conclusion, thanks go to the Lord Almighty for the opportunity, health and energy to complete this study.

LIST OF ABBREVIATIONS AND ACRONYMS

BoQ	Bill of quantities
CCTV	Closed circuit television
CESA	Consulting Engineers South Africa
CoC	Certificate of compliance
CPD	Continuing professional development
DoD	Department of Defence
DoPW	Department of Public Works
ECSA	Engineering Council of South Africa
FTP	File Transfer Protocol
IEEE	Institute of Electric and Electronics Engineers
ISU	Information-seeking and using
IT	Information technology
LIS	Library and information science
NASA	National Aeronautics and Space Administration
PA	Principal agent
PMI	Project Management Institute
R&D	Research and development
R&F	Records for Future
QS	Quantity surveyor
STI	Scientific and technical information

TABLE OF CONTENTS

CHAPTER 1 ... 1

GENERAL INTRODUCTION ... 1

1.1 INTRODUCTION ... 1

1.2 BACKGROUND ... 1

1.3 RESEARCH PROBLEM ... 6

1.3.1 Objectives of the study ... 6

1.3.2 Research questions ... 6

1.4 LITERATURE REVIEW ... 7

1.5 IMPORTANCE OF THE STUDY ... 8

1.5.1 Theoretical contributions ... 8

1.5.2 Research methodological contributions ... 9

1.5.3 Practical contributions ... 9

1.6 METHODOLOGY ... 9

1.6.1 Ethics ... 10

1.6.2 Delimitation of the study ... 10

1.7 KEY CONCEPTS ... 10

1.7.1 Collaboration ... 10

1.7.2 Collaborative information behaviour ... 11

1.7.3 Components and elements within information behaviour ... 11

1.7.4 Consulting engineers ... 12

1.7.5 Context ... 12

1.7.6 Encountering ... 13

1.7.7 Engineering contexts ... 13

1.7.8 Information ... 13

1.7.9 Information behaviour ... 14

1.7.10 Information (behavioural) activities ... 14

1.7.11 Information needs ... 14

1.7.12 Information seeking 15
1.7.13 Information sharing 15
1.7.14 Personal dimension 16
1.7.15 Situation awareness 16
1.7.16 Social networking 16
1.7.17 Social networks 17
1.7.18 Tasks 17
CHAPTER 2 20
CONCEPTUALISING INFORMATION BEHAVIOUR: A LITERATURE REVIEW 20
2.1 INTRODUCTION 20
2.2 BACKGROUND 20
2.3 DEFINING INFORMATION BEHAVIOUR 21
2.3.1 Information activities 24
2.3.2 Personal dimension 25
2.3.3 Context 27
2.3.4 Information needs 33
2.4 CONSIDERING KEY COMPONENTS FOR AN OPERATIONAL DEFINITION OF INFORMATION BEHAVIOUR 40
2.5 OPERATIONAL DEFINITION OF INFORMATION BEHAVIOUR 42
2.6 CONCLUSION 43
CHAPTER 3 44
INFORMATION BEHAVIOUR IN ENGINEERING PRACTICES 44
3.1 INTRODUCTION 44
3.2 BACKGROUND 44
3.3 ENGINEERING CONTEXT 45
3.3.1 Profession 45
3.3.2 Discipline 47
3.3.3 Education and training 48

3.3.4 Membership of statutory bodies and learned societies 48
3.3.5 Nature of work in an engineering practice....50
4. Verbally encoded information (papers and discussion) Physically encoded information (products)....58
3.3.6 Engineering projects....59
3.3.7 Practice and work environment 61
3.3.8 Reflection on the engineering context....67
3.4 PERSONAL DIMENSION OF ENGINEERS....68
3.4.1 Cognitive phenomena 68
3.4.2 Conative phenomena 70
3.4.3 Affective phenomena....72
3.5 INFORMATION NEEDS....73
3.5.1 Contextual determinants of information needs....74
3.5.2 Personal dimension....76
3.5.3 Reflection on engineers' information needs....77
3.6 ENGINEERS' INFORMATION ACTIVITIES 78
3.6.1 Information seeking....78
3.6.2 Information searching....81
3.6.3 Awareness of information and information encountering 81
3.6.4 Information use 82
3.6.5 Information transfer and information communication 84
3.6.6 Information sharing....85
3.6.7 Reflection on engineers' information activities 85
3.7 THE MANIFESTATION OF INFORMATION BEHAVIOUR IN THE ENGINEERING CONTEXT....86
3.8 CONCLUSION 90
CHAPTER 4....91
INFORMATION BEHAVIOUR OF CONSULTING ENGINEERS 91

4.1 INTRODUCTION 91
4.2 BACKGROUND 91
4.3. CONSULTING INDUSTRY 92
4.3.1 Contextual elements 93
4.3.2 Personal dimension of consultants 98
4.4 CONTEXT OF CONSULTING ENGINEERING 101
4.4.1 Projects 101
4.4.2 Work roles 105
4.4.3 Tasks 106
4.5 PERSONAL DIMENSION OF THE CONSULTING ENGINEER 107
4.5.1 Cognitive phenomena 107
4.5.2 Conative phenomena 109
4.5.3 Affective 110
4.6 CONSULTING ENGINEERS' INFORMATION NEEDS 111
4.6.1 Contextual factors 111
4.6.2 Personal dimension 114
4.6.3 Reflection on information needs 114
4.7 INFORMATION ACTIVITIES 116
4.7.1 Information seeking 116
4.7.2 Information gathering 119
4.7.3 Awareness of information and information encountering 120
4.7.4 Information use 120
4.7.5 Communication 121
4.7.6 Reflection on information activities 122
4.8 MANIFESTATION OF CONSULTING ENGINEERS' INFORMATION BEHAVIOUR 124
4.9 CONCLUSION 126
CHAPTER 5 127

ENGINEERS' COLLABORATIVE INFORMATION BEHAVIOUR 127
5.1 INTRODUCTION 127
5.2 BACKGROUND 127
5.3 COLLABORATION 129
5.4 CONTEXTUAL ELEMENTS AFFECTING COLLABORATION 131
5.4.1 Organisations 131
5.4.2 Organisational culture 132
5.4.3 Social norms 133
5.4.4 Social networks 134
5.4.5 Resources 136
5.4.6 Projects 139
5.4.7 Work roles 140
5.4.8 Tasks 141
5.4.9 Reflection on contextual elements 142
5.5 PERSONAL DIMENSION 143
5.5.1 Cognitive phenomena 143
5.5.2 Conative phenomena 144
5.5.3 Affective phenomena 145
5.5.4 Reflection on the personal dimension component 147
5.6 INFORMATION NEEDS 148
5.6.1 Information needs deriving from context 148
5.6.2 Information needs deriving from the personal dimension 151
5.6.3 Reflection on information needs 152
5.7 COLLABORATIVE INFORMATION ACTIVITIES 153
5.7.1 Collaborative information seeking 154
5.7.2 Communication 157
5.7.3 Information sharing 160

5.7.4 Reflection on collaborative information activities.....163
5.8 MANIFESTATION OF ENGINEERS' COLLABORATIVE INFORMATION BEHAVIOUR 164
5.9 CONCLUSION.....166
CHAPTER 6.....168
RESEARCH METHODOLOGY.....168
6.1 INTRODUCTION.....168
6.2 BACKGROUND.....168
6.3 RESEARCH IN INFORMATION BEHAVIOUR.....169
6.4 QUALITATIVE RESEARCH.....170
6.5 NARRATIVE INQUIRY.....173
6.5.1 Temporality.....175
6.5.2 People's stories.....176
6.5.3 Action.....177
6.5.4 Certainty.....177
6.5.5 Context.....178
6.6 DATA COLLECTION.....178
6.6.1 Consent.....179
6.6.2 Sampling.....179
6.6.3. Interviews.....182
6.6.4 Reliability and validity.....189
6.7 DATA ANALYSIS.....194
6.8 CONCLUSION.....195
CHAPTER 7.....197
STORY OF ENGINEERING PROJECTS.....197
7.1 INTRODUCTION.....197
7.2 BACKGROUND.....197
7.3 ENGINEERING PROJECTS AND PROJECT TEAMS.....198

7.3.1 Client 200
7.3.2 Community leaders 201
7.3.3 Appointments to engineering projects 201
7.4 ENGINEERING PROJECT STAGES 208
7.4.1 Inception stage 209
7.4.2 Concept viability 211
7.4.3 Detail design 216
7.4.4 Documentation and procurement 221
7.4.5 Contract administration and inspection 223
7.4.6 Close-out 229
7.5 REFLECTION 230
7.5.1 Context 231
7.5.2 Personal dimension 233
7.5.3 Information activities 234
7.6 CONCLUSION 238
CHAPTER 8 240
REPORTING ON CONSULTING ENGINEERS' INFORMATION BEHAVIOUR 240
8.1 INTRODUCTION 240
8.2 BACKGROUND 240
8.3 THE INFLUENCE OF CONTEXT ON INFORMATION BEHAVIOUR 241
8.3.1 Engineering profession 241
8.3.2 Organisational context 245
8.3.3 Projects 254
8.3.4 Work roles 262
8.3.5 Tasks 263
8.3.6 Reflection on the influence of context in information behaviour 263
8.4 PERSONAL DIMENSION 264

8.4.1 Cognitive element....................264
8.4.2 Conative element....................266
8.4.3 Affective element....................268
8.4.4 Reflection on the personal dimension....................271
8.5 INFORMATION NEEDS....................272
8.5.1 Information needs arising from the context....................273
8.5.2 Information needs arising from the personal dimension....................276
8.5.3 Reflection on information needs....................278
8.6 INFORMATION ACTIVITIES....................279
8.6.1 Collaborative information seeking....................279
8.6.2 Awareness and encountering....................282
8.6.3 Information gathering....................282
8.6.4 Information use....................283
8.6.5 Communication....................285
8.6.6 Information sharing....................290
8.6.7 Reflection on collaborative information activities....................293
8.7 MANIFESTATION OF CONSULTING ENGINEERS' INFORMATION BEHAVIOUR....................294
8.8 CONCLUSION....................297
CHAPTER 9....................298
CONCLUSIONS, LIMITATIONS AND RECOMMENDATIONS....................298
9.1 INTRODUCTION....................298
9.2 CONCLUSIONS TO THE RESEARCH QUESTIONS....................298
9.2.1 Research question one: What are the key concepts contributing to the information behaviour of consulting engineers?....................299
9.2.2 Research question two: Which elements are typical of consulting engineers' work environment?....................301
9.2.3 Research question three: Which elements in the personal dimension of consulting engineers affect their information behaviour?....................305

9.2.4 Research question four: Which information needs necessitate collaboration among team members of a consultancy engineering project? 308
9.2.5 Research question five: What information activities arise from the interaction between the engineering context and the personal dimension of consulting engineers? 310
9.2.6 Research question six: Which sources of information take preference during task completion of a consulting engineer's project? 314
9.2.7 Concluding answer to the overall research question 314
9.3 LIMITATIONS OF THIS STUDY 315
9.3.1 Limitations of the literature study 316
9.3.2 Limitations of the empirical study 316
9.4 RECOMMENDATIONS 317
9.5 FUTURE RESEARCH 317
9.6 VALUE OF THIS STUDY 319
9.6.1 Methodological contribution 319
9.6.2 Conceptual framework for consulting engineers' information behaviour 320
9.6.3 Social networks as sources of engineering information 320
9.7 SUMMARY AND FINAL COMMENTS 321
LIST OF REFERENCES 322
APPENDIX A 352
APPENDIX B 354
PERSONAL INFORMATION 354

LIST OF TABLES

Table	DESCRIPTION	PAGE
Table 3.1	A profile of engineers' information needs	77
Table 3.2	A profile of engineers' information activities	86
Table 4.1:	A profile of consulting engineers' information needs	115
Table 4.2:	A profile of consulting engineers' information activities	123
Table 5.1	A profile of collaborative information needs	153
Table 5.2	A profile of collaborative information activities	164
Table 6.1	Respondents' profiles	182

LIST OF FIGURES

FIGURE	DESCRIPTION	PAGE
Figure 2.1	Graphic representation of the components that affect information behaviour	42
Figure 3.1	Information processing in technology (Thomas Allen 1977:4)	58
Figure 3.2	Basic components of engineers' information behaviour	89
Figure 4.1:	Core components contributing to the information behaviour of consulting engineers.	125
Figure 7.1	Depiction of consulting engineers' collaborative information behaviour	235
Figure 7.2	Consulting engineer's network of projects	237
Figure 8.1	Framework of consulting engineers' collaborative information behaviour	296

CHAPTER 1

GENERAL INTRODUCTION

1.1 INTRODUCTION

People work and live in social settings and these settings motivate them to use information (Wilson 2006: 666). Researchers in the field of information behaviour are especially interested in how people in a group context make use of this phenomenon to interact with each other. As a result, the phenomenon "social networking" currently receives a lot of attention in different fields of research, for example, management sciences, communication studies, information science and information communication technologies. This study will focus on a group of South African consulting engineers residing in the Gauteng Province, to acquire an understanding of the role their project teams and social networks have on their information behaviour.

In addition, the purpose of this study is to determine to what extent social networks contribute to our understanding of the information behaviour phenomenon in general. In order to determine the core problem and the variables initiating the use of social networks among consulting engineers, the following section provides background to the context in which consulting engineers operate. From this background the research problem will be formulated, the key concepts of the study identified and a brief indication of the proposed research methodology for the study will be given.

1.2 BACKGROUND

The focus of information behaviour studies is to acquire an understanding of "all instances where people interact with their environment in such a way that leaves some impression on them" (Bates 2009: 2381). Bates (2009: 2382) argues that library and information services are one such environment that initially received substantial attention in information behaviour research. Bates' (2009) argument is supported by Fisher and Naumer (2006: 93), Vakkari (2003: 416) and Wildemuth and Case (2009: 35). These researchers observed that early information behaviour researchers focused their studies on information systems or services. They also noted that early information behaviour researchers looked at the use that was being made of those systems and services in order to improve information services and information systems. Examples of studies that focused on the improvement of information systems are the studies conducted by Belkin, Oddy and Brooks (1982), Taylor (1968), and Wilson (1973).

Other environments in which the information behaviour phenomenon is also studied are the work-related environment (vocational setting) and every-day life information setting. During the 1980s, information behaviour researchers shifted their focus to the work environment (Bawden 2006: 672). Of particular interest to this study are the professional groups that were researched in their work-related environments. These included scientists, engineers, veterinarians, auditors, lawyers, health care professionals, dentists and scholars (Bawden 2006: 672; Case 2006: 295-301; Cheuk Wai-Yi 1998; Fisher & Julien 2009: 320-325; Leckie, Pettigrew & Sylvain 1996).

During the 1990s and 2000s, information behaviour researchers expanded their focus by incorporating individuals' total environment when investigating their information behaviour (Bates 2009: 2387). Furthermore, these later studies recognised the effect that the social context and the social situation have on people's information behaviour. Studies with this focus primarily investigated individuals' information behaviour within the context of their social networks. In these studies the concept "social network" relates to the communication among individuals, with reference to patterns of connection and resonance interaction (Sonnenwald 1999: 180; Wellman & Berkowitz 1988: 4,16).

Engineers are professionals whose work environments seem to affect their information behaviour considerably. This is an aspect that has interested a number of information behaviour researchers. As a result, various studies have been conducted on engineers' work-related information behaviour. According to Leckie, Pettigrew and Sylvain (1996) and Pinelli, Bishop, Barclay and Kennedy (1992), these studies investigated the information sources engineers used, factors that affected their source selection and the social networks that supported their information-seeking activities. However, none of these studies seemed to have focused on the role, or the potential influence that engineers' social networks could have on their information behaviour.

Based on their literature review, Tenopir and King (2004: 75) found that the nature of engineers' work and the tasks they need to complete affect their information behaviour. Tenopir and King's (2004) findings are supported by Pinelli's (2001: 140) description of engineering work as fundamentally being both a "social and technical activity".

In order to do their work, engineers seem to work in teams (often simultaneously on multiple projects) and individual engineers coordinate and integrate their work (Kwasitsu 2003: 466). An important observation made by Sonnenwald (1996: 279) is that engineers' work teams include participants from different disciplines, organisations and cultures. She ascribes this phenomenon to the fact that the creation of innovative artefacts may require specialists from a variety of disciplines and contexts. The required specialists might not necessarily work in one organisation or even in the same country. This explains why Pinelli (2001: 140) observed that the completion of an engineering project is dependent on the individual engineer's ability to maintain successful social relationships with vendors and personal relations among work team members.

Pinelli's (2001) and Sonnenwald's (1996) observations that engineers tend to work in groups, are supported through the research findings of a number of information behaviour studies. These include the studies conducted by Allard, Levine and Tenopir (2009: 453); Anderson, Glassman, McAfee and Pinelli (2001); Du Preez (2008: 329-330); Ellis and Haugan (1997: 393); Fidel and Green (2004: 577-578); Hansen (2002); Hertzum (2002); Hertzum and Pejtersen (2000); Hirsh (1999); Hirsh and Dinkelacker (2004: 808); Hurd, Weller and Curtis (1992: 137); Palmer (1993: 77); Robinson (2010: 656) and Shuchman (1981: 168). Some of the reasons that these researchers assign to engineers' reliance on personal relations and personal contacts for information, which relate to the nature of engineering work, are: the engineering discipline, inherent personalities of engineers, engineers' ways of addressing problems, and their learning styles. From the reasons given it seems that the working environment, personal traits and interpersonal relations could be some of the aspects that can influence engineers' information behaviour.

In line with the observations made by Pinelli (2001) and Sonnenwald (1996), Du Preez (2008) observed during her research on the information-seeking behaviour of consulting engineers in South Africa that her target group relied heavily on their social networks as sources of project-related information. The respondents in her study indicated a dual purpose during interacting. That is, they not only need to communicate specific project-related information to their team members, but also need to seek specific project-related information from team members. From the interviews, it became apparent to Du Preez (2008) that certain project-related information can only be acquired from the engineers' clients or work team members. In such instances these persons were the engineers' only sources of task-related information. Therefore, it seems that consulting engineers have a preference for personal contacts, depending on the situation. This could explain Hertzum and Pejtersen's (2000: 776) findings, indicating that engineers would sometimes seek documents to find people.

However, despite research findings indicating engineers' preference for personal contacts as sources of engineering information, only a few studies addressed the nature of engineers' social network-related information behaviour. These include the studies conducted by Allen (1977); Bruce, Fidel, Pejtersen, Dumais, Grudin and Poltrock (2003); Fidel, Pejtersen, Cleal and Bruce (2004); Kremer (1980) and Zipperer (1993). The focus of these studies was on the flow of information in an organisation, the motives for engineers' collaborative information retrieval, and only one analysis of engineers' social networks.

Apart from the possible effect engineering work and engineers' social networks could have on their information behaviour, engineering projects also seem to have an effect. The possible effect engineering projects could have on engineers' information behaviour relate to the fact that engineers could be simultaneously involved in more than one project (Du Preez 2008: 173, 348; Du Preez & Meyer 2011: 82; Kwasitsu 2003: 462); engineering projects are subdivided into project stages (Allen 1966; Aurisicchio, Bracewell & Wallace 2010: 711; Du Preez 2008: 176-177; Ellis & Haugan 1997: 386; Freund, Toms & Waterhouse 2005); engineering projects need to be completed within a specified timeframe (Allard, Levine & Tenopir 2009: 445; Hertzum & Pejtersen 2000: 776; Hirsh 1999: 476; Robinson 2010: 655), and that each engineering project has a project budget (Fidel & Green 2004: 568).

It was not the first priority of the above-mentioned studies to investigate the possible effect that engineers' social networks have on their task-related information behaviour. Therefore, it seems likely that not much attention has been given to engineers' use of people as sources of information. However, some suggestions were made by a few information behaviour researchers for studies focusing on people as sources of engineering information. These include studies modelling people as sources of information (Hertzum & Pejtersen 2000: 776); studies determining the extent to which engineers depend on their colleagues (Tackie & Adams 2007: 77) and studies focusing on how engineers decide whom to ask (Robinson 2010: 656). These findings are especially important since they endorse Granovetter's (1973: 1366) statement that people tend to be motivated to seek information from resources available to them within their initial social network.

From this discussion it seems as if information behaviour studies focusing on engineers did not consider the project-related work environment of engineers, which is the context in which engineers' information behaviour manifests itself. Furthermore, engineers work in teams that include persons from different disciplines, organisations and even cultures. The social interaction among team members has a dual purpose: that is, sharing information with team members, as well as seeking information from team members. What impact the social context (the engineering project) and the social situation have on engineers' information behaviour is also not reflected in the literature.

From the discussion so far it seems clear that the problem areas summarised below have not been adequately addressed in the literature, and therefore require further investigation regarding:

1. the information behaviour of consulting engineers within their work context,
2. consulting engineers' collaborative information behaviour activities, such as information seeking, sharing and communicating, and
3. the use of social networks as a resource in consulting engineers' task completion.

1.3 RESEARCH PROBLEM

As indicated in the background to this chapter, people are often engineers' only sources of certain project-related information. Furthermore, engineers (including consulting engineers) can be simultaneously involved in different engineering projects. Each project therefore provides the context in which engineers' conduct certain information actions that reflect their information behaviour. Consulting engineers seem to be to a large extent dependent on personal contacts to provide them with information for decision-making during different phases of a project. Therefore, the core question for this study can be formulated as follows:

> What is the role of social networks in consulting engineers' information behaviour – with special reference to consulting engineers in South Africa?

1.3.1 Objectives of the study

This study has four objectives:

- to investigate the information behaviour of consulting engineers in their work context
- to investigate consulting engineers' collaborative information behaviour activities, such as collaborative information seeking, sharing and communication
- to investigate and acquire an understanding of the influence that consulting engineers' social networks has on their task-related information behaviour
- to develop a model that would support information behaviour studies focused on social networks as a resource in task completion.

1.3.2 Research questions

In order to investigate the core question and to achieve the objectives of this study, it is necessary to address the following research questions:

1. What are the key concepts contributing to the information behaviour of consulting engineers?
2. Which elements are typical of consulting engineers' work environment?
3. Which elements in the personal dimension of consulting engineers affect their information behaviour?
4. Which information needs necessitate collaboration among team members of a consultancy engineering project?
5 What information activities arise from the interaction between the engineering context and the personal dimension of consulting engineers?
6. Which sources of information take preference during task completion of a consulting engineering project?

1.4 LITERATURE REVIEW

The literature review of this study comprises four chapters. The information behaviour literature was first reviewed to acquire an understanding of the key concepts that are essential to an understanding of consulting engineers' information behaviour. Wilson's (1999: 249; 2000: 49) encapsulating information behaviour definition guided this discussion and the development of a framework to guide the study. The consecutive three literature review chapters provides the background to the information behaviour of engineers in general, on consulting engineers in particular, and on collaborative information behaviour. Certain information behaviour themes could be identified from the literature review chapters to support data analysis in the empirical component of the study.

The identified information behaviour themes that are important to this study are: context, the personal dimension, information needs and information activities.

In order to conduct the literature review for this study, the researcher was guided by the review by King, Casto and Jones (1994). This review is fairly comprehensive and reports on 456 studies on engineers' means of communications. The studies in their review are grouped into the following three main focal points:

- The use engineers make of information.
- Interpersonal scientific and technical information (STI) communication.
- Information behaviour research approaches.

Although guided by the studies mentioned above, the literature review for this research proposal was extended to include searches for “information behaviour and engineers”, “information-seeking and engineers”, “social networking and engineers”, “collaborative working and engineers”, and “collaborative learning and engineers” in various bibliographic databases, the Internet as well as specific open access journals that are available on the Internet. Table of contents alerts were set up for all journals in which useful articles were found to ensure the researcher remained updated for the duration of the study.

1.5 IMPORTANCE OF THE STUDY

The importance of a study is measured in terms of the theoretical, methodological and practical contributions it makes.

1.5.1 Theoretical contributions

The aim of this study is to explore the role of social networks and work teams in the information behaviour of consulting engineers during task completion of an engineering project. Cibangu (2013) and Vakkari (2008) are both concerned with the lack in theoretical contributions made by studies in the field of information science. By probing the information behaviour literature to address the required research elements (i.e. what, how, why, who, when, and where) for theory building, as identified by Cibangu (2013: 196), this study endeavours to make a theoretical contribution to information behaviour research.

The first theoretical contribution is made through the development of a conceptual framework that could be used to explore the information behaviour of professional groups such as consulting engineers. The development of such a conceptual framework can contribute to a better understanding of the role of social networking in the information behaviour of professionals.

The second theoretical contribution is the contribution that is made to the existing knowledge of the information behaviour of consulting engineers. This is important since "engineering is a diverse profession and there are some specific differences in communication patterns within the various subfields and branches as a result of this diversity" (Tenopir & King 2004: 72,74). Only a few studies have been conducted on the information behaviour of consulting engineers. These include the studies by Du Preez (2008), Gralewska-Vickery (1976) and Ward (2001).

1.5.2 Research methodological contributions

Research contributions are made when a research approach or design guides a study which was not or is seldom used to guide studies in a specific field of interest. Narrative inquiry is a research approach and method that has seemingly not been used much in information behaviour research. By possibly being the first information behaviour study focusing on engineers that used narrative inquiry as a research approach and method, this study also makes a research contribution.

1.5.3 Practical contributions

A study into the project-related flow of information among professional team members can assist project leaders to adequately manage personal information communication in a project. Therefore, the findings from this study could guide the development of an information system to assist engineers in finding people. Such a development would support Fidel and Green's (2004: 579) and Hertzum and Pejtersen's (2000: 775) call for such a system. Fidel and Green (2004: 578) reckon that encouraging engineers to create and maintain such networks will increase the number of people the engineer knows, both inside and outside an organisation.

1.6 METHODOLOGY

The nature of the study requires an understanding of the variables in the consulting engineer's work environment and their involvement in engineering projects that shape their information behaviour. As opposed to quantitative studies, which are focused on confirming phenomena rather than understanding them, this study followed a qualitative research approach. It is a phenomenological study and falls within the interpretivist research paradigm. Narrative inquiry was deemed the most suitable research method for the study. This is because narrative inquiry is a conversation between theory and life. It also studies the experiences of people as stories and the objective is to adopt a particular view of experience as phenomenon under study (Connelly & Clandinin 2006: 477). The literature reviews focusing on research methodology in information science that were conducted by Cibangu (2013), Fidel (1993), Sutton (2009), Vakkari (2008) and Wang (1999) did not report on narrative inquiry as a research method.

1.6.1 Ethics

Ethical conduct is important in research. In order to comply with the ethical requirements of a study, the responding engineers were asked to sign a consent form prior to the narrative interviews. A copy of the consent form appears in Appendix A.

1.6.2 Delimitation of the study

The field of engineering is vast and engineers work in a variety of fields, which could vary from academia to consulting engineering, to name but two possibilities. This study is limited to consulting engineers involved in the building industry in South Africa. This decision does not negate the possibility that other types of consulting projects could prompt different information needs and activities.

1.7 KEY CONCEPTS

The key concepts for this study are information, information behaviour, information-seeking, information needs, tasks, collaboration, social networking, information sharing, situation awareness, and context.

1.7.1 Collaboration

Sonnenwald (2003: 68; 2008: 645) defines scientific collaboration as the “interaction taking place within a social context among two or more scientists that facilitates the sharing of meaning and completion of tasks with respect to a mutually shared, superordinate goal.”

Both engineers and scientists work in structured social settings where they systematically interact with colleagues (Pinelli 2001: 142). These can be described as interpersonal networks of co-workers (Savolainen 2009: 39). The ways in which their social settings are structured influence their information behaviour. In view of these findings, the above definition is applicable to both engineers and scientists.
Within the context of this study, collaboration is viewed as the social interaction that takes place among the team members of an engineering project, which facilitates the seeking and sharing of information, to ensure the successful completion of the engineering project they were commissioned for.

1.7.2 Collaborative information behaviour

With the definition of collaboration by Sonnenwald in the preceding paragraph in mind, and in view of the accepted definition for information behaviour (section 1.7.9), collaborative information behaviour is defined for the purposes of this study as the interaction and behaviour of a group of persons in relation to sources and channels of information. This includes their collaborative activities dealing with the seeking, sharing and communication of information.

1.7.3 Components and elements within information behaviour

In the information behaviour literature, Savolainen (2014) refers to "conceptual chaos" when he discusses the interchangeable use of terminology. One such example is the interchangeable use of components and elements. However, in mathematics, "components" is defined as "a subset of a set, not contained in any other connected subset of the set" (Dictionary.com 2015). As an adjective, Dictionary.com (2015) describes components as "forming or functioning as a part or aspect; a constituent". With these two definitions, and with the purpose of this study in mind, a component is viewed as a subset of the conceptual framework that is used to guide the study.

Dictionary.com (2015) also offers the following mathematical definition for "elements": "an entity that satisfies all the conditions of belonging to a given set". In consideration of these definitions, components and elements are synonymous as both refer to parts of units. However, Dictionary.com (2015) notes that the term “elements” denotes a fundamental part, whereas components make up a compound system. With this in mind, elements are viewed as being subordinate to components and each of the components in the suggested information behaviour conceptual framework includes a number of elements.

1.7.4 Consulting engineers

In view of the findings reported on by Du Preez (2008: 174) and Gralewska-Vickery (1976: 266), consulting engineers can be defined as being experts in their field of engineering. They work in diverse environments, are employed by clients for their advice and guidance, to design systems, and to manage, upon the directives of their clients, the completion of engineering projects. Furthermore, they have nothing to sell except their service, time, knowledge and judgement. This definition is accepted for the purpose of this study.

1.7.5 Context

Context is a “kind of time-space ‘container’ where phenomena reside and activities take place, constrained by the boundaries of the context” (Savolainen 2009: 38). Context also is “something that people do” (Dourish 2008: 22) and it is “embedded in action and practices” (Savolainen 2009: 39).

Social contexts, such as organisations and work teams, provide the context within which information is shared (Sonnenwald 2008: 645). Social networks can also provide the contexts for information seeking and sharing (Courtright 2007: 281-284). Since social relations among people persist irrespective of whether the organisational context or tools are changing around them (Hirsh & Dinkelacker 2004: 808), engineering work teams can form the foundation for engineers’ social networks. In this study, consulting engineers’ organisations, client organisations, work teams and consulting engineers’ social networks can be regarded as elements of the engineering context within which information behaviour manifests itself.

1.7.6 Encountering

Based on Erdelez's (1997; 2005) research, Case (2007: 331) defines encountering) as the "accidental or serendipitous exposure to information that turns out to be relevant to a pre-existing information need, or which sparks curiosity about an emerging topic of interest". For purpose of this study, encountering is viewed as a subconscious information-seeking activity which manifests itself in consulting engineers' activities where they consciously observe their environment for possible information that could support them in their work.

1.7.7 Engineering contexts

As in the definition for context (section 1.7.5), engineering contexts refer to the contexts in which consulting engineers work and in which information behaviour manifests itself. In this study, the engineering context includes various contexts such as the engineering profession and the consulting industry. Also, the consulting industry context consists of a number of elements such as organisations, social networks and project teams.

1.7.8 Information

Krikelas (1983: 6) views information as "any stimulus that reduces uncertainty". When following Case's (2007: 40) definition, this stimulus can "come from whatever appears significant to a human being, whether this [stimulus] originates from an external environment [e.g. a work task] or a psychologically internal world [e.g. personal knowledge, personal experience and personal views]".

Jaeger and Burnett (2010: 14) understand information as "the sum total of the content – facts, knowledge, feeling, opinions, symbols, and context – conveyed through communication between individuals or groups through any physical or virtual medium".

In the context of this study, information can imply any stimulus that comes from consulting engineers' projects or existing information that could assist them in solving a problem that arises from these projects. Such information can be derived from the engineering project itself, for example, the designs of fellow professional team members. Alternatively this could also be information conveyed to them by their clients, suppliers and contractors, or information retrieved from printed documents such as text books, manuals, engineering codes of practice and regulations.

1.7.9 Information behaviour

Wilson (1999: 249; 2000: 49) defined information behaviour as “the totality of human behaviour in relation to sources and channels of information, including both active and passive information seeking and information use”. This definition of information behaviour “encompasses face-to-face communication with others as well as the passive reception of information without any intention to act on the information given” (Wilson 2000: 1). This includes the activities dealing with the generation, communication, use, information-seeking and interactive information retrieval (Ingwersen & Järvelin 2005: 384). People working in the same area can also filter information before passing it on to their colleagues (Ellis & Haugan 1997: 399).

In this study, the emphasis will be on the information seeking and sharing of consulting engineers, which are two collaborative information activities.

1.7.10 Information (behavioural) activities

For the purpose of this study, Wilson’s (1999: 249; 2000: 49) explanation, that information behaviour is observable in information activities, is accepted. He emphasised information seeking and use as information behaviour activities. However, other information activities are also important to this study. These include searching, sharing, communication and social networking.

1.7.11 Information needs

Krikelas (1983: 6) defines an information need as recognition of the existence of an uncertainty in the personal or work-related life of an individual that can be reduced or solved through the use of information. Such an information need then often triggers information-seeking behaviour (Savolainen 2007: 114).

Case’s (2007: 333) explanation of an information need can be used to contextualise information needs within the parameters of this study: “information needs arise when individuals sense a problematic situation or information gap, in which their internal knowledge and beliefs, and model of the environment fail to suggest a path towards the satisfaction of their goals”.

In the context of this study, information needs are consulting engineers’ need for information to successfully complete specific tasks (e.g. completing the design for a project or constructing the design) of an engineering project for which they were commissioned.

1.7.12 Information seeking

Information seeking refers to “any activity of an individual that is undertaken to identify a message [information] that satisfies a perceived need [for information]” (Krikelas 1983: 6). Furthermore information seeking is a form of human behaviour that involves “the active examination of information sources … to satisfy the information need, or to solve a problem” (Ingwersen & Järvelin 2005: 386). This implies that information seeking is “just as much about making coherent sense of information as it is about finding extant information” (Karamuftuoglu 1998: 1070; 2008: 958). Information seeking can, however, be an individual or collaborative activity (Prekop 2002: 535).

In the context of this study, this definition of information seeking does not determine the type of information sources from which consulting engineers may seek information. However, the definition includes information seeking from both formal and informal sources of information, irrespective of whether the information source is a personal contact, a printed or a digital source.

1.7.13 Information sharing

“Information sharing is fundamentally a social act” (Burnett 2000: 2) and an essential activity in collaborative work (Sonnenwald 2006: 1). It includes the provision of information, confirmation that the information has been received, and confirmation that the information is understood by all (Sonnenwald 2006: 1).

In this study, information sharing refers to all the activities that consulting engineers embark on to communicate their engineering designs in a project and the requirements of their designs (e.g. physical space, electricity and water supply, costs, etc.) to their project-related network to ensure access to all members involved.

1.7.14 Personal dimension

The personal dimension refers to users' inner mental states (Hepworth 2007: 4) or mental structures (Nahl 2001: 1) that are associated with information behaviour. Three inner mental states are identified by Hepworth (2007: 41). They are: cognitive (i.e. thinking processes), conative (inherent factors that affect behaviour such as motivation) and affective responses (e.g. trust). The term "inner mental states" will be used in this study.

1.7.15 Situation awareness

Situation awareness is an important component of collaboration (Sonnenwald, Maglaughlin & Whitton 2004: 990) and can be defined as the "continuous extraction of environmental information, integration of this information with previous knowledge to form a coherent mental picture in directing further perception and anticipating future events" (Vidulich, Dominguez, Vogel & McMillan in Sonnenwald, Maglaughlin & Whitton 2004: 990). This requires an understanding of the integrated meaning of what is being perceived in light of individual goals before a suitable action can be chosen (Endsley 1995: 33-34), thus integrating "individual and social levels of cognitive orientation" (Cool 2001: 25). In this study, situation awareness refers to consulting engineers' abilities to identify information that is relevant to their task completion, understand the situation and base their decisions on their knowledge and understanding of the situation.

1.7.16 Social networking

Social networking is defined by Rouse (2006) as "the practice of expanding the number of one's business and/or social contacts by making connections through individuals".

In this study, social networking refers to the conscious activities that consulting engineers engage in to develop their personal relationships with clients and other role players in engineering projects, with the view of expanding their business and social contacts.

1.7.17 Social networks

Social networks are social systems (Huemer, Von Krogh & Roos 1998: 134) and refer to the existing relationships and interaction between actors, the availability of resources within the network and the exchange of resources between the actors (Haythornthwaite 1996: 323). Information, social support, or influence can be exchanged (Haythornthwaite 1996: 323-324).

In this study, social networks refer to the existing relationships between consulting engineers, their clients and other role players in engineering projects. The definition also refers to social networks as an information resource in which the consulting engineers exchange engineering information.

1.7.18 Tasks

A task is what someone does to achieve a goal (Hackos & Redish 1998: 56). Tasks can therefore be regarded as a series of actions undertaken in pursuit of a particular goal (e.g. the completion of an engineering project) by an actor. The performance of a task includes physical and cognitive actions (Vakkari 2003: 416). Such performance has a recognisable purpose, beginning, and end (Byström & Järvelin 1995: 193). It consists of a series of subtasks that can be labelled as actions or operations (Vakkari 2003: 417). Sequences of subtasks are named plans, procedures, or scripts (Hackos & Redish 1998: 71-73; Shepherd 1998: 1541).

In the context of this study, "task" is interpreted in terms of the different activities (e.g. advising a client, designing a system or managing the construction of a design) consulting engineers need to carry out to successfully complete the engineering project they were commissioned for. The sequence in which the tasks need to be completed is determined by the seven stages that make up the life cycle of an engineering project. These are the report, preliminary design, design, tender, working drawing, construction and target procurement stages.

1.8 OUTLINE OF CHAPTERS

The chapters of this thesis are as follows:

- **Chapter 2: Conceptualising information behaviour: a literature review**
  The purpose of this chapter is to review the literature on key concepts that are essential for an understanding of the information behaviour of engineers in their work environment.
- **Chapter 3: Information behaviour in engineering practices**
  This chapter addresses the factors present in the engineering context, the interaction between the engineering context and the personal dimension of engineers and how these give rise to information needs and information activities.
- **Chapter 4: Information behaviour of consulting engineers: a literature review**
  The purpose of this chapter is to determine the distinctive information behaviour of consulting engineers, compared to the information behaviour of engineers in general, that has been discussed in Chapter 3.
- **Chapter 5: Engineers' collaborative information behaviour**
  This chapter addresses collaboration and elements in the context and personal dimensions of engineers that could potentially give rise to their information needs and affect their collaborative information behaviour whilst working in teams.
- **Chapter 6: Research methodology**
  Chapter 6 provides an overview of the research methodology followed in this study. This includes an explanation of narrative inquiry as a research approach, sampling, data collection methods applied and how the data was analysed.
- **Chapter 7: Story of an engineering project**
  Different methods can be applied to analyse narrative data. One method is to re-story the empirical data. Based on the empirical data, Chapter 7 tells the story of

an engineering project. It introduces the project team and describes the progression of an engineering project with focus on the information activities during each stage of the project.

- **Chapter 8: Consulting engineers' collaborative information behaviour: findings**
  Narrative data can also be analysed thematically. Chapter 8 provides a thematic analysis of the empirical data. The different aspects that underlie Wilson's (1999; 2000) information behaviour definition provided the thematic framework for this analysis.
- **Chapter 9: Conclusions, limitations and recommendations**
  This chapter covers the concluding answers to the research questions, indicates the limitations of the study and makes recommendations for future research.

CHAPTER 2

CONCEPTUALISING INFORMATION BEHAVIOUR: A LITERATURE REVIEW

2.1 INTRODUCTION

The purpose of this chapter is to review the literature on key concepts essential to understand the information behaviour of consulting engineers within their working environment. The key concepts that are essential to an understanding of information behaviour will be derived from the widely accepted information behaviour definition by Wilson (1999: 249; 2000: 49). The different aspects that make up the definition will be analysed in more detail to note the different views reported in the literature and to note finer nuances. An operational definition that will guide the study will be based on interpretations of the analysis of the different information behaviour elements.

2.2 BACKGROUND

The phrase “information behaviour of consulting engineers within their working environment” from the introduction to this chapter encapsulates the two most prominent concepts of this investigation. These are “information behaviour” and the “context” in which information behaviour manifests. This phrase also delimits the concept “information behaviour” to the information behaviour of a specific group of people, which is consulting engineers. This therefore also requires that the nature of the context in which these engineers operate should be considered. That is the consulting engineers’ “working environment”.

Various researchers investigated information behaviour from different perspectives. Wilson (1999: 250) noted that researchers have been studying information behaviour long before the concept “information science” was coined. These researchers addressed information behaviour from various perspectives. Wilson (1999:250) observed that researchers attempted to describe information-seeking activities, the consequences of the activity and the relationships between different stages of information behaviour.

In order to acquire an understanding of consulting engineers' information behaviour, it is therefore necessary to acquire an understanding of the core aspects contributing to their information behaviour and how these aspects affect their task completion. Therefore, in order to get a clear picture of consulting engineers' information behaviour as well as their working environment, it will be necessary, with the aid of a literature review, to conceptualise the concepts "information behaviour" and "context". It will also be necessary to identify and conceptualise those concepts that seem to give rise to, and affect information behaviour.

2.3 DEFINING INFORMATION BEHAVIOUR

In order to understand what information behaviour entails it will be necessary to determine what information behaviour comprises. Since his seminal article on user studies and information needs published in 1981, Wilson has developed his definition of information behaviour into a generic and comprehensive definition of the concept, which can serve as a guideline to study the information behaviour of various groups of people within different contexts. Therefore, Wilson's (1999: 249; 2000: 49) definition of information behaviour will be used as a point of departure to determine the different aspects that seem to be necessary to understand the manifestation of the information behaviour phenomenon. According to Wilson (1999: 249; 2000: 49), information behaviour is "the totality of human behaviour in relation to sources and channels of information, including both active and passive information seeking and information use". It seems that "totality of human behaviour", to which Wilson's (1999: 249; 2000: 49) definitions refer, focuses primarily on all information activities in respect of information sources and resources. The reason he gives for his focus on observable information activities can be found in Wilson's (2005) description of the evolution of his information behaviour models. In this discussion, Wilson (2005: 32) noted that behaviour is observable and information needs are not. Although Wilson's (1999: 249; 2000: 49) definition provides for all information behaviour-related activities, he emphasises information seeking and information use as two very specific activities that are associated with information behaviour.

Furthermore, in his definition of information behaviour, Wilson (2000: 49) indicates that information seeking could both be active and passive. He continues by stating that information-seeking and information use behaviour “includes face-to-face communication with others as well as the passive reception of information”. The example Wilson (2000: 49) gives for the passive reception of information is watching television advertisements without any intention to act on the information given. Bates (2009: 2381) supports Wilson (2000) when she explains that people receive information passively by absorbing information in the context of their daily living “simply through being aware”. She therefore adds “awareness” as an example of passive information seeking. Bates’ (2009) addition of “awareness” as an example of information seeking is supported by Allen, Karanasios and Slavova (2011: 776), Bawden (2011) and Erdelez (1997). They identified passive exposure or by chance encountering of information as examples of passive information seeking. The inclusion of passive information seeking to the definition for information behaviour is important for a study of engineers’ information behaviour since engineers, as reported by Shuchman (1981: 27-28), put a high value on the information around them. The reason Shuchman gives is that engineering problems require original solutions and need to be worked out at the “bench”.

Furthermore, the inclusion of passive information seeking in the information behaviour definition proposed by Allen et al. (2011: 776), Bawden (2011), Erdelez (1997) and Wilson (1999: 249, 257; 2000: 49) can be understood in addition to the definition for information behaviour that is proposed by Bates (2009: 2381). According to her, information behaviour covers “all instances where people interact with their environment in such a way that leaves some impression on them — that is, adds or changes their knowledge store”. Bates’ (2009: 2381) inclusion of “leaves some impression on them” in her description of information shows the affective influence information has. This is a kind of internal experience or awareness of information based on users’ existing state of knowledge. Bates’ understanding therefore also reflects personal emotions of people that could result in responding actively by either accepting or avoiding the information that was received.

Regarding the aspects that seem to be necessary for an understanding of the manifestation of the information behaviour phenomenon, the definition proposed by Pettigrew, Fidel and Bruce (2001: 44) can be aligned with, and expands Wilson's definition as far as the information activities component of the information behaviour definition is concerned. According to the definition they propose, information behaviour is "the study of how people need, seek and use information in different contexts, including the workplace and everyday living". This definition by Pettigrew et al. (2001: 44) highlights the same information behaviour activities that are highlighted in Wilson's definition. However, their definition also includes two other components namely information needs and context. Based on Allen (1996: 57-59), Byström (2002: 588), Case (2007; 2012: 81-85), Cole (2011) and Leckie, Pettigrew and Sylvain (1996: 180), it seems clear that both information needs and context are not information activities, but they give rise to, or can trigger information activities that are recognised (observed) as information behaviour.

From the discussion thus far, it seems that a strong emphasis has been placed on the more visible and observable components of information behaviour (meaning the information activities mentioned by Wilson and others). However, carefully considering the literature, there seems to be an underlying awareness of the effect that inner emotions, emerging as information needs, have and the effect the environment (also reported as context) has on information behaviour. The effect of inner emotions and the environment also contributes to information behaviour, which is reflected in information actions taken by either individuals or groups of people, such as using, organising and sharing information. Such actions can be added to the observable activities of information behaviour already mentioned. For example, certain engineering tasks could require engineers to seek information from specific sources such as an engineering standard. Therefore, it seems necessary to take a closer look at the following three aspects that are reported on in the literature and which seem to contribute to an understanding of the manifestation of the information behaviour phenomenon:

- information action resulting from inner emotions and experiences that give rise to information needs and which are reflected in information activities
- the contexts in which people operate that determine the type of information action taken at a given time or situation
- information needs.

The purpose of the following paragraphs is to acquire a better understanding of the role each of these aspects has as possible components of Wilson's (1999; 2000) information behaviour definition.

2.3.1 Information activities

Although Wilson addressed different aspects of information behaviour in his definition of the concept over a period of time, he seemed to focus on information activities as an aspect of his 1999 and 2000 definitions. The two information behaviour activities that received prominent attention in his 1999 and 2000 definitions are information seeking and information use. With Wilson's definition of information behaviour in mind, Case (2006: 293) micro-interprets information behaviour by expanding the activity aspect of the definition. He stresses that information behaviour includes "purposive information seeking, serendipitous encountering of information, the giving, sharing and use of information". The activities of giving information and sharing information often relates to human behaviour within a social context, where people network or collaborate to reach consensus on information-related matters. Inclusion of these actions seems to be indicative of the social nature of information behaviour where more than one person is involved. Case's (2006: 293) addition of giving and sharing as information activities to the information behaviour definition has implications for the information behaviour of users who work within certain contexts, such as engineers who normally operate in a group. Engineers Cheimets, Gordon and Tull (2009: 26) reported on the implications information behaviour activities, such as sharing and giving, have on engineering work. This will be discussed in more detail in section 3.6.6.

2.3.2 Personal dimension

Although the Wilson (1999; 2000) definition focuses primarily on information activities as a core component of his information behaviour definition, it refers to the “totality of human behaviour”, which indicates that, underlying to information activities, there could also be other components that can influence information behaviour, such as the personal dimension. For example, Bates (2009: 2381) acknowledges in her definition that information behaviour can change a person’s “knowledge store”.

From the previous discussion it seems as if a personal aspect, that is inner mental states, should form part of the information behaviour definition. In his 1981 article, Wilson acknowledges (but does not discuss it in detail) that certain human needs prompt information behaviour. It was Hepworth (2007: 41) who made a useful contribution to an understanding of the inner mental states that form part of the information behaviour, when he clearly identified and discussed the different inner mental states that are associated with information behaviour. The inner mental states he discussed are cognitive (thinking processes), conative (inherent factors that affect motivation and preferred ways of learning) and affective responses (feelings). Nahl (2001: 1) refers to mental structures when she discusses cognitive and affective mental states. These are discussed consequently.

2.3.2.1 Cognitive phenomena

Kent (2005) describes cognitive phenomena as “complex” phenomena. He argues that cognitive phenomena “typically involve the spontaneous emergence of ‘concepts’ or ‘ideas’ which are formulated out of ‘thoughts’ or ‘feelings’ that are holistic in nature.” This description of cognitive phenomena includes the cognitive phenomena that were identified by Eisenberg and Berkowitz (1990), and which were highlighted by Hepworth (2007: 41). The cognitive phenomena they identified are thinking skills such as the recognition of relevance, analysis, synthesis, induction, deduction, evaluation and thinking processes, such as defining a problem. Two ways in which cognitive phenomena seem to affect a person’s information behaviour, that was reflected on in the literature, include the recognition of an information need and the prompting of certain cognitive information activities by these information needs.

The cognitive phenomena that affect information needs that were identified by Allen (1991: 7) include conceptual knowledge (that is a knowledge of the subject), task knowledge and a knowledge of the resources that are used. People acquire their subject knowledge, task knowledge and knowledge of the resources available that are available in specific subject fields through education, training and work experience. Therefore, cognitive phenomena that were identified by Allen (1991) are indicative of the education and training a person received. This probably explains why Taylor (1991: 223) observed that the education and training people receive affect their information behaviour.

2.3.2.2 Conative phenomena

In the psychology literature, Huit (1999) describes conation (conative phenomena) as the "connection of knowledge and affect to behaviour and [that] is associated with the issue of 'why'". Also, Baumeister, Bratlavsky, Muraven and Tice's (1998) findings indicate that conative phenomena is the personal intentional, planned, deliberate, goal-oriented, or striving component of motivation. Nahl (2001: 1) does not refer to conative phenomena in her reference to mental structures of a personal dimension, but she adds the sensorimotor structure. She also observed that the sensorimotor structure provides the motivation for certain behaviour.

Two types of conative phenomena that seem to affect information behaviour are self-efficacy (Wilson 1999: 257) and learning styles (Ford, Wood & Walsh 1993). Self-efficacy, according to Bandura (1995: 2), refers to "the belief in one's capabilities to organise and execute the courses of action required to manage prospective situations". Bandura (1995: 2) further noted that a person's self-efficacy (i.e. the person's beliefs) plays a major role in how a person approaches the goals, tasks, and challenges with which he or she is faced. Similarly, Case (2012: 153) indicated that self-efficacy (i.e. beliefs) constrains a person's thinking and level of motivation to seek information. The explanation he offers is that beliefs are about facts and the person's relation to his or her current situation. If that person does not believe more information is required to solve a problem, it is unlikely that he or she will seek information.

Learning styles is another conative phenomenon that seems to have an effect on information behaviour. Ford et al. (1993) found that individual learning styles can be associated with different types of information behaviour. With the findings of Ford et al. in mind, Hepworth (2007: 53) stressed a need to understand specific phenomena in society, such as cultural, environmental and social factors, that are linked to how people learn. These also affect individuals' information behaviour. For example, the engineering process affects how engineers learn by doing and using (Taylor 1991: 235).

2.3.2.3 Affective phenomena

Affective phenomena, such as thoughts and emotions, are associated with information seeking. Kuhlthau's (2005: 232) information search process model describes how the interplay of thoughts, feelings and actions affect information searching behaviour. She has found that uncertainty causes affective symptoms of anxiety, lack of confidence, frustration and confusion. She also found that these affective symptoms are associated with vague, unclear thoughts about a topic or question and that, as knowledge states shift to more clearly focused thoughts, the individual feels more confident. Hepworth (2007: 50) observed doctoral students' information behaviour during the literature review phase and reported similar behaviour. Also, Fosmire (2012: 49) reported on how affective phenomena affect engineering students' information behaviour. He observed that students became more uncertain, confused and doubted themselves when they encountered inconsistent and incompatible information.

2.3.3 Context

Apart from the effect information activities and the personal dimension have on information behaviour, context also seems to affect people's information behaviour. The definition by Pettigrew et al. (2001), discussed in section 2.3, points out that information behaviour takes place within a certain context, which could either be the workplace or an everyday life setting. However, it appears that context is one of the concepts that seem difficult to describe precisely. For example after an extended effort to review treatments of context, Dervin (1997: 13) came to the conclusion that there is no “term that is more often used, less often defined, and when defined, defined so variously as context”. Courtright (2007) and Pettigrew et al. (2001) also share Dervin’s (1997: 752) view.

Pettigrew et al.’s (2001) inclusion of “context” in their definition of information behaviour is supported by Courtright’s (2007: 276) observation in her literature review of the concept “context” in information behaviour. She observed that most information needs, seeking and use researchers consider context to be a “frame of reference” for information practices and information behaviour. Other descriptions of context which can be aligned with Courtright’s observation are the descriptions offered by Cool (2001: 8) and Johnson (2003: 736). Cool (2001: 8) describes contexts as “frameworks of meaning” while Johnson (2003: 736) refers to contexts as “frameworks for meaning systems or interpretation”.

“Setting” is a term used by Allen and Kim (2001), Byström (1996) and McKenzie (2004) in relation to context. According to Allen and Kim (2000), context relates to “socially defined settings” in which information users are found.

Taylor (1991: 218) describes context in a different manner. He describes contexts as “information use environments”. The explanation he offers is that the information choices users make are not only based on the “subject matter” (content) but also on other elements of the context within which the user lives and works. These contexts are the “information use environments”. According to him, users select from among sources that could be useful to them at particular times in these “information use environments”. Taylor (1991: 218) continues by explaining that the elements that affect users’ information choices within a specific “information use environment” relates to those elements that affect the flow and use of information, and determine the criteria that are used to evaluate the relevance of information sources. Although Taylor hails from an era before the concept information behaviour came into vogue, he provides us with useful information on the elements in a context that affect what we today understand as information behaviour. Bates (2009: 2381) also refers to the “environment” in which people interact with information.

Case (2007: 13) adds a further perspective to the view that context is a frame of reference, a reference of meaning, a setting or an information use environment. According to him, the concept context relates to “a particular combination of person and situation”. With this in mind, Case reviewed information-seeking studies in three general categories: the occupation studied, the social role of the persons under investigation, and the demographic groupings. Therefore, by adding the notion of a “combination” of person and situation to the definition, Case does three things: he adds situation as an element of context; he places context in a social environment; and he implies that context can also be described by using a combination of elements. Case’s (2007: 13) perspective of contexts can be aligned to Havelock’s (1986: 85) perspective of social systems in which he notes that the “configuration of elements can be changed in countless ways”.

2.3.3.1 Elements of context

From the discussion so far it seems evident that within a context there are also a variety of elements present that can influence people’s information behaviour. Not all researchers report these as elements. For example, Sonnenwald (1999: 179) identifies some characteristics of contexts. The characteristics she identified include place, time, goals, tasks, systems, situations, process, organisations and types of participants. It seems as if the elements of a context can include human elements (e.g. persons and types of participants, such as engineers, architects, etc.) and non-human elements (e.g. situations and tasks). According to Courtright (2007: 290), the human and non-human elements of a context are “tightly interwoven, highly dependent, and constantly evolving”. The tightly interwovenness and interdependency of the different characteristics in a context are also observed by Schutz and Luckman (1974), who see them as indicative of the existing shared relationship among participants. This underlying awareness of elements and their relationships probably explains why Johnson (2003: 739) maintains that context is “an elaborated specification of the environment within which information seeking is embedded”.

Vakkari (1997: 457) comments on the embeddedness of information activities in the broader context of people’s worlds. He observed that studies focusing on information needs and information seeking are no longer studying these aspects as ends in themselves, but that they are seen as “embedded in the actions, tasks and situations they are supporting”. In addition, Rieh (2004: 751) found that context cannot be separated from its elements, but should be understood as contextual entities interplaying with other social, cultural, situational, and individual factors that affect information behaviour. This view of context is in accordance with the cultural-historical perspective of context as it is proposed by Allen et al. (2011: 776). They understand context to be a “dynamic and changing environmental variable”. The explanation they offer is that context is embedded in action where the present context is a result of past actions and where past actions give rise to current practices and meanings.

Considering that there seems to be wide acceptance that a context has boundaries, the understanding of context boundaries and their effect on information behaviour will be addressed in the next section.

2.3.3.2 Context boundaries

The South African concise Oxford dictionary (2002: 133) defines boundary as a “line marking the limits of an area”. The concept “boundary” can therefore be regarded as something that demarcates a realistic or an abstract area. When applied to context, Havelock (1986: 79, 85) argues that each context requires boundaries not only to differentiate it from other contexts but also to preserve the integrity of the context, while allowing survival of the context through their permeability. As mentioned in the previous section, there are a number of elements of context that can act as contextual boundaries. Three of these elements, identified by various researchers, are time, space and organisations and are discussed below.

a. Space

Space as an element of context can refer to a temporary social setting such as an information ground that resembles a “synergistic environment created when people come together for a singular purpose” (Pettigrew 1999: 811). Space as an element can also be represented as a “small world” (Chatman 1999: 210), which has both a spatial and a physical dimension.

b. Time

Time is, according to Sonnenwald and Iivonen (1999: 436), a non-spatial continuum in which actions and events occur. They differentiate between three temporal aspects that are related to time: an episode (a short period of time), an interval (a longer period of time with a distinct starting and ending), and an eon (a long, continuous period of time). According to Savolainen (2006: 111), these authors did not consider the conceptual nature of temporal factors in greater detail. He is of the opinion that time, as temporal factor in information behaviour research, is problematic. The reason he gives is that temporal factors tend to be “everywhere” and that time is embedded in all human interaction instead of human action being embedded in time. Savolainen (2006: 112) argues that temporal factors can be defined as “qualifiers of access to information” and could “specify the information seeking as a process”.

c. Organisations

Organisations seem to be examples of contexts that have both spatial and physical dimensions as boundaries. An organisational scientist, Aldrich’s (2006: 1) description of organisations supports this assumption. According to him, organisations provide natural boundaries for context in that they delineate the activities taking place within them. Johnson (2003: 750) offers a similar explanation. According to him, the individuals working in an organisation are embedded in a physical world that involves recurring contact with an interpersonal network of managers and co-workers.

These descriptions of organisations offered by Aldrich (2006) and Johnson (2003) also seem to describe context as a “kind of container”. Both Dervin (1997: 14) and Savolainen (2006: 111; 2009: 38) have a problem with such conceptualisations of context. According to Savolainen (2006: 111; 2009: 38) such conceptualisations draw on the assumption that information behaviour activities take place within a kind of container, but that these activities are also constrained by the boundaries of the context. Both Courtright (2007: 286) and Savolainen (2009: 38) observed that the container conceptualisation of context leads researchers to think of context as a set of stable delineated entities that can be conceptualised independently of the activities of their participants. The explanations offered by Johnson (2003: 750), Rosenbaum (1996) and Taylor (1991: 218) of how an organisational context affects people's information behaviour are illustrative of Courtright and Savolainen's observations. According to them, organisations affect workers' information behaviour in the following ways:

- Organisational rules and resources shape information practices within an organisation, and therefore may control or restrict individuals' information behaviour (Rosenbaum 1996).
- The physical context of an organisation stabilises an individual's information field and determines the nature of the information an individual is exposed to (Johnson 2003: 750).
- Information use environments such as organisations affect the flow and use of information within the organisation and determine the criteria that are used to evaluate the information (Taylor 1991: 218).

The conceptualisation of context as a set of stable, delineated entities is contrary to Allen et al.'s (2011) understanding of context. According to them, context is a dynamic information behaviour component. Although context cannot solely be defined as a time-space container, time and space are two influential elements of context.

2.3.3.3 Situation as an element of context

Sonnenwald (1999: 179) argues that a flow of situations arise within each context. Following Sonnenwald's arguments, Cool (2001: 8) explains situation as "the dynamic environments, within which interpretive processes unfold, become ratified, change, and solidify". This view implies that situations could develop through a process of change from an unstable environment to something that could be more stable. A similar view is proposed by McCreadie and Rice (1999: 59). They describe situation as a "particular set of circumstances from which a need for information arises". McCreadie and Rice's (1999: 59) use of "circumstances" in their description also points out the unstableness of the concept "situation".

In his paper on context, Johnson (2003: 736) discusses context in three senses. These are: context is equivalent to the situation in which information users find themselves; context relates to contingency aspects of situations that have specific effects; and contexts are frameworks of meanings. From the first two senses of context it seems as if context is something that develops in a situation. This is contrary to the findings from other researchers indicating that situation is an element of context and that a situation develops in a context.

Apart from Johnson's (2003) view that context is equivalent to situation, the terms are also used interchangeably in the literature. The interchangeable use of the concepts situation and context concerns Wang (2011: 25-26). She explains context as being mostly an external component while situation can be both external and internal elements, and is more dynamic and personal than context. Wang (2011: 26) further explains that situational factors, as an internal element, include personal factors such as the person's knowledge of the task and perception of the task goals. With Wang's (2011: 25-26) explanation in mind, it seems that context cannot be equivalent to situation, but situation can be an element of context.

2.3.3.4 Contextual elements as factors affecting information behaviour

The different elements that make up the context in which information behaviour arises seems to become factors affecting information behaviour. This view is illustrated by Robson and Robinson's (2013) information-seeking and communication model. This model illustrates how information seeking and communication is either inhibited or motivated by elements in the context.

2.3.4 Information needs

In his article "On user studies and information needs", Wilson (1981: 4) reflected on the existing interrelationship among information behaviour components. He also stated that information-seeking behaviour (an information behaviour activity) results from the recognition of a need. As shown in section 2.3, the definition proposed by Pettigrew et al. (2001: 44) is aligned with and extends Wilson's definition. They added information needs and context to their definition. Therefore, although Wilson's definition of information behaviour does not explicitly mention information needs as a component of the definition, it can be viewed as a component thereof.

Case (2012: 5) defines an information need as "a recognition that your knowledge is inadequate to satisfy a goal that you have". The phrase "a recognition that your knowledge is inadequate" in Case's (2012) definition describes knowledge as a cognitive phenomenon and the recognition of an information need as an acknowledgement of a gap in the person's knowledge base. Considering that personal knowledge is a cognitive element in the personal dimension of a user, it therefore seems as if information needs arise from the existing interaction between elements in the personal dimension and elements in the context.

A second element of Case's (2012) information needs definition relates to goals that need to be satisfied. These goals can be cognitive or affective goals, as emphasised by Kuhlthau (2004). The goal in a cognitive need would be to fill a knowledge gap to ensure task completion, whereas an affective need is focused on reducing feelings of uncertainty. Therefore, it seems that the goal that needs to be satisfied becomes a factor, which not only gives rise to information needs, but also affects information needs. However, information needs do not necessarily lead to information seeking. This was highlighted in a statement made by Ingwersen and Järvelin (2005), indicating that "information needs may lead to information seeking and formulation of requests for information".

2.3.4.1 Different research perspectives of information needs

From the literature it seems as if information needs have been studied from different perspectives. The perspectives Allen (1996: 57) identified are cognitive-, sociological-, organisational- and economic perspectives. For the purposes of this discussion, the organisational and economic perspectives of information needs will be grouped under one heading with the sociological perspective. Cognitive perspectives will be discussed in their own right under a separate heading.

a. Cognitive perspectives of information needs

According to Allen (1996: 57-59), studies viewing information needs from a cognitive perspective emphasise the role of knowledge structures, the cognitive processes of learning, and interpretation in defining information needs. He observed that studies following this approach attempted to explain how individual variables, such as people's perceptions of a situation, based on their knowledge and past experiences, influence individual information behaviour. These observations are further supported by an earlier article by Wilson (1981: 9) in which he stated that the performance of specific tasks and the processes of planning and decision-making are the principal generators of cognitive information needs. Therefore, it seems that information needs arise when the individual's knowledge fails and does not provide the individual with an unambiguous interpretation of the situation or a course of action. This is in line with Belkin, Oddy and Brooks' (1982) arguments for an Anomalous State of Knowledge (ASK).

b. Social perspective

Tasks don't seem to be the only factors affecting the information-seeking path that is taken to satisfy an information need. According to B.L. Allen (1996: 74-77), social factors influence how people perceive the situations in which they are found and to some extent determine the alternative actions they will take. He maintains that the actions people take to provide for their information needs are dependent on the situation as well as the group (e.g. a work team). The reason he gives is that the available courses of action (i.e. information-seeking paths) may be different in different situations as well as different groups. The social factors Allen (1996) identified are similar to the factors Wilson (1981) identified, which were discussed in the above paragraph.

Also, Allen (1996: 78) maintains that the situation and the group's values, goals and collective knowledge base affect the information-seeking path selected by the group. He argues that groups "perceive, know, and need information in different ways than their individual members". An observation reported on by Thomas Allen (1977: 106) explains B.L. Allen's (1996) claims. He observed that, within the context of a specific engineering project or task, team members share certain knowledge and that each team member knows what the other is referring to. Allen (1996: 80) also noted that new information needs could be created if individual team members do not communicate their knowledge of the situation or task effectively. As a result, ineffective information communication affects the information-seeking path that is taken to solve an information need. It was probably with this in mind that Allen (1996: 78) noted that studies viewing information needs from a social perspective have to consider both the individual's perception of the situation as well as the group's perception of the same situation.

2.3.4.2 Conditions giving rise to information needs

In his review of information behaviour literature, Case (2012: 81-87) identified certain conditions that give rise to information behaviour. These conditions include seeking answers, the reduction of uncertainty, and making sense. Due to various factors other than thosethat were identified in the literature that give rise to, and affect information needs, include a need for inspiration, types of needs, the goal of the need (e.g. a task), the cognitive level of the need, and the context in which the information need arises. Information needs for inspiration seem to be unique information needs for specific user groups such as creative artists (Mason & Robinson 2011), photographers (Cox 2013) and architects (Makri & Warwick 2010).

a. Types of needs

The concept "need" is central to many different disciplines (Naumer & Fisher 2009: 2452). According to Naumer and Fisher (2009: 2452), psychology provides the best known descriptions. This is specifically from Maslow's hierarchy of needs. Maslow (1943) categorised needs as being physiological, safety, love/belonging/esteem and self-actualisation. In his analysis of human needs, Wilson (1981: 7) observed that psychologists mostly used a simpler categorisation of human needs than the one used by Maslow. According to him, the psychologists' categorisation of human needs is physiological needs, affective needs, and cognitive needs.

In his discussion on information needs, Wilson (1981: 7) also indicates the interrelationship between the different types of need and notes that the problems relating to the satisfaction of cognitive needs (such as a failure to satisfy the need) may result in affective needs. It is probably with this in mind that Wilson (1981) suggested that “information needs” are secondary needs that arise “out of the desire to satisfy the primary needs”. He further suggests that, as part of the search to satisfy a need, individuals may engage in information-seeking behaviour. Considering these arguments, it seems evident that information needs can give rise to a response that culminates in observable information activities, for example, information seeking. Green (1990 in Case 2012: 78) also came to this conclusion in his analysis of the debates on the nature of information needs.

However, Wilson (1981: 8) also suggested that, due to various other factors other than the information need itself, information seeking may not occur at all. Factors he mentioned include the importance of satisfying the need, the penalty incurred by acting in the absence of full information, the availability of information sources, and the costs of using them.

b. Goals, work roles and tasks

Green (in Case 2012: 78) views needs as “always instrumental” in “reaching a goal”. This view is supported by Leckie et al.’s (1996: 180) findings. They found that, in a work-related context (i.e. an instrumental utility), people’s information needs are prompted by their work roles and their work-related tasks. Leckie et al. (1996: 181) further indicated that, in a work-related context, tasks are embedded in work roles. Their findings are supported by an earlier statement made by Wilson (1981: 9) in which he indicated that information needs arise out of the “roles an individual fills in social life” and that a set of activities and responsibilities are attached to work roles. Savolainen (2012) used the concept “contextual needs” to describe this kind of information need. Furthermore, Allen (1977: 23, 34) and Ellis and Haugan (1997: 401) observed that, as people progressed through a project, their task-related information needs varied, requiring them to take a different course of action, or select a different information-seeking path. The reasons Ellis and Haugan offer for this phenomenon is that different information channels serve different problem-solving functions.

c. Seeking answers and the cognitive level of information needs

In his characterisation of the origins of information needs, Taylor (1968) focused on how and why people sought answers by asking questions at a library. He then described four stages or levels of information needs. The stages or levels of information needs he identified are:

- Visceral needs. This is an unexpressed need for information which results from “a vague sort of dissatisfaction” (Taylor 1968: 182).
- Conscious needs. During this level of information needs, people form some conscious mental description of their information needs, but the formulation is still ambiguous.
- Formalised needs. Taylor (1968: 182) explains that people, at this level, are able to form a qualified and rational statement of their information needs.
- Compromised needs. At this stage, the rational statement is presented to the information system (and often adapted) in anticipation of what information can be retrieved from the information system.

Cole’s (2011: 1216) claims that individuals experiencing information needs seldom know what is required to satisfy their information needs. However, as indicated by Wilson (1981: 8), and discussed in section 2.3.4.1a, the cognitive level at which a user experiences an information need might not result in active information-seeking behaviour.

d. Reduction of uncertainty

In his definition of an information need, Atkin (1973: 206) viewed an information need as “a function of extrinsic uncertainty produced by a perceived discrepancy between the individual’s current level of certainty ...” In his discussion of Atkin’s definition, Case (2012: 83) noted that, in Atkin’s view, people sense differences between what they know and want to know. They therefore compare their current level of knowledge against the “goal states” they wish to reach and react by seeking information whenever they sense uncertainty. Atkin’s (1973) view can be aligned with the work of Belkin et al.

(1982) and Kuhlthau (2004), aimed at advancing a view that information reduces uncertainty.

e. Making sense

Dervin (1983: 156) believes that people have a need to “make sense” of the world. She believes that a person perceives some kind of “gap” that requires filling and that, when applied to an information need, can be filled by what the needing person regards to be information. The strategies people employ to “bridge the gap” to find the information they require are shaped by their conceptualisation of both the “gap” and the “bridge” (e.g. the information-seeking path) and by the answers and sources they receive (Case 2012: 85).

f. Context

The context in which an information need arises is, according to Wilson (1981: 5), the most important factor affecting information needs. One of the contextual factors that seem to affect, for example, engineers’ information needs, that were reported on by Tenopir and King (2004: 75), relates to the nature of the work engineers are doing. Other contextual factors that seem to affect information needs relate to the frequency with which the need arises, the importance of the information need, the predictability of the outcomes of the need, and the complexity of the task from which the need arose. The information behaviour researchers that reported these findings in their studies on engineers’ information behaviour include Ellis and Haugan (1997), Freund, Toms and Waterhouse (2005), Leckie et al. (1996), and Pinelli (2001).

Byström (2002: 588) reported a different finding, showing the effect context has in satisfying an information need. She found that information that is needed to complete a specific task is only related to that task and will seldom be used again to complete a different task.

From the above discussion on information needs it seems as if information behaviour researchers have studied information needs from mainly two perspectives, that is, a cognitive and a social perspective. Different circumstances seem to give rise to information needs and prompt information activities.

2.4 CONSIDERING KEY COMPONENTS FOR AN OPERATIONAL DEFINITION OF INFORMATION BEHAVIOUR

The generic definitions of information behaviour, developed by Wilson and others, as discussed in sections 2.3 and 2.3.2 respectively, have laid the base for studying the information behaviour of diverse groups of people. However, the literature study revealed that the personal and contextual dimensions respectively harbour elements that are instrumental in the emerging of information behaviour. This refers to the information behaviour of individuals, as well as people operating in a group within a designated context, and was discussed in sections 2.3.1 and 2.3.3. With insights gained from this study and with the guidance of the researcher's supervisor, a framework was developed that comprises key components with a particular relationship among these components. It seems that interaction among the components eventually gives rise to information activities where information behaviour becomes observable. The four key components selected for purposes of this study are context, personal dimension, information needs and information activities.

Revisiting the widely accepted information behaviour definition formulated by Wilson, it is evident that the Wilson definition (originally based on information-seeking behaviour) accepts that information-seeking activities are prompted by information needs. The definition also accepts that information activities such as seeking and searching are followed by information use activities. However, literature consulted regarding the existing definitions does not consider the demands that the elements of the context imposed on the user (or user groups). Neither did the consulted literature address the manner in which people respond when the three phenomena (cognitive, conative, affective) embedded in their inner experiences are exposed to outside impressions, or to demands for information. Therefore, the literature study on personal dimensions, and the contexts in which they operate, succeeded in bringing to light how the interaction between the elements of the personal and contextual dimensions trigger responses such as information needs, responsible for the emergence of information behaviour, that can be observed. Although Wilson (1999: 249; 2000: 49) acknowledged that the “totality of human behaviour” include all information activities, little attention is given to responses (less observable) resulting from the interaction between inner emotions and elements present in the context(s) in which people operate.

In consideration of Wilson’s (1999; 2000) definition of information behaviour, and the contributions made to it by various researchers, it seems that information behaviour comprises observable activities resulting from an awareness of a need for information. There seems to be two major dimensions (components) that respectively harbour elements serving as factors that can give rise to information needs, which consequently result in observable information activities. Robson and Robinson (2013: 187) refer to these dimensions as contexts.

For the purpose of this study, Figure 2.1 graphically depicts the four basic components comprising information behaviour, as the concept is currently understood. These include (ii) the personal dimension of information users and (i) the environmental context in which they operate respectively, and which harbour elements that can determine how people respond when confronted with a problem. Due to the existing interaction that takes place between the personal dimension and the environmental context, (iii) needs emerge that require information to solve a problem. In turn the awareness of an information need can cause a response of taking action to find information. How, when, where, and what type of information activities are performed reveal the information activities (iv) of the person in need of information. The double pointed arrow in Figure 2.1 represents the interaction between the elements of the personal dimension (i.e. people’s inner experiences) and elements in the environmental context to indicate how this interaction gives rise to information needs. In turn, information needs give rise to information activities. The possibility then exists that information activities could also give rise to different needs. This possibility was not explored in detail in the study and will need to be revisited at a later stage.

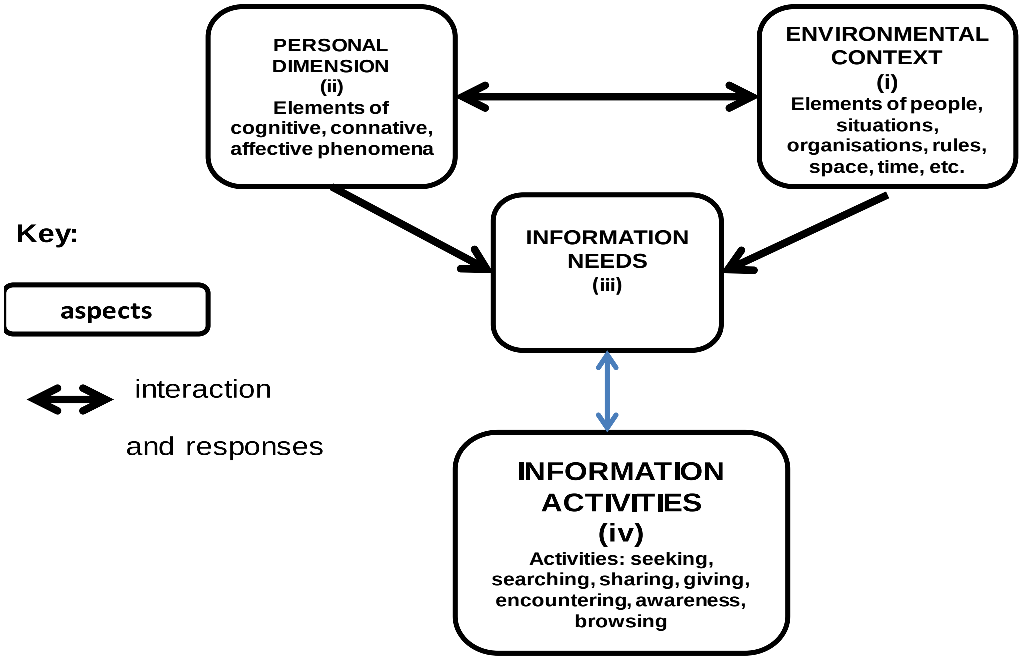


Figure 2.1: Graphic representation of the components that affect information behaviour

2.5 OPERATIONAL DEFINITION OF INFORMATION BEHAVIOUR

Insights gained from the literature study on the personal and the contextual dimension seem to provide a broader base for the investigation of the information behaviour of a specific group, such as practicing engineers that distinguish their information behaviour from that of other groups in terms of using information to achieve a set goal.

Based on Wilson's (1999; 2000) definition and the contributions made by many information behaviour researchers, the following operational definition is proposed for purpose of this study:

> The interaction between the context, the personal dimension (i.e. inner experiences) and information needs, gives rise to information related activities such as information seeking, sharing, communication and use.

2.6 CONCLUSION

The focus of this chapter was a literature study to determine which aspects and circumstances can give rise to the information behaviour of individuals and groups. The widely accepted definition of Wilson (1999; 2000) was accepted as a point of departure. Literature consulted with regard to people's inner experiences, and the contexts in which people operate, revealed valuable insights into the interaction between the elements of a context and inner experiences of individuals that give rise to observable information activities, as well as less observable actions initiating information behaviour. The insights gained were applied graphically in Figure 2.1 to serve as a framework that could guide the following study on the information behaviour of engineers, which will be addressed in the next chapter.

CHAPTER 3

INFORMATION BEHAVIOUR IN ENGINEERING PRACTICES

3.1 INTRODUCTION

The purpose of this chapter is to identify and discuss the literature related to the components of a framework for information behaviour for engineers, based on the proposed framework developed in Chapter 2. Therefore, this discussion will cover the four respective components and the typical attributes of an engineering context, as well as typical features of the personal dimension of engineers. Thereafter attention will be paid to the information needs and typical information activities of engineers. This will then be followed by its manifestation in engineers' information behaviour.

3.2 BACKGROUND

The generic information behaviour framework that was developed in Chapter 2 can also be applied to a study of engineers' information behaviour. However, the generic framework does not include all the elements that are required to describe engineers' information behaviour. For example, one such element is the requirement to work in teams. Due to this requirement, engineers collaborate and network with their fellow team members. As noted by Thomas Allen (1977: 232-235) and engineers Cheimets, Gordon and Tull (2009: 26), this requirement not only affects the individual engineer's information behaviour, but also the information behaviour of the team. Other important elements in the engineering context that should be addressed include engineers' need to use sources related to the engineering discipline,such as codes of practice, standards and regulations (Korobili, Malliari & Zapounidou 2011), the nature of engineering work (Wolek 1969: 471), and the flow of engineering information (Allen 1977).

Since certain elements in the engineering context also seem to affect the personal dimension of engineers, the elements in the engineering context will be examined first to learn how they affect engineers' information behaviour.

3.3 ENGINEERING CONTEXT

The discussion on context in section 2.3.3 showed that a context has boundaries and has a number of elements that influence to a large extent the type of information needs of users functioning in the context. The elements of a context that were identified by Sonnenwald (1999: 179) include tasks, goals, systems, situations, processes, organisations, work, and types of participants. Engineers are also professionals (Court 1997: 129), and the engineering profession can therefore be viewed as an element of the engineering context that requires discussion. Other elements of the engineering context that will be addressed include the education and training requirements of engineers, engineering disciplines, statutory engineering bodies and learned societies, the nature of engineering work, engineers' work roles, engineering tasks and engineering projects. The discussion will attempt to highlight those aspects in the context of the engineering environment that could have an effect on engineers' information behaviour, and which could be different from other professional groups.

3.3.1 Profession

The *South African concise Oxford dictionary* (2002) defines "profession" as a "paid vocation, especially involving training and a formal qualification". Engineering is one such profession. The Engineers' Council for Professional Development (1941: 456; Smith 2011) defines "engineering" as "the creative application of scientific principles to design or develop structures, machines, apparatus, or manufacturing processes, or works utilising them singly or in combination; or to construct or operate the same with full cognisance of their design; or to forecast their behaviour under specific operating conditions; all as respects an intended function, economics of operation and safety to life and property". According to this definition, the aim of engineering is to translate scientific principles by means of innovation processes into practical equipment or procedures that can be applied in practice to improve or enhance processes. The process of translating scientific principles into equipment or procedures requires cognitive actions from engineers. Actions of engineers are based on their existing knowledge of the engineering discipline involved, their developed problem-solving skills and their intellectual abilities.

Whereas the Engineers' Council for Professional Development's (1941) definition refers to the "creative application of scientific principles" to engineering designs or structures, the definition of engineering proposed by the Consulting Engineers South Africa (CESA) (2003a: 1) describes engineering as an applied science. Also, CESA (2003c: 1) describes engineering as a calling in which "broad and highly specialised knowledge are combined and applied with skill and judgement in the service of mankind". Both these definitions concur with Fosmire's (2012: 47), observation that "engineers are always solving someone's problems".

When considering statements from the aforementioned engineering definitions, such as the "application of scientific principles", "an applied science", "specialised knowledge", and "skills and judgement", engineering education and training seem to be very important to the engineering profession. Furthermore, the requirement that engineers need to consider the "intended function, economics of operation and safety to life and property" of their work, also points out the expected service ethics of the engineering profession.

The expected service ethics that can be derived from the definition above, proposed by the Engineers' Council for Professional Development (1941; Smith 2011), include striving to render a high quality service or product and an adherence to high safety standards in respect of people and property. The notion for high quality work and safety standards are further supported by the statutory requirements contained in engineering codes of conduct, for example, the Engineering Council of South Africa's (ECSA) (2006) Codes of Conduct. For example, ECSA's (2006) Codes of Conduct reveal a demand for high levels of responsibility and ethical conduct from professional engineers to ensure that the available resources are used efficiently, engineering works are environmentally sound and sustainable, and risks are managed throughout the lifecycle of the product or system. Policies, as reflected in codes of conduct, control the work ethics of engineers and serve as parameters within which they have to operate.

The expected service ethics, that is the "high quality service or product", an "adherence to high safety standards", and the "demand for high levels of responsibility" are requirements for engineering work. However, these requirements are also criteria that are applied when sources are selected. From an information behaviour point of view, this implies that these criteria also become factors influencing information behaviour.

3.3.2 Discipline

Engineering work is often linked to specific discipline-based specialisations (Leckie, Pettigrew & Sylvain 1996: 164). As professionals, engineers are expected to have a strong knowledge base in their engineering discipline of choice and to be familiar with the methods of applying their knowledge to real problems (Court 1997: 129; Engineering Council 2011; Engineering Council of South Africa (ECSA) 2010; Freund, Toms & Waterhouse 2005). In the information behaviour literature, Shuchman (1981: 316) identified some of the major engineering disciplines, namely, civil, electrical, mechanical, industrial, chemical, environmental and aeronautical engineering. However, more subdisciplines are currently being taught at various engineering schools across the world. These include the Boston University College of Engineering (www.bu.edu/eng), Vanderbilt School of Engineering (engineering.vanderbilt.edu), and the University of Pretoria (www.up.ac.za).

The following are examples of information behaviour studies that were conducted on engineers working in specific engineering disciplines and subdisciplines:

- aerospace and aeronautical engineering (Bruce, Fidel, Pejtersen, Dumais, Grundin & Poltrock 2003; Fidel & Efthimiadis 1999; Holland, Pinelli, Barclay & Kennedy 1991; Pinelli, Barclay, Kennedy, Glassman & Demerath 1991; Pinelli, Bishop, Barclay & Kennedy 1992; Pinelli, Glassman, Oliu & Barclay 1989; Vicenti 1990)
- earth science engineering (Gralewska-Vickery 1976)
- software engineering (Freund et al. 2005; Milewski 2007; Montesi & Navarrete 2008).

Korobili et al.'s (2011: 161) survey among engineering and philosophy graduate students of the Aristotle University found that, apart from the selection of specific sources of engineering information, engineering disciplines do not seem to affect engineers' information-seeking behaviour critically. According to them, this phenomenon can be explained by the fact that there are no significant differences in students' academic environments. Korobili et al.'s findings are similar to Du Preez's (2008: 251) findings. She postulated that engineers' information behavioural responses to their information needs relate to their selection of specific discipline-related sources (e.g. codes of practice, regulations and standards). Therefore, when considering these findings it seems as if engineering disciplines affect the selection and use of discipline-related sources.

3.3.3 Education and training

As stipulated by the Engineers' Council for Professional Development (1941), prospective engineers are required to complete an engineering degree. Also, the degree must be accredited by a national statutory body or bodies. Examples of South African national statutory bodies are the South African Qualifications Authority (SAQA) and the Engineering Council of South Africa (ECSA). Apart from completing an engineering degree, the prospective engineer also needs to demonstrate competence against standards that are determined by the statutory body (ECSA 2010). In order to demonstrate their competence, prospective engineers are required to complete an internship under the guidance of a professional engineer, a requirement that was also observed by Gralewska-Vickery (1976: 257, 259-262), an information behaviour researcher.

The required engineering education and training, as well as the need to complete an internship, contribute to the development of engineers' personal knowledge and skills. These requirements, set by the engineering profession, and their contribution to the development of engineers' personal knowledge and skills, will be discussed in more detail in section 3.4.

3.3.4 Membership of statutory bodies and learned societies

Statutory bodies and learned societies are another aspect related to the engineering context which seems to influence engineers' information behaviour. This is because engineering, as a profession, is regulated and legally defined by a government body to ensure the safety of engineering products. Statutory engineering bodies and learned societies therefore set certain requirements in terms of what engineers should know and learn. These bodies also provide the boundaries within which engineers must operate. Examples of statutory bodies that regulate engineering, whilst ensuring the interest of the profession, include the Engineering Council of South Africa (ECSA); the Accreditation Board for Engineering and Technology, Inc. (USA) (www.abet.org); the Canadian Council of Professional Engineers (www.ccpe.ca); the Engineering Council (UK) (www.engc.org.uk); the Hong Kong Institution of Engineers (www.hkie.org.hk); the World Federation of Engineering Organisations (www.wfeo.net), and the International Federation for Consulting Engineers (FIDIC) (www.fidic.org).

As indicated on their websites, statutory bodies for engineering can also be members of the International Engineering Alliance. In terms of their membership of the Alliance, statutory engineering bodies can be signatories of six different international agreements governing engineering practices. One of these agreements is the Washington accord (www.washingtonaccord.org). This agreement regulates engineering qualifications and professional competence internationally. Based on this agreement, engineers are allowed to practise their profession in any country that has signed this agreement, irrespective of whether they received their training in that country or not. For the purpose of this study it is important to keep in mind that the Engineering Council of South Africa (ECSA) is a signatory member of the Washington Accord. The international agreements among statutory engineering bodies are indicative of the regulatory nature of engineering and the high standards that are set for engineering on an international level.

Apart from the statutory body that governs engineering in a country, engineers can also be members of local and/or international learned societies that are related to their individual engineering disciplines, interests, or areas of specialisation (Du Preez 2008: 2-3). These learned societies also support engineering education and provide engineers with advice and information. For example, the International Federation of Consulting Engineers (FIDIC) (www.fidic.org) provides consulting engineers with various guidelines on contract conditions, forms of tender, and client agreements which consulting engineers need to adhere to. These guidelines can be general guidelines and can be for specific engineering disciplines. Three examples of FIDIC guidelines are: *Short form of contract; Conditions of contract for electrical and mechanical works;* and *Conditions of contract for construction.* In instances where the learned society provides members with guidelines and other advice, the society becomes a resource of engineering information. Some of the learned societies for engineers include the Cement and Concrete Institute (www.cnci.org.za); Institute for Measurement and Control (www.instmc.org.uk); the South African Institute of Electrical Engineers (www.saiee.org.za); and the Society for Professional Engineers (www.professionalengineers.co.za and www.professionalengineers-uk.org).

These statutory bodies and learned societies promote the development of engineering standards, regulations and the codes of practice to which engineers' work needs to adhere. The requirements that are set by them are published in engineering codes of practice, international and national engineering standards, as well as national and local government regulations (for example, the *South African National Building Regulations* (*SANS 10400*). South African engineers can acquire most of these sources from the South African Bureau of Standards (SABS) (www.sabs.co.za). An examination of the 2005 Standards South Africa Catalogue (ICS-1-ICS-31) shows that each engineering discipline has its own standards, regulations and codes of practice.

Statutory bodies and learned societies therefore have a dual role. These bodies and societies not only regulate the engineering profession but also serve as a source of engineering information. This includes the provision of guidelines on the signing of agreements with clients as well as different forms of tender and contract conditions.

3.3.5 Nature of work in an engineering practice

The Engineers' Council for Professional Development (1941) (an American engineering council) described engineering as an applied science in which engineers apply scientific principles to design or develop structures, machines, or manufacturing processes. The outcomes of engineering work can therefore be described as tangible products. In order to apply scientific principles to their designs, Consulting Engineers South Africa (CESA) (2003a: 3) indicated that engineering involves a large measure of empirical experience and requires engineers to base their engineering decisions on previous experiences and certain cognitive actions.

Four information behaviour studies offer good explanations of how engineers base their actions on their knowledge and personal experiences. The first study was conducted by Wolek (1969: 471). He observed that much of engineers' work centres on working models (prototypes) of a system, which provided them with the opportunity to test and understand the performance of the technology they are developing. In the second study, Montesi and Navarrete (2008: 1415) also reported on the importance of existing products and systems as sources of information in product development.

In the third study, Jagtap and Johnson (2010: 2452) reported on the value of in-service information and maintenance records as sources of information to redesign or improve existing products. These records reflected information on how various components in the product can deteriorate. In the last study, Du Preez (2008: 201, 207, 245-246) reported that engineers photographed the electronic control panels of an existing plant. They thereafter used the photographs (as information) to recreate the circuit drawings they required. She also reported that, in instances when the required information was not available, these engineers would rely on basic engineering principles.
Considering this discussion on the nature of work in engineering practice, it seems evident that engineering not only involves the design and development of new products, but also involves the maintenance of existing products. The nature of the work therefore sets requirements for the type of information that is needed. Such information could include in-service information and maintenance records.

3.3.5.1 Engineering designs

The nature of engineering can also be described by looking at engineering designs. The International Technology Education Association (2007: 90) regards engineering design as the core problem-solving process of technological development. Furthermore, The Association regards engineering design to be as fundamental to technology as inquiry is to science. Two engineers, Hubka and Eder (1987: 123), defined engineering design as a “process performed by humans aided by technical means through which information in the form of requirements is converted into information in the form of descriptions of technical systems, such that this technical system meets the requirements of mankind”.

Consulting Engineers South Africa (CESA) (2003a: 3) described engineering design as a combination of science and art. This view and the aforementioned view of engineering design, proposed by Hubka and Eder (1987), explain Friedel and Liedtka’s (2007: 31) observation that engineers sometimes need to make connections between seemingly unrelated ideas when they prepare their designs.

Friedel and Liedtka’s (2007: 31) observation is also endorsed by Thilmany’s (2005) description of an engineering project in which a group of engineers were commissioned to construct an enormous 100 tonne sculpture in the St Louis Zoo. In order to construct the sculpture, various design processes had to be followed. These processes involved the conversion of the metal sculptor’s hand drawings into engineering drawings, steel-cutting specifications and eventually art.

Sonnenwald (1996: 277) and Sonnenwald and Lievrouw (1996: 180) also observed that engineers use concurrent design methods that emphasise the integration of engineering, manufacturing, marketing and distribution, maintenance and repair, disposal and recycling and application (end-user) information during the design process. Their observation is supported in the engineering literature by Alisantoso, Khoo, Lee and Lu (2006). The engineers participating in Alisantoso et al.’s (2006) study described the collaborative design process of a vacuum cleaner. They explained that the vacuum cleaner’s design had to incorporate both functional (the vacuum cleaner) and non-functional (manufacturing, marketing, etc.) information. The vaccuum cleaner’s design involved a team of people from different subject fields and the engineers had to use concurrent design methods. To acquire the information they required, the engineers actively sought information from their team members. During this information-seeking process the engineers also had to share information related to their own engineering disciplines’ needs that had to be considered in the design. The individual engineers could then, based on the cooperatively agreed solution to the design problem, complete the designs for the components of the vacuum cleaner they were responsible for. This process of integrating information from different subject fields requires engineers to apply their subject knowledge, empirical knowledge and personal experience to their designs.

When considering the descriptions of what engineering design entails, it seems evident that the requirements set by an engineering design determine the subject knowledge and skills that are required to complete the task successfully. As with service ethics (section 3.3.1), the requirements that are set therefore also become the criteria that are applied for source evaluation and selection. As such, these criteria then act as factors shaping information behaviour.

3.3.5.2 Requirements for service delivery

As shown in the definition of engineering (section 3.3.1), engineering is a service-oriented profession. In order to adhere to the requirements of a service-oriented profession, certain service delivery requirements must be met. The service delivery requirements that were identified through the definition and the discussion on the professionalism of engineering include engineers' need to render work of a high quality whilst ensuring their work complies with high safety standards. Furthermore, engineers are required to conduct their work in an ethical manner, accept responsibility for their work throughout the lifetime of the product they had developed, and ensure that the available resources are used efficiently (this was shown in section 3.3.1). Further service requirements relate to the specified time frame and budget within which engineering tasks have to be completed. This could be why Tenopir and King (2004: 137) noted that time could be regarded as a "scarce resource". They therefore believe that engineers would not be willing to spend time reading if they did not consider the information obtained to be of value to their work.

Furthermore, Pinelli (2001: 148) identified three time and cost factors that influence engineers' decisions to select and use (or create) specific information:

- their subjective perception of acquiring the required information in the time they have available to complete their project, task or solve the problem;
- their perception of the relative cost (money and/or effort) of these alternatives; and
- their managers', clients', contractors' or team members' anticipated acceptance of their solution to the problem.

The time and cost factors identified by Pinelli (2001: 148) are also illustrated by Hertzum and Pejtersen's (2000: 766, 769) findings. They reported that the engineers at Novo Nordisk were advised to search internally for information. In this manner the engineers would avoid spending time and resources on work that had already been done by others in the organisation. In addition, the engineers received valuable input by contacting a well-informed colleague. Robinson (2010: 655) reported similar findings. The engineers in his study asked people for the information they required rather than searching for the information from a nonhuman source. This is an instance where cost as a factor of context gives rise to information behaviour that represents inner feelings such as preference or rejection. Case (2007: 154) regarded this type of information behaviour, where cost affects information behaviour as a cost-benefit paradigm, as a "trade off" between the efforts required to employ a specific strategy. He also described it as a normative approach which can be applied toward conscious decisions regarding the expenditure of effort to achieve some goal. The norms engineers apply when consciously deciding on what information to use are determined by the contextual factors discussed in sections 3.3.1, 3.3.3 and 3.3.4 (e.g. engineering regulations, engineering standards and engineering disciplines (section 3.3.2)).

Hertzum and Pejtersen (2000: 769) identified "intellectual effort or social effort" as a time and cost factor. They explained that this factor requires engineers to explain their information need in such a way that it triggers the other person's attention and gets him/her constructively involved. This could be time-consuming. To avoid this effort, the engineers preferred to ask nearby colleagues. The explanation Hertzum and Pejtersen (2000: 769) offered for this tendency is that nearby colleagues are often "somewhat familiar with the context of the problem and thus need less information about the concrete situation to provide the appropriate answer".

A last time and cost factor relates to the immediacy of engineers' information needs, especially in critical phases of their designs. Therefore, in order to save time, engineers would, when they are confronted with a problem, tend to rely on their own knowledge and experience first before seeking for information from a different source (Leckie et al. 1996: 163). A few researchers, like Anderson, Glassman, McAfee and Pinelli (2001: 148), Hertzum (2002: 11) and Pinelli (2001: 145), noted that this tendency could also be interpreted as an information-seeking behaviour which is consistent with the "principle of least effort".

Service delivery requirements, such as quality of work, safety standards, ethical conduct and adhering to specific time frames and budgets, also become factors shaping information behaviour. Furthermore, the cost and time factor contributes to the immediacy of engineers' information needs.

3.3.5.3 Importance of teamwork

Teamwork seems to be another aspect that has implications for information behaviour in everyday engineering practice. Engineers Cheimets, Gordon and Tull (2009: 26) stated that product development is about teamwork. According to them, a significant part of engineers' work takes place in a group, even though engineers may prefer working on their own. This notion is supported by Thilmany's (2005) description of the metal sculpture and Alisantoso et al.'s (2006) description of the collaborative process in designing a vacuum cleaner, which was discussed in section 3.3.5.1. From those descriptions, it seems evident that the project teams involved engineers from various engineering disciplines, as well as persons from other professions such as marketers.

Apart from representing different engineering disciplines and other non-engineering professions, team members, especially when consultants are involved, can also come from different organisational backgrounds. A computer scientist, Moshowitz (1997: 37), noted that team members who come from different organisational backgrounds could also be involved simultaneously in temporary relationships with multiple organisations. He maintained that relationships with different organisations can constrain an individual's information communication behaviour. This was also reported on in the information behaviour studies conducted by Fidel, Pejtersen, Cleal and Bruce (2004: 950) and Sonnenwald and Lievrouw (1996: 184). The effect of multiple relationships with client organisations and project teams on engineers' information behaviour will be discussed in more detail in Chapter 5.

Team members also seem to affect each other's information behaviour. According to Cheimets et al. (2009: 26), the effect individual team members have on a team has as much to do with how the individual engineer interacts within the team with fellow team members as it has to do with the engineer's technical skills. This line of reasoning is supported by Thomas Allen's (1977: 232-233) findings, indicating how social norms, such as different statuses (e.g. the different statuses between the design engineer and those engineers assigned to the testing of the system) undermine communication in a work team**.**

Lastly, Cool and Xie (2000: 9) found that the norms of a project team seem to affect engineers' source selection. According to them, the resource used least frequently was people outside of the company with whom engineers do not normally collaborate. The explanation Taylor (1991: 237) gave for this phenomenon is that many engineers work on products of a proprietary nature. External information exchange is therefore not encouraged. Thomas Allen (1977: 94) also considered two more reasons. According to him, team members have a shared knowledge of their project, while information received from non-team members has limited relevance to the same project.

With the requirement to work in teams in mind, Cheimets et al. (2009: 26) and Lappalainen (2009) discussed engineers' need to negotiate their technical needs and objectives with their team members to ensure they achieve their goals. In doing so, engineers also need to preserve their relationships with fellow team members. According to Cheimets et al. (2009: 26), the application of technical negotiation skills ensure that engineers explore all possible solutions to the problem they are confronted with.

Engineers' need for communication skills was also observed by information behaviour researchers like Friedel and Liedtka (2007: 30) and Pinelli (2001: 140). Based on the findings from their literature review, Tenopir and King (2004: 48) also reported on engineers' needs for communication skills.

Different means are utilised by engineering teams to communicate project-specific information to fellow team members. The different means that were identified by Heisig, Caldwell, Grebici and Clarkson (2010: 508) include drawings, models, reports, plans, minutes and correspondence. Furthermore, Hirsh and Dinkelacker (2004: 808) and Katz and Tushman (1979: 159) found that each engineering project can develop particular communication structures and networks to support the project team's communication and information needs. However, Katz and Tushman (1979: 159) observed that the nature of the communication structure can also affect the technical performance of engineers.

3.3.5.4 Information flow

The nature of engineering work is also marked by the flow of engineering information. According to Thomas Allen (1977: 172), engineers require information from both formal and informal sources to complete their tasks. He explains that formal sources of engineering information are generally in a written or verbal format. When they make something, engineers physically encode (make something tangible) the verbal or written information they have used. The descriptions of engineering designs given by Hubka and Eder (1987: 123), Jagtap and Johnson (2010: 2452) and Wolek (1969: 471), which were discussed in sections 3.3.5 and 3.3.51, illustrate Thomas Allen's explanation. Thomas Allen (1977: 4) used the following diagram (Figure 3.2) to illustrate the flow of engineering information from a verbally encoded format to a physically encoded format. The diagram also shows that engineers, in the process of physically encoding information, produce verbally encoded information (e.g. engineering drawings, tender documents and reports).

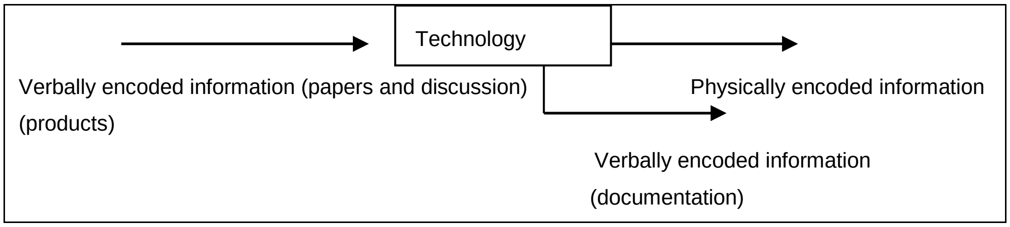


Figure 3.1: Information processing in technology (Thomas Allen 1977: 4)

The implication of the physical encoding of information is that an engineering product, for example a building, is the encoded product of architectural and engineering drawings, and other project-related documents that were used and created during the planning, design and construction stages of the building. When engineers then have to use physically encoded information to solve an engineering problem, they first have to understand (visualise) and interpret the information. Then, based on the insights they gain from these cognitive processes, transfer their insights to conscious problem-solving activities. This process of transcription was also described by engineers Heisig et al. (2010: 501,508), pointing out engineers' need for information from existing products' designs as well as these products' service records to assist them with future engineering tasks. This description of the flow of engineering information explains why Taylor (1991: 235) could claim that "engineering consumes information, transforms it and produces a product or a system which itself is information bearing. But it is not in verbal form".

The flow of engineering information has implications for the availability of certain engineering information. As noted by the engineer Mascitelli (2000: 182), one implication is that not all engineering knowledge and information can be captured in documents and drawings. A second implication was observed by Hertzum and Pejtersen (2000: 770). They found that no information on a product is available in a written form unless someone felt a need to write it down and spent the time doing it. To solve the problem of unavailable engineering formation in a written format, engineers usually visited construction sites or installations to observe how similar engineering problems were solved. This was reported on by Du Preez (2008: 326-329).

3.3.6 Engineering projects

The concept "project" is defined by the *South African concise Oxford dictionary* (2002: 392) as an "enterprise carefully planned to achieve a particular aim". Whereas this generic definition focuses on the planning of something (an enterprise) in view of achieving something, the Project Management Institute (PMI) (1996: 4) takes the definition a step further. The PMI (1996: 4) characterises projects as being performed by people, constrained by limited resources, and as being planned, executed, and controlled. The PMI (1996: 4) further explains that projects may involve a single person or many thousands; may require less than 100 hours to complete or more; may involve a single unit of one organisation or may cross organisational boundaries as in joint ventures. In section 3.3.5.1, two examples of engineering projects were discussed, namely, Thilmany's (2005) description of the construction of a metal sculpture at the St Louis Zoo and Alisantoso et al.'s (2006) description of the design of a vacuum cleaner. Other examples of engineering projects include the development of a new product or service (such as a transport service like the Gautrain in South Africa); effecting a change in structure, staffing or style of an organisation; designing a new transportation vehicle; developing or acquiring a new or modified information system; and constructing a building or a facility.

In the discussion on flow of information in engineering work (section 3.3.5.4) and engineers' work roles (section 3.3.7.1), reference was made to the effect of stages in engineering work on engineers' information behaviour. From the literature it seems that engineering projects can also be subdivided into different project stages. The following discussion will address the possible effect of engineering project stages on the information behaviour of engineers.

Engineering projects have a starting point and an end. ECSA (2010) referred to these two stages as the inception stage and the close-out stage. The tasks in the project can be subdivided into different stages or phases. The studies conducted by Aurisicchio, Bracewell and Wallace (2010: 711), Du Preez (2008: 176-177) and Ellis and Haugan (1997: 386) reported on the division of projects into stages or phases. For example, Ellis and Haugan (1997: 389) identified five phases in their study. Each of these phases could be subdivided into a number of stages. Du Preez (2008) used the stages in an engineering project that were identified by the Engineering Council of South Africa (ECSA) (2010) to structure some of the data in her empirical study.

The results from Jagtap and Johnson's (2010: 2452) study suggest that the type of information accessed depends on the stage of the design process. This could be due to the fact that engineers need to complete different tasks during the different stages of an engineering project. Research findings that confirm this notion include the studies by Du Preez (2008), Ellis and Haugan (1997), Freund et al. (2005), and Montesi and Navarrete (2008). According to the findings from Ellis and Haugan's (1997: 401-402) and Montesi and Navarrete's (2008: 1422) studies, the tasks for the initial stages (the critical design stages) of engineering projects require information from various sources of information. These include both formal and informal sources of information. Du Preez (2008: 321-322) and Freund et al. (2005: 16) reported similar findings, namely that the different project stages can be associated with different patterns of information use. They found that the initial stages of an engineering project involved more information seeking and engineers did more background reading. Jagtap and Johnson (2010: 2451) also reported on this phenomenon. The redesign engineers in their study accessed a considerable amount of in-service information during what they named the clarification stages of the project.

Two reasons are offered in the literature for why the initial stages in a project have an effect on engineers' information behaviour:

- tasks requiring completion in the early stages of a project are characterised by greater uncertainty (Lowe, McMahon & Culley 2004: 417)
- engineers need to explore new products and technologies that could be useful in their designs during the initial stages of the project (Hirsh & Dinkelacker 2004: 809).

In South Africa, CESA (2003b) and ECSA (2010) provided some guidelines on the tasks engineers have to complete during each stage of an engineering project. A study of the suggested tasks proposed by ECSA for each project stage shows that the tasks in an engineering project become more directly related to the production or construction of a specific engineering object or facility as the project progresses. The effect of these stage-related tasks on engineers' information behaviour is reported on by Du Preez (2008: 320-321) and Freund et al. (2005). They observed that the engineers' information behaviour patterns during the project stages, following the initial stages, are focused on more detailed and procedural information. During the final project stages the engineers were more involved with project management tasks. The information that engineers required during these final stages of a project was derived from the project itself.

Certain elements in an engineering project seem to shape engineers' information behaviour. These include aspects such as the duration of the project, the project stage and the nature of the project. Further aspects that need to be considered relate to the nature of the project. These include considerations of whether the project is focused on developing a new product or whether it is about effecting changes to an existing structure, or product.

3.3.7 Practice and work environment

Sheppard, Colby, Macatangay and Sullivan (2006: 435) described engineering practice as the complex, thoughtful and intentional integrations of a problem-solving process and specialised knowledge to a meaningful end. According to Aurisicchio et al. (2010: 711), a work context, in this case an engineering practice, can be described "through the environment in which information seekers [e.g. engineers] work, their work roles [e.g. as consulting engineers], the project type, the stage of the project life cycle and the task or activity type". This description of work practices is endorsed by Veshosky (1998: 58) when he stated that engineering is context specific. Engineering practices have been noted to be very diverse and have been studied in various environments:

- academic environments (Du Bruyn 2004; Engel, Robbins & Kulp 2011; Fernàndez, Lòpez, Rubio & Marco 2009; Finn & Johnston 2004; Hiller 2003; Fidel, Pejtersen, Cleal & Bruce 2004; Korobili et al. 2011; Robbins, Engel & Kulp 2011; Shuchman 1981; Tenopir & King 2004)

- business environments, including studies conducted in corporate environments (Cool & Xie 2000; Du Preez 2008; Hirsh & Dinkelacker 2004; Mueller, Sorini & Grossman 2006; Palmer 1993; Schwarzwalder 2001; Ward 2001)
- industrial environments (Aurisicchio et al. 2010; Bigdeli 2007; Jagtap & Johnson 2010; Nwagwu & Segilola 2013; Rosenberg 1967; Rosenbloom & Wolek 1970)
- government environments (Hansen & Järvelin 2005; Tackie & Adams 2007).

The different environments in which engineers work also determine the type of work that they do. Examples of the type of engineering work reported include consulting engineering (Du Preez 2008; Palmer 1993; Ward 2001); design engineering (Allard et al. 2009; Kwasitsu 2003); redesign engineering (Jagtap & Johnson 2010); patent engineering (Hansen & Järvelin 2005), and innovation engineering (De Smet 1992).

3.3.7.1 Work roles

The work environment also determines engineers' work roles and tasks. Therefore, as identified by Leckie et al. (1996: 180-181), work roles and associated tasks are two contextual factors that seem to affect information behaviour. The *South African concise Oxford dictionary* (2002) defines "role" as a person's "function in a particular situation". This definition is supported by Audunson's (1997: 76) view of roles. According to him, roles contain identifiable norms that govern likely information practices, which make it possible to predict the way that a person occupying a certain position will behave. Fidel and Pejtersen (2004) are of the view that the identifiable norms that are contained in roles relate to those criteria or "sets of directions" which guide individuals occupying a position in what is expected of them. Norms therefore govern work roles and as such function as both constraints and enablers for information actions.

Audunson (1997: 79) also argued that the position the person occupies could be identified through certain observed behaviour. One such behaviour could relate to the activities a person needs to do and which are governed by the work role's norms. This is why Huvila (2006: 20-22) describes a "work role" as a "distinct set of activities in a work which again refers to a distinct set of activities within a person's life world".

As early as in 1966, Thomas Allen (in Kwasitsu 2003: 459) arrived at the conclusion that engineers' work roles affect the sources of information they seek. However, despite this acknowledgement, few studies explicitly discuss work roles and the effect they have on engineers' information behaviour. The studies that did mention the possible effect work roles could have on engineers' information behaviour investigated their task-related information behaviour within different work environments. The work roles of engineers that were identified by information behaviour researchers include academics (Engel et al. 2011); consulting engineers (Du Preez 2008; Gralewska-Vickery 1976: 266; Ward 2001: 169); designers, processors and manufacturers (Court 1997; Kwasitsu 2003; Sonnenwald 1996); redesign and maintenance engineers (Jagtap & Johnson 2010), and researchers and product developers (R&D) (Hertzum 2002: 7; Hirsh 1999: 474-475; Sonnenwald 1995: 863).

According to the literature review conducted by Tenopir and King (2004: 75), the information behaviour of R&D and design engineers received the most scholarly attention. The work roles of R&D engineers that were identified by Ellis and Haugan (1997: 386), Hertzum (2002: 7), Hirsh (1999: 474-475) and Sonnenwald (1995: 863) include roles as researchers, project managers, designers and developers. Gralewska-Vickery (1976), Kwasitsu (2003), and Montesi and Navarrete (2008) were of the few researchers that pertinently reported on the effect work roles have on engineers' information behaviour. Gralewska-Vickery (1976) discussed engineers' work roles in terms of the different stages in their careers. She observed that engineers' work roles affected their information behaviour in different ways,including the following:

- student engineers were required to acquire background knowledge and practical skills
- junior engineers sought advice from supervisors and observed their behaviour
- intermediate engineers advanced their engineering training by reading more, attending conferences and entering into discussions with other engineers
- senior engineers sought information from intermediate engineers. They also returned to educational institutions to be educated in business administration.

The work roles that were identified in Kwasitsu's (2003: 465) study can be related to the different stages in microchip production. Montesi and Navarrete (2008) reported on the work roles of software engineers. Both the studies by Kwasitsu (2003) and Montesi and Navarrete (2008) found that engineers' work roles determined the type of information that was sought and used. Montesi and Navarrete (2008: 1415) also found that the information that engineers would use could come from existing products or systems, formal documents, or from informal discussions with their team members.

Although only a few studies explicitly discussed engineers' work roles, the preceding discussion attempted to show the effect different work roles have on engineers' information behaviour. It also showed that engineers' work roles are seemingly linked to their career stage and the type of work they are required to do. Based on Huvila's (2008: 802, 810) view of the concept "work role", the term can also be used to explicate the underlying concept of tasks. The following discussion will therefore examine the effect engineers' tasks have on their information behaviour.

3.3.7.2 Tasks

Whereas engineers' work roles are linked to the type of work they do, tasks, as described in section 3.3.6.1 by Audunson (1997: 79), refer to those activities engineers need to complete that are governed by their work roles. Hackos and Redish (1998: 56, 69), two software engineers, defined tasks as "a series of actions undertaken in pursuit of a goal". According to them, a meaningful product can be the result of task completion.

The definition for tasks offered by Byström (2007) is based on Hackos and Redish's (1998) definition. According to her, tasks are "a purposeful set of linked concrete or cognitive activities performed by people (or machines); normally it has a meaningful purpose as well as an identifiable beginning and end." Whereas Hackos and Redish (1998) merely referred to tasks as a "set of actions", Byström's (2007) definition specifies that the activities are concrete or cognitive and different task activities are linked in a certain logical order. In engineering, Hansen and Järvelin (2005: 1107-1108) identified the sequential order in which tasks are completed in patent offices. Also, in engineering projects, tasks seem to be linked sequentially when one considers that certain tasks should be completed within each of the different stages in an engineering project. This was explained in section 3.3.6.

Engineers are expected to make informed decisions in a number of task-related situations, for example, they have to decide between the usefulness of different products (e.g. different closed circuit television (CCTV) cameras). According to Hertzum and Pejtersen (2000: 762), the choices they need to make are largely dependent on their understanding of the context of the task and on their success in obtaining information about the product that they would use. For example, one of the responding engineers in Du Preez's (2008: 188-189) Masters' study reported that he would seek information from his client, the brochures or catalogues he had received from suppliers, or he would base his decisions on his personal knowledge and experience.

Apart from the physical or cognitive nature of tasks, Byström and Järvelin (1995: 194) and Vakkari (1999: 825-826) also indicated that tasks could be simple or complex. Therefore, apart from task goals, task complexity also needs to be considered in a discussion on how tasks affect engineers' information behaviour.

a. Task goals

A task's goal depends on the context and the situation in which the task originates and could also have preconditions, such as time constraints (Byström & Hansen 2005: 1054; Toms 2011: 47). The preconditions that are set for tasks could be set by the task performers themselves or by others (Byström 2007). It therefore appears as if certain elements in the engineering context, such as tasks, and the preconditions that are set for them, become factors that determine task goals. The factors that were identified by Taylor (1991: 237) include the client's specifications, which dictate their solutions to the problem, the properties of the materials they need to use, the specific design and the time available for task completion. Fidel and Green (2004: 568) and Mench (2002: 147) (who is an engineer) added the client's budget to this list. These factors then influence engineers' information behaviour in that they set certain requirements in terms of the information that engineers will have to use.

In their discussion on how tasks are chosen to reach certain goals, Hackos and Redish (1998: 57-59) indicated that task goals determine the approach that will be taken to complete these tasks. According to them, people have many options, or a combination of options, they could choose from to complete their tasks successfully. This is supported by Hertzum and Pejtersen’s (2000: 762) and Ward’s (2001: 170) observations of how engineers approach their tasks. According to their observations, engineers have some freedom in deciding on the approach they would follow to complete their tasks.

b. Task complexity

The concept “task complexity” was used by Vakkari (1999: 825-826) to indicate the “degree of pre-determinability of task performance.” The pre-determinability of a task can then, according to Vakkari (1999: 825-826), be subdivided into the pre-determinability of its information requirements, process, and outcome. Vakkari (1999: 826) described simple tasks as tasks where the elements of the tasks are pre-determined. In engineering, Freund et al. (2005: 14) observed that engineers, when they need to complete a simple task, generally refer to the documents in their personal collections.

In contrast to simple tasks, complex tasks are new tasks and decision-making tasks that require information to complete (Vakkari 1999: 826). Vakkari (1999: 826) posited that it is not possible to determine the outcomes of complex tasks in advance. As a result, one can expect that the degree of uncertainty about task inputs and task requirements are higher in complex tasks than in simple tasks. This view of task complexity is supported by Byström and Järvelin (1995: 194). According to them task complexity refers to “the degree of uncertainty about the task inputs, process, and outcome”. The findings and observations from four studies on engineers’ information behaviour are descriptive of how task complexity affects engineers’ information behaviour.

- Tushman (1978: 626) observed that the variations in task complexity affected the amount of information that engineers needed to process to ensure successful task completion

- Shuchman (1981: 27) found that engineers had to integrate information from various sources when they were confronted with complex tasks
- Anderson et al. (2001: 148) observed that the responding engineers in their study widened their search from oral contacts to literature searches as their task complexity and the associated task uncertainty increased
- Katz and Tushman (1979: 160) observed that engineers' oral communication is more frequent in research projects, in which they are faced with complex tasks, than in technical services projects. They also found that the engineers in their study had different communication networks for complex tasks (e.g. high-performing projects), as compared to simple tasks (e.g. routine tasks such as technical services projects). In a later study, Tushman (1982: 351) reported similar findings.

As shown in this discussion, task goals and task complexity are two task-related factors that have an effect on engineers' information behaviour. Therefore, it seems as if different types of tasks instigate different information needs and prompt different information-seeking strategies. Apart from engineers' information needs, various other factors, such as engineers' personal knowledge and experience also seem to have an effect on their task performance.

3.3.8 Reflection on the engineering context

Various aspects in the engineering context that could potentially influence engineers' information behaviour received attention in this discussion. These aspects included the engineering profession, engineering disciplines, education and training, as well as membership of statutory bodies and learned societies. The discussion highlighted the role these aspects play in engineering practice and how they affect engineers' selection of information.

The discussion also highlighted the fact that engineering designs need to adhere to certain conditions and requirements. In turn, the set requirements become criteria that are applied to source selection. As such, the conditions and requirements for engineering designs become factors shaping the information behaviour of engineers.

3.4 PERSONAL DIMENSION OF ENGINEERS

In section 2.3.2, it was shown that certain inner mental states can be associated with information behaviour. These are cognitive (i.e. thinking processes); conative (i.e. inherent factors that affect motivation and preferred ways of learning) and affective responses (feelings). The following discussion will attempt to highlight some of the elements in the personal dimension of engineers that have an effect on their information behaviour.

3.4.1 Cognitive phenomena

Certain cognitive phenomena seem to affect individuals' (including engineers') information behaviour. B.L. Allen (1991: 7) identified three types of cognitive phenomena that have an effect on information behaviour, and which are as applicable to engineers as to information users in general. The cognitive phenomena he identified are conceptual knowledge, task knowledge and knowledge of the resources that are used.

As shown in Chapter 2, section 2.3.1.1, people acquire their subject knowledge, task knowledge and knowledge of the resources that are used through their education, training and work experience. The discussion in section 3.3.3 showed that the different statutory engineering bodies and learned societies influence the education and training of engineers. Vicenti (1990) maintained that engineering knowledge is developed and formalised to meet engineers' needs in a particular domain (i.e. engineering discipline and type of engineering work). Vicenti (1990) also noted that some items of this knowledge are clearly distinguishable (whilst others are not).

Engineers' personal knowledge seems to determine whether and when they will seek information from formal sources or not. For example, Ellis and Haugan (1997: 393, 401-402) and Shuchman (1981: 34) found that engineers generally rely on their personal knowledge and experience. It was only when their personal knowledge, experience and contacts proved to be inadequate to solve the problem at hand that the engineers in Fidel and Green's (2004: 570) and Ward's (2001: 173) studies accessed formal sources of information. However, when they did seek information from formal sources, the intended use of the information and the engineers' personal knowledge and expertise determined the level of detail that was sought in the information (Freund et al. 2005: 14).

In Chapter 2 (section 2.3.1.1) it was indicated that cognitive phenomena affect people's information behaviour in two ways, namely, the recognition of information needs and the resulting cognitive activities. Although the literature focusing on engineers' information behaviour did not address the recognition of information needs, there were some reports on engineers' cognitive activities and their problem-solving skills.

3.4.1.1 Cognitive activities

In the information behaviour literature, Vicenti (1990: 246) identified three types of cognitive activities with which engineers had to be equipped to ensure task completion. The activities he identified are:

- searching their past experiences to find knowledge that has proved useful
- incorporating novel features thought to have a chance of working
- "winnowing" (i.e. evaluating something to identify useful elements) the conceived variations to choose those most likely to work.

The cognitive activities that were identified by Vicenti (1990) enable engineers to make connections between different ideas and to findsolutions to problems with which they are faced.

3.4.1.2. Problem-solving skills

The Business Dictionary (2013) describes problem solving as "the process of working through details of a problem to reach a solution ... and [which] can be a gauge of an individual's critical thinking skills". In engineering, problem-solving skills can be described as those skills utilised by engineers to find solutions to their problems. From their literature reviews on engineers' information behaviour, Leckie et al. (1996: 165), Tenopir and King (2004: 48) and Ward (2001: 173) found that the problems engineers encounter have a conceptual and a hard data side. Engineering problems can therefore affect engineers' information behaviour in various ways. Some of the ways that were reported in the literature include the following:

Ward (2001: 173) reported that engineers need different types of information sources when they have to solve conceptual and hard data engineering problems. For example, engineers would rely on "knowledge clubs" to solve conceptual engineering problems, but would find information in the literature indispensable when they had to solve hard data engineering problems.

Ellis and Haugan (1997: 393, 401-402) and Shuchman (1981: 34) found that engineers generally rely on their personal knowledge and experience. They also reported that engineers would consult with their personal contacts when they were faced with problem-solving decisions.

Lera, Cooper and Powell (1984: 114), three designers, claimed that there are certain prerequisites for information to be useful in problem-solving tasks. The prerequisites they mentioned are that the information must be accessible, relevant to the problem and designers should be able to apply it readily to the problem. When considering these claims, it seems as if engineers' problem-solving skills can also be linked to their ability to select information from their own knowledge base that is relevant to the problem. This implies that engineers apply their problem-solving skills to seek relevant information to acquire the necessary understanding or insight that enable them to actively solve the problem.

3.4.2 Conative phenomena

The discussion on conative phenomena in Chapter 2, section 2.3.1.2, indicated that two types of conative phenomena could affect engineers' information behaviour. These are self-efficacy (beliefs) and learning styles, which will be discussed below.

3.4.2.1 Self-efficacy

In the discussion on conative phenomena in Chapter 2, section 2.3.1.2, it was indicated that self-efficacy affects the way in which people approach their tasks, goals and challenges. In order to decide on the best approach, they then ask “why” questions. Although not identified as self-efficacy, it seems as if the effect self-efficacy has on engineers’ information behaviour can be illustrated by means of Friedel and Liedtka’s (2007: 30) observations. They observed that engineers raise questions about the way things are done when they need to acquire information for a new task (especially at the onset of a new engineering project). Engineers then consider whether the way things are done is necessary, natural or customary.

As shown in section 3.4.1.1, engineering design requires the process of converting engineers’ visual perceptions, ideas and available technical information into physical products. This conversion process requires certain cognitive actions. Considering the arguments of Vicenti (1990), it seems as though the required cognitive actions that are undertaken by engineers are based on their existing knowledge of the product they need to design, as well as their empirical experience of similar product designs.

Lastly, when considering Tenopir and King’s (2004: 137) previously reported observation that time could be regarded as a “scarce resource”, it seems as if time is a factor which has implications for engineers’ information behaviour with regard to information selection, use and self-efficacy. The effect of time as a “scarce resource” on the information behaviour of engineers will be discussed in more detail in section 3.7.1.1.

3.4.2.2 Learning styles

In his discussion on engineers’ personal knowledge, Court (1997: 126) focused on the link between engineers’ personal knowledge and their mental processing activities. According to him, this linkage between personal knowledge and mental processing activities is the “mental state of ideas, facts, concepts, data, techniques, etc. recorded in an individual’s memory”. The process of mentally recording knowledge can be described through a person’s learning style. Engineers seem to learn by doing (i.e. being involved in repetitive tasks). This assumption is further supported by the observations made by a number of information behaviour researchers:

- Gralewska-Vickery (1976: 260-261) observed that junior engineers undertook routine technical work, which tended to be repetitive.
- Ward (2001: 171) observed that junior engineers often did the "legwork" and were assigned to routine technical work to ensure that they gain experience.
- Taylor (1991: 235) and Rosenbloom and Wolek (1970) found that engineers learn by doing and by using certain information and products. Rosenbloom and Wolek (1970: 120-140) illustrated this when he reported on engineers' use of the feedback they had received from users of their products to improve these products' efficiency. Similarly, information collected from repeated observations of the actual operation of products was used to improve product efficiency.

Apart from engineers' learning styles, the discussion in section 3.4.1 also reports on engineers' cognitive activities and their problem-solving skills. Since conation is about making a link between knowledge and behaviour, the cognitive activities in task completion and the problem-solving skills of engineers also need to be addressed.

3.4.3 Affective phenomena

As discussed in section 2.3.1.3, affective phenomena, such as thoughts and emotions, are associated with information seeking. In her research, Kuhlthau (2004: 44) found that task performers express feelings of uncertainty and apprehension at the initial stages of a task. They then recall previous projects in which they required similar information and their actions frequently involved discussing possible approaches to the task. In an information behaviour study focusing on engineers, Bin Guo (2007) reported on the effect task uncertainty has on engineers' information behaviour. He reported a positive link between task uncertainty and the information sources that were used by engineers, both in terms of frequency of use and in width. However, the frequency of network source use was an exception.

Fosmire (2012: 49) also reported on the effect thoughts and emotions have on engineering students' information behaviour. He observed that the students became more uncertain, confused and doubted themselves when they encountered inconsistent and incompatible information.

As shown in this discussion on the personal dimension of engineers, certain inner mental states have an effect on engineers' information behaviour. The mental states that Fosmire (2012) discussed are cognitive, conative and affective phenomena. When considering Bin Guo's (2007) and Fosmire's (2012) findings it seems as if the relationships that exist between the different mental states, as well as the interaction between the personal dimension of engineers and situations within the engineering environment, give rise to information needs. In turn, these information needs prompt certain information activities.

3.5 INFORMATION NEEDS

In his 1981 article, Wilson referred to the existing relationship among information behaviour aspects and stated that information-seeking behaviour results from the cognition of an information need. The information needs component is the third component in the suggested information behaviour framework (Figure 2.1). As shown in Chapter 2, section 2.3.4, information needs are representative of a personal dimension of the user, where factors in both the individual's mental structures and personal circumstances prompted the need.

In his examination of the contextual features of an information need, Savolainen (2012) found two approaches in studies on information needs, namely, subjective and situational approaches. According to him, studies with a subjective approach characterised information needs in the internal context of the user, whereas studies with a situational approach analysed the contexts of the information need. The engineering context and engineering practice are examples of contexts in which engineers' information needs can be studied.

When considering Wilson's (1981) and Savolainen's (2012) discussions on information needs, it seems evident that certain elements in the personal dimension, as well as elements in the context, can give rise to information needs. Furthermore, these elements act as determinants of the information need in terms of how it is conceptualised and what is required to satisfy the need. Information needs is the third component in the information behaviour framework (Figure 2.1). The following discussion will highlight how the interaction between the context (component i) and the personal dimension (component ii) gives rise to information needs.

3.5.1 Contextual determinants of information needs

According to Savolainen (2012), the context in which an information need arises determines how the need is conceptualised. Based on his analysis of the literature on information needs, he identified three major contexts in which information needs arise. These are situation of action, task performance and dialogue.

3.5.1.1 Situation of action

McCreadie and Rice (1999: 58) understand situation as “the particular set of circumstances from which a need for information arises”. According to Savolainen (2012), these circumstances are bound to some concrete requirements and conditions of action. The findings reported by Thomas Allen (1977), Byström (2002) and Ellis and Haugan (1997) support Savolainen’s (2012) observation. Their findings show how the context or situation in which an information need arises determines the information-seeking path and the information that is required.

When considering the discussion on the engineering context (section 3.3), it seems as if there are various elements in the engineering context, as well as situations of action, that affect engineers’ information needs. Some of these include:

- the problem-solving nature of engineering work (Fosmire 2012: 47)
- the regulated nature of engineering work which requires it to adhere to certain standards and regulations (Smith 2011)
- the flow of engineering information, due to which not all engineering information can be documented (Mascitelli 2000: 182)
- service delivery requirements, such as the specified time frame and budget (Anderson et al. 2001: 148; Hertzum 2002; Leckie et al. 1996: 163; Pinelli 2001: 145)
- engineers’ need for information from existing products (Heisig et al. 2010: 501, 508; Jagtap & Johnson 2010: 2454; Montesi & Navarrete 2008)

- urgency of the information need (Anderson et al. 2001: 148; Hertzum 2002; Leckie et al. 1996: 163; Pinelli 2001: 145). Pinelli (2001: 145) observed that engineers' information needs are immediate, especially during the critical phases of design. To satisfy their needs, engineers usually want "a specific answer, in terms and format, that is intelligible to the engineer – not a collection of documents that he must sift, evaluate, and translate before he can apply them" (Cairns & Compton 1970: 375). This was supported by Fidel and Green (2004: 572) and Ward (2001: 173) when they stated that engineers pragmatic needs determine their source selection.
- Access to information that is accurate and relevant to the information need (Hirsh 1999: 484)
- information needed is seldom found in one source (Shuchman 1981)
- the environment in which engineers work (Du Preez 2008; Korobili et al. 2011). Engineers' work roles and tasks are also related to their work environment and could determine their information needs (Kwasitsu 2003: 465). A last aspect related to engineers' working environment, is their career stages. This was reported on by Gralewska-Vickery (1976: 281).

Apart from the context or situation in which an information need arises, Savolainen (2012) also found that information needs may undergo changes within or between situations. As shown in section 3.3.6, engineers' information behaviour changes as an engineering project progresses through different stages. It can therefore be assumed that the different stages in an engineering project would also affect engineers' information needs. In addition, CESA (2003a: 1) noted that each project has certain unique characteristics. This could therefore mean that different projects could affect engineers' information needs in different ways.

3.5.1.2 Tasks

In Chapter 2, section 2.3.4.1.1, it was indicated that task performance is the main generator of cognitive information needs. Incidentally, research focusing on engineers' information needs seemed to have focused mainly on engineering tasks and task-related information needs. Furthermore, Friedel and Liedtka (2007: 31), Mueller et al.

(2006) and Ward (2001) found that engineers' task-related information needs seem to be aimed at solving problems that arise during product development. For example, Thomas Allen (1977: 23,34) and Ellis and Haugan (1997: 401) found that individual engineers' information needs varied as these engineers progressed through an engineering project, and that they took different courses of action to provide in their information needs. The reason Ellis and Haugan (1997: 401) offered for the different courses of action taken by engineers to provide in their information needs was that different information channels served different problem-solving functions. Byström's (2002: 588) finding in a non-engineering study, that the information necessary to complete a specific task is only related to that task, endorses Ellis and Haugan's (1997) reasoning.

3.5.1.3 Dialogue

Dialogue is the third contextual determinant of information needs that was identified by Savolainen (2012). He understood dialogue to be the written or spoken conversational exchange between two or more individuals. According to Savolainen (2012), communicative factors become central in the dialogue context. Information needs that arise from the dialogue context are therefore needs that arise within a social environment. As explained in Chapter 2, section 2.3.4.1b, social factors influence how people perceive situations and determine the alternative actions they will take. Also, as indicated by B.L. Allen (1996: 74-77), the available courses of action may be different in different situations, as well as in different groups.

3.5.2 Personal dimension

In addition to the contextual determinants of information needs, certain aspects in engineers' personal dimension also give rise to information needs. The aspects that were identified by Case (2012), and discussed in section 2.3.4, include seeking answers, the reduction of uncertainty, and making sense. Of these aspects, it seems as if studies reporting on engineers' information behaviour only reported on the reduction of uncertainty (an affective phenomenon) as a motivator of engineers' information needs. In these studies, Lowe et al. (2004: 417) observed that tasks requiring completion in the earlier stages of a project seem to be characterised by greater uncertainty. In order to reduce their uncertainty, Anderson et al. (2001: 148) observed that engineers widened their information search.

Apart from the aspects that were identified by Case (2012), information behaviour researchers also reported on information needs that can be linked to engineers' cognitive phenomena. That is engineers' personal and research interests (Du Bruyn 2004). According to Du Bruyn (2004), engineering lecturers' information needs revolved around these interests.

3.5.3 Reflection on engineers' information needs

In view of this discussion in section 3.5, as well as the discussion on the context of engineers and their personal dimension, a profile (Table 3.1) could be compiled to graphically illustrate the factors that prompt engineers' information needs. Table 3.1 visually depicts engineers' information needs.

Table 3.1: A profile of engineers' information needs

A profile of engineers' information needs						
Contextual Factors		**INFORMATION NEEDS**				
		Context			**Personal Dimension**	
		Situation of action	**Tasks**	**Dialogue**	**Cognitive**	**Affective**
Engineering environment	Profession	●			●	●
	Engineering disciplines	●		●	●	
Engineering practice	Engineering designs	●			●	
	Service delivery	●	●		●	
	Teamwork			●	●	
	Information flow	●			●	
	Work roles	●			●	
Tasks	Task complexity		●		●	
	Task performance		●		●	
	Projects	●	●		●	
Personal dimension	Cognitive phenomena				●	
	Affective phenomena					●

The suggested profile shows how the different elements in the context of engineers and their personal dimension affect the three contextual types of information needs. The profile also shows how cognitive and affective phenomena affect engineers’ information needs. From Table 3.1 it seems as if most of the elements in the engineers’ context and their cognitive and conative phenomena give rise to information needs that belong within the situational and cognitive needs domains, whereas the profession and affective phenomena give rise to affective information needs, as suggested by Savolainen (2012).

3.6 ENGINEERS’ INFORMATION ACTIVITIES

The fourth component in the suggested information behaviour framework (Figure 2.1) focuses on information activities. In the discussion on the information behaviour definition in Chapter 2, it was shown that the existing interaction between various aspects in the engineering environment and the personal dimension of engineers gives rise to information needs, which in turn prompt certain information activities. The two information activities that were identified by Wilson (1999: 249; 2000: 49) in his information behaviour definition, and which were discussed in section 2.3.1, are active and passive information seeking and information use. However, from the studies reported in the literature on engineers’ information behaviour, it seems evident that there are more information activities than only information seeking and use. These activities include information transfer, communication and sharing, as identified by Case (2006: 293), which will be discussed below.

3.6.1 Information seeking

Information seeking is a “conscious effort to acquire information in response to a need or gap in your knowledge” (Case 2012: 5). From the discussion on the engineering context and engineers’ personal dimension, it seems as if a number of elements from these two aspects affect engineers’ information-seeking behaviour. The following paragraphs will aim at determining those elements and highlight some of the studies that discussed them.

3.6.1.1 Contextual elements

The elements in the engineering context, which are also factors affecting engineers' information-seeking behaviour, and which were reported on in the discussion on context (section 3.3), include engineering disciplines, work roles, tasks and engineering projects. However, there are certain other factors that were investigated in information-seeking behaviour studies which are also contextual factors. These include the availability and accessibility of information, time and cost, and information overload.

a. Availability and accessibility of information

In their studies, Anderson et al. (2001: 147), Gerstberger and Allen (1968: 277), Kremer (1980: 53-119), and Tackie and Adams (2007: 77) reported that availability and accessibility affected engineers' source selection. According to their findings, engineers aimed at minimising their losses in terms of the effort they must expend to gain access to the required information. Other aspects related to availability and accessibility, which were reported to affect engineers' selection of sources, include the technical quality of the information (Anderson et al. 2001; Gerstberger & Allen 1968: 277) and the perceived importance of the information to the task (Anderson et al. 2001: 147; Tackie & Adams 2007: 77).

b. Time and cost

Time and cost is a service delivery requirement. The effect this factor has on engineers' information behaviour was reported on by Allard, Levine and Tenopir (2009: 444), Hertzum and Pejtersen (2000: 776), Hirsh (1999: 476), Robinson (2010: 655), and Sonnenwald and Iivonen (1999: 436). They reported that time and cost affect engineers' selection of information sources as well as their perception of the availability and accessibility of the required information.

c. Information overload

The concept "information overload" is used to describe situations in which there is too much information and such a situation can be as detrimental to an engineering project as too little information (Robinson 2010: 641). In her study, Jackson (2001: vii) found that the flow of information was directional in information overload situations. Furthermore, the information was often incomplete or changed frequently. In order to manage their information environment, the engineers in her study used both proactive and reactive strategies. One of the strategies employed by the engineers in Ellis and Haugan's (1997: 399) study to avoid information overload was to participate in discussions with their personal contacts. These engineers believed that informal discussions were more effective than reading to acquire the information they required.

3.6.1.2 Elements in the personal dimension

Ward (2001: 173) reported that engineering problems have a conceptual side, a hard data side and a personal side. The personal side that affects engineers' information behaviour can be described as their personal dimension. This was discussed in Chapter 2, section 2.3.2 and in section 3.4. Some of the information-seeking behaviour reported on in studies involving engineers can be linked to the cognitive, conative and affective phenomena that make up the personal dimension of engineers.

a. Cognitive phenomena

Cognitive phenomena seem to affect engineers' information source or channel selection. According to Ellis and Haugan (1997) and Tackie and Adams (2007: 77), engineers' selection of sources is based on their personal knowledge and experience of using the source. However, as reported by Du Preez (2008) in section 3.3.5, engineers apply their engineering knowledge innovatively to find the information they want by photographing electrical control panels to recreate the circuit drawings they required.

b. Conative phenomena

According to Shuchman (1981: 27-28), engineers do not always find all the information they require in one source. Their conative phenomena therefore seem to affect their ability to identify the missing data and then learning who has it.

c. Affective phenomena

Engineers' personal preferences are an affective phenomenon. Ward (2001: 173) reported that engineers' personal preferences and temperament were important determinants in their information-seeking behaviour. The research findings reported by Holland and Powell (1995) and Hurd, Weller and Curtis (1992) indicated that engineers prefer "word of mouth" communication and personal libraries when seeking for information. The study by Milewski (2007) reported similar findings. The engineers in Milewski's study preferred web browsing, asking friends and co-workers, and reading documents, as opposed to to interacting with newsgroups, contacting vendor support or taking courses.

3.6.2 Information searching

Information searching, according to Hepworth (2007: 51-52), is a specific cognitive information activity. The service delivery and service requirement elements of the engineering context seem to affect engineers' information searching. In section 3.3.5.2, it was shown that time and cost are important factors affecting engineers' decisions on where to search for information and which sources to select.

A few studies specifically focused on engineers' information-searching behaviour on the Internet. These are the studies by Fidel and Efthimiadis (1999); Kraaijenbrink (2007) and Montesi and Navarrete (2008). The most important findings from these studies revealed that engineers narrowed their searches more frequently than broadening their searches (Fidel & Efthimiadis 1999: 319); engineers' experienced a gap between the amount of information available and the quality of the information they required (Kraaijenbrink 2007: 1370); information searching builds upon historical and experiential data (Montesi & Navarrete 2008: 1411).

3.6.3 Awareness of information and information encountering

In his discussion of his information behaviour definition, Wilson (1999: 249; 2000: 49) noted that information seeking includes face-to-face communication and the passive reception of information. Examples of the passive reception of information that were identified by Allen, Karanasios and Slavova (2011), Bates (2009), Bawden (2011) and Erdelez (1997) include awareness of information and information encountering.

Bates (2009: 2381) explained that information awareness simply means being aware of information and Bawden (2011: 9) alluded to information encountering as the "finding of useful information by accident". In the discussion of their model of the information seeking of professionals, Leckie et al. (1996) indicated that an awareness of information was one of the factors that shape individuals' information needs. They argued that an individual's awareness of information can determine the information-seeking path that will be taken.

In studies focusing on engineers' information behaviour, Birnholz (2005), Du Preez (2008: 331) and Sonnenwald and Pierce (2000) reported on engineers' awareness of information. They reported that engineering information is everywhere and through their awareness of such information, engineers remain abreast of new developments in their field of engineering. In a military environment, Sonnenwald and Pierce (2000: 474) reported that situational awareness was crucial for task completion.

3.6.4 Information use

The concept "information use" has been ill-defined in the information behaviour literature. As Kari (2010) discovered, the concept can be described from various viewpoints. For the purpose of this study, Meyer's (2003: 110) understanding of information use will suffice. According to her, information use can be understood as the manner in which people handle information when collecting, searching, accessing and communicating information. As with information seeking, the reports on engineers' use of information can be subdivided into the engineering context and engineers' personal dimension.

3.6.4.1 Engineering context

The studies reporting on the use of information that relate to the engineering context addressed the value of information that is immediately available (Shuchman 1981); as well as information quality, accessibility and availability (Bin Guo 2007; Kwasitsu 2003).

Bin Guo (2007: 1984) reported a positive link between task uncertainty, task complexity and the use of information sources. The only exception Bin Guo (2007) found was related to the frequency with which network sources were used. He also reported a positive link between the educational level, work experience and source use of engineers.

3.6.4.2 Personal dimension

The personal dimension seems to affect engineers' information behaviour both cognitively and affectively. Bin Guo (2007) and Kwasitsu (2003) reported on information use that could be associated with engineers' cognitive phenomena. According to them, engineers' educational level and experience could be linked with the frequency with which specific sources of information were used.

Engineers' preference for using information from their own collections or that is close at hand was reported by Holland et al. (1991), Shuchman (1981) and Zipperer (1993). Bigdeli (2007) also reported on engineers' preferences for the use of certain information channels.

Trust is another affective factor which affects engineers' selection of information sources. In their studies, Hertzum (2002: 2-3) and Tseng and Fogg (1999: 41-42) distinguished four types of trust (credibility) on which engineers based their trust in sources:

- first hand experience or experienced credibility,
- reputation,
- simple inspection of surface credibility, and
- general assumptions and sterotypes of presumed credibility.

In line with these four types of trust, Van House, Butler and Schiff (1998: 341) found that the physical distance between people affects their readiness to trust each other. Du Preez (2008: 331) and Hertzum (2002) reported that engineers showed a preference for sources they trusted or that were known for their trustworthiness.

3.6.5 Information transfer and information communication

Havelock (1986) defined the concept "information transfer" as "[t]he process by which knowledge [information] gets communicated from one person to another, from one organisation to another, from one social system to another, and from one culture to another." Information behaviour researchers, such as Thomas Allen (1977) and Rosenbloom and Wolek (1970), studied information transfer within the context of new technological developments. Rosenbloom and Wolek's (1970: 112) findings showed the important role of people in the information transfer process, by providing information directly and by referring users to other sources. Thomas Allen (1977: 291) emphasised the importance of organisational structures that support information transfer and free communication among project team members.

In a later study, Tushman (1982) used the term "communication" rather than information transfer to indicate the same processes discussed by Thomas Allen (1977) and Rosenbloom and Wolek (1970). Tushman (1982: 350) explained that the verbal interaction (communication) that takes place among engineers allows for timely information exchange, rapid feedback and critical evaluation. Furthermore, communication provides the opportunity for real-time recoding and synthesis of information.

Tushman (1982: 349) also argued for the importance of communication networks in a research and development setting and he noted that there is no one best communication pattern. Furthermore, he argued that different projects require different types of communication patterns. Tushman's arguments are supported by Ellis and Haugan's (1997: 393) observations. According to them, internal communication (that is communication within the organisation) is focused at colleagues in engineers' own departments or project teams. However, they also observed that engineers' external communication was projected towards their suppliers and vendors.

Lastly, Thomas Allen (1977: 232-233) found that social norms, such as different statuses (e.g. the different statuses between the design engineer and those engineers assigned to the testing of the system), undermine communication in a work team.

3.6.6 Information sharing

In their study, Ellis and Haugan (1997: 392) found that the sharing of information in engineering projects is characterised by collaboration, oral information transfer through meetings, or electronic information exchange. It seems as if Ellis and Haugan (1997) then used a different term to describe information activities, previously identified as information transfer and information communication. Talja (2002) supported this notion when she noted that the term "information sharing" is used as an umbrella concept that covers a wide range of collaborative information behaviour. Talja and Hansen (2006: 114) regarded information sharing to be an interactive process which "incorporates both active and explicit and less goal oriented and implicit information exchanges". Fidel, Pejtersen, Cleal and Bruce (2004: 944) extended this description when they stated that information sharing "denotes direct information exchanges among those involved in sharing a problem".

Since collaborative information behaviour will be the focus of Chapter 5, engineers' information sharing activities will be discussed in more detail in that chapter.

3.6.7 Reflection on engineers' information activities

With reference to the above discussion on engineers' information activities, as well as keeping in mind the discussion on the different aspects that underlie Wilson's (1999; 2000) information behaviour definition, a profile of engineers' information activities could be compiled; Table 3.2 reflects the suggested profile. The profile also shows how various elements in the engineering context, as well as the different phenomena in the engineers' personal dimension, gave rise to specific information activities.

Table 3.2: A profile of engineers' information activities

A PROFILE OF ENGINEERS' INFORMATION ACTIVITIES								
Dimensions		**INFORMATION ACTIVITIES**						
Context	**Elements**	**Seeking**	**Searching**	**Use**	**Transfer**	**Sharing**	**Communication**	**Awareness**
Engineering environment	Profession			●				
	Disciplines	●		●				
Engineering practice	Designs	●		●		●	●	
	Service delivery	●	●	●				
	Teamwork			●	●	●	●	
	Information flow			●	●	●		
	Work roles	●		●		●	●	
Tasks	Task complexity	●		●			●	
	Task performance	●		●				
	Projects	●		●		●	●	
Personal dimension	Cognitive	●	●	●				●
	Affective	●		●				

When considering Table 3.2, it seems evident that the engineering context and engineers' personal dimensions only prompt active information-seeking activities. However, in the discussion on engineers' information activities, Birnholz (2005), Du Preez (2008), and Sonnenwald and Pierce (2000) did report on passive information behaviour activities, such as an awareness of information and situational awareness. This could be put to the fact that the discussions on the context and the personal dimension of engineers did not refer to situations or instances where engineers rely on their awareness of information to provide in their information needs.

3.7 THE MANIFESTATION OF INFORMATION BEHAVIOUR IN THE ENGINEERING CONTEXT

The purpose of the discussion in Chapter 2 was to develop an information behaviour framework that could be used to guide this study. That discussion was based on Wilson's (1999; 2000) encapsulating definition of information behaviour and contributions that were made to the definition by other researchers such as Allen et al.

(2011), Bates (2009), Bawden (2011), Case (2012), and Erdelez (1997). To ensure a logical discussion, this chapter first addressed the engineering context and thereafter investigated the personal dimension of engineers. The discussion endeavoured to show the existing relationship and interaction between the engineering environment and the personal dimension of engineers. From that discussion, it seems as if certain elements in the engineering context, such as their profession, discipline, education, training, etc., greatly influence cognitive, conative and affective structures in the personal dimension of engineers.

It was also indicated that engineering is a regulated profession. The regulated nature of a profession requires that engineering work complies with certain standards, regulations and engineering codes of practice, which are sources of information developed by various statutory engineering bodies and learned societies. The review showed that the regulated nature of engineering determines the type of information sources engineers need to use when completing an engineering task. Since engineers are held ethically responsible for the “economics of operation and safety to life and property” of the products or services they develop (Engineers' Council for Professional Development 1941: 456), their contextual requirement seems to influence their choice of information in terms of quality.

Elements in the engineering context were discussed in more detail to reveal their contribution to engineers’ information behaviour. These elements include the nature of engineering work, the work context of the engineer, the individual engineer’s work roles and tasks, engineering projects and engineering teams. With regard to the nature of engineering work, it was learnt that engineers need to design and develop products and that the work they do must adhere to certain service delivery requirements. The various requirements that are set for engineering designs seems to be criteria for source selection and in this process become factors affecting engineers’ information behaviour.

The discussion also showed that the information engineers use to complete their designs is not necessarily in a written format. They often need to examine existing products and product documentation for the information they require.

The discussion revealed to what extent the personal dimension has an influence on engineers' information behaviour. It became apparent that the personal dimension of the engineer could also be subdivided into three mental states, namely, cognitive, conative and affective. Elements which could be used to describe engineers' cognitive phenomena included their subject knowledge and their knowledge of the resources they need to use. It became clear that engineers acquired their knowledge through their education and training. Evidence was revealed that engineers' knowledge base is greatly determined by the engineering environment and that work experience contributes much to the development of engineers' knowledge base, their problem-solving skills and the other cognitive activities they need to accomplish.

Considering the elements of the personal dimension in general (explained in Chapter 2), the literature revealed that engineers' conative structures (i.e. their self-efficacy and learning styles) enable them to make the connection between their engineering knowledge and the actions they need to take to ensure task completion. This includes their ability to identify an information need, and link their information needs to the information sources that will provide them with the answers they require. It was also shown that affective phenomena generally trigger the recognition of a need for information (component iii in Figure 2.1), which motivates information seeking and information use activities (component iv in Figure 2.1).

The literature review revealed that the elements that are instrumental to the information behaviour of people in general are also present in the work environment of engineers. The difference lies in the nature of the elements in the work environment and the requirements set by these work environments. The elements and requirements are all factors that give rise to specific information activities. These include activities such as collaborative information access, the creation of products from ideas, and information sharing among team members to save cost and time.

From the insights gained from the discussion in section 3.6, it seems evident that engineers' information activities evolve due to the interaction between the personal dimension, the environmental context and information needs. The literature consulted revealed that engineers' information activities are not restricted to seeking and search activities only, but also include awareness, use, transfer, communication and sharing.

Based on reports in the literature and the discussion on the different aspects affecting engineers' information behaviour, a profile of engineers' information behaviour could be compiled, similar to the generic information behaviour profile in Figure 2.1 in Chapter 2. From the suggested profile in Figure 3.1, it seems evident that the interaction between specific elements in the context and in the personal dimension of engineers gives rise to particular activities. For example, interaction between tasks present in the engineering context, and elements such as personal knowledge and skills in the engineers' personal dimension, gives rise to information needs, which in turn prompt information activities such as seeking, use and communication.

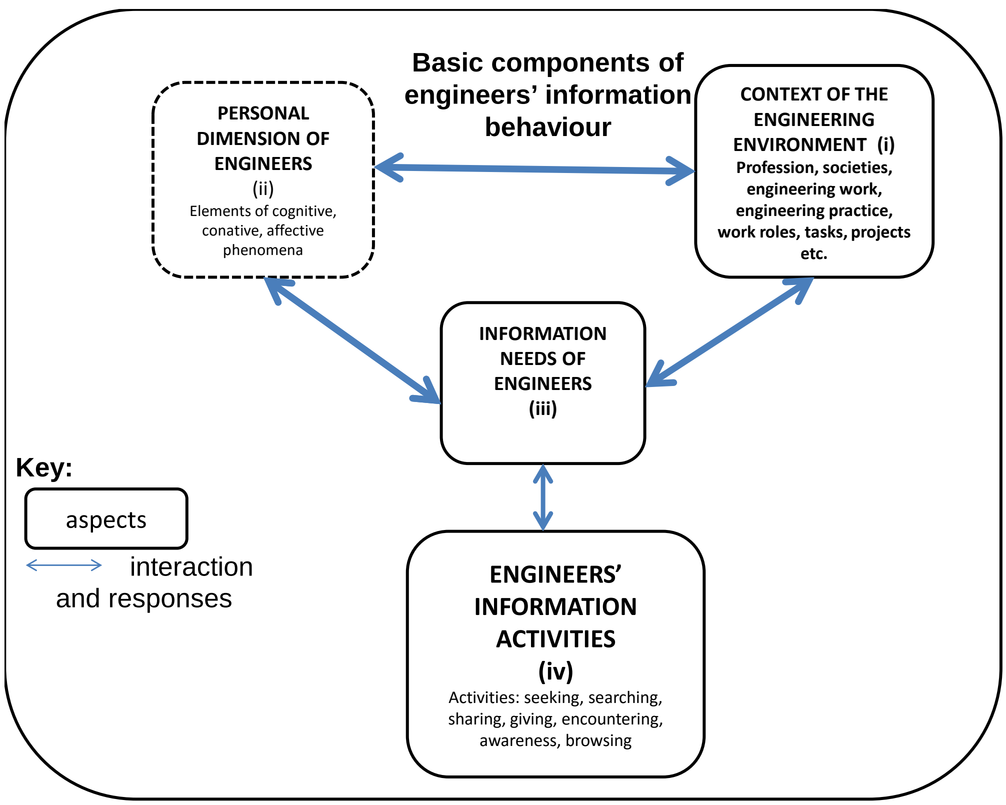


Figure 3.2 Basic components of engineers' information behaviour

3.8 CONCLUSION

The focus of this chapter was to review the literature dealing with engineers' information behaviour. The suggested information behaviour framework that was developed in Chapter 2 guided the literature review on engineers' information behaviour in this chapter. The framework includes four components and shows how the interaction between elements in the engineering context and the personal dimension of engineers gives rise to information needs. In turn information needs prompt various information activities.

The literature study revealed that certain information activities result from collaboration processes in which engineers are involved. These activities include information transfer, communication and sharing. Of these three, information sharing has become the umbrella concept for collaborative information activities, which could include social networking.

Although the literature review reflected on engineers' information behaviour in general, it did not reveal what causes the distinction in consulting engineers' information behaviour. The literature study of Chapter 4 will focus on specific aspects in the consulting industry, and the personal dimension of the latter, that could give pointers to support an empirical investigation.

CHAPTER 4

INFORMATION BEHAVIOUR OF CONSULTING ENGINEERS

4.1 INTRODUCTION

The purpose of this chapter is to determine the distinctive information behaviour of consulting engineers, compared to the information behaviour of engineers in general, which was discussed in Chapter 3. In order to do so it will be necessary to establish, by means of a literature study, what has been reported on the different components of the information behaviour model, as it applies to consulting engineers.
With this in mind the following aspects will be addressed:

- the consulting industry
- the context of consulting engineering
- the personal dimension of consultants and consulting engineers
- information needs of consulting engineers
- information activities of consulting engineers
- manifestations of consulting engineers' information behaviour.

4.2 BACKGROUND

From the literature review covered in Chapter 3, it became evident that the interaction between elements of the contextual component and the personal component gives rise to engineers' information behaviour in general. The discussion also showed that the specific work environment of engineers – this includes both the type of work they do as well as the organisation that employs their services – affects their information behaviour. The requirements set by engineers' work environments are also relevant to consulting engineers' work environments, except for additional requirements resulting from their status as consultants. For example, the typical work environment of the consulting engineer requires of the consulting engineer

- to provide expert advice in their areas of practice
- the work they do for their clients' needs to comply with the criteria set by their clients without compromising the standards that are set by their profession
- their work is subject to agreement with the work of fellow team members
- they have strict time and budget restrictions within which they need to operate, and
- they are required to deliver high quality work.

In order to adhere to these requirements that are set by their work environment, consulting engineers seem to need very specific information that would assist them in their decision-making and planning tasks.

Typical conditions and situations of the consulting industry will subsequently be discussed to acquire a better understanding of where these elements in the working environment of the consulting engineer derive from. The discussion will also focus on identifying the possible influence of elements, deriving from the consulting industry, on consulting engineers' information behaviour.

4.3. CONSULTING INDUSTRY

As indicated in the introduction, the interaction between elements of the context and elements of the personal dimension helps to shape the information behaviour of engineers. Since engineers can function in different types of environments, it seems possible that the information behaviour of consulting engineers can be influenced by the consulting industry.

A business consultant, Stryker (2011: vii, 3), referred to the concept "consultancy" as a dynamic process which rests on a discernable set of principles and practices. He defines consulting as "an assignment in which a consultant and a client seek to resolve a client organisational issue using a specified process". The definition proposed by Stryker (2011: 3) was endorsed by management consultants Sturdy, Handley, Clark and Fincham (2009). They regarded consultancies as "part of the broader field of the professional and business services” and describe consultants as professionals who provide their clients with expert advice or solutions for a fee.

Glückler and Armbrüster (2003: 277) extend Sturdy et al.’s (2009) description of consultants when they state that consultants work in a knowledge-intensive organisational environment. This statement by Glückler and Armbrüster (2003: 277) was endorsed by Kubr (in Robertson & Swan 2003: 834) and Kunda (1996 in Robertson & Swan 2003: 833). According to them, consultancies can be regarded as knowledge-intensive firms that differentiate themselves by means of the specialised knowledge and services they offer. Stryker (2011: 2-3) supported this view, when he stated that organisations are the context of consultancies, whereas the content of the consultancy is the issue, and the consultant is the collaborator, that is the person who has the disciplinary education and experiential training in the consulting process.

Sturdy et al. (2009) noted that boundaries – specifically knowledge and organisational boundaries – are core to discussions on consultancies. The knowledge boundary that is relevant to this study is engineering and will be addressed in section 4.4, where consulting engineers’ information behaviour is discussed. Apart from being a boundary element in discussions on consultancies, organisations are also contextual elements that could shape the information behaviour of consulting engineers. This was discussed in Chapter 2, section 2.3.3.1.

This discussion highlighted some characteristics of the consulting industry. These include a “discernable set of principles and practices”. The differentiation of consultants is based on their specialised services and subject knowledge. Furthermore, consultants are the collaborators who offer their specialised knowledge and they have had experiential training in the consulting process.

4.3.1 Contextual elements

Considering Stryker’s (2011: 2) view that organisations are the context of consultancies and that consultants are the collaborators who offer their specialised knowledge and services to their clients, organisations can be viewed as a contextual element which could affect consultants' information behaviour. This was endorsed by Sonnenwald (1999: 179) when she identified organisations as a contextual element in the consulting industry that could shape consultants' information behaviour. In addition to organisations, she also identified contractual agreements as a contextual element. According to her, contractual agreements set the parameters within which the consultant must operate. These two contextual elements will be discussed consequently.

4.3.1.1 Organisations

In addition to Sonnenwald's (1999) and Stryker's (2011) identification of organisations as a contextual element, human relations specialists Czarniawska and Mazza (2003: 275) also identified organisations as a contextual element of consultancies. Zhang and Benjamin (2007) define organisations as "human gatherings at different levels who share certain values, beliefs, goals, institutions and processes". They further indicate that organisations can be classified as informal or formal, by structure (working groups, departments, businesses, nations and societies) or by purpose (industry sectors, non-profit organisations, governments, etc.).

Zhang and Benjamin's (2007) observations that certain values, beliefs, goals and processes are shared within an organisation, are endorsed by a number of information behaviour researchers such as David Allen and Wilson (2003: 40), Rosenbaum (1993; 1996) and Solomon (1997: 1110-1111). According to them, organisational rules and resources shape information practices, and the activities of the individual members of organisations reinforce the organisational rules and resources. Johnson (2003: 750) therefore could state that the physical context in organisations not only stabilises individuals' information fields, but also determines the nature of the information they are exposed to. Johnson (2003: 750) also indicated that individuals working in an organisation are exposed to the same communication channels and networks. This is why Aldrich (2006: 5) could state that organisations seem to provide natural boundaries that delineate the activities taking place within them.

The discussion thus far has indicated that certain organisational factors affect information behaviour. However, Lamb, King and Kling (2003: 104-105) observed that a number of extra-organisational factors, such as regulations, industry-wide infrastructures and client expectations, also influence information practices in organisations. This is similar to the influences the engineering context exerts on engineering practices, which were discussed in Chapter 3.

Organisations often employ consultants to bring new knowledge from outside into an organisation, either as some form of knowledge transfer, or as part of the consulting process (Sturdy et al. 2009). Certain persons in the organisation then act as the consultants' contact persons within the organisation and are the consultants' clients (Stryker 2011: 3). According to Stryker (2011), the consultants' clients are those persons in an organisation who make fundamental decisions about the organisation's activities, such as the need to employ the services of a consultant.

However, the employment of consultants to bring new knowledge into an organisation could be problematic for the consultant. According to Sturdy et al. (2009), this is because the knowledge they bring could be incompatible with the client organisation's needs.

In addition to their role to bring new knowledge to an organisation, Czarniawska and Mazza (2003: 275) and Sturdy et al. (2009) observed that consultants usually work in a different "space" than their own organisational environment. This implies, according to Sturdy et al. (2009), that consultants always remain "outsiders" to their client organisations. In addition to being "outsiders" to their client organisations, consultants can also be involved in multiple projects with multiple organisations (Mowshowitz 1997: 37). They can therefore have temporary relationships with multiple client organisations.

4.3.1.2 Contractual agreements

Some of the rules that shape consultants' information behaviour can be found in the contractual agreements they are required to sign with their clients. According to Glückler and Armbrüster (2003: 276), consultants are often appointed to develop and co-produce a product with their clients. The contractual agreement that is signed between the client and the consultant specifies the parameters within which the consultants need to operate. Three parameters could be identified in the literature. The first parameter relates to the “level of effort” that should be expended by the consultants at each stage of their projects (Consulting Engineers South Africa (CESA) 2003b: 3). The other two parameters were identified by Glückler and Armbrüster (2003: 276). These parameters are the time frame and the budget that has been made available for the project. Although Czarniawska and Mazza (2003: 274) approached the time frame and budget from a contractual agreement point of view; they highlighted the effect these two factors have on each other. According to them, consultants’ time is “an item in the client’s budget and is managed like all other items in that budget”.

The effect time and budget, as contextual boundary factors, have on information behaviour was observed by Lee and Thomas (2008) and Hansen and Haas (2001). In their study Lee and Thomas (2008) observed that time frame and budget restrictions pressurise consultants in making decisions and in delivering actionable knowledge to their clients. They also found that consultants perceive the cost of searching and retrieving information from information systems in terms of the time and effort they had afforded in finding relevant information. Due to these time and cost pressures, Hansen and Haas (2001: 26) observed that consultants tend to seek information from a knowledge source that provides ready-to-use information, which would require the minimum time and effort from the consultant’s point of view. Therefore, it seems as if time and budget restrictions determine the “level of effort” that should be expended on when seeking for information.

The knowledge sources that provide consultants with ready-to-use information that were identified by Su and Contractor (2011: 1258) seem to be personal contacts. In instances where consultants work in project teams, Su, Huang and Contractor (2010: 591) noted that these consultants seemed to prefer seeking information from their team members. However, as observed by Su and Contractor (2011: 1258), seeking information from personal contacts could be difficult when consultants are required to travel. This is because face-to-face discussions with personal contacts and the physical transfer of knowledge are not possible when consultants are away from their own organisations.

4.3.1.3 Task performance dimensions of consultants

In addition to the contractual and organisational dimensions as contextual elements that affect information behaviour, which were identified by Sonnenwald (1999: 179), Chapter 3 also identified tasks as a contextual element. Strategic managers, Haas and Hansen (2007: 1137), identified three specific task performance dimensions that are critical to teams (organisations) conducting knowledge-intensive tasks, which affect information activities. According to them, knowledge-intensive tasks include new product development, service improvement, process management tasks and management consulting tasks. The three task performance dimensions they identified are time savings, quality of work output, and signal of competence. Haas and Hansen (2007: 1137) noted that certain contextual factors are likely to affect these three task performance dimensions, namely, the task team's use of electronic documents (information) and personal advice. Although, Haas and Hansen (2007) regard use of information and personal advice as contextual factors affecting task performance.

To summarise, three elements in the consulting industry act as contextual elements that could potentially affect consulting engineers' information behaviour. These include the consultants' organisation and their client organisations, the contractual agreements they sign with their clients and, lastly, their tasks, which seem to be knowledge-intensive tasks where consulting engineers are involved in product development, service improvement and process management. In addition to these elements, the discussion also showed that:

- Consultants are employed to bring new knowledge to the client organisation
- Consultants can have temporary relationships with multiple organisations
- Consultants sign contractual agreements with their clients that set boundaries such as a set time frame and budget, which need to be considered
- Consultants are appointed for knowledge intensive tasks such as product development, improving services or managing processes

- Certain elements in an organisation can shape consultants' information behaviour. These include organisational values and goals, rules and resources, communication structures and networks. However, there are also a number of extra-organisational elements that could affect consultants' information behaviour. These include regulations and industry-wide infrastructures
- Consultants generally use electronic documents that are available in their organisations, as well as personal advice
- External factors such as regulations, industry-wide infrastructures and client expectations affect consultants' information behaviour

4.3.2 Personal dimension of consultants

In the generic discussion of information behaviour in Chapter 2, it was shown that certain elements in the personal dimension of the information user affect the user's information behaviour. These elements can be derived from the user's cognitive, conative and affective phenomena. Since these elements in the personal dimension of consultants could also have implications for the information behaviour of consulting engineers, it is important to determine which elements in the personal dimension of consultants were reported on in the literature.

4.3.2.1 Cognitive phenomena

Certain cognitive phenomena shape individuals' information needs, which in turn give rise to information activities. The cognitive phenomena that were identified in Chapter 2 (section 2.3.1.1), which give rise to information activities, include conceptual knowledge (that is knowledge of the subject), task knowledge and the knowledge of the resources that are used. In the literature on the consulting industry, Stryker (2011: 3) observed that consultants are the collaborators who offer their specialised knowledge and services to their clients. This means that consulting, as it was noted by Glückler and Armbrüster (2003: 277), is a "two-way interaction" that is ideally perceived as a process of mutual learning and cooperation.

4.3.2.2 Conative phenomena

Self-efficacy, as shown in Chapter 2 (section 2.3.1.2), is a conative phenomenon. Although not identified as such, this is also an aspect that was reported on in the literature focusing on the consulting industry. For example, Sturdy et al. (2009) reported on one area in which consultants' work affects their information behaviour. They observed that much of their work involves dealing with obscure knowledge, and the new knowledge the consultant brings to the organisation is incompatible with the client's needs. Consultants are then often challenged by how to translate such obscure and ambiguous knowledge directly into actionable advice that would quickly improve clients' productivity (Kramer 1988).

4.3.2.3 Affective phenomena

Affective phenomena are the third phenomenon in the personal dimension of individuals. In Chapter 2 (section 2.3.1.3), it was shown that affective phenomena cause symptoms such as anxiety, lack of confidence, frustration and confusion. Certain factors in the consulting industry also seem to cause these symptoms. For example, Robertson and Swan (2003) and Sturdy et al. (2009: 390) found that consultants work in an insecure industry where they experience many uncertainties about their work roles and organisational environments. In addition, Robertson and Swan (2003) also reported that consultants experience a high level of fluidity and uncertainty in their internal and external work environment.

Czarniawska and Mazza (2003: 270) identified a second affective factor which could contribute to consultants' feelings of insecurity. According to them, separation from the consultants' "previous social environment and their previous way of life" could contribute to feelings of insecurity. Such separation generally happens when consultants are required to start working with a new team on a different project once a project has been completed.

In addition to the separation from their previous social environment, Czarniawska and Mazza (2003: 267, 270) also observed that the transition to a client's situation not only contributes to feelings of insecurity, but also to feelings of frustration. They used the following quote from an interview to illustrate this point:

> "I study mathematical models, use regression analysis and apply econometric models, but upon entering the 'office of the client' all I am interested in are organisational behaviour, and coordination and control systems."

The explanation Czarniawska and Mazza (2003: 272) offered for this consultant's frustration relates to the fact that consultants continuously find themselves in temporary working conditions for a limited period of time. It is possible that these frustrations can also contribute to feelings of insecurity.

Lastly, Glückler and Armbrüster (2003: 270, 278) noted that the interactive nature of consulting in product development carries some uncertainty for both the consultant and the client. In order to reduce these uncertainties, the personal experience evolving from the interaction between clients and consultants becomes very important. Glückler and Armbrüster (2003: 2787) further argued that trust becomes embedded in this client and consultant interaction and, once established, clients will tend to transact with their trusted consultants, where trust is based on their experiences of interacting with the consultant.

From this discussion on the personal dimension of consultants, it seems evident that certain elements in the context of the consulting industry affect consultants' information behaviour cognitively, conatively and affectively. For example, feelings of uncertainty, insecurity, frustration and trust were identified as affective elements in the personal dimension of individuals, and knowledge as a cognitive element, whereas the translation of knowledge into actions represents conative phenomena. The interaction between the different mental structures and elements in the context gives rise to information activities such as information seeking, sharing, communication and use.

In addition to the elements in the personal dimension of engineers that were identified in Chapter 3 (section 3.4.1), the elements in the personal dimension of consultants could also have implications for consulting engineers' information behaviour.

The following sections, based on the components of the contextual framework depicted in Figure 3.1, will focus on consulting engineers and those aspects that specifically affect their information behaviour.

4.4 CONTEXT OF CONSULTING ENGINEERING

Knowledge is one of the contextual boundaries that were identified by Sturdy et al. (2009) for consultancies. Engineering is one such knowledge boundary. From the discussion on the consulting industry, it became apparent that characteristics of the consulting industry do bring a new dimension to the nature and work of the consulting engineer. The following discussion will now report on findings in the literature on how the working environment and contextual elements in the consulting industry shape consulting engineers' information behaviour.

The concept "consulting engineer" refers to the type of work the consulting engineer does and spans various engineering disciplines. In section 4.3, consultants were described as professionals who provide their clients with expert advice for a fee and who work in a knowledge-intensive organisational environment. Du Preez (2008: 174) and Gralewska-Vickery (1976: 266) offered a similar description for consulting engineers. According to them, consulting engineers are experts in their field of engineering. They also found that these engineers work in diverse environments, are employed by clients for their advice and guidance, to design systems, and to manage, upon the directives of their clients, the completion of engineering projects. In addition to these characteristics of consulting engineers, Gralewska-Vickery (1976: 266) also noted that consulting engineers have "nothing to sell except their service, time, knowledge and judgement".

4.4.1 Projects

Consulting engineers are appointed by their clients for various reasons. These include the planning, design, development and construction of engineering products, such as buildings or a communication system. When deciding on whom to appoint, CESA (2003b: 2) noted that a client will take note of the names of consulting engineers who have been involved in the design of similar projects and who have been recommended by other clients. This implies that clients' appointments are based on consulting engineers' expertise in a specific field of engineering as well as their ability to perform. CESA's (2003a) observation was supported by Glückler and Armbrüster's (1976) discussion on experienced-based trust relationships between client and consultant, where clients will tend to transact with trusted consultants. Experience-based trust relationships could be why Gralewska-Vickery (1976: 266) found that consulting engineers need to sustain their relationships with their clients to ensure the continued use of their services through the renewal of work relations in a new engineering project.

In their guidelines on client-consulting engineer relationship, Consulting Engineers South Africa (CESA) (2003a: 1) noted that each prospective project and prospective client have certain unique characteristics. CESA (2003a) also indicated that different clients, or even the same client at a different time, may have different priorities and objectives with respect to specific projects. Therefore, consulting engineers and their clients enter into a contractual agreement prior to the onset of an engineering project. The contractual agreement then enables the engineers to adopt an appropriate frame of mind so that they can apply their knowledge and skills to effectively meet the client's needs and priorities (CESA: 2003a: 2).

The following discussion will focus on the service delivery requirements of engineering projects and some of the other factors that were identified in the literature. These factors include the geographic location of the project and consulting engineers' temporary relationships with their clients' organisations.

4.4.1.1 Service delivery requirements

To enable them to complete a task successfully, consulting engineers need to reach a full and clear understanding of what the client wants. CESA's (2003b) discussion on the contractual agreement between clients and engineers mentioned that such agreements are set for "each stage of the project". This implies that a consulting engineer may not necessarily be appointed for the full project, and could only join the project team at a later stage of the project. Evidence in this regard was reported by Du Preez (2008: 179-

227), where the responding engineers in her study were not involved in all stages of the projects they reported on.

In the discussion on contextual boundaries in section 4.3, three parameters were highlighted within which consultants need to work. Two of these parameters relate to the project time frame and budget. The effect that cost and time have on engineers' information behaviour was discussed in section 3.4.2.1. In that discussion, as well as the discussion on contractual agreements (section 4.3.1.2), it was indicated that time was a "scarce" resource which was managed as part of the client's budget. The finding in Du Preez's (2008: 332) study on the information seeking and needs of consulting engineers endorses this point. She found that consulting engineers did not have the time available to seek for new information and that they regarded the time spent to seek for information as time that was lost to complete the task. Du Preez's (2008) finding endorses Byström and Järvelin's (1995: 196) findings when they point out that situational factors, such as time, affect individuals' interpretation of their information needs. Situational factors, such as the "situation of action", as it was shown by Savolainen (2012) and discussed by Julien and Michels (2004: 552), are temporal factors that determine the timeframe in which information is needed. Furthermore, as demonstrated by Westbrook (2008: 245), information needs are temporarily sensitive and undergo changes as the individual proceeds from one situation to another. This implies that the specific situation in which consulting engineers need information will determine the information source that is selected and the amount of information that is required to provide in the specific information need.

According to CESA (2003a: 3) there is another contractual agreement which is linked to the agreed time frame and budget agreements. This parameter relates to the "level of effort" that should be expended by consulting engineers at each stage of their projects. The agreed level of effort determines how much time the consulting engineer needs to expend on the project. This includes the time that is required to seek for new information. Du Preez (2008) also found that consulting engineers confirmed not having the time available to seek for new information. Although none of the previous information behaviour studies focusing on engineers (including consulting engineers) have addressed the effect the “level of effort” requirement has on engineers’ information behaviour, Anderson et al. (2001: 148) and Gerstberger and Allen (1968) reported on engineers’ information behaviour, which they interpreted as being consistent with “Zipf’s principle of least effort”. They found that, according to this principle, where information users seek to minimise the total work that must be expended, engineers tend to rely on oral communication for the transfer of information. Ward (2001: 169) also reported that consulting engineers tend to value informal contacts with colleagues when they experience time pressures.

When considering CESA’s (2003a: 4) discussion on the responsibilities and liabilities of the consulting engineer, it seems as if the “level of effort” requirement also requires consulting engineers to have some legal knowledge. In their discussion CESA (2003a) advises consulting engineers to ensure that their contracts for engineering services are carefully drawn up and that the scope of services and responsibilities are described in detail. Du Preez (2008: 291) reported on the importance of having a mentor who was “clued up on contract documents” and assisted a consulting engineer when she had to draw up contract documents.

The effect that time and budget have on engineers’ information behaviour was discussed in Chapter 3, sections 3.3.5.2 and 3.7.1.1. It was indicated that engineers will only spend time reading if the information obtained is of value to their work. It was also reported that time and cost affect engineers’ selection of information sources as well as their perception of the availability and accessibility of the required information.

4.4.1.2 Geographic location of the project

A second contextual aspect of an engineering project that could shape consulting engineers’ information behaviour is the geographic location of the project. For example, Du Preez (2008: 318) reported that the geographic location of an engineering project could affect consulting engineers’ selection of information sources. She reported that different geographic locations determined the use of specific codes of practice, as well as the means that were used to communicate project-related information to team members. For example, the responding consulting engineers in Du Preez’s (2008) study, who were managing projects in distant locations, relied more on faxes and digital photographs to communicate and receive site-related information than those engineers reporting on a local project. These findings are supported by Su and Contractor (2011: 1258) and Su, Huang and Contractor (2010: 591) when they reported that face-to-face communication with team members is difficult when consultants are required to travel.

The discussion on engineering projects highlighted some elements that could shape the information behaviour of consulting engineers. The first two project-related elements derive from the personal dimension of consulting engineers. That is their subject knowledge and expertise, as well as their ability to perform. The other project-related elements derive from the consulting context. These are the contractual agreements that are signed with clients, the set parameters for the project (i.e. time frame, budget and level of effort). These parameters determine the amount of time the consulting engineers will spend reading and seeking for new information. Lastly the geographic location of the project affects consulting engineers' source selection and the preferred means of communication on a project.

4.4.2 Work roles

From the description of consulting engineers (section 4.4), it seems as if the work roles of consulting engineers are mostly of an advisory and managerial nature. As part of their advisory and managerial roles consulting engineers could be required to assume roles as researchers, designers, design analysts and technical specialists for the same project (Du Preez 2008: 327; Gralewska-Vickery 1976: 266-267; Ward 2001: 169).

Ward (2001: 169) reported that consulting engineers' information seeking related to the advice they had to give to their clients. In order to advise their clients, Gralewska-Vickery (1976: 267) observed that consulting engineers require technical information, project-oriented information, public information, privately available information, information available in printed sources (e.g. codes of practice, acts, government regulations, design procedures, etc.), project-related information generated by themselves, and current business information. Both Du Preez (2008: 323-330) and Ward (2001: 171) found that these engineers seek the information they require from their personal memories, personal files, books, organisational communications, records of previous work, other engineers, clients, manufacturers and suppliers, manuals and brochures, and personal contacts.

Lastly, Gralewska-Vickery (1976: 266) also observed that consulting engineers, to some extent, act as gatekeepers for firms that require a specialist opinion. This implies that these engineers selectively share information with their clients. Gatekeeping therefore could have implications when it comes to controlling the flow of information.

In terms of consulting engineers' work roles, Leckie, Pettigrew and Sylvain (1996: 166) reported that consulting engineers use more information than average and are "among the biggest consumers of information in engineering". Leckie et al. (1996) also found that consulting engineers need current and accurate information as well as external market information about vendors and customers.

4.4.3 Tasks

Tasks and task performance are contextual elements in both the engineering context and the consulting industry. Engineers' tasks, as it was explained in Chapter 3 (section 3.3.7.2), are embedded in their work roles and are shaped by the engineering project they have been appointed to. The discussion in section 3.3.7.2a also showed that the tasks engineers need to complete can be simple or complex. This also seems to be true of consulting engineers. Gralewska-Vickery (1976: 267) and Ward (2001: 171) found that the complexity of consulting engineers' tasks determines the nature of the information that is required and where it will be found. Du Preez (2008: 320-321) linked the importance of information in complex tasks to the availability and accessibility of the information. She found that information was often not available in complex tasks and that the responding consulting engineers in her study then relied on their engineering judgement or returned to basic engineering problems to find the solution to the problem.

Gralewska-Vickery (1976: 267) noted that the information engineers use can be classified in various ways. Her classifications included project-orientated information (that is project-specific information such as contractual agreements, the project design, and other information generated by engineers themselves during a project) or technical information. The technical information consulting engineers need to complete their tasks, which was identified by Gralewska-Vickery (1976: 267), included design methods, data, computer programs, and model studies. She also noted that the technical information engineers need is taught by engineering courses.

4.5 PERSONAL DIMENSION OF THE CONSULTING ENGINEER

In Chapter 2 and Chapter 3, it was shown that the personal dimension of an information user is one of four aspects which underlie Wilson’s (1999) encapsulating information behaviour definition. In the respective discussions it was also shown that the discussion on users’ personal dimensions can be subdivided into cognitive, conative and affective phenomena. In the following discussion, the effect of these phenomena on consulting engineers’ information behaviour will be discussed according to the elements present in the personal dimension of the information behaviour model, as it was illustrated in Figure 2.1, and adapted for engineers’ information behaviour in Figure 3.1.

4.5.1 Cognitive phenomena

Three cognitive phenomena that distinguish individuals as being experts are their conceptual knowledge, task knowledge and knowledge of the resources that are used. As shown in the general discussion on cognitive phenomena in Chapter 2 (section 2.3.1.1), individuals acquire this type of knowledge through their education, training and work experience. In the definition for consultants and the descriptions that were offered for consulting engineers by Du Preez (2008: 174) and Gralewska-Vickery (1976: 266), it was indicated that consultants are experts in their subject fields. Apart from the requirement that consulting engineers should be experts in their field of engineering, the three studies focusing on consulting engineers’ information behaviour did not specifically report on the effect cognitive phenomena have on consulting engineers’ information behaviour. However, the effect consulting engineers’ cognitive phenomena have on their information behaviour could be derived from the findings of these studies.

One finding, which shows the effect cognitive phenomena have on consulting engineers' cognitive activities, was reported by Ward (2001: 171). He reported on consulting engineers' busy lifestyles and the fact that they were involved in multiple activities within a short time span. He found that these engineers would then often have to deal with new things. In such instances they would either apply old knowledge to new problems or had to learn totally new areas of knowledge. The effect consulting engineers' knowledge has on the performance of their tasks, which was demonstrated by Ward (2001), endorses Vicenti's (1990) findings that engineers embark on three types of cognitive activities to ensure task completion. The activities he identified that were discussed in Chapter 3 (section 3.4.1.2) are: searching past experiences, incorporating new and novel ideas, and "winnowing" conceived variations to choose the most likely one to use.

In her study, Du Preez (2008: 233) also reported that consulting engineers would rely on their "engineering judgement" in instances where no other information was available. The ability to rely on "engineering judgement" seems to be indicative of consulting engineers' problem-solving skills. In addition to the problem-solving skills behaviour reported on by Du Preez, Ward (2001: 70) reported that the consulting engineers in his study relied on rational means to gain insight. These means included knowledge of pre-existing solutions, logical analysis and the filtering and systematising of other people's views.

Problem-solving skills were identified as a cognitive element in the personal dimension of engineers in Chapter 3 (section 3.4.1.2). Problem-solving skills are also a cognitive requirement for consultants. Sturdy et al. (2009) explain this requirement when they indicate that consultants' knowledge may be incompatible with the client organisation's needs. Consulting engineers then need to apply their problem-solving skills to find a solution to the problem they are faced with.

Certain contextual elements also seem to affect consulting engineers' information behaviour cognitively. A contextual element that was reported on by Du Preez (2008) is the geographic location of the project. As shown in section 4.4.1.2, Du Preez (2008: 318) found the geographic location affected the manner in which consulting engineers communicated information, not only with team members, but also with contractors on the construction site. For example, they require the ability to interpret information presented to them on photographs or faxes of problems encountered on the construction site.

4.5.2 Conative phenomena

As shown in Chapter 2 section 2.3.1.2, two types of conative behaviour seem to affect information users' information behaviour. These are self-efficacy and learning styles. However, Case (2012: 153), in his discussion of Johnson's (1997) model, noted that self-efficacy is not only about facts, but also about users' relation to the current situation. That is, the degree to which users has control over events. With this in mind, and according to what has been reported on the requirements of the consultancy industry on consulting engineers, it seems plausible that consulting work could affect engineers' information behaviour conatively. For example, CESA (2004) stresses consulting engineers' responsibility to protect their organisations and themselves against professional liability claims. In order to do this, they have the responsibility to ensure that they do not try to save costs by "cutting corners". Furthermore, it is their duty to provide their clients with excellent, rather than merely adequate advice. According to CESA (2004), adhering to these responsibilities will ensure they are known for their integrity and good sense. These are qualities that gain them the respect of the engineering community.

Also, consulting engineers are obligated to provide their clients with excellent rather than merely adequate engineering service (CESA 2004: 3). In order to do so, they need to remain abreast of current technology and remain competitive in a market that demands quality service at a reasonable price.

In order to remain abreast of new technological developments, Du Preez (2008: 328-329) reported that engineers would visit construction sites, factories and other installations.

4.5.3 Affective

Affective phenomena, such as thoughts and emotions, are associated with information seeking. In the discussion on affective phenomena in Chapter 2 (section 2.3.1.3), it was indicated that affective phenomena cause symptoms of anxiety, lack of confidence, frustration and confusion. In the discussion on the affective phenomena of consultants (section 4.3.2.3), Czarniawska and Mazza (2003), Robertson and Swan (2003) and Sturdy et al. (2009) indicated that consultants experience feelings of uncertainty, separation and frustration. In that discussion it was also shown that consultants and clients, in order to reduce uncertainties, would build on a trust relationship and as a result clients tend to transact with trusted consultants.

The studies by Du Preez (2008), Gralewska-Vickery (1976) and Ward (2001) that focused on consulting engineers' information behaviour did not report on how these affective phenomena influence consulting engineers' information behaviour. However, when considering the statement made by knowledge managers Lee and Thomas (2008: 3547), it can be concluded that time and budgetary restrictions could trigger affective responses. According to them, time and budgetary restrictions pressurise consultants into making decisions and delivering feasible solutions that can be acted upon. Ward (2001: 170) found that individual consultants reacted differently when they experienced time pressures. He found that some tended to be thorough and systematic while others improvised and took short cuts. Taking short cuts could affect the quality of the engineering services that are rendered and as a result engineers could be facing professional liability claims. Time and budgetary restrictions are therefore also a great concern of Consulting Engineers South Africa (CESA) (2003c). CESA (2004: 4) notes that consulting engineers often find it difficult to make a profit without neglecting their responsibilities for details in design, ensuring specifications are adhered to and cross checking their designs.

From the literature study regarding the effect of the requirements of contextual elements on consulting engineers' personal responses, it seems obvious that little attention has been paid by researchers to this aspect. For the purpose of the model of the information behaviour of consulting engineers, it will thus be necessary to follow up empirically on the lack of information regarding how elements of the personal dimension respond to information requirements of contextual elements.

4.6 CONSULTING ENGINEERS' INFORMATION NEEDS

The existing relationship and interaction between individuals' contexts and their personal dimensions give rise to information needs. When considering Leckie et al.'s (1996) findings, consulting engineers need and use a lot of information. As shown in Chapter 3 (section 3.5.), engineers' information needs result from contextual elements, as well as from their personal dimensions. Literature in this regard will be discussed consequently.

4.6.1 Contextual factors

In his discussion on the context in which information needs arise, Savolainen (2012) identified three contextual factors that determine information needs. These include situation of action, tasks and dialogue.

4.6.1.1 Situation of action

Situation of action is the first contextual determinant of information needs that was identified by Savolainen (2012). As described in Chapter 3 (section 3.5), the concept "situation of action" refers to those circumstances from which an information need arises. From the discussion thus far in this chapter, it seems as if certain elements in a consulting industry and the work environment of consulting engineers determine the "situation of action" that gives rise to information needs. The following examples of elements in the consulting industry that seem to shape consulting engineers' information needs were reported on:

- organisational factors, such as organisational values, beliefs, goals and processes (Zhang & Benjamin 2007); and organisational rules and resources (Allen & Wilson 2003; Rosenbaum 1993; Rosenbaum 1996; Solomon 1997)
- industry-wide infrastructure (Lamb, King & Kling 2003)

- the client organisation's needs and expectations (Sturdy, Handley, Clark & Fincham 2009)
- legal knowledge for the preparation and dealing with contractual agreements (CESA, 2003a).

Similar to the information needs that are prompted by elements in the consulting industry, certain elements in the consulting engineering context also seem to give rise to information needs. These include the engineering project, where the engineering project determines the "situation of action" in which the information needs arise. Each engineering project also includes elements that can be derived from the consulting industry, such as contractual agreements and client needs. In addition to the aforementioned elements, Du Preez (2008) also determined that the geographic location of the project could determine needs for specific types of information and the need to communicate information to team members by using electronic media such as faxes and emails.

In addition to what was reported on engineers' information needs in the discussion on situation of action, Gralewska-Vickery (1976: 266-267) also noted consulting engineers' need for business information. She observed that consulting engineers need to sustain their relationships with their business contacts, as these engineers rely on their contacts with prospective users of their services. This implies that engineers need to find their contacts and sustain their relationships (i.e. both personal and business) with them to ensure the contacts' continued use of their services through the renewal of work relations in new engineering projects. Savolainen (2009: 39) described the networks that develop in this manner as interpersonal networks of co-workers.

The reported findings on consulting engineers' information needs are summarised by Ward's (2001: 172) findings that pragmatic needs, rather than the intrinsic nature of information sources and services, determined engineers' information seeking. These findings endorse Thomas Allen (1977) and Ellis and Haugan's (1997) findings, indicating that the context or situation in which an information need arises determines the information-seeking path and the information that is required by the engineer.

4.6.1.2 Tasks

Tasks are the second contextual determinant of information needs identified by Savolainen (2012). In the literature addressing consulting engineers' information needs, Du Preez (2008: 315) identified some task-related factors that affect consulting engineers' information needs. The task-related factors she identified include the context of the task, task complexity and the importance of the information to the task. As shown in Chapter 3 (section 3.5.2.1), the context of engineering tasks and the complexity thereof determine the nature of the information that is required, as well as the courses of action that are taken to provide in the engineers' information needs. Du Preez (2008: 320) also reported that tasks can become routine when consulting engineers are involved in a number of similar projects. In repetitive tasks, consulting engineers seldom needed additional or new information but relied to a greater extent on their personal knowledge and experience. In her findings, Du Preez (2008: 320-321) linked the importance of information in complex tasks to factors such as the availability and accessibility of information. The availability or accessibility of information therefore were also factors that prompted information needs.

4.6.1.3 Dialogue

Dialogue is the last contextual element of information needs identified by Savolainen (2012). The need for dialogue was discussed in Chapter 3 (section 3.5.1.3) in relation to engineering projects and engineers' need to communicate project-related information with fellow team members. Allen (1970 in Veshoshky 1998: 59) noted that, due to the contextual nature of engineering, engineers find it difficult to communicate with external colleagues about a problem. He suggested that this is because they need to convey contextual information to enable the colleague to understand the problem.

Consulting engineers seem to have another reason for dialogue (or communication). This was highlighted by CESA (2003a: 2) and was not previously mentioned by the three studies focusing on consulting engineer's information behaviour. That is a need for consulting engineers to understand what their clients want. This need for specific project information and an understanding of clients' needs, can only be satisfied through dialogue, or communication between consulting engineer and client. In addition to acquiring project-specific information, Gralewska-Vickery (1976: 266) observed that consulting engineers have to represent the client on projects and communicate project information to a number or persons (stakeholders). These persons include contractors, manufacturers and suppliers. Du Preez (2008: 239, 299, 331) and Ward (2001: 170) reported similar findings on the need to communicate with stakeholders on an engineering project.

4.6.2 Personal dimension

From the discussion on the consulting industry and consulting engineering, it is evident that consulting engineers need to ensure that their conceptual knowledge remains up to date with the latest developments in their field of engineering. As Glückler and Armbrüster (2003) stated, consulting is a process of mutual learning. In addition to their need to remain updated on developments in their field, consulting engineers need to reduce the uncertainties that develop in their work environment. In order to deal with some of the uncertainties, consulting engineers need to build their clients' trust in their abilities (Glückler & Armbrüster 2003) and sustain their relationships with their clients (Gralewska-Vickery 1976). When viewed as a means to reduce uncertainties, trust can be viewed as a factor that supports consulting engineers in reducing feelings of uncertainty.

4.6.3 Reflection on information needs

In view of the discussion in Chapter 3, as well as the discussion on the consulting industry and consulting engineering (sections 4.5 and 4.5), a profile (Table 4.1) could be compiled to graphically illustrate those factors in the engineering context in general, and in the consulting industry, which affect consulting engineers' information needs.

Table 4.1: A profile of consulting engineers' information needs

A PROFILE OF CONSULTING ENGINEERS' INFORMATION NEEDS						
Contextual Factors		**INFORMATION NEEDS**				
		Context			**Personal Dimension**	
		Situation of action	**Tasks**	**Dialogue**	**Cognitive**	**Affective**
Engineering environment	Profession	●			●	●
	Engineering disciplines	●		●	●	
Engineering practice	Engineering designs	●			●	
	Service delivery	●	●		●	
	Team work			●	●	
	Information flow	●			●	
	Work roles	●				
Tasks	Task complexity				●	
	Task performance				●	
	Projects	●	●		●	
Personal dimension	Cognitive phenomena				●	
	Conative phenomena					
	Affective phenomena					
CONSULTING INDUSTRY						
Contextual	Organisations	●	●	●		●
	Contracts	●	●			●
	Tasks		●			●
Personal						●
Consulting engineering	Projects	●	●	●	●	●
	Work roles	●	●		●	
	Tasks		●	●	●	
Personal Dimension	Cognitive		●		●	
	Conative	●	●			
	Affective	●				●

As in Table 3.1, the suggested profile in Table 4.1 shows that elements in the consulting industry, as well as the work environment of the consulting engineer, affect the three different types of contextual information needs. In addition to the different types of contextual information needs, the consulting industry could also prompt affective information needs. Table 4.1 highlights some of the elements in the consulting engineers' context and their personal dimension (cognitive and conative phenomena) that give rise to their information needs. It seems evident that consulting engineers' information needs are prompted by situations and situational and cognitive needs. Elements in the personal dimension, such as the need to remain updated and to build trusting relationships, are other important triggers to information needs, as suggested by Savolainen (2012).

4.7 INFORMATION ACTIVITIES

When considering the information behaviour model in Chapter 2, according to which the literature review in this study is structured, information activities seem to be one of the most important aspects in the information behaviour of any user group.

Consultants, as indicated by Glückler and Armbrüster (2003: 277) and discussed in section 4.3, work in a knowledge-intensive organisational environment. In such an environment, Haas and Hansen (2007: 1137) found that the processes and outputs of task completion entail a streamlined process of electronic document use (information gathering), knowledge generation, expertise sharing, and advice giving. In the discussion on consulting engineers' information needs (section 4.6), it was indicated that consulting engineers also have a need to communicate project-related information with fellow team members. Information communication can therefore be added to the list of information activities that were identified by Haas and Hansen (2007). With the exception of information gathering and knowledge generation, the list of information activities identified by Haas and Hansen are similar to the information activities engineers are involved in that were discussed in Chapter 3, section 3.7. Although not discussed as an information behaviour activity, it was implied in the discussion on information flow (Chapter 3, section 3.3.5.4).

The information activities that were reported by Du Preez (2008), Gralewska-Vickery (1976) and Ward (2001) include information seeking and use, interpersonal communication, awareness raising of information, and information gathering. The following discussion will report on these activities in relation to consulting engineers.

4.7.1 Information seeking

In Chapter 3, it was shown that a number of elements in the context dimension and personal dimension of engineers give rise to and have an effect on engineers' information behaviour.

4.7.1.1 Contextual factors affecting information seeking

The contextual elements that were reported on in Chapter 3 included availability and accessibility of information, time and cost, and information overload. When considering the discussion on the consulting industry in section 4.3.1, it seems as if certain organisational and extra-organisational elements could also shape consulting engineers' information activities. These contextual elements include organisational values, beliefs, goals, processes, rules and resources. As indicated in section 4.3.1, these organisational elements determine the information resources that are available within the organisation. Organisational elements therefore also shape the information practices (including information seeking) of individuals within the organisation.

The extra-organisational elements that were identified by Lamb et al. (2003) include regulations, industry-wide infrastructures and client expectations. When considering the discussion on the engineering context (Chapter 3, section 3.3.4) and projects as an element in the context of consulting engineers (section 4.4.1), these extra-organisational elements are also present in the engineering context. These include the requirement that engineering designs adhere to national standards and statutory regulations, the unique characteristics of projects, and the requirements of consulting engineers' clients. Du Preez (2008: 324-325) reported that consulting engineers buy these sources, since they anticipate that they may need them for more than one project and prefer to have their own copies available.

a. Time and cost

The contractual agreements that are signed between consulting engineers and their clients are generally representative of clients' expectations and include boundary elements, such as time and cost. As reported in section 4.3.1.2 by Su and Contractor (2011: 1258), time and cost prompt consultants to use "ready for use" information. Personal contacts seem to be sources of "ready for use" information. Du Preez (2008: 289-290) reported that personal contacts, such as suppliers, are good sources of technical information. Ellis and Haugan (1997: 399) noted that this preference to seek information from personal contacts could have a time-saving effect.

b. Engineering project

Each engineering project is unique and could require the use of different sources of information. Ward (2001: 173) found that pragmatic needs, rather than the intrinsic nature of information services or sources, determined the information-seeking behaviour of consulting engineers in his study. He explained that, irrespective of the nature of the information source and the type of information that is included in the source, the information that is sought must be relevant to the specific situation or application for which it is required. Du Preez (2008: 317-318) reported similar findings. According to her, the geographic location of a project determines the code of practice that is sought to guide consulting engineers in their designs.

Consulting engineers' pragmatic needs for information are also determined by the project stage. Du Preez (2008: 321-323) showed that consulting engineers sought information from a variety of sources during the initial stages of the project. The information they sought during the later stages of the project came from the project itself.

c. Availability and accessibility of information

In Chapter 3 (section 3.7.1.1a) it was shown that availability and accessibility affected engineers' selection of information sources. Du Preez (2008: 332) reported that consulting engineers innovatively sought for information when the information they required was not available to complete their tasks. Du Preez (2008: 332) also reported that consulting engineers would rely on their engineering judgement, or return to basic engineering principles, to find the solution to the problem in instances where information was not available or accessible. Ward (2001: 170) reported similar findings. He reported that some engineers would then be innovative or would improvise.

4.7.1.2 Elements in the personal dimension affecting information seekin

In section 3.7.1.2, it was reported that some of the information-seeking behaviour of engineers could be linked to the cognitive, conative and affective phenomena in the personal dimension of these engineers. The findings reported on in the information-seeking literature of consulting engineers reported on the effect trust (an affective state of the personal dimension) has on consulting engineers' information-seeking behaviour. Du Preez (2008: 331) found that trust affected the selection of information sources and products, as the engineers in her study showed a preference for sources they already knew and trusted, as compared to newer products and sources.

When considering this discussion on the information seeking of consulting engineers, it seems evident that consulting engineers' information seeking is shaped by a number of contextual elements. These include their individual organisations, client expectations and the engineering industry. Also, they seek information from specific sources such as standards, statutory requirements and regulations, and these sources are often available within the consulting engineers' own organisations.

4.7.2 Information gathering

Although the literature review in Chapter 3 (section 3.7.2) discussed engineers' information searching, Ward (2001) used the term "information gathering" rather than information searching. Ileperuma (2002: 23) defined "information gathering" as "the ways and means used by scholars to collect information". "Gathering of data" is one of the steps in the research process illustrated in Blom's (1983) task performance model. Aguillar (1967) also used the term "information gathering" in his description of the environmental scanning process of collecting information about businesses' external environments. Similarly, Sandstrom (1994) also referred to "information gathering" as an information behaviour activity in her "optimal foraging theory".

In their discussion on engineers' information behaviour in a corporate environment, Mueller, Sorini and Grossman (2006: 2) observed that the engineers in their study often had a life cycle for information gathering where their need for information suddenly changed. This depended on the development phase of the project in which they were involved.

When it comes to consultants' information gathering, Ward (2001: 171) found that the proportion of time spent on gathering information for a project varied. Junior engineers were often required to gather information. In instances where the engineers made use of the library, Ward's (2001: 172) study reported browsing to be a successful method for information gathering.

4.7.3 Awareness of information and information encountering

The concept information awareness is generally used to refer to the passive reception of information which, according to Bates (2009: 2381), is the manner in which most people receive information. According to Leckie, Pettigrew and Sylvain (1996), users' direct knowledge of information sources and their perceptions about the information contribute to their awareness of information, which in turn will affect their information-seeking behaviour. Due to users' awareness of information, Bawden (2011: 9) observed that users would often serendipitously or accidentally encounter information that could be useful for a task. The concept information encountering was first coined by Erdelez (1997). She indicated that this type of information acquisition is commonly associated with browsing and environmental scanning.

In the field of engineering, Birnholz (2005), Du Preez (2008: 293, 324), and Sonnenwald and Pierce (2000), reported that engineering information is everywhere. One of the respondents in Du Preez's (2008: 293) study noted that engineering information is everywhere, which is an indication of his constant awareness of engineering information. The responding engineer described an incident where he serendipitously encountered an article in an in-flight magazine which discussed the same Voice over Internet Protocol (VoIP) exchange model he was using in a different project.

4.7.4 Information use

In the discussion in Chapter 3 (section 3.7.4), it was indicated that information use studies in engineering either addressed the concept from an engineering context perspective, or from a personal dimension perspective. The studies reported on in Chapter 3 that focused on the use of information in an engineering context found that engineers require information that is immediately available and accessible. Furthermore, the use of information sources could be linked to task uncertainty and task complexity. In addition to these findings, certain contextual elements from the consulting industry could also affect the use of certain information sources by consulting engineers. One such contextual element is organisational boundaries. This is if one considers David Allen and Wilson's (2003: 40), Johnson's (2003), Rosenbaum's (1993; 1996) and Solomon's (1997: 1110-1111) observations that organisational rules and resources shape information practices and activities and the nature of the information that is available within the organisation. Haas and Hansen (2007: 1134), for example, discussed why the reservoirs of electronic documents, the use of these electronic documents, and the pools of experts in an organisation affect task-level outcomes in terms of time saving and work quality.

The sources of information that are used by consulting engineers seem to be available internally as well as externally to the engineers' organisations (Du Preez 2008: 324-330; Gralewska-Vickery 1976: 267-277; Ward 2001: 171). These sources include the engineers' personal knowledge and personal files, books, codes of practice, acts and regulations, technical journals, trade literature, design software, digital cameras, Internet, email, conference attendance and visits to construction sites.

4.7.5 Communication

The verbal interaction (communication) that takes place among engineers involved in an engineering project allows for timely information, rapid feedback and critical evaluation (Tushman 1982: 350). Since engineers, including consulting engineers, generally work in project teams, interpersonal communication is an important information activity for them, and the concept also involves aspects such as information sharing and collaboration. Tushman's (1982) findings were endorsed by Gralewska-Vickery (1976: 270). According to her findings, personal, face-to-face communication is important when the consulting engineer requires immediate feedback, or intervention when something is found to be beyond comprehension. She also noted that such interpersonal communications assist consulting engineers in guarding themselves against an overload in the amount of information that is received. Furthermore, as Gralewska-Vickery (1976: 270) indicated, teamwork facilitates discussions. Du Preez (2008: 330) also found that consulting engineers are sometimes reliant on people as sources of information. The examples she gave include client's needs and geotechnical engineers' reports.

Apart from facilitating information transfer and sharing in projects, Gralewska-Vickery (1976: 271) also reported a different reason for personal face-to-face communication (conversations). According to the interviewees in her study, conversations "bring people together and create bonds of confidence and loyalty". Gralewska-Vickery (1976: 271) also reported that when they communicate with their clients, team members or suppliers, consulting engineers get to know the person they are dealing with, how that person thinks and to what extent the consulting engineer could rely on the person. Personal, face-to-face communication therefore seems to be a means to build trust between consulting engineers, their clients, project team members and suppliers.

However, certain elements in the contextual environment affect face-to-face communication. One such example was reported on by Ward (2001: 171). He mentioned instances where communication was blocked when consulting engineers were involved in secret projects. He also reported on a tendency among people to withhold knowledge for personal or political ends.

In addition to this discussion on the importance of face-to-face communication as a source of engineering information, organisations and organisational boundaries could also be a factor affecting communication. According to Johnson (2003: 750), individuals in an organisation are "embedded in a physical world that involves recurring contacts with an interpersonal network of managers and co-workers". As a result, certain communication networks develop within organisations. An example of such communication networks was identified by Ward (2001: 171). He identified the presence of "knowledge clubs" in which groups of engineers frequently aired problems, and tried out solutions. According to him, the existence of knowledge clubs reflected an open and communicative working culture.

4.7.6 Reflection on information activities

As in Chapter 3, the discussion on the consulting industry and consulting engineers' information activities assisted in compiling a profile of consulting engineers' information activities. Table 4.2 reflects the suggested profile. The profile also shows how the various elements in the engineering context, consulting industry, consulting engineering environment, as well as the different phenomena in the engineers' personal dimension interact, and how these give rise to specific information activities.

Table 4.2: A profile of engineers' information activities

A PROFILE OF CONSULTING ENGINEERS' INFORMATION ACTIVITIES									
Dimensions		**INFORMATION ACTIVITIES**							
Context	**Elements**	**Seeking**	**Searching / gathering**	**Use**	**Transfer**	**Sharing**	**Communication**	**Awareness**	**Encoun-tering**
Engineering environment	Profession			•					
	Disciplines	•		•					
Engineering practice	Designs	•		•		•			
	Service delivery	•	•	•					
	Team work			•	•	•	•		
	Information flow			•	•	•			
	Work roles	•		•		•	•		
Tasks	Task complexity	•		•			•		
	Task performance	•		•					
	Projects	•		•		•	•		
Personal dimension	Cognitive	•	•	•				•	•
	Affective	•		•					
CONSULTING INDUSTRY									
Contextual	Organisations	•		•	•	•	•		
	Contracts	•	•	•			•		
	Tasks	•	•	•			•		
Personal				•					
Consulting engineering	Projects	•	•	•	•	•	•	•	
	Work roles	•	•	•	•	•	•		
	Tasks	•	•	•	•	•	•	•	
Personal dimension	Cognitive	•	•	•				•	•
	Conative			•					
	Affective	•							

When considering Table 4.2, it seems evident that the engineering context and engineers' personal dimensions mainly prompt active information-seeking activities. This is except for consulting engineering projects, and tasks which also seem to prompt passive information activities, such as awareness.

4.8 MANIFESTATION OF CONSULTING ENGINEERS' INFORMATION BEHAVIOUR

In this chapter, the discussion showed how two different contexts, namely, the consulting industry and the work environment of the consulting engineer, affect consulting engineers' information behaviour. Contextual elements in the consulting industry, which seem to affect consulting engineers' information behaviour, include the following:

- organisations (that is the consulting engineers' own organisation as well as their clients' organisations)
- the contractual agreements they sign with their clients
- task performance.

The effect these elements have on consulting engineers' information behaviour seem to manifest in their projects, their work roles and in the specific tasks they need to perform.

Apart from the elements in the consulting industry environment that seem to affect consulting engineers' work environment, these elements also affect their personal dimension. Furthermore, certain contextual determinants of consulting engineers' information needs can be derived from the situation of action, tasks and dialogue. As a result of the requirements set by the consulting industry, consulting engineers seek, share, gather, use and communicate information. They are also acutely aware of information in their environment that could be useful in task completion and therefore are also prone to information encountering.

The discussion in this chapter therefore gave rise to the adaptation of the information behaviour model which was presented in Chapter 2. The model further enabled the researcher to discover those aspects that were least addressed in the information behaviour of engineers in general (Chapter 3), and thereafter consulting engineers, which in turn made it possible to compile profiles of engineers' and consulting engineers' information behaviour.

In order to illustrate consulting engineers' information behaviour graphically, Figure 2.1 was adapted once again to become Figure 4.1. In Chapter 3, Figure 3.1 was placed in a frame and the term "engineer" was included in each of the boxes representing the four aspects that underlie Wilson's (1999: 249; 2000: 49) definition of information behaviour. This allowed Figure 3.1 to graphically illustrate the personal context and environmental context of the engineer as a user of engineering information. The current adaption of the framework depicted in Figure 4.1 shows consulting engineering as a context which overlaps the engineering environment context and the consulting industry context.

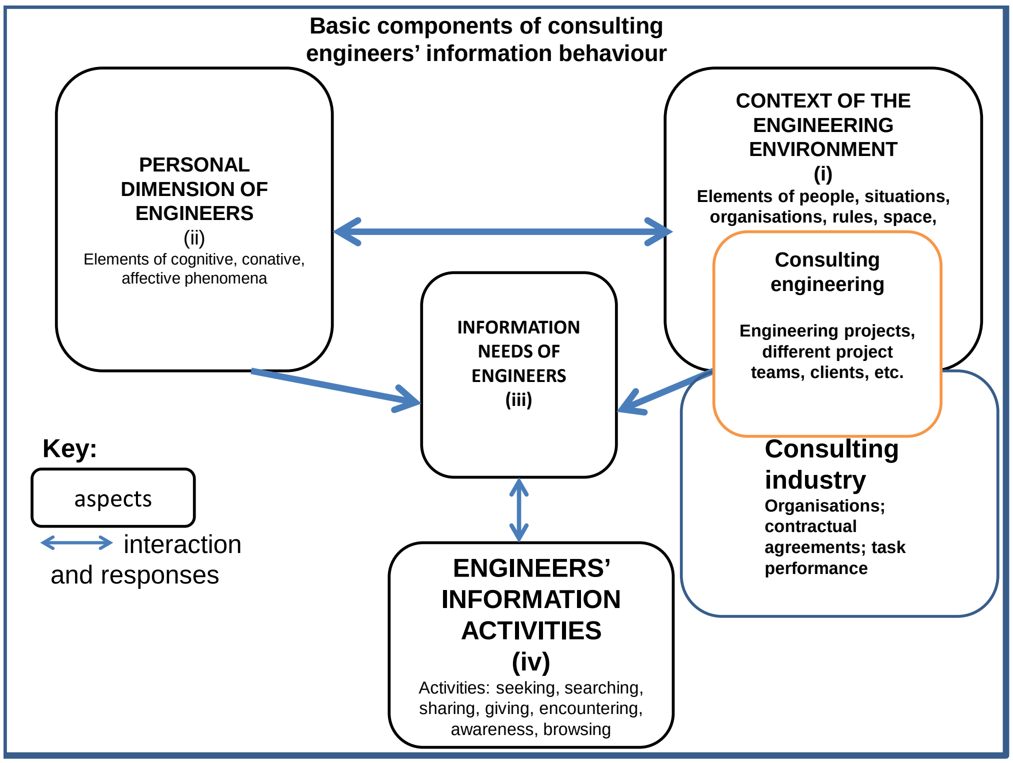


Figure 4.1: Core components contributing to the information behaviour of consulting engineers.

This reminds one of Lievrouw's (2001) model of context indicating that individuals can inhabit multiple contexts. This depiction of the consulting engineering context suggests that consulting engineers operate within both the engineering environment and the consulting industry contexts.

4.9 CONCLUSION

Whereas the purpose of Chapter 3 was to review the literature on the information behaviour of engineers in general, the focus in this chapter was on the information behaviour of consulting engineers. As in the previous two chapters, the four prominent components underlying information behaviour, originating from Wilson's (1999:249; 2009: 49) model, were highlighted. These are the context, the personal dimension, information needs and information activities. In this discussion, it was shown that consulting engineers' context overlaps with the engineering context as well as with the context of the consulting industry. This literature study also showed gaps in research on the different information behaviour activities of consulting engineers in terms of people as important sources of communication, collaboration and communication networks among consulting engineers.

With this in mind, Chapter 5 will focus on collaborative information behaviour and endeavour to learn from the literature how people (and more specifically engineers) seek, share, transfer and communicate information, as well as how they network in a collaborative environment.

CHAPTER 5

ENGINEERS' COLLABORATIVE INFORMATION BEHAVIOUR

5.1 INTRODUCTION

The purpose of this chapter is to review what the literature has reported on collaboration among engineering teams, and how this eventually contributes to the role of social networks in the information behaviour of consulting engineers. With the structure of the proposed conceptual framework for information behaviour of consulting engineers in mind, the following aspects will be addressed:

- Collaboration and the contextual elements in collaboration that could potentially affect the collaborative information behaviour of engineers working in teams
- Elements in the personal dimension of team members that derive from team work that could affect engineers' information behaviour
- Evidence related to the interaction between elements in a collaborative environment and the personal dimension of engineers that give rise to their information needs, and in turn motivate collaborative information activities. These activities include information seeking, use, communication and sharing

5.2 BACKGROUND

In her discussion of the term "information behaviour", Bates (2009: 2381-2382) noted that the term is also "the term of art used in library and information science (LIS) to refer to the sub discipline that engages in a wide range of types of research conducted in order to understand the human relationship to information". She further argued that, in comparison to other social and behavioural science fields, LIS researchers study people with the "purpose of understanding information creation, seeking, and use". According to her, the study of information behaviour can cast a very wide net in which the LIS researcher looks into individual interactions as well as group and societal interactions with information. When the researchers did look into these interactions, they were surprised to discover how much information people got from their friends and colleagues (Bates 2009: 2386). Allen and Kim (2001) and Savolainen (1993) also noted that social interaction with information can only occur within a certain context. When considering that the nature of engineering work requires engineers to collaborate and work in project teams, it seems evident that engineers' project teams can provide the context within which societal interactions with information occur.

As shown in Chapter 3 (section 3.3.6), each engineering project sets its own requirements in terms of the project's goal, the resources that are available relating to the project, the time that is available to complete the project and the team members that are appointed. That discussion also showed the effect these requirements have on individual engineers' information behaviour. However, the collaborative information behaviour of project teams was not addressed. As indicated by Bruce, Fidel, Pejtersen, Dumais, Grudin and Poltrock (2003: 140), project team members are a group of people who have been brought together to solve a problem which is the goal of the team. CESA (2003a: 1) also noted that consulting engineers are appointed to a project team for their personal knowledge and expertise.

Management scientists Borgatti and Cross (2003: 433) also indicated that the social relationships within a group are important for acquiring information, learning how to do one's work, and to solve cognitively complex tasks collectively. In view of the importance of social relationships in a group, it seems possible that social networks could develop as a result of the social interaction and resulting social relationships that are developed in team work. This may also have an application to the setting of consulting engineers, who can be involved in more than one engineering project simultaneously and come from different organisational backgrounds. The social experiences and social relationships team members have developed through working in an organisation, and working on different engineering projects, also seem to be important.

As shown in the discussions in Chapter 3 and Chapter 4, good communication and technical negotiation skills are important in team work. This is because engineers are not only required to share their engineering knowledge, but also have to share the projects' requirements for their individual engineering disciplines with fellow team members. During the design and construction phases of a project, engineers also need to negotiate their technical and resource needs to ensure successful task completion. Therefore it seems possible that collaboration stimulates the information activities of team members, such as information seeking, communication and sharing.

Based on a literature review, the following discussions will therefore endeavour to learn more about the different elements in social contexts that could shape collaboration and collaborative information behaviour.

5.3 COLLABORATION

Sonnenwald (2003: 68; 2008: 645) defined collaboration as the "interaction taking place within a social context among two or more scientists [including engineers] that facilitates the sharing of meaning and task completion with respect to a mutually shared, superordinate [common] goal". As stated by B.L. Allen (1996: 57), a common goal includes group learning, group problem-solving and group decision-making. These are cognitive activities deriving from team members' personal dimension. However, a common goal can also have some contextual requirements or constraints. This is shown in the description for a common goal that was offered by Attfield and Dowell (2003: 202). According to them, a goal in collaboration is embodied by the product constraints and the available resources that dictate the means by which the goal is achieved. Rasmussen, Pejtersen and Goodstein (1994: 51-52) and Sonnenwald and Lievrouw (1996: 181) provided an example of a common goal in engineering which shows the cognitive activities as well as the contextual requirements for a common goal. They observed that engineers need to understand the context in which the product or system they are developing will be used, so that the product will be compliant with the existing structures, products or systems it is meant to support.

Apart from a common goal, successful collaboration also requires a common ground (Finholt 2002: 97; Olson & Olson 2000: 144; Sonnenwald 1995: 873; Sonnenwald & Pierce 2000: 474). A common ground, as defined by Finholt (2002: 96), is the "shared cognitive understanding that allows collaborators to successfully coordinate their effort to accomplish joint work". Finholt's (2002) definition is endorsed by psychologists Clark and Brennan's (1991: 127) requirements for collaboration. According to them, collaborators need to have mutual knowledge, beliefs, and assumptions.

Sonnenwald and Lievrouw (1996) illustrated the need for team members to arrive at a common ground when they state that team members often come to a project with pre-existing patterns of work activities, specialised work languages, different expectations and perceptions of quality and success, and different organisational constraints and priorities. This is endorsed by Hyldegård (2006: 287) and Olson, Olson and Hofer's (2005: 1) observations. They observed that people who had previously collaborated successfully, had arrived at a common working or management style, and their interactions and expectations are aligned and are likely to reach a common ground when working together on a different project.

However, absence of a common ground could result in team members challenging or contesting one another's contributions (Sonnenwald & Pierce 2000: 475). Cox (2007: 783) suggested that too much diversity among team members could be a reason why collaborators do not arrive at a common ground. The reasons suggested by Sonnenwald and Pierce (2000: 475) include personal past experiences, different perceptions of the problem and their individual solutions to the problem.

Some factors that determine the degree to which people collaborate were identified by Cleal, Andersen and Albrechtson (2004: 18). These factors include the degree of interdependency among work tasks, the need for diverse information from different disciplines to complete the task, the commonality among tasks and among work processes and goals, and the compatibility among organisational values and priorities.

The process of arriving at a common goal and a common ground seems to be a democratic process which involves all team members. This is one of the conditions Shah (2012: 16) identified for effective collaboration. In addition to being democractic and inclusive, Gray (1989) stressed the interdependency of team members. The explanation she offers is that collaboration is a give-and-take process and the process is designed to produce solutions which could not be achieved if the team members worked independently.

However, apart from the importance of arriving at a common ground of work among team members, Cleal et al. (2004: 18) also considered how the differences and diversity among team members could motivate collaboration. They maintained that the differences in expertise and preferences could also contribute to improving the quality of work.

In addition to the preconditions for collaboration, Courtright (2007: 282-284) identified some contextual elements that are present in a collaborative environment. This include rules, resources, culture, social networks, social norms, collaborative requirements in the workplace, tasks or problem situations and work roles.

When considering the suggested information behaviour model for consulting engineers in Chapter 4, elements that can be derived from both the contextual and personal dimensions of engineers could also influence their collaborative information behaviour. The following sections deal with the involvement of the respective components of the framework in collaborative activities of engineers.

5.4 CONTEXTUAL ELEMENTS AFFECTING COLLABORATION

Different kinds of collaboration develop within different work environments (Cleal et al. 2004: 18). Some of the elements that are present in a specific work team, which could shape information behaviour that were identified in the discussion on collaboration (section 5.3), include work roles and tasks, a common goal and a common ground. However, Borgatti and Cross (2003: 433) also identified some factors that are not team-related and which could shape the information behaviour of work teams. The elements they identified include social networks, social relationships, organisations, access to information, and cost. These elements will form the focus of the following discussion.

5.4.1 Organisations

As defined in Chapter 4 by Zhang and Benjamin (2007), organisations are “human gatherings at different levels who share certain values, beliefs, goals, institutions and processes”. In an organisation, certain organisational structures are required to create a context or situations that would promote cooperation and trusting relationships among groups. Johnson (1997) used the term “frameworks for interaction” to describe these organisational structures. According to him, “frameworks of interaction” are “a set of interrelated conditions” that promote certain levels of shared understanding of meanings, orientate collaborators and establish the ultimate purpose for continuing interaction. This is similar to Luhmann’s (1995 in Solomon 2002: 232) explanation. He explained that the existing organisational structures recognises and permits certain kinds of action, but cuts off the actions of other systems. As a result, the creation of contexts that would promote cooperation and trust also seem to “splinter” an organisation into different functional groups (Johnson 1993a in Johnson 2003: 744). Due to the “splintering” of an organisation into different functional groups, organisational structures have the potential to limit people’s attention and views of situations. As observed by Solomon (2002: 232), organisational structures can therefore inhibit and prohibit actions that would support information discovery.

According to Aldrich (2006: 5), organisations provide natural boundaries that delineate the activities taking place within them. This observation is supported by Prekop (2002: 536) when he indicates that each organisation tends to have its own issues, perspectives, knowledge and other important elements that influence the information behaviour of individuals in that organisation. The elements present in an organisation that influence information behaviour, as identified by David Allen and Wilson (2003), Rosenbaum (1993; 1996) and Solomon (1997: 1110-1111), are organisational rules and resources, as well as the nature of the information individuals working within the organisation are exposed to. In addition to the exposure to specific information, Audunson (1997: 71) observed that membership of a group contributes to decisions on source selection, the use of information channels and the time that is spent on information seeking and use.

5.4.2 Organisational culture

Culture is the “collective programming of the mind that distinguishes the members of one category of people from those of another” (Hofstede 1984: 51). In the workplace, the concept “culture” refers to the shared understanding of organisational norms and patterns and the organisational climate that is produced by workers interacting in that culture (Allen & Wilson 2003: 35). According to David Allen and Wilson (2003: 36-37), a recursive relationship exists between climate and culture, for example, where a climate of mistrust reinforces and legitimises a culture of risk avoidance. This generally happens when programmes in an organisation are changed, and individuals attempt to secure their positions within the organisation.

The different cultures of employees working for an international organisation can also affect a team's information behaviour. One such example comes from Olson and Olson (2000: 170-171). In their study on the human interaction among global teams, they found that cultural differences could result in misunderstandings among team members.

5.4.3 Social norms

The concept "social norms" seems to be a concept that is related to culture. Chatman (1996: 203) used the social psychologist Muzafer Sherif's 1936 definition to define social norms. According to this definition, social norms are the "customs, traditions, standards, rules, values, fashions and all other criteria of conduct which are standardised as a consequence of the contact of individuals". The concept "social norms", according to Burnett and Jaeger (2008), refers to visible and behavioural aspects of social activities. Social norms therefore also allow for standards of "rightness" and "wrongness" in social appearances and therefore point the way to acceptable standards and codes of behaviour (Burnett, Besant & Chatman 2001: 537). As such, social norms seem to be an element that holds a group of people together and which sets parameters around the communication processes within the group. As a result, Chatman (1996: 204) argued that social norms affect the exchange of information within groups of people and act as reference points in which information sharing may be expected to occur.

Alisantoso, Khoo, Lee and Lu (2006) noted that engineering teams involve engineers from different engineering disciplines as well as people from other professions. Also, team members can come from different organisational backgrounds (Fidel, Pejtersen, Cleal & Bruce 2004; Mowshowitz 1997). As observed by Thomas Allen (1977: 232-233), the different social norms that exist within an engineering team, due to the diverse backgrounds of team members, can undermine communication among team members.

5.4.4 Social networks

In her review on contexts, Courtright (2007: 282) identified social networks as a context that shapes information practices. Social networks are constructed when people or organisations interact (Salancik 1995: 345). Each social network "represent[s] patterns of social interactions among people" (Pepe 2010: 46). Therefore, Cho, Lee, Stefanone and Gay (2005: 436) and Sonnenwald (1999: 180; 2008: 655) noted that social networks provide the foundation for collaboration and socialisation that may span organisational and national boundaries.

Cross, Parker, Prusak and Borgatti (2001: 100), Finholt (2002: 75) and Von Seggern (1995) reported on the importance of social relationships among team members. Von Seggern (1995) noted that productivity is dependent on collaborative networks and the exchange of new ideas. Also, Kraut and Streeter's (1995) findings showed that the outcomes of projects with a high degree of uncertainty was improved by extensive interpersonal networks. However, Cross, Parker, Prussak and Borgatti (2001: 111) observed that collaboration could fail when team members do not socially relate to each other and do not know what their fellow team members know. These observations are endorsed by Finholt (2002: 75) when he suggested that the productivity of engineering project teams are dependent on the amount and the quality of engineers' interaction with their team members.

In addition to the quality of interaction among team members, an awareness of team members' activities also seems to be important. This was shown by Sonnenwald, Maglaughlin and Whitton (2004: 997) and Sonnenwald and Pierce (2000: 471) in their discussion of team members' reliance on the collection and use of information that updates them on the current state of their teams' activities. Computer-supported cooperative work (CSCW) researchers Dourish and Belotti (1992) and Symon, Long and Ellis (1996) suggested that maintaining such an awareness would assist team members to coordinate their work. Sonnenwald et al. (2004: 997) and Sonnenwald and

Pierce (2000: 471) observed that dense social networks support team members in creating their awareness of information.

Social relations amongst people persist irrespective of whether the organisational context or tools are changing around them (Hirsh & Dinkelacker 2004: 808). This implies that social relations that develop among team members for the duration of a project will continue to exist once the project has been completed. According to Nardi, Whittaker and Schwarz (2002: 207), the shared experience and relationships that developed during the project then serve to establish relationships that may form the basis for future joint work. They describe the social networks that develop in this manner as being intentional networks.

Notwithstanding the importance of social networks as a source of information, Courtright (2007: 282) noted that social networks are not always accessible and beneficial to all team members and that information within a social network is not always reliable, useful or used. According to David Allen and Wilson (2003: 33) this happens in instances when team members do not share information or block team members from persons who have the necessary expertise.

Granovetter (1973) reported that people tend to seek information resources that are available in their initial social networks. This is endorsed by Cross et al. (2001) when they observed that people tend to seek help from people with whom they frequently interact. In a computer-supported collaborative environment Cho and Lee (2008: 563) also reported that pre-existing social networks have an effect on information source selection.

When considering the different aspects that seem to affect the development of social networks and the factors that affect the development of social networks, it seems as if social networks have a number of advantages for project and team work. These include the following:

- Social networks provide the foundation for collaboration. In addition to being the foundation of collaboration, collaboration can fail when team members do not socially relate
- Productivity is dependent on the amount and the quality of interaction between team members
- Social interaction promotes the exchange of new ideas, and projects with a high degree of uncertainty can benefit from this exchange of ideas and social interaction
- Dense social networks support individual team members in creating and maintaining an awareness of information. An awareness of information updates team members on the current state of team activities and assist them in coordinating their work
- The shared experiences and relationships that can be derived from team work could form the basis for future joint work. This is because indivuals tend to seek help from people they frequently interact with
- Since people tend to seek information resources that are available in their initial social networks, pre-existing social networks could have an effect on team members' information source selection.

The mentioned advantages social networks have for team work could offer some explanation for engineers' reported need to seek information from personal contacts. Unfortunately only a few studies focusing on engineers' information behaviour (including studies on engineers' collaborative information behaviour) addressed the potential role of social networks as a source of information for engineers.

5.4.5 Resources

Resources, according to Attfield and Dowell (2003: 200), can be subdivided into cognitive or internal resources and physical or external resources. The internal resources that are recognised in a team reflect the individual team members' personal knowledge and expertise. The external resources that were identified by Attfield and Dowell (2003) include time and information resources.

5.4.5.1 Time

Time is one of the preconditions of tasks (Byström & Hansen 2005; Toms 2011). When viewed as a precondition of a task, the concept time refers to the specified time frame that is available to complete the task (Tenopir & King, 2004: 137). As a resource, Attfield and Dowell (2003: 195) calculated the user costs of information seeking as an action in economics. When viewed as an action in economics, Tenopir and King (2004: 137) observed that engineers regarded time to be a “scarce resource”. As a result, engineers would not be willing to spend time reading if they did not consider the information obtained to be of value to their work. Hertzum and Pejtersen (2000) and Pinelli (2001) also investigated the effect that time has on information behaviour. They viewed time as a resource in terms of the social effort that had to be expended to find the required information.

5.4.5.2 Information resources

Johnson (2003: 750) found that organisations (including social networks) stabilise the information fields and determine the nature of the information individuals are exposed to. David Allen and Wilson (2003: 33) also commented on the importance of the quality of the information that is available in an organisation, as well as that it should be the right kind of information. The external and internal information resources, identified by Attfield and Dowell (2003: 191) to support work in an organisation, include electronic archives and domain knowledge. Reddy and Jansen’s (2008: 268) findings suggest that instances where information resources reside in multiple and dispersed systems could trigger collaborative information behaviour.

In addition to the type and nature of information that is available, Widén-Wulff, Ginman, Södergård and Tötterman (2008: 346) noted the existing relationship between information input and knowledge output within different kinds of social contexts (e.g. organisations or work teams).

Sonnenwald (2008: 454) and Sonnenwald and Pierce (2000: 463) pointed out the value of information for successful collaboration in an organisation. They observed that the timely exchange of information is vital for planning and decision-making purposes. However, they cautioned that, in instances where data is not exchanged timeously, team members would challenge the contribution of others.

David Allen and Wilson (2003: 33) used the concept "information politics" to describe instances where information is not shared with team members. They identified three forms of information politics: hoarding (i.e. denying others access to information), distortion (i.e. consciously changing the meaning of information) and blocking (i.e. denying others access to people who owned information or had expertise in an area).

In addition to the availability and accessibility of information, Audunson (1997: 75) also pointed out that there are certain norms about the sources of information or information channels that could be expected to provide credible information.

5.4.5.3 Communication infrastructure

Since communication is such an important aspect of collaboration, communication infrastructure could also be regarded as a resource that supports collaboration. David Allen and Wilson (2003: 39) noted that information technologies have made it easier to transfer information from one person to another and make information resources available. According to Finholt (2002: 97), collaborators therefore rely on information technology to overcome time and space barriers. They also require sufficient information communication technology infrastructure that is able to handle modern information and the dissemination thereof.

Nardi et al. (2000; 2002: 206) observed that work teams have embraced communication technologies such as email, voicemail, instant messaging, fax, papers, and cellular telephones, as well as personal digital assistants. Burford and Park (2014) added tablet devices to the list and found that these mobile devices proved to be extremely valuable access points for digital information such as email. According to them, mobile tablet devices were also used to post information to forums and engage in Facebook, a social media site on the Internet. These findings are congruent with those of Kakihara and Sørensen (2004: 181). They observed that the use of mobile technologies enabled extensive geographical movement in daily work activities, as well as enabling them to interact with a wide range of people through both physical and virtual means. In the field of engineering, Finholt (2002: 90) observed that engineers use collaborative technology when they have to confer over engineering drawings and other visual data.

Despite the advantages that communication technologies have in overcoming geographic and time barriers, they do not make cultural and social boundaries disappear (Espinosa, DeLone & Lee 2006; Tan, Wei, Watson, Clapper & McLean 1998). In fact, Cho and Lee (2008: 567) reported that pre-existing social relationships affect computer-mediated-communication (CMC) interaction patterns.

5.4.6 Projects

A project, as defined in Chapter 3 (section 3.3.6), is an enterprise which is carefully planned to achieve a particular aim. It is performed by people and constrained by limited resources. The people (team members) often come from different organisational, cultural, linguistic, ethnic or national backgrounds (Fidel, Pejtersen, Cleal & Bruce 2004: 950; Sonnenwald & Lievrouw 1996: 180). The nature of the project will determine who are appointed to the project team.

As part of their description of how project teams evolve, Von Krogh, Ichijo and Nonaka (2000: 14) noted that project teams can be formed from the outside by a manager or an engineer who is responsible for developing a product. According to them, project team members can include people from various subject disciplines and other interest groups. Furthermore, project team members can even be drawn from various businesses, functional areas and departments, customers (or clients), suppliers or other partners.

When a project team includes consultants, Czarniawska and Mazza (2003: 273) noted that they are usually drawn from other organisations. In addition, Moshowitz (1997: 37) found they could be self-employed and simultaneously have temporary relationships with multiple organisations. This explains Sturdy et al.'s (2009) claims that consultants and clients often inhabit different social and occupational worlds and spend little time with each other. As a result of this new relationship, Sturdy et al. (2009) observed the introduction of new network “boundaries” in project teams.

Once a project team has been appointed, the team members start interacting with one another, organise themselves, and share their knowledge to achieve a goal. According to Von Krogh et al. (2000) the evolution from a group of individual persons into a project team becomes part of the team’s collective memory. The tacit knowledge that is nurtured in this way enables members to carry on relationships over a period of time.

The relationships that develop among individuals over time, together with the project team members’ different backgrounds and contexts, have the potential to constrain the flow of information within a project team. This was reported on by Cho and Lee (2008), Espinosa et al. (2006) and Watson-Manheim, Chudoba and Crowston (2002). It can therefore be assumed that the flow of information within a project team, as well as the nature of the project, will influence the team members’ information behaviour. This will need to be tested empirically.

5.4.7 **Work roles**

Other organisational structures that could facilitate or inhibit information behaviour, which was identified by Solomon (2002: 238), include work roles and tasks. Goffman (in Sonnenwald & Lievrouw 2000: 182) defines roles as “the activity the incumbent would engage in were he to act solely in terms of the normative demands upon someone in his position”. Sonnenwald and Lievrouw (2000: 182) note that a person can perform more than one role and functions primarily through interaction with others.

Since tasks are linked to specific roles, Bruce, Fidel, Pejtersen, Dumais, Grudin and Poltrock (2003: 151) argue that well-defined work roles help to identify the range of responsibilities and tasks of a team member relative to other members of the team. Although each team member has his own role, Fidel et al. (2004: 945) observed that their contributions are affected by the contributions from others.

5.4.8 Tasks

Tasks, as defined by Audunson (1997: 79), refer to those activities that individuals need to complete that are governed by their work roles. Certain tasks, as indicated by communication scientists Ellis and Fisher (1994: 4,17), can only be completed in teams. According to them, teams tend to be more successful in the completion of complex tasks. The reason they offer for this phenomenon is that groups can draw on the pool of information and talent available within the team. However, not all tasks that emerge in a group can be completed by the group. Nardi et al*.* (2002: 205) observed that certain tasks still need to be completed by individuals. According to them, personal social networks are becoming more and more important as sources of information for such tasks.

The collaborative interaction that derives from the task dimension can either be direct or indirect (Foster 2009: 83). Foster (2009: 83) explained direct collaboration as those instances when team members seek, retrieve, share and use information as part of a common activity. When team members contribute to a discussion, respond to comments or recommendations that are made by their colleagues, they collaborate indirectly. Collaborators' activities may be focused on the collaborative creation or use of documents (for example engineering drawings or tender documents), or these activities can be focused on human beings where advice or expertise is sought from others (Hansen & Järvelin 2005: 1110-1111).

Interestingly enough, tasks also seem to be one of the most significant barriers in collaboration. According to Finholt (2002: 95) and Olson and Teasley (1996: 426), one of the reasons for this phenomenon relates to the fact that most group practices and routines assume a shared space. They also noted that co-location is essential for some tasks. Geographically distributed project teams could therefore have a negative impact on collaboration, unless team members are able to travel periodically to a centrally agreed place for meetings.

Lastly, Rasmussen, Pejtersen and Goodstein (1994) noted that team members should understand the context in which the completed product will be used. According to them, such an understanding will assist team members in ensuring that the completed product will suit the patterns of task performance, the organisational structure, social interaction and individual preferences it is meant to support.

5.4.9 Reflection on contextual elements

In summary, the different contextual elements that could affect collaborative information behaviour include organisations, organisational culture, social norms, social networks, resources, projects, work roles and tasks. From the discussion it seems evident that these elements could affect the information behaviour of individuals and project teams. Although projects develop within organisations, project teams do not necessarily embrace the organisational culture and social norms. It seems that each project team develops its own communication structures, organisational culture and social norms. Apparently these cultures and norms are influenced by the individual team members' own organisational culture and norms and their acquired experiences of collaborating on various other projects. Furthermore, the information behaviour of groups seems to be influenced by the collective memory, knowledge and expertise of these groups, as well as individual team members' personal social networks.

As an element of context, social networks seem to have a number of advantages for project work and group tasks. These advantages include providing the foundation for collaboration, improved productivity, the promotion of an awareness of information that is available and providing the basis for future joint work. In addition to these advantages, individual social networks also determine the nature of the information available in the network. Furthermore, it was shown that social networks are important sources of information for individual tasks that need to be completed in group work.

For a collaborative project to be successful, team members should also arrive at a common ground. A common ground would ensure that their interactions and expectations are aligned. If team members do not arrive at a common ground, individual team members could challenge or contest fellow team members' contributions and the collaborative effort could fail.

Project teams include a number of individuals who have their own skills, expertise, knowledge and experiences. With this in mind, the following discussion will address the effect individual team members' personal dimensions have on the collaborative information behaviour of teams.

5.5 PERSONAL DIMENSION

In her definition of collaborative information behaviour (CIB), Hyldegård (2006: 277) stated that apart from physical activities, collaborative information behaviour also involves the "cognitive and emotional experiences of individuals acting as group members". These experiences were described in Chapter 2 as cognitive and affective phenomena in the personal dimension of information users.

5.5.1 Cognitive phenomena

The three types of cognitive phenomena that affect users' information behaviour, as identified by B.L. Allen (1991: 7), include conceptual knowledge, task knowledge and knowledge of the resources that are used. In a collaborative environment, human resources experts, Attfield and Dowell (2003: 191), supported B.L. Allen when they identified the following cognitive phenomena: team members' domain knowledge, their accumulated knowledge of a subject (expertise), working memory, and cognitive structures, such as the development of internalised plans.

In her study, Hyldegård (2006: 287) observed the need for a group to have a clear focus of the project. To arrive at such a focus, Sonnenwald and Lievrouw (1996: 180) noted that team members mutually explore their individual and shared understanding of the design problem, the situation that generated it and how they may best work together to create an innovative and effective solution to the problem. As observed by Prekop (2002: 536), this process also includes individuals' knowledge and experience of accessing both formal and informal information within an organisational context.

5.5.2 Conative phenomena

In the field of psychology, Huit (1999) uses the concept “conative phenomena” to discuss the connection between people’s knowledge and their behaviour. From the studies conducted by Cho and Lee (2008), Hyldegård (2006), Olson and Olson (2000), Shapira, Kantor and Melmed (2001) and Widén-Wulff et al. (2008), it seems that two conative phenomena affect the information behaviour of project teams. These phenomena are motivation and coping.

5.5.2.1 Motivation

Successful collaboration requires team members who are motivated to work together (Olson & Olson 2000: 144). In the context of psychology, Cherry (2013) defined “motivation” as “the process that initiates, guides and maintains goal-oriented behaviours”. With Cherry’s (2013) definition in mind, motivation can be regarded as a conative phenomenon rather than an affective phenomenon, as Hyldegård (2006) viewed it to be.

In her study, Hyldegård (2006: 293,295) found that the way that individuals in groups view motivation could be associated with certain social aspects and that these social aspects manifested themselves in the group members’ agreements to perceptions of uncertainty, frustration and disappointment. In addition, the group members’ preferences of information sources seemed to be affected by their objective in arriving at a shared understanding of the project.

Shapira et al. (2001: 885) reported on an incident where some team members lacked motivation to participate. These team members, whom they named “free-riders”, hardly made any contributions to the group, even though they were likely to benefit from the system. They recommended that further study of a substantial nature was required on how to deal with free-riders.

Lastly, the concept “collaboration readiness” is often used in relation to collaborative work and refers to the extent that potential collaborators are motivated to work with each other (Olson, Olson & Hofer 2005: 2). According to Olson and Teasley (1996:

425), collaboration readiness also requires a social responsibility and a commitment, even when face-to-face meetings are not possible.

5.5.2.2 Coping

When considering the different social boundaries that develop as a result of team work, coping can be a very important skill. In the context of psychology, Weiten and Lloyd (2008), used the concept “coping” to refer to the conscious efforts that are expended to solve personal and interpersonal problems. According to Widén-Wulff et al. (2008: 346), coping in a social society requires a personal ability to transfer across cultural and social boundaries. Cho and Lee (2008: 567), for example, reported on how team workers in their study had to cope with the different boundaries that were related to their personal social networks, work groups and national or cultural boundaries, whilst utilising collaborative technologies. According to them, an inability to cope with these boundaries could impede collaboration.

5.5.3 Affective phenomena

Affective phenomena that seem to have an effect on teams’ collaborative information behaviour include trust and uncertainty.

5.5.3.1 Trust

Collaboration may lead to faster progress and better exploitation of a discovery, but collaboration also means giving up exclusive access to the discovery (Zucker, Darby, Brewer & Peng 1996: 108). This is especially the case in industrial environments where scientific discoveries have a commercial value. Trust is therefore an important factor in successful collaboration. Rousseau, Sitkin, Burt and Camerer (1998: 395) defined trust as “a psychological state comprising the intention to accept vulnerability based upon positive expectations of the intentions or behaviour of another”. Trust therefore implies

- that one will not take advantage of the other’s vulnerability,
- that trustees have “confident expectations”, such as trust that others will keep their promises, and

- fellow collaborators will produce work of high quality.

Collaborators' employment by the same organisation or different organisations seems to be a factor which has an effect on trust in collaboration. Zucker et al*.* (1996: 108) have, for example, determined that trust is generated readily among collaborators working for the same organisation (or groups) and that distrust seems to affect collaboration across organisational (or group) boundaries.

Establishing a common ground is a prerequisite for trust (Olson & Olson 2000: 168). Due to a lack of face-to-face interaction, geographically distributed team members seem to find it difficult to establish a common ground and build a trusting relationship (Cross, Parker Prusak Borgatti 2001: 115). The research conducted by Olson and Olson (2000: 168) confirms this notion in that the remote teams in their study were less effective and reliable than teams who had face-to-face contact. They also reported that trust is fragile when information is communicated electronically only, but that face-to-face discussions culminated into cooperation.

In addition to being a prerequisite for collaboration, trust, believability and, in some instances, emotional support are primary conditions of information sharing (Beldad, De Jong & Steehouder 2011: 224; Chatman 1991: 440; Hayter 2006: 25; Savolainen 2009: 42; Von Krogh et al. 2000).

Lastly, Cho and Lee (2008: 563) observed that boundaries that develop between different work groups also seem to constrain information-seeking and information-sharing behaviour. They are of the opinion that individuals tend to perceive information received from former team members to be more trustworthy than information received from team members in a new working group.

5.5.3.2 Uncertainty

In literature on communication, Brashers (2001) noted that people experience uncertainty when they need to make decisions, plan events or interact with others. According to him, "uncertainty exists when the details of situations are ambiguous, complex, unpredictable, or probabilistic; when information is unavailable or inconsistent and when people feel insecure in their own state of knowledge". Kuhlthau (2005: 232) endorses Brashers' description when she stated that information seeking is initiated by uncertainty, which results from a lack of understanding (i.e. lack of knowledge) or a gap in meaning. Chowdhurry, Gibb and Landoni (2014) also noted that information needs and the pressure to satisfy them may create psychological uncertainty in users. As noted in Chapter 2, section 2.3.1.3, uncertainty is a cognitive state which causes affective symptoms of anxiety, lack of confidence, frustration and confusion.

In her information search process (ISP) model, Kuhlthau (2005: 232) noted that uncertainty decreases when an information searcher proceeds towards the completion of the search process. However, Wilson, Ellis, Ford, Foster and Spink (2000; 2002: 706) argued that uncertainty may arise at any of the four stages of their problem-solving model (i.e. problem recognition, problem definition, problem resolution, and solution management). Their argument is endorsed by the findings in Hyldegård's (2006: 294-295) collaborative essay writing project where some of the team members perceived feelings of uncertainty and disappointment at the end of the project. She also observed that these feelings were the result of intragroup divergence in foci, motivations and ambitions.

5.5.4 Reflection on the personal dimension component

The literature cited in the above discussion shows how certain phenomena within engineers' personal dimension could have an effect on their collaborative information behaviour. The most important cognitive phenomena seem to be their personal knowledge and expertise as well as their ability to develop plans.

As previously stated, successful collaboration is dependent on team members' ability to arrive at a common ground. Team members' motivation to collaborate is therefore a prerequisite. To be motivated also requires of team members to be socially responsible and committed to solving problems. Good coping skills are therefore also important.

Trust seems to be the most important affective phenomenon that could have an effect on consulting engineers' collaborative information behaviour. This is because a trusting relationship is required to establish a common ground among team members and it is also a prerequisite for information sharing. Uncertainty is another affective phenomena which has an effect on collaborative information behaviour. Contrary to the effect it has on individuals' information behaviour, it seems that uncertainty could remain a factor throughout a collaborative project and could result in satisfaction or disappointment regarding the outcomes of the project.

For purposes of this chapter, it is equally important to determine how the literature reports on information needs in a collaborative environment.

5.6 INFORMATION NEEDS

Information needs, according to Cole (2011: 1223), arise in users by the context in which the information users find themselves. This was also discussed in Chapter 2 to Chapter 4. Apart from information needs that arise in information users, Gross (1999: 501; 2001) noted that an information need may be imposed on the user by a third party. According to her, imposed information needs emanate from relationships between people. The following discussion will therefore focus on information needs that arise in a collaborative environment, and how group members react to such needs. In this regard, Chatman (2000: 10) reported that individual users will not seek information if their group chooses to ignore the information. The reason she gives is that the group functions well without the additional information.

The focus in the following paragraphs is to determine those elements in a collaborative environment that prompt project teams and individual team members' information needs.

5.6.1 Information needs deriving from context

As indicated in Chapter 3 (section 3.5.1), Savolainen (2012) identified three major contexts in which information needs arise. These are situation of action, task performance and dialogue.

5.6.1.1 Situation in action

"Situation in action", according to McCreadie and Rice (1999: 58), refers to "the particular set of circumstances from which a need for information arises". Savolainen (2012) noted that the situations in which people experience an information need do not manifest themselves as time-space constellations of action, but are bound to the requirements and conditions of human action. When considering the discussion in section 5.3, the requirements and conditions of human action seem to be determined by organisations, organisational culture, social norms, social networks, resources, projects, work roles and tasks. As shown in section 5.4.2, each project team develops its own organisational culture and organisational structures, where project teams are reliant on limited resources that were made available for their projects. This could make project teams complex information environments.

In David Allen and Wilson's (2003: 40) study, respondents described their information needs in complex information environments. According to them, their information environments were becoming less structured when more information channels, with more potentially relevant information, were available. Due to team members' diverse organisational backgrounds, not all potential information sources are available to all project team members

In addition to the availability of information sources, Audunson (1997: 69) noted that decision-makers might have realistic preferences and complete information on possible courses of action. But if this knowledge and these preferences are not communicated to all team members, a need for information arises among these team members, which in turn prompt information-seeking activities. As indicated in section 5.4.5.2, David Allen and Wilson (2003) described this type of behaviour as "information politics".

5.6.1.2 Tasks

Leckie, Pettigrew and Sylvain (1996: 161) and Savolainen (2012) noted that tasks or problems that need to be solved give rise to information needs. Tasks also impose certain information requirements that must be met to ensure task completion (Byström &

Järvelin 1995: 192). In addition to the information requirements of tasks, Leckie et al. (1996) noted that the strategies that are deployed to meet those needs vary due to a variety of factors. These factors include organisational culture, individual habits, and the availability of information systems and sources.

One task-related factor in a collaborative environment, which could influence information needs, was discussed by Bryce Allen (1997: 116-117). According to him, a work team can have information needs that go beyond individual team members' information needs. He indicated that group needs do not replace individual needs, but that group and individual information needs occur concurrently. He therefore argued that information needs may occur that are quite different from individual information needs.

Bruce et al*.* (2003: 142) provided an example of information needs in engineering design teams. According to them, these engineering teams' information needs are concerned with isssues of content, design management, scheduling and uses. They also observed that individual team members make design information needs known to the team when they need certain information to do their work. The team also expressed information needs related to management, scheduling issues and client specific needs.

5.6.1.3 Dialogue

Savolainen (2012) understands dialogue as being a written or spoken conversational exchange between two or more individuals and that the constituents of dialogue provide a rich repertoire of factors that affect the formation and satisfaction of information needs during the course of conversation. Lundh (2010) and Savolainen (2012) emphasised the importance of Taylor's 1968 model in this regard. According to them, Taylor's (1968) model implies that a "process of negotiating" is unavoidable when a user interacts with a librarian or information system to satisfy an information need.

From a sociocultural perspective, Lundh (2010) supported Taylor and suggested that information needs are formed through linguistically communicated processes of negotiation that take place within different groups (e.g. work teams). These negotiation processes seem to be important in engineering teams. In engineering literature, Cheimets et al*.* (2009: 26) and Lappalainen (2009) emphasised engineers' need to negotiate their technical needs and objectives with their team members. These views are endorsed by Bryce Allen (1997: 117) when he noted team members' responsibility to communicate their individual information needs and perceptions of the problem to ensure that all team members are in agreement.

The diverse use of terminology among team members working in different teams and in different subject domains could also be a factor affecting communication-related information needs (Cleal et al. 2004:18).The importance of a shared terminology within engineering project teams was also reported on by Heisig, et al. (2010: 527) and Tushman (1977: 590). Tushman (1977: 590-591) noted that conceptual and linguistic differences inhibit communication and hinder the free flow of information within a team.

5.6.2 Information needs deriving from the personal dimension

Certain aspects that can be derived from the personal dimension of individual team members could also affect communication in a collaborative environment. Software engineers Balmaceda, Schiaffino and Godoy (2014) identified personality traits as one such aspect and found that personality affects the way in which a person interacts with others.

Perception is a second aspect in the personal dimension of team members that could affect information needs in a collaborative environment. Bryce Allen (1997: 115), explained that individuals' approach to information needs is influenced by the context in which the need arises, as well as the social processes involved in defining and meeting information needs. He stresses the importance that two people with different backgrounds will behave similarly in the same situation. Bryce Allen (1997: 116) further explains that a group's collective perception of a situation depends on whether the individual team members perceive the situation in the same manner as their fellow team members.

5.6.3 Reflection on information needs

The discussion in section 5.6 showed that information needs in a collaborative environment emanate from relationships among people and that information needs could be imposed on a user by a third party. As with information needs of individuals, certain elements in the context in which users find themselves also give rise to information needs in a collaborative environment. The contextual elements that can be derived from the situation in action that give rise to information needs include organisations, social networks and project teams. It therefore seems as if project teams can be viewed as complex information environments where not all information is available to all team members. Furthermore, the task-related information needs of work teams go beyond the information needs of individual team members and can occur concurrently with the information needs of the team.

It also seems that information needs are formed through linguistically communicated processes of negotiation. One of the reasons for this is the diverse use of terminology among team members from different subject disciplines. However, it also seems that team members' personal traits and perceptions further contribute to the information needs of individuals and team members.

Table 5.1 provides a profile of users' (including consulting engineers') collaborative information needs.

Table 5.1: A profile of collaborative information needs

A PROFILE OF COLLABORATIVE INFORMATION NEEDS							
Contextual elements		**INFORMATION NEEDS**					
		Context			**Personal Dimension**		
		Situation of action	**Tasks**	**Dialogue**	**Cognitive**	**Conative**	**Affective**
Organisations		•	•	•		•	•
Organisational culture		•		•			•
Social norms		•		•	•	•	•
Social networks		•	•	•	•		•
Resources		•			•		
Projects		•	•	•	•	•	•
Work roles		•	•	•	•	•	•
Tasks		•	•	•	•	•	•
Personal dimension							
Cognitive		•			•	•	•
Conative	motivation	•			•	•	
	coping	•			•	•	•
Affective	trust	•		•	•		•
	uncertainty	•	•	•			•

As in Table 3.1 and Table 4.1, the suggested profile of collaborative information needs in Table 5.1 shows that the elements in the collaborative environment in which engineers work can affect the three different types of contextual information needs. It also seems that most information needs emanate from the situation of action. The discussion in a previous section also shows that cognitive, conative and affective phenomena affect the information needs of individual team members as well as that of the project team as a group.

5.7 COLLABORATIVE INFORMATION ACTIVITIES

In their examination of collaborative information behaviour definitions, Reddy and Jansen (2008: 257) identified two important collaborative information behaviour concepts. These concepts include collaboration (people are working together to seek information) and resolving of information needs. The concept "collaboration" and the elements in collaboration (i.e. organisations, social networks, organisational culture, social norms, resources, work roles and tasks) that affect information behaviour were discussed in section 5.3. The activities in which people become involved to resolve information needs include information generation (Hyldegård 2006: 279); information seeking, sharing and retrieval (Reddy, Jansen & Spence 2011; Talja & Hansen 2006); collaborative grounding (Hertzum 2008); and information transfer (Bruce et al. 2003: 147). However, it should be kept in mind that in Chapter 3 (section 3.7.5), it was indicated that in this study information communication is the preferred term for information transfer. Therefore, the term "communication" will be used instead of "information transfer".

Of the collaborative information activities identified above, collaborative information seeking, information communication and information sharing will be discussed subsequently. The discussion will also look at how collaborative grounding affects collaborative information seeking.

5.7.1 Collaborative information seeking

As shown in Chapter 1, information seeking is the process where humans purposefully seek information that will satisfy their information needs. The concept "collaborative information seeking" is defined by Hertzum (2008: 958) as "the information-seeking activities performed by actors to inform their collaborative work combined with the collaborative grounding activities involved in making this information part of the actors' shared understanding of their work". According to Hertzum (2008: 958), these activities can occur in a collaborative context but can also be performed by individual team members.

As shown in Chapter 3, certain elements in the context or work environment of users affect their information-seeking behaviour. The contextual elements that seem important in a collaborative environment include collaborative grounding, and information overload.

5.7.1.1 Collaborative grounding

Collaborative information-seeking activities include "collaborative grounding" (Hertzum 2008: 960). According to Clark and Brennan (1991: 128), Gazan (2010: 694), Hertzum (2008: 958), and Olson and Olson (2000: 144,157-166), collaborative grounding activities are aimed at actively constructing a shared understanding among collaborators. This seems similar to the concept "learning-in-working", which was originally identified by organisational scientists Brown and Duguid (1991: 53). Both concepts include an understanding of the information needs of groups, the information-seeking processes and information channels through which information is understood, filtered and distributed among collaborators. Brown and Duguid (1991: 53) point out that arriving at a shared understanding is important to avoid misunderstandings among team members.

In addition to the importance of arriving at a shared understanding, Hertzum (2010: 648, 960) also noted that collaborative grounding may assist collaborators in identifying the core persons in a project team. Such identification can support cross-disciplinary information exchange among project team members.

5.7.1.2 Information sources

An individual's perception of the expertise level of an information source also has an impact on collaborative information seeking (Su & Contractor 2011: 1257). The individual's social communication with other team members and their information seeking interaction with the knowledge source further influences the team's collective information seeking.

5.7.1.3 Projects

Starting a new project can be challenging when it comes to information seeking. Research and development management researchers Ernst and Vitt (2000: 116) argued that this could be because a new group of people are required, to use new resources and to find new ways of working together. In addition, each individual has his or her own expectations of what has to be done.

In addition, Bruce et al. (2003: 143) observed that team members use a variety of strategies for getting the information they needed. These include asking team members or people outside the team, such as colleagues they had previously worked with on other projects.

5.7.1.4 Tasks

As shown in Chapter 2, the context (i.e. the environment and the domain) in which the task arises affects engineers' information-seeking behaviour. This is supported by Hyldegård's (2006) study. She found that even though teams demonstrated cognitive information-seeking experiences similar to individuals, these experiences resulted from information-seeking activities, work-task activities and intragroup interactions respectively.

An important factor affecting task-based collaborative information seeking seems to be the establishment of a collective focus among team members (Foster 2009: 101). This explains why Hertzum (2010: 652) reckoned that collaborative grounding is the main challenge in collaborative information seeking.

In addition, the nature of the task (i.e. the structure and the complexity of the task) also has an impact on engineers' information-seeking behaviour (Foster 2009: 85).

5.7.1.5 Information overload

The concept "information overload" is defined by David Allen and Wilson (2003: 34) on a personal and an organisational level. On a personal level, they defined information overload as "the perception ... that the flow of information associated with work tasks is greater than can be managed effectively, and a perception that overload in this sense creates a degree of stress for which his or her coping strategies are ineffective". At an organisational level, they defined information overload as a "situation in which the extent of perceived individual information overload is sufficiently widespread within the organisation as to reduce the overall effectiveness of management operations". The main distinction between these two definitions highlights the fact that the concept, when viewed from a personal point of view, is a perception. However, when viewed from an organisational point of view, it reflects “a situation-in-action” which requires management to intervene.

Information overload arises when the use of information communication technologies is being abused (Allen & Wilson 2003: 38-39). According to David Allen and Wilson (2003: 35), this generally happens when people indiscriminately disseminate papers or electronic documents. For example, Whittaker and Sinder (1997) noted that email overload creates problems for personal information management and hence results in perceptions of information overload.

In the field of engineering, Robinson (2010: 654) reported that the respondents in his study spent more time receiving information they had not requested, and also spent more time giving unrequested information than in providing requested information. Kratzer, Leenders and Van Engelen (2008: 274) observed similar behaviour. In their analysis of leadership structures in engineering design teams, they observed that team leaders who dominate discussions and searches for innovative solutions are prone to information overload.

Aurisicchio, Bracewell and Wallace (2010: 708) reported on the effect information overload has on engineers’ information-seeking behaviour. According to them, engineers who perceive an overload of information, find it time-consuming and complicated to seek information from amongst the multiple sources they had received.

5.7.2 Communication

The concept “communication” refers to the “process of sending or exchanging information” (Shah 2012: 13). According to Brashers (2001: 491), people “engage” in or avoid communication so that they can reduce their uncertainty and satisfy their information needs. Shah (2012: 13) maintained that communication is one of the core requirements for successful collaboration. Hansen and Järvelin (2005: 1110) observed that communication, as a collaborative information behaviour activity, can be document related or human related.

5.7.2.1 Human related communication

Human related communication can be direct or indirect (Hansen & Järvelin 2005: 1110).

a. Direct communication

Direct communication can be explained by using an example of an engineering project where team members discuss a problem they need to solve and to reach consensus on how they should proceed in specific situations. During such discussions, engineers negotiate their technical needs (Cheimets, Gordon & Tull 2009: 26; Lappalainen 2009) and apply their communication skills (Friedel & Liedtka 2007: 30; Pinelli 2001: 140; Tenopir & King 2004: 48). As indicated by Sonnenwald and Lievrouw (1996: 182), communication is the means utilised by team members to make their contributions to a project. In addition, Hertzum (2010: 652) found that it is not only faster to communicate information orally, but the communicator also has instant assurance that the recipient did receive the information.

b. Indirect communication

Apart from person-to-person information exchange, Ellis and Fisher (1994: 66, 70-72) noted that team members do not necessarily communicate directly with each other. Hansen (2002: 234) explains that this happens when certain information becomes available outside the team and intermediaries are used to pass the information on to the rest of the team. For example, Katz and Tushman (1979: 145-146) reported that, in engineering, interaction with sources external to a team is essential for product development. To facilitate this type of indirect communication, Hansen (2002: 234) and Katz and Tushman (1979: 139) noted that certain persons in a project team assume specialised boundary-spanning roles. These persons then deal with external professional and consultant domains. The manner in which these people deal with external information resembles Katz and Tushman's (1981: 103) description of gatekeepers. According to them, gatekeepers are individuals who are connected with internal colleagues and external sources of information.

The importance of boundary-spanning roles in collaboration was also observed by Sonnenwald and Lievrouw (1996: 182) and Tushman (1977: 587). According to them, boundary-spanning roles can be classified according to the type of boundaries they span, which could be organisational, task, discipline, and personal boundaries.

Indirect communication is also facilitated through document-related collaborative information behaviour activities. These involve the creation of, or using of, documents such as working notes and reports (Hansen & Järvelin 2005: 1110). For example, Hertzum and Pejtersen (2000) reported on two studies where engineers searched for documents to find people and searched for people to obtain documents. Du Preez (2008: 209) and Leckie et al. (1996: 187) also reported that engineers produce tender documents, engineering drawings and reports to communicate project-related information.

Ernst and Vitt (2000), Hansen (2002: 234) and Hirsh and Dinkelacker (2004) observed that indirect communication can potentially affect the effectiveness of team members' information seeking and productivity. The reason they give is that, especially in the initial stages of a project when the communication roles have not yet been established, all team members may not receive the information or the wrong information is passed on.This lack of formal communication structures then constrains team members' use of the knowledge structures and the sources of information available to them within the team, since they simply don't know whom to ask.

5.7.2.2 Factors affecting communication

As with information seeking, certain factors seem to affect successful collaboration. One of the factors that seems to affect successful collaboration is team leadership.It is the responsibility of team leaders to coordinate their groups' activities with other groups in the team. As observed by Lee and Cho (2011: 214), communication within a group can become segregated if the team leader allows group members to form smaller groups. They observed that when this happens, communication and information sharing within a group become segregated and this then impedes of the team's ability to learn, perform and satisfy their clients.

In instances where team leaders dominate a team's communication, Kratzer et al. (2008: 273) and Leenders, Van Engelen and Kratzer (2003: 85) observed that the leaders' dominance inhibited the team's creativity and information sharing.

5.7.3 Information sharing

In his review of the literature on information sharing, Wilson (2010) found that information behaviour researchers did not focus much on information sharing. According to Burnett (2000: 2), "information sharing" is fundamentally a social act. It is also a means for accomplishing something (Ikeya, Awamur & Sakai 2011: 90). Reddy and Jansen (2008: 257, 264) defined information sharing as "activities that a group or team of people undertake to identify and resolve a shared information need". This definition is endorsed by Fidel et al. (2004: 944) and Talja and Hansen (2006: 114). They regarded information sharing as an interactive process which incorporates both explicit and implicit information exchanges among a group of people who share a problem. As observed by Reddy and Jansen (2008: 257, 264), information sharing allows team members to collect pieces of information which can be put together to resolve information needs that arise from the shared problem. Also, they can only share information they have already acquired (Hansen & Järvelin 2005: 1102; Poltrock et al. 2003).

One of the functions of information sharing in a collaborative work environment is that members of a work team will reduce the duplication of effort. Cross, Rice and Parker (2001: 440) and Olson, Grudin and Horvitz (2005: 1985) explained this when they indicated that members of a work team, who belong to the same functional and hierarchical position in an organisation, are likely to have the same information needs and require the same information resources.

However, information sharing should not be confused with expertise sharing. Knowledge managers Tiwana and Bush (2005: 88) noted that expertise sharing has a competitive side where individuals tend to protect their knowledge. According to them, this is especially the case when the experts' knowledge cannot readily be observed or codified. When considering the nature of consulting engineers' work, it seems possible that consulting engineers share information and expertise when they are involved in an engineering project.

Also, information sharing does not necessarily involve information seeking (Talja & Hansen 2006: 128). This is because people sometimes give (share) existing information without seeking information themselves. For example, collaborators sometimes proactively recommend or forward information or contacts to colleagues (O'Day & Jeffries 1993: 3; Poltrock et al. 2003: 242; Prekop 2002: 539; Sonnenwald & Pierce 2000: 468; Twidale et al. 1997: 769); share documents and document histories with team members (Hansen & Järvelin 2005: 1114; O'Day & Jeffries 1993: 4), and create documents or records for use by others (Hansen & Järvelin 2005: 1115; O'Day & Jeffries 1993: 5). In order to be able to share information, McDonald and Ackerman (1998: 1) noted that individuals first need to identify and select the resources (expertise) that can be shared. This process involves choosing among people with the required skills and expertise.

5.7.3.1 Means of sharing information

Information can be shared verbally or electronically, as well as formally or informally. Oral information sharing occurs when team members communicate the information they share directly to team members during formal meetings and at conferences and seminars, or through informal encounters (Ellis & Haugan 1997: 393; Pilerot & Limberg 2011: 320). According to Hayter (2006: 28), informal information sharing encounters are often incidental and opportunistic, arise out of chats and take place in a safe and caring environment. Scheduled coffee and tea breaks seem to be one such setting that would facilitate information sharing (Birnholz 2005: 114-115; Brown & Duguid 1991: 45; Engel, Robbins & Kulp 2011: 561; Sonnenwald 2008: 656; Twidale, Nichols & Paice 1997: 769).

Much information is also shared electronically (Ellis & Haugan 1997: 393). Electronic mail, bulletin boards and mailing lists are used for these purposes (Finholt 2002: 76). Some organisations also encourage the creation of discussion groups and open forums organised around specific subjects (Anderson, Glassman, McAfee & Pinelli 2001: 151).

Pilerot and Limberg (2011: 321) determined that web-based social networks, such as LinkedIn and Facebook, are potentially information rich areas that are utilised by many for information-sharing purposes.

Making recommendations is another method that is frequently used to share information. Nichols and Twidale (2011: 209-211) maintained that recommendations are a mechanism that is used to cope with a large quantity of information and to enable people to locate the required information more efficiently. Furthermore, if the persons making the recommendations are experts in their field, the recommendations are then based on authoritative information.

5.7.3.2 Context

As with information seeking, certain contextual elements seem to have an effect on information sharing. One such element refers to the type of information that is sought. Chatman (1996: 198) observed that the type of information that is being sought will determine the extent to which the information is shared. For example, Beldad et al. (2011: 224) and Chatman (1991: 440; 1996: 196) observed that people will not share information when the information is of a personal nature and when they perceive sharing the information to be a threat to their privacy.

5.7.3.3 Personal

Individuals' previous experiences of sharing information also seem to have an effect on information sharing. For example, Beldad et al. (2011: 227-228) found that people's previous experiences of information sharing often determine their willingness to share information. However, in instances where the expected benefits from the disclosure of the information outweigh the costs (risks) that are incurred, Beldad et al. (2011) found that people would share information. This would even be in instances where they don't completely trust a situation.

5.7.4 Reflection on collaborative information activities

It appears from the literature that the collaborative information activities that received the most attention from researchers are information seeking, communication and information sharing. An awareness of information and an awareness of fellow team members' activities also seem to be important. The only study that seems to have focused on this activity is by Sonnenwald and Pierce (2000). Their findings were discussed in section 5.4.4 and hence not repeated here.

The discussion of the three different collaborative information activities revealed that, although certain information-seeking activities occur in a collaborative context, they can also be performed by individuals. Furthermore, information sharing does not necessarily involve information seeking and communication as the means through which team members share information and make their contributions to the team.

However, it seems as if there are certain contextual elements that influence successful information seeking, sharing and communication. In addition to the contextual elements that were discussed in Chapter 3 and Chapter 4, collaborative grounding seems to be important. Collaborative grounding is aimed at ensuring a shared understanding of the task or problem and hence the avoidance of misunderstandings among team members. The shared understanding of the problem will also determine the type of information that is sought by the team, and from where or whom it is sought.

Other important contextual elements include leadership structures. Depending on the degree in which team leaders dominate the team's activities, leadership structures can cause information overload and inhibit the team's creativity and information sharing. The research cited in the discussion on collaborative information activities reported on users in general as well as on engineers' collaborative information activities. Although not all aspects in this discussion specifically reported on engineers' collaborative information activities, it was possible to develop a profile of engineers' collaborative information behaviour activities. This profile is reflected in Table 5.2.

Table 5.2: A profile of collaborative information activities

A PROFILE OF COLLABORATIVE INFORMATION ACTIVITIES				
		Collaborative information activities		
Dimensions	**Elements**	**Seeking**	**Communication**	**Sharing**
Context	Organisations	●	●	●
	Organisational culture	●	●	●
	Organisational norms		●	●
	Social networks	●	●	●
	Projects	●	●	●
	Work roles	●	●	●
	Tasks	●	●	●
PERSONAL DIMENSION				
Cognitive		●	●	●
Conative	Motivation	●	●	●
	Coping	●	●	●
Affective	Trust	●	●	●
	Uncertainty	●	●	●

When viewing Table 5.2, it seems evident that all the elements in the context and personal dimensions of engineers affect their collaborative information activities. In Chapter 3 and Chapter 4 it was shown that collaboration is a distinguishing characteristic of engineers' (including consulting engineers') information behaviour. It is hoped to learn from the empirical component of this study whether consulting engineers actively share and communicate information with their project team members.

5.8 MANIFESTATION OF ENGINEERS' COLLABORATIVE INFORMATION BEHAVIOUR

In this chapter, the discussion focused on collaborative information behaviour in general and showed how certain elements in the context, and in the personal dimension of individuals and team members, give rise to both collaborative and individual information needs. In turn, information needs prompt information activities such as information seeking, information sharing and communication.

The contextual elements that influence the collaborative information behaviour of project teams, as well as individual team members, seem to include organisations, organisational culture, social norms, social networks, resources, projects, work roles and tasks. One of the elements, namely social networks, seem to hold some advantages for project work or team work, being a potentially important source of task-related information.

Furthermore, it seems important to note that each project team develops its own organisational culture and social norms. Also, project teams' culture and norms can be influenced by individual team members' organisational cultures and norms as well as the culture and norms of the organisation in which the project is being developed. Successful collaboration is therefore dependent on the team's ability to arrive at a shared understanding (common ground) of the task or problem that needs to be solved.

In addition to organisational culture and social norms, the organisational structure of a project team also seems to be important. The discussion showed that team leaders who dominate the team tend to inhibit the team's communication and information-sharing activities as well as their creativity. Dominating team leaders also tend to cause information overload.

The discussion on social networks in section 5.4.4 also showed that the social relations that develop among team members persist irrespective of whether their organisational contexts change. Established social relationships among team members therefore could promote productivity, stimulate the development of new ideas, and provide the foundation for current and future collaboration.

Elements in the personal dimension of individual project team members that seem to be important are their personal knowledge, their ability to develop plans, motivation to collaborate, have coping skills, and be able to transfer across cultural boundaries. Also, team members must have the ability to solve their interpersonal problems.

The information needs that emanate from the relationships between people (e.g. the relationship between project team members) can be individual needs and needs imposed on them by a third party. With this in mind, it seems as if project teams can become complex information environments.

Lastly, the discussion focused on collaborative information activities such as information seeking, communication and information sharing. As with information needs, information seeking in a collaborative environment can be both an individual and a group activity. Information sharing can only be a group activity, which does not necessarily involve information seeking, whereas communication is the means used by team members to make their contributions to the team. This is apparently when they share their knowledge, expertise and the information they have sought.

5.9 CONCLUSION

Whereas the discussions in Chapter 3 and Chapter 4 focused on the information behaviour of engineers and consulting engineers, this chapter focused on their collaborative information behaviour. To facilitate such a discussion, Wilson's (1999; 2000) encapsulating definition for information behaviour was once again taken as a point of departure. The aspects that underlie Wilson's information behaviour definitions also underlie the definitions for collaboration that was proposed by Sonnenwald (2003: 68; 2008: 645) and Reddy and Jansen's (2008) definition for collaborative information behaviour. These aspects are people, contexts, information needs that arise from the interaction between people and their contexts, and information activities such as seeking, sharing, and communication.

From the literature reviews reported on in Chapter 3 to Chapter 5, it seems as if very little is known about consulting engineers' information activities within a work team. The focus in the studies conducted by Du Preez (2008), Gralewska-Vickery (1976) and Ward (2001) mainly reported on the type of information consulting engineers sought, shared and used. These three studies, as well as other studies discussing engineers' information behaviour in general, reported that engineers work in teams and that their personal contacts are important sources of engineering information. However, a few studies focused on engineers' collaborative information behaviour and the factors that influence their collaborative information behaviour. These include the studies by Bruce et al. (2003), Hirsh and Dinkelacker (2004), as well as a number of studies by Sonnenwald and her colleagues. Unfortunately, these studies did not address engineers' social networks per se, and the role of social networks in providing for engineers' information needs. This is despite the advantages social networks seem to have for team work. Therefore, in view of the gap in the information behaviour literature focusing on social networks, as well as the need to test the potential benefits of social networks empirically, the purpose of this study is to investigate consulting engineers' social networks and collaborative information behaviour. Such an investigation could contribute to a better understanding of the role of social networks in a professional setting.

This chapter concludes the literature review for the study. With the empirical component of the study in mind, Chapter 6 will focus on the research methodology that will be followed.

CHAPTER 6

RESEARCH METHODOLOGY

6.1 INTRODUCTION

In order to investigate the role of social networks in consulting engineers' information behaviour, an appropriate research approach needs to be selected. Therefore, the purpose of this chapter is to discuss the qualitative research approaches as well as the narrative inquiry strategies and techniques that were employed to collect and analyse the empirical data for the study. Aspects such as the validity and reliability of the data and research ethics will also be addressed.

6.2 BACKGROUND

The empirical component of a research project is guided by the research method that is followed. According to Sutton (2009: 4381), research methods are the "systematic procedures that researchers use to collect and process data in order to put their theories to the test which in turn leads to the development of new theories".

As explained by Sutton (2009: 4381), the research process involves three different levels of analysis, which are philosophy and theory, methods and techniques and data. In turn, these three levels of analysis are guided by the research approach that is followed, which could be quantitative, qualitative or a combination of quantitative and qualitative research approaches.

Sutton (2009: 4382) also explained that the nature of the study determines the research approach and the research methods that are employed. The nature of the study is determined by the subject field, which provides the theoretical underpinning for the study, as well as the research questions that need to be answered. The current study is an information behaviour study which derives from the field of information science and "how", "what" and "why" questions need to be answered in order to answer the research question.

In order to make an informed decision on the best research approach and research methodology for the current study, it is necessary to learn from the literature which research approaches and methods are mostly used for information behaviour research.

6.3 RESEARCH IN INFORMATION BEHAVIOUR

Research approaches and research methods that guided previous studies in a specific subject field could support decisions regarding the best research approach for a study. In the field of information science, Fidel (1993: 219, 222) reported a surge in qualitative research. In his review of the trends and approaches in information behaviour research, Vakkari (2008) also observed a trend towards qualitative research as well as a trend to combine several research techniques. Fisher and Julien (2000:318) noted that most of the research methods and techniques employed in information behaviour research come from the social sciences and are typically used in triangulation.

Based on his review, Sutton (2009: 4388-4389) observed that much qualitative research in information science is informed by the case study approach, whereas few studies follow the ethnographic approach. Other research approaches used in information science that were identified by Sutton (2009: 4389) include grounded theory and ethnomethodology. According to Sutton (2009: 4389), ethnomethodology is a phenomenological research approach and entails the study of commonplace behaviour in natural contexts.

In the three preceding literature review chapters, it was shown that consulting engineers generally work in teams. It was also suggested that their personal contacts are important sources of task-related information. All the information behaviour studies reporting on engineers' information behaviour were qualitative studies. For this reason, and since the intention is to acquire an in-depth understanding of why personal contacts are so important to consulting engineers, this study will follow a qualitative approach. The following discussion will now divert to qualitative research and qualitative research approaches.

6.4 QUALITATIVE RESEARCH

In his discussion of qualitative research methods in library and information science, Sutton (2009: 4380) noted that qualitative research is a diverse collection of philosophies, historical traditions, discipline-specific concepts and useful practices. However, qualitative research is often conveniently described in terms of the nature of the data that is collected, which then distinguishes it from quantitative research data. The definitions offered by Punch (1998) and Cibangu (2013) attest to that. In his definition, Punch (1998: 4) describes qualitative research as "empirical research where the data are not in the form of numbers". Cibangu's (2013: 195) definition is a bit more comprehensive. He considers qualitative research as "research wherein the investigation of that which is being studied and the analysis of obtained data are not statistical, and involve at least one participant or object (n = 1)". The definition offered by Gorman and Clayton (1997) is even more comprehensive and reveals something of the collection of philosophies and research traditions that Sutton (2009) refers to. According to Gorman and Clayton (1997: 23), qualitative research is "a process of inquiry that draws data from the context in which events occur, in an attempt to describe these occurrences, as a means of determining the process in which events are embedded and the perspectives of those participating in the events, using induction to derive at possible explanations based on observed phenomena". This definition notes that qualitative research is a process of inquiry, that qualitative studies are conducted within a certain context, are descriptive in nature and qualitative data is analysed deductively. However, when one considers Fidel's (1993: 231) argument, qualitative research can also be inductive.

The first aspect indicated in Gorman and Clayton's (1997) qualitative research definition has the implication that the process of inquiry regarding a certain phenomenon or event can involve a number of participants. This view is supported by Pendleton and Chatman (1998: 747) when they note that a qualitative research methodology is a suitable research methodology to explore patterns of collective behaviour.

The phrase "… draws on data from the context in which events occur …" in Gorman and Clayton's (1997) definition draws the attention to the importance of "context" in qualitative research. Sutton (2009: 4382) also regards context as being central to qualitative research. According to him, human action must be understood in its socio-cultural context and cannot be studied in isolation. This view is endorsed in a statement made by Denzin and Lincoln (1994: 2). According to them, qualitative research involves an interpretive and a naturalistic approach which allows researchers to study phenomena in their natural settings.

The interpretive and naturalistic approach to a study, as well as the ability to study phenomena in their natural settings, seems to make qualitative research an important research approach for information behaviour studies. Fidel (1993) believes that qualitative research offers the best methods for exploring human behaviour. Urquhart (2011: 40) supports this view when she states that qualitative research allows researchers to explore attitudes, opinions and the context of information seeking and use.

In addition to studying the information behaviour of individuals, Bertelotti and Tagliaventi (2007: 43) discussed the potential of qualitative studies to offer an “exhaustive and thorough understanding of social dynamics”. Pettigrew (1997: 234) demonstrated this in her study by showing that certain themes in social network data could only emerge from qualitative data. Hersberger (2003) also used qualitative research methods in her social network research.

Creswell (2013: 69-110) observed a number of scenarios related to qualitative research approaches. In the first scenario the researchers did not identify any specific approach to qualitative research they were using. In the second scenario the researchers adopted a specific approach to qualitative research. In these studies the methods section provided a detailed discussion of the meaning of the approach, why it was used, and how it would inform the procedures of the study. In order to support researchers in identifying a research approach to their studies, Creswell (2013: 69) discussed five qualitative research approaches. The research approaches he discussed are narrative inquiry, phenomenological research, grounded theory research, ethnographic research and case study research.

Case study research and narrative inquiry are two research approaches that are discussed by Creswell (2013), which seem to be appropriate qualitative research methods for this study. As described by Creswell (2013: 70,97), both methods will allow the researcher to study consulting engineers' information behaviour in a "real life" setting. According to Creswell (2013: 97), case study research allows the researcher to collect data over a period of time from "multiple sources of information" (e.g. observations, interviews, documents and reports). Although a case study approach would allow for an in-depth study of consulting engineers' information behaviour in a specific project, it would be a too restrictive approach to follow. This is because a case study would restrict the research to one or two specific engineering projects. Such a study would not allow for the exploration of information behaviour issues that are not related to the projects (cases) under investigation, which may manifest during the study.

Therefore, narrative inquiry, which is about individuals' stories of their lived experiences (Creswell 2013: 70), will allow the researcher to learn from the consulting engineers' stories of their personal experiences of working in teams and using information collaboratively. Furthermore, it could be expected that the engineers' stories would not be restricted to one project and information behaviour manifesting in different projects could therefore also be explored. This decision is supported by Clandinin and Connelly (1995: 4-5). Their description of a professional knowledge landscape is similar to what is already known of the work environment of consulting engineers. According to them, the professional knowledge landscape is "composed of relationships among people, places and things". They see this as both an intellectual and a moral landscape. Clandinin, Murphy, Huber and Orr (2010) specifically used narrative inquiry to investigate the professional knowledge landscape of teachers. They believed that narrative inquiry provided them with the best method to investigate personal relationships within a professional knowledge landscape.

However, when considering Sutton's (2009) review of research approaches in qualitative information science research, it seems as if narrative research is not a research method generally used by information science researchers. Researchers that did write about narrative inquiry include Charon (2001; 2006), a medical practitioner;

Chase (2005), a sociologist; Clandinin and Connelly (2000), educational researchers; Czarniawska (2004), an organisational theorist, and Polkinghorne (1995) an educational researcher. However, it is believed that, by following the narrative research approach, this study could therefore be making a contribution to research methodology in the field of information behaviour, a subfield in information science.

In the discussion thus far the focus was on qualitative research approaches and the philosophical assumptions and research frameworks that guide qualitative studies. It was indicated that the current study will be guided by a narrative inquiry approach and a social constructivist theoretical framework. Furthermore, it is envisioned that the study will generate contextual and experimental knowledge.

Narrative inquiry as a research approach is discussed in more detail in the following section.

6.5 NARRATIVE INQUIRY

Narrative inquiry is a way of understanding experience and it is a research methodology (Clandinin & Caine 2008). As noted by Clandinin and Caine (2008), narrative inquiry is used by researchers across various disciplines and multiple professional fields to acquire an understanding of and make meaning of experience through conversation, dialogue, and participation in the ongoing lives of research respondents.

Narrative researchers seem to be looking across their subject fields to bring in new ways of thinking about phenomena and about changing inquiry (Clandinin & Connelly 2000: 4). In qualitative research, Creswell (2013: 70) found that the concept “narrative” can refer to the phenomenon that is being studied or the method that is being used in a study. When used as a method, narrative inquiry begins with the experiences and lived stories of individuals (Creswell 2013: 70). As explained by Clandinin and Caine (2008), narrative inquiry then allows for an “intimate study of individuals’ experiences over time and context”. Chase’s (2005: 656) definition of narrative inquiry was formulated with the view of narrative inquiry as an intimate study of experiences in mind. She defines narrative inquiry as “meaning making through the shaping or ordering of experience”.

The focus in her definition is on what can be learnt from the story or experiences that are shared in a story.

Czarniawska's (2004) understanding of narratives and narrative inquiry considers the part of Clandinin and Caine's (2008) explanation dealing with "individuals' experiences over time and context". According to her, the concept refers to "spoken or written text giving an account of an event/action or series of events/actions, chronologically connected".

In addition to the description of narratives and narrative inquiry that is offered by Chase (2005), Clandinin and Caine (2008), Czarniawska (2004) and Polkinghorne (1995: 11) also describe narrative inquiry as a research approach. Polkinghorne (1995: 11), for example, views narrative inquiry as an "analytical process that produces storied accounts through engaging in narrative reasoning, noticing the differences in people's behaviour".

These definitions and descriptions of narrative inquiry are summarised in Connelly and Clandinin's (2006: 477) understanding of narrative inquiry. They understand narrative inquiry as "the study of experience as story", as "a way of thinking about experience" and as a methodology which "entails a view of the phenomenon". According to them, researchers who use narrative inquiry methodology adopt a particular view of experience as the phenomenon under study.

The philosophical underpinning of narrative inquiry has been ascribed to John Dewey's Theory of Experience (Clandinin & Caine 2008: 542). The two criteria for experience that were identified by Dewey are "interaction" and "continuity". According to Clandinin and Caine (2008: 542), these two criteria provide the grounding for attending to experience through a three-dimensional narrative-inquiry space, with dimensions of temporality, place and sociality.

In their exploration of the specific places where narrative inquiry comes in as a way of thinking about experience, Clandinin and Connelly (2000: 21,29) identified certain boundaries, which they called life boundaries, through which experience can be described. Dewey's two criteria of experience, that is, "interaction" and "continuity", provided the theoretical frame for the identification of tension at the life boundaries. The tensions Clandinin and Connelly (2000: 21) identified that relate to "interaction" are temporality, people, action, certainty and context. These "interaction" boundary tensions are also described by Charon (2006), a medical practitioner, as elements that characterise narrative inquiry. The elements Charon (2006) identified include temporality, singularity, causality, intersubjectivity, and ethicality. Although different terminology is used by Charon (2006), the elements she identified seem to exhibit certain similarities with the life boundary tensions related to "interaction" that were identified by Clandinin and Connelly (2000).

In his review of the literature on narrative inquiry, Creswell (2013: 71-72) observed that a specific set of features emerged that could define narrative inquiry boundaries. The set of features that were identified by Creswell (2013) are the same as the elements identified by Charon (2006) and exhibit similarities with the tensions that relate to "interaction" that were identified by Clandinin and Connelly (2000).

The following paragraphs therefore attempt to reveal more of the different elements or features of life stories, which can also relate to the existing tension boundaries related to Dewey's "interaction" criterium of narrative inquiry.

6.5.1 Temporality

Temporality refers to the order in which things happen. As explained by Clandinin and Connelly (2000: 29-30), all events have a past, a present as it applies at the time, and an implied future. This is due to temporal changes when individuals narrate their stories. Creswell (2013: 71) noted that narrative researchers often hear and shape narrative stories into a chronology. He further noted that a temporal change is conveyed when individuals talk about their experiences and their life stories. This view is supported by Clandinin and Connelly (2000: 30) when they pointed out the close link that exists between temporality and people as life boundaries.

As a life boundary, the reporting of narratives can also cause tension for the researcher. As Clandinin and Connelly (2000: 30) found, there is a tension between the chronology of events and how these histories would influence the interpretation thereof.

The concept temporality can also be applied to engineering projects. As indicated in section 3.3.6, engineering projects are completed in stages. The responding consulting engineers' stories of engineering projects could then be chronicled according to the different stages of engineering projects. When applied to data analysis, the different project stages will support the identification of patterns in consulting engineers' information seeking, sharing, communication and use.

6.5.2 People's stories

According to Creswell (2013: 70-71), narrative inquiry is about collecting individual persons' stories, reporting individual experiences, and chronologically ordering the meaning of those experiences. With Chase's (2005: 657) view of narratives in mind, narratives are ways of making sense of the world. Creswell (2013: 70) noted that life course stages (temporality) can be used to order experiences.

Narratives generally have a storyline (Charon 2006). The storyline urges researchers to make sense of why things happen. Savin-Baden and Van Niekerk (2007: 464) did not agree altogether with Charon (2006). They suggested that narratives do not necessarily have a plot or structured storyline but are interruptions of reflection in a storied life. Their view is supported by Denzin (2004). He noted that individuals' lives have "turning points" or "interruptions" and it is the researcher or biographer's task to highlight these turning points when they tell the stories.

In addition to being chronologically ordered and having storylines or reflections, Charon (2006) noted that narratives cannot be performed or retold in the same manner. Individuals' experiences can therefore not be replicated. Narratives therefore represent singular events.

While collecting data for her masters' dissertation, Du Preez (2008) observed that consulting engineers enjoyed sharing their experiences of engineering projects.

Although the engineers were prompted in time-line interviews to discuss their information behaviour for a specific project, the consulting engineers interrupted their stories with reflections on similar events in other projects. In this manner, the consulting engineers' "stories" of their projects provided rich data. Although each story was unique, similar patterns of information behaviour could be identified from the different respondents' stories.

6.5.3 Action

In narrative thinking, action is seen as a sign of something that needs to be interpreted. Clandinin and Connelly (2000: 30-31) noted that this is a process of connecting action and meaning – that is the mapping out of the interpretive pathway between action and meaning in terms of a narrative history. Charon (2001: 1898), explained that the intersubjective domains of human knowledge and activity are probed during the mapping process. These views seem to explain Creswell's (2013: 71) findings that narrative stories may shed light on the identities of individuals and how they see themselves.

In the current study, activity as an element of narratives enabled the researcher to observe the effect the context of an engineering task and the consulting engineers' personal knowledge and experience have on their information behaviour.

6.5.4 Certainty

The interpretations of events are usually expressed as a kind of uncertainty (Clandinin & Connelly 2000: 31). Clandinin and Connelly (2000: 31-32) therefore stressed the importance of ensuring certainty by equating relationships between knowledge and performance.

By comparing the data collected from a number of interviews, in which consulting engineers told their personal stories of engineering projects, with the findings reported in the literature, it was possible to ensure certainty in this study. Also, this collection of similar data at different points in the research project contributes to the reliability of the data. This will be discussed in more detail in section 6.6.4.1.

6.5.5 Context

In Chapter 2 section 2.3.3, it was shown that the context component of the information behaviour model includes various elements. Some of the elements that were identified include place, time, tasks, situations, processes, organisations and types of participants. Clandinin and Connelly (2000: 32) and Creswell (2013: 72) noted the importance of context for narrative inquiry and they identified elements of context similar to those that were identified in Chapter 2. According to them, narrative stories occur in specific places or situations and context is therefore necessary to make sense of the story, person or event. According to Clandinin and Connelly (2000: 32), context can be analysed into variables, and certainty measures can be attached to the contextual variables. Both Clandinin and Connelly (2000) and Creswell (2013) therefore stressed the importance of viewing the person in context when analysing and discussing narrative data.

In the preceding four literature review chapters regarding the definition of information behaviour, it was shown that context gives rise to information needs and in turn determines information activities that are performed to seek, find, share, communicate or use information that is relevant to the information need. Context as a boundary element in narratives is therefore an important aspect to consider when analysing narrative data in an information behaviour study.

This discussion on narrative inquiry attempts to show that narrative inquiry as a research method is about learning from the stories or experiences that are shared by individuals. Also, stories seem to exhibit certain features. These are temporality, singularity, causability, intersubjectivity and ethicality.

The discussion will now divert to data collection and data analysis according to the narrative inquiry as a research method.

6.6 DATA COLLECTION

Apart from decisions regarding the research approach to be followed, the research design also includes data collection and data analysis. Creswell (2013: 145) used the concept “data collection” when he discusses the procedures involved in data collection and data analysis. According to him, the concept data collection also means getting permission to conduct the research, conducting a sampling strategy, developing means for recording information, storing the data and preparing to deal with ethical issues that might arise. The following discussion will focus on data collection as Creswell (2013) used the concept. In addition to the theoretical issues that need to be considered in the research design, the following discussions will also report on how the theory is applied in this study by describing the procedures that were followed.

6.6.1 Consent

One of the first steps in data collection is to gain permission to conduct the study on a research site, as well as preparing a consent form which is signed by the individual respondents. This view is supported by Nunkoosing (2005: 699) when he notes that researchers have the duty to explain the risks involved when participating in the research to the prospective respondent. In turn, respondents have to agree by giving their consent to participate in the research project. This is generally done through the signing of a consent form. The elements that need to be included in the consent form, as identified by Creswell (2013: 153), included the respondents’ rights to withdraw from the study, the purpose of the study and the data collection procedures, a confidentiality clause, known risks of participation, benefits of the study, and the respondents’ and researchers’ signatures. The permission form that was used in the current study includes these elements and appears in Appendix A.

6.6.2 Sampling

The concept “sampling” refers to the process of selecting respondents to participate in a study. A combination of sampling strategies was followed in this study. Babbie (2010: 191-192) distinguished between probability and non-probability sampling strategies. He explains that non-probability sampling strategies involve the selection of a “random sample” from a list containing the names of all persons in the population that is being sampled. The non-probability sampling strategies that seem to be important for the current study include the following:

- Theoretical sampling. Marshall (1995: 523) noted that this sampling method requires of the researcher to build interpretative theories from the emerging data and to select a new sample to examine and elaborate on this theory. According to him, this is the most important sampling strategy for grounded theory studies. Ellis and Haugan (1997) used theoretical sampling in their information behaviour study of engineers working for an oil company.
- Snowball sampling. According to Babbie (2010: 193), snowball sampling is a non-probability sampling method which is often employed in field research. According to this sampling method, each person interviewed may be asked to suggest additional people for interviewing.
- Convenience sampling. Marshall (1995) explained that convenience sampling involves the selection of the most accessible subjects. He reckons this sampling method is the least costly for the researcher.
- Purposive or judgement sampling. Babbie (2010: 193) and Marshall (1995: 523) explained purposive sampling as a type of sampling in which the sample units are selected on the basis of the researcher's judgement about which ones will be most useful or representative for the study. Marshall (1995: 523) noted that this is the most common sampling strategy and a more intellectual sampling strategy.

Creswell (2013: 155) found that narrative studies use the purposive sampling strategy. The reasons he gave for this phenomenon is that narrative researchers reflect more on who to sample since the individuals need to have stories to tell about their lived experiences.

For the purpose of this study, and in consideration of the attributes of the respective sampling methods, it was decided to use a combination of purposive, snowball and convenience sampling. The sampling in this project was executed as follows:

An architect provided the researcher with the contact details of consulting engineers who worked with him on an award-winning medical facility. All of the consulting engineers on the architect's contact list were contacted and invited to participate in the research. With the exception of two engineers who could not participate, due to time restrictions, all the invited engineers participated. Team members from an electrical engineering company, two mechanical engineering companies and a civil engineering company suggested that other colleagues also be interviewed. The suggested engineers all responded positively to the request and eventually fifteen (15) engineers were interviewed. In addition to discussing their involvement in building projects, the civil engineers and one electrical engineer also described their involvement in infrastructure development projects. This included the design and constructing of electrical networks, roads and other services such as sewerage lines and water provision.

As explained by Creswell (2013: 157), the sample size in a qualitative study is to study a few sites and to collect extensive detail about each site or individual that is being studied. He argued that the intent of qualitative research is not to generalise the information, but to acquire an understanding of a phenomenon. He also observed that narrative inquiry studies often include only one or two individuals. However, in the case of this study one or two consulting engineers would not have presented sufficient information to acquire an understanding of consulting engineers' collaborative information behaviour. Therefore fifteen engineers, representing the various engineering disciplines generally involved in a building project, were invited to participate in the study. Some of the engineers were employed by large companies while others (e.g. the acoustics engineer and the residential engineer) worked on their own. Table 6.1 profiles the respondents.

Table 6.1: Respondents' profiles

RESPONDENTS' PROFILES		
Responding consulting engineer	Engineering discipline	Years in industry
A	Structural / residential	38 years
B	Electrical	20 years
C	Electrical	40 years
D	Structural – steel	Not indicated
E	Structural – concrete	26 years + 5
F	Civil engineering – roads	40 years
G	Mechanical	40 years
H	Civil	2 years
I	Civil	28 years
J	Electrical	5 years
K	Electrical	10 years
L	Electronic – Acoustics	31 years
M	Electrical	11 years
N	Mechanical / project management	Not indicated
O	Electronic	2 years

6.6.3. Interviews

The method according to which data is collected and recorded is the third data collection aspect that was identified by Creswell (2013). In his literature review on qualitative research methods employed by library and information science researchers, Sutton (2009: 4382) observed that two methods are widely used by qualitative researchers to collect data. These are participant observation and in-depth interviewing. Fisher and Julien (2009: 319) also reported that interviews are the primary method used by information behaviour researchers. As observed by Dunn (1983: 454), ethnographic interviews and observational methods, such as survey sociometry and co-citation analysis, are methods used in social network studies. These data collection methods are generally used in quantitative studies. Since the current study is conducted in the field of library and information science and is a qualitative study, interviews and observation proved to be the most suitable data collection methods for the current study.

However, the data collection requirements for narrative inquiry studies also need to be considered. According to Creswell (2013: 72), narrative stories are collected through different forms of data. These include interviews, observations, documents, pictures, and other sources of qualitative data.

The term “interview” means that two persons are conversing about some common interest and are exchanging their views (Kvale 2007: 8). When used in research, Kvale (2007: 3) noted that “knowledge is constructed” in the interaction (conversation) between the interviewer and the interviewee. This view was supported by dental researchers Gill, Stewart, Treasure and Chadwick (2008: 292) and Nunkoosing (2005: 699) when they noted that the purpose of the research interview is to explore the views, experiences, beliefs and/or motivations of individuals concerning specific matters. Nunkoosing (2005: 699) stressed the importance of narration in such experiences and views. When considering Kvale’s (2007: 13) note that interviews allow interviewees to describe their activities, experiences and opinions in their own words, narration is possible in interviews.

Although interviews are conversations, they go beyond the spontaneous exchange of views in everyday conversation and require careful questioning and listening to ensure that tested knowledge is obtained (Kvale 2007: 11). This view was endorsed by Nunkoosing (2005: 699) when he stated that interviews deal with thinking and talking. This then requires linguistic transactions and some relationship between at least two persons. Nunkoosing (2005: 699) also noted that interviews invite and persuade individuals to think and talk consciously and unconsciously about their experiences and views.

As explained by Babbie (2010: 318), qualitative interviews are based on a set of topics that need to be discussed rather than the use of a standardised set of questions. According to Rubin and Rubin (1995: 43), this then makes the design of a qualitative interview flexible, iterative and continuous, where the questioning is redesigned throughout a research project. However, interviewing in narrative inquiry is slightly different. According to Clandinin and Connelly (2000: 112), narrative inquiry interviews involve participants in the creation of a framework on which their oral histories can be constructed. They explained that participants begin to recollect their experiences and to construct the outlines of a personal narrative through this process. With this in mind, the researcher asked the responding engineers to provide some background information on their own organisations and to describe their individual roles in an engineering project. The consulting engineers were thereafter asked to tell their stories of an engineering project. It was therefore not necessary to use a formal interview schedule, although a semi-structured interview schedule was prepared for in case it was needed.

In addition to the involvement of participants in the creation of the inquiry framework, Savin-Baden and Van Niekerk (2007: 464) also noted the role of the researcher in the interview process. According to them, the researcher has to be an effective listener who sees the interviewee as a storyteller rather than a respondent. The researcher attempted to follow this protocol, but in some instances found it necessary to prompt the engineers to elaborate on their stories by, for example, providing more detail of their interaction with project team members.

Researchers such as Creswell (2013: 173), Kvale and Brinkmann (2009) and Nunkoosing (2005) stressed the importance of reflecting on the relationship that exists between the interviewer and the interviewee. One of the problems in this relationship that was highlighted by Clandinin and Connelly (1995: 110) and Kvale and Brinkmann (2009) is the power of asymmetry. According to Clandinin and Connelly (2000: 110), the nature of an interview sets up an unequal power dynamic between the interviewer and the respondent. They believe the interview is “ruled” by the interviewer where the dialogue is based on the researcher’s agenda. This agenda is informed by the researcher’s interpretation of the information and the respondent’s “counter control” where some of the information is withheld. As Nunkoosing (2005: 702) explained this, respondents choose the aspects they are most interested in telling. Nunkoosing (2005) cautioned that the “counter control” measures exercised by respondents when they withhold information could affect the researcher’s ability to determine the authenticity of the data. Since the consulting engineers were requested to share their experiences of an engineering project from its inception until the close-out stage, they generally spoke freely about their projects – at least this was the researcher’s impression. They also elaborated on the progression of a project, the nature of the information that is required during each stage, and the flow of engineering information on a project. Some of the engineers needed more prompting than others, but this was because they regarded the information the researcher was interested in as being obvious and not necessarily something out of the ordinary.

Clandinin and Connelly (2000: 110) identified some aspects that could have an effect on the interviewer-interviewee relationship and the counter control measures exerted by respondents. The first aspect they identified relates to the way an interviewer acts, questions and responds in an interview. They cited an example given by Anderson and Jack (1991). In this example, the interviewers had either ignored more subjective dimensions of the respondents’ lives or had accepted comments at face value when a pause, a word, or an expression might have invited the narrator to continue. In this study, the researcher did not accept comments at face value and did not ignore some of the subjective dimensions in the engineers’ stories. This decision is supported by the literature review chapters on the effect individuals’ personal dimensions have on information behaviour. It was therefore important that the researcher prompted the responding consulting engineers to continue with their stories and to share their personal experiences and views.

A second aspect that affects interviews, which was identified by Clandinin and Connelly (2000: 110), relates to the conditions under which the interview takes place. The conditions they referred to include the place (a busy office compared to the respondent’s home) the time of day and the degree of formality that is established. In this study, all the interviews were conducted at the consulting engineers’ offices, in locations such as a boardroom. Only the resident engineer preferred to meet the researcher at a coffee shop. It was, however, possible to find a relatively quiet space and the interview could proceed uninterrupted. Also, the acoustics engineer preferred visiting the researcher at her home for the interview.

In addition to the purpose, interviewer and respondent relationships and the interview conditions, Clandinin and Caine (2008: 7), Kvale (2007: 12) and Gill, Stewart, Treasure and Chadwick (2008) also identified some ethical issues that need to be considered.

These researchers noted that the social relationship that develops between the interviewer and respondent depends on whether the interviewer can create a situation where the respondent perceives it safe to talk about private events, knowing that it could be used publicly. Kvale (2007: 12) noted that this requires a delicate balance between the researcher's concern to pursue interesting knowledge and the ethical respect for the respondent's integrity.

Gill et al. (2008: 291) noted that interviews can be structured, semi-structured, or unstructured. Interviews can also be a combination of structured and semi-structured or can be oral history interviews. Clandinin and Connelly (2000: 111) noted that the oral history interview is one of the most common interview formats used in narrative inquiry. They also noted that various strategies can be used to obtain data in narrative inquiry, which could range from using a structured set of questions to asking participants to tell their own stories in their own way. In this study, oral history interviews were conducted in which the responding engineers were requested to tell their own stories in their own way. When the engineers required some prompting to reveal certain information, a semi-structured interview schedule was used.

6.6.3.1 Interview schedule

The interview schedule, or interview protocol as Kvale and Brinkmann (2009) referred to it, is a guide with a few open-ended questions. Creswell (2013: 164) explained that the questions are often the sub-questions that were derived from the research question.

Therefore, in order to ensure that the sub-questions for this study were covered, the researcher prepared a semi-structured interview schedule. This schedule was used to support the researcher when it seemed that the responding engineers' stories did not answer all the research questions adequately. However, the responding engineers enjoyed telling their stories of engineering projects and the semi-structured interview schedule was merely used to stimulate the responding engineers' thoughts in the initial stages of the interviews. This interviewing technique provided the researcher with the ideal opportunity to discover the role of social networks in the responding engineers' information behaviour, without having to ask pertinent questions.

The questions in the interview schedule were organised as follows:

- Personal information. In order to acquire some background information, the responding consulting engineers were asked to indicate their engineering disciplines, give a rough indication of their years of experience as consulting engineers and share some information on the organisation they work for. This required information on the size and structure of the organisation. This question was asked to determine the responding consulting engineers' roles in their organisations.
- Project information. The responding engineers were asked to select a project they were involved in and to describe the nature of the project briefly. They also had to indicate which engineering disciplines were represented on the work team, who the project leader was, what their task or role was in the selected project and how their roles fitted in with the roles of the other work team members.
- Clients' and the engineering discipline's needs for the project. The consulting engineers were asked to indicate the different client needs and requirements for the project and who was tasked to collect this information. Apart from clients' needs, other engineering disciplines could also have certain needs that affected the responding engineers' tasks. Also, the engineers were requested to give an indication of how this information was communicated and who communicated the information.
- Communication within a work team. The engineers were requested to indicate which means were utilised to communicate with fellow team members and whether there were any formal structures according to which information was communicated. The responding engineers also had to indicate the different technologies they used to communicate project-related information, as well as any information communication problems they experienced.
- Project information. In order to acquire an understanding of the type of information that is shared in a work team, responding engineers were requested to indicate what information was required during each stage of the engineering project.
- Personal contacts and social networks. The questions relating to this information required of the responding engineers to indicate whether they had previously worked

with some of the team members on other projects and how this working experience affected their collaboration on the current project.

The interview schedule did not include any pertinent questions on the responding engineers' social networks. The purpose of narrative inquiry and oral history interviews is to allow the respondents to tell their own stories without asking too many pertinent questions. The researcher therefore has to be sensitive for specific information that not only would answer the research question, but present the researcher with new information that was not previously reported on or discussed in the literature. With this in mind, the researcher had hoped that the responding engineers would spontaneously share information that could be identified as social networking and that was indicative of the role social networks play in their information behaviour.

A sample of the interview schedule appears in Appendix B.

6.6.3.2 Administering the interview

Clandinin and Connelly (2000: 112) noted that respondents are often involved in creating "annals and chronicles" as a way to create a framework on which to construct their oral histories. This process of composing the annals and chronicles then supports the respondents in recollecting their experiences and in constructing the outlines of their personal narratives. With this in mind, the researcher requested the responding consulting engineers to tell their stories of an engineering project and to use the different stages in an engineering project as a framework for their personal stories.

In order to answer the research question and sub-questions, information on specific aspects of the responding engineers' information behaviour was needed. However, the researcher also wanted to learn from the responding engineers' stories about the role of people as sources of engineering information. With this in mind, the responding engineers were requested to describe their roles in an engineering project before they shared their experiences of engineering projects. Since much could be learnt from the literature review about the formal sources of information they use, the responding engineers were asked to focus on their interaction with fellow team members or other personal contacts throughout an engineering project. In conclusion, the engineers were asked to give an indication of their years of experience as engineers and to share something of their own organisations and the information that is available in their own organisations.

By allowing the responding consulting engineers to share their experiences, the respondents were able to provide the researcher with a general overview of building projects. They were therefore able to share information that would not compromise their privacy or work relations in any manner. This also ensured a relaxed atmosphere during the interviews and they shared more information than the researcher had expected to collect.

Most of the interviews were conducted in Afrikaans. Only the interviews with Engineers D, K, L, M and N were conducted in English. Quotes from the Afrikaans interviews were freely translated into English for the purpose of data analysis. The researcher's first language is Afrikaans and she did the translations herself.

All the interviews were recorded. The researcher experienced some problems with her recorder during the first three interviews and most of the data obtained from those interviews were filled in with notes taken during the interviews. Thereafter the researcher used her cell phone and recorder simultaneously to record the interviews. Having two different recordings of the same interview ensured that no data could be lost. The researcher transcribed all the interviews herself.

The reliability and validity of the research data are important when determining how accurately the measurements reflect the real life situations. This is then the focus of the following paragraphs.

6.6.4 Reliability and validity

Although some researchers dispute the validity of qualitative research, Fidel (1993: 231) asserted that qualitative research is scientific. She noted that the arguments of the researchers disputing the validity of qualitative research were focused on the reliability and validity of quantitative data. The replication of a study is one of the means through which quantitative researchers ensure reliability and validity. However, even though qualitative studies cannot be replicated in the same manner as quantitative studies, Pendleton and Chatman (1998) noted that one of the objectives of qualitative research is to make an effort to address issues of reliability and validity. As indicated by Vakkari (2008), the trend among information behaviour researchers to combine several research techniques is a reflection of efforts being made to address these issues.

6.6.4.1 Reliability

The concept “reliability” was defined by Babbie (2010: 150) as that “quality measurement method that suggests that the same data would have been collected each time in repeated observations of the same phenomenon”. In the information behaviour literature, Pendleton and Chatman (1998: 743) offered a similar definition for reliability. According to them, reliability relates to the degree in which observations are reported as consistent with some phenomena during the time the researcher is in the field. Apart from collecting similar or the same data at different points in a research project, as indicated by Babbie (2010) and Pendleton and Chatman (1998), Case (2012: 209) added another requirement. According to him, reliability is demonstrated when data collection is repeated under similar conditions and using similar data collection instruments each time. These definitions and descriptions therefore seem to imply that multiple respondents should provide the same or similar information when the same interview schedule is administered.

In the current study, the researcher was the only person collecting data. As explained in section 6.6.3, all the interviews were conducted in the respondents’ offices. That is, with the exception of the resident engineer and the acoustics engineer who met the researcher at a restaurant and at her home respectively. This arrangement provided the responding consulting engineers with environments in which they felt comfortable and where they could freely describe and discuss their experiences of information use in engineering projects. This arrangement and the data analysis methods that were employed contributed to the reliability of the study.

However, there also seem to be a number of factors which could affect qualitative research data. Babbie (2010: 151) identified the issue of subjectivity as a potential reliability problem. According to Babbie (2010: 151), the issue of subjectivity could manifest itself in two different ways. Firstly, when different interviewers collect data and their own attitudes and demeanours influence the answers they get from the respondents. Secondly, when different persons code the collected data and code it differently. Creswell (2013: 253) referred to this as the "stability of responses to multiple coders of data sets". However, with regard to the present study the subjectivity problem was overcome by the fact that the researcher was the only person who collected the research data. Therefore, stability of responses could be ensured. The researcher was also the only person who transcribed and coded the data.

Asking questions to which people don't know the answers is a further problem that could affect the reliability of research data. In order to ensure reliability, Babbie (2010: 152) advised that researchers should only ask respondents about things they are likely to answer. Since the oral history interview strategy requires of respondents to tell their own stories, the researcher could not ask the responding consulting engineers any questions to which they did not know the answers. Furthermore, although the interview schedule was prepared to be used as a prompt if necessary, it was eventually merely used to support a thematic analysis of the data in Chapter 8.

6.6.4.2 Validity

The validity of the research data is another aspect which needs to be considered when designing an investigation. In the information behaviour literature, Case (2012: 208) defined validity as "the extent that the measurement procedures accurately reflect the concept that is being studied". Whereas Case's (2012) definition focuses on the accurate reflection of the measurement procedures, Pendleton and Chatman's (1998: 744) definition considers the analysed data. They defined validity as "the degree to which a researcher has a true or honest picture of the phenomenon being studied".

As explained in the discussion on narrative inquiry (section 6.4.4), the interpretations of events are usually expressed as a kind of uncertainty. Clandinin and Connelly (2000:

31-32) therefore stressed the importance of ensuring certainty (validity) in narrative data.

Shenton (2004: 64) employed four criteria to ensure validity in qualitative research. The criteria he identified correspond with the four constructs in Guba's (1981: 79-82) Model of Trustworthiness of Qualitative Research, namely, truth value, applicability, consistency and neutrality. The criteria that were employed by Shenton (2004: 64) are credibility, transferability, dependability and confirmability.

a. Credibility

The concept "credibility" deals with the question of whether the findings are congruent with reality. The strategies Shenton (2004: 64) proposed that can be employed to obtain credibility in a study include the following: adoption of established qualitative research methods; developing a familiarity with the culture of participating organisations; random sampling strategies; triangulation; tactics to help ensure honesty in respondents, and a thick description of the phenomenon being investigated.

Due to the nature of the study it was not possible for the researcher to familiarise herself with the culture of any of the individual consulting engineering companies that were represented by the respondents. However, she did familiarise herself with the context of engineering work and how this context affects consulting engineers' information behaviour. This resulted in a thick description of the phenomenon. Since a specific organisation was not investigated, it was not possible to do random sampling. However, a combination of snowball, purposive and convenience sampling was employed, which are also well accepted sampling methods in qualitative research.

In a qualitative research design, triangulation is also a technique that was identified by Shenton (2004), which could support researchers in ensuring the validity of research data. Triangulation involves corroborating evidence from different sources to shed light on a phenomenon (Creswell 2013: 251). According to Shenton (2004: 66), such corroboration may take the form of comparing the behaviour described by one person with those of other individuals in a comparable position. Triangulation was achieved in this study by comparing the fifteen responding engineers' stories and their reported behaviour. Each one of the engineers told their own story of an engineering project and illustrated their stories with examples from different types of engineering projects in which they were involved. Triangulation was also achieved by comparing the engineers' stories with reported findings in the literature.

b. Transferability

Transferability refers to the extent to which the findings of a study can be applied to other situations (Shenton 2004: 69). However, Shenton (2004: 69) noted that the results of a qualitative study must be understood within the context of the particular study and it is more important to assess whether the findings may be true for people in different settings. The responding consulting engineers' stories of engineering projects reported application of the same information to similar projects executed elsewhere. Furthermore, much of the research results in the current study could also be compared with other studies on engineers' information behaviour, and it is believed that a similar study would be able to replicate at least some of the results.

c. Dependability

Dependability is defined in the Free Dictionary (2015) as a form of trustworthiness or reliability. According to Shenton (2004: 71), it is important to ensure that the processes in the study are reported in detail to ensure dependability. This would then enable readers of the research report to develop an understanding of the methods and their effectiveness. To ensure dependability in this study, the researcher aimed at providing detailed descriptions of the procedures that were followed.

d. Confirmability

Confirmability seems to be comparable to objectivity concerns. Shenton (2004: 72) stressed the need to ensure that the findings are a reflection of the respondents' experiences and ideas rather than the characteristics and preferences of the researcher. He highlighted the role of triangulation in promoting confirmability to reduce the effect of bias.

In this study it was attempted to comply with the requirements for reliability and validity. Attention was paid as far as possible to aspects such as credibility, transferability, dependability and confirmability to ensure reliability and validity, and to reduce bias to the minimum. Also, the oral history interview technique supported the researcher in being unbiased during the interviews. Since the responding engineers shared their stories freely, the researcher did not need to ask them pertinent questions on their project-related information behaviour.

6.7 DATA ANALYSIS

Once the data has been collected in an empirical study, it needs to be analysed. According to Creswell (2013: 180), data analysis in qualitative research involves a number of basic steps, and different qualitative research approaches can have some additional steps. Other than in a quantitative approach where data is first analysed and then discussed, the analysis and reporting of qualitative data can be done simultaneously. The focus in the following discussion will therefore be on data analysis in a narrative inquiry study and to describe how the data was analysed and reported in the current study.

According to Polkinghorne (1995: 15), narrative analysis is the procedure through which the researcher organises the data collected from interviews into a coherent developmental account. This process requires the synthesising of data rather than a separation of data into different themes or topics. When considering Creswell's (2013: 189) discussion, researchers who follow this procedure take a literary orientation to their data analysis. He explains that a literary orientation to data analysis requires of researchers to retell the stories they have collected into a chronological sequence, and to incorporate the setting or place of the participants' experiences.

However, Rosenthal (1993) noted that there are two levels of narrative analysis: the analysis of the experienced life story and the narrated life story (i.e. the literary orientation described by Creswell). He explained that the purpose of analysing the experienced life story is to interpret and reconstruct the case, whereas the analysis of the narrated life story is to reconstruct the experienced and lived story. Riesmann

(2008: 19) identified four strategies to analyse the experienced life story. These are: thematic, structural, a combination of thematic and structural, and dialogic analysis.

The data analysis for this study was completed over two chapters, where two of these four narrative inquiry data analysis procedures were followed. The first data analysis chapter (i.e. Chapter 7) involved a literary orientation and the different consulting engineers stories' of their experiences on building projects were reconstructed into one story. In doing so, attention was paid to the chronology of events and attempts were made to structure the engineers' stories according to the different stages in a building project that were identified by the Engineering Council of South Africa (ECSA) (2014). These are the report stage, preliminary design stage, design and tender stages, working drawing stage, construction stage, and the targeted procurement stage. The purpose of this data analysis is to acquire some background on engineering projects, as well as contextualising engineering projects to ascertain which elements in engineering projects have an effect on consulting engineers' information behaviour in general.

A thematic data analysis approach was followed in Chapter 8. The themes that were used to analyse the data are: context, personal dimension, information needs and information activities. This analysis focused especially on the consulting engineers' collaborative information behaviour and the roles of their personal contacts in providing them with information. The data was analysed and discussed simultaneously.

6.8 CONCLUSION

The focus in this chapter was on the research methodology that was followed in the current study and to report those decisions that determined the research design of the study. An investigation of the different qualitative research approaches suggested narrative inquiry to be the best approach for the study. Narrative inquiry was therefore explored further. This was followed by a discussion on data collection and data analysis.

There are different methods according to which data is analysed in narrative studies. Two of these methods were applied to this study. The first method is to re-story the collected data and the second is to analyse the collected data thematically. The purpose of Chapter 7 is to re-story the collected data to learn more about the context of consulting engineers’ project-related information behaviour.

CHAPTER 7

STORY OF ENGINEERING PROJECTS

7.1 INTRODUCTION

The purpose of this chapter is to narratively report the empirical data that was collected from consulting engineers by developing a story of an engineering project. The consulting engineers' story of an engineering project is preceded by a description of engineering projects and an introduction of the project team and the team members' roles in a typical building project. A brief reflection on these consulting engineers' information behaviour follows the engineering project story. In this reflection, the consulting engineers' project-related information behaviour is graphically illustrated and the focus is on the role of people as sources of engineering information. The development of engineers' social networks is also illustrated.

7.2 BACKGROUND

The discussions in the literature review chapters showed that consulting engineers generally work in project teams. It was also suggested that personal contacts are important sources of engineering information. In section 6.4 it was indicated that an interpretive and naturalistic approach to a qualitative study, as well as the ability to study phenomena in their naturalistic settings, is an important research approach for information behaviour studies. Since narrative inquiry is a way of thinking about and understanding experience, as well as a way of making sense of the world, narrative inquiry seemed the most appropriate research approach and method for the current study.

As shown in section 6.7, narrative data analysis procedures require the organisation of the data into a coherent development account – this is a literary orientation of the data, which requires a reconstruction (hereafter re-storying) of the experienced and lived stories of the respondents. However, it was also noted that Riesman (2008) identified four strategies that could be applied to analyse narrative data: thematic, structural, a combination of thematic and structural, and dialogic or performance analysis. With these strategies in mind, a thematic analysis of the data will be presented in Chapter 8.

Since the purpose of this chapter is to re-story the consulting engineers' personal stories of engineering projects, some framework or structure is required to ensure a chronological progression for the story. The Engineering Council of South Africa (ECSA) (2014) subdivides engineering projects into different stages and the prescribed ECSA stages were used for this purpose.

During data analysis, the researcher identified similarities in the engineers' personal stories that were representative of each stage in an engineering project. Thereafter, a story of an engineering project could be developed using quotes from the responding engineers' stories.

As shown throughout the literature review, context is an important aspect when studying the information behaviour of individuals. In section 6.5.5, context was also indicated to be important when developing a story in narrative inquiry. Therefore, in order to contextualise their stories, the engineers' descriptions of an engineering project and the "project team" for this "building project" will first be introduced.

7.3 ENGINEERING PROJECTS AND PROJECT TEAMS

Consulting engineers can be involved in various types of engineering projects. As shown in section 3.3.6, the Project Management Institute (PMI) (1996: 4) describes projects as being "performed by people, are constrained by limited resources and are planned, executed and controlled". With regard to this investigation, responding Engineer N compares projects to "the story of a human being. A project has a beginning and an end."

Engineer F explained engineering projects as follows: "Clients require that some structure be built and such a structure can be anything. It can be a road, a building, a pipeline, electrical networks, etc." The processes involved in building the structure is then viewed as an engineering project. The project "starts with the client. Someone wants to build a building and they approach an architect … and when they [i.e. the client and the architect] are happy with the provisional design, then they will get other professionals in" [Engineer J]. Engineer M also describes the beginning of a project. According to him, the architect will already "have a draft of what the output of the project is" when he starts engaging with the professional team.

The development of a project from its inception until its close-out (project completion) is described by Engineer F as "starting with a clean slate and giving the client a house". Engineer F further notes that the client has the right to "drop in" to see how the project progresses and has the right to require some changes. However, the client does not have the right to require "huge" changes when the builder is putting the roof on [Engineer E].

In addition to having a life cycle, each project is "unique" [Engineer I]. Engineer F explains the uniqueness of a project as follows: "… although the same design principles are applied, a house is designed differently to a hospital or an office building …". He further explains that, "… the different design requirements for each type of building, requires a different set of technical knowledge which in turn involves different engineering professions …".

The viewpoints of the responding engineers above support Engineer E when he notes that "the consulting team of a building project is multidisciplinary and rather big as compared to other construction type of projects". The narratives revealed that work roles and tasks are contextual elements that influence people's information behaviour. The following subsections, reconstructed from the responding engineers' narratives, reveal in more detail the work roles and tasks of members in a consulting team of a building project. These team members include the consulting engineers' "client", the architect, quantity surveyor and the team of consulting engineers who represent the different engineering disciplines on the project.

7.3.1 Client

Consulting engineers' "clients" are any juristic person or any governmental authority engaging consulting engineers for services on a project (Engineering Council of South Africa (ECSA) 2014: 8). Since clients have certain requirements for a project, they have an important role in any engineering project. Engineer I explains a client's role when he states that the client needs to "communicate certain information. He has to say he wants a five bedroomed house, or a two bedroomed house, or whatever."

Engineer B identified two types of clients: "those who are technically knowledgeable and those who rely on the consultant's advice for guidance". Engineer G supports this grouping of clients when he explains that "clients are not necessarily technical persons; they are managers, project managers ... Sometimes you will find a project manager who has some technical background and who knows something of everything, just enough to manage and to ask the right questions".

When considering clients who rely on the consultant's advice and guidance, Engineer O noted that "client[s] unfortunately do not always know exactly what they want". Engineer L therefore noted that the consultant should generally be "thinking for the client. You must tell him, there are four avenues open for you. This one is the best. It implies the following … If you chose this route, you can fire me."

Clients who are technically knowledgeable include clients who "have a corresponding trade [engineering sections or disciplines] within the Department [or Company]" [Engineer D]. These clients could have their own project teams who have come up with concept designs that need to be implemented [Engineer G]. According to Engineer D, the engineers would then "liaise with the clients' engineer. Give them our input. They critique our designs ensuring that costs are not unnecessarily blown up or also just check or making sure that whatever we are doing is as per guidelines set out by the … [client]."

There are also "sponsor and owner clients" [Engineer I]. Engineer I explained that the mining industry has project sponsors (the mining company), and project owners (the specific mine that wants to use the facilities). Similarly, Engineer O referred to user clients. In his case, the institution client plans and pays for the project, but a specific department or section in the institution are the users [the user clients] of the completed project. The project sponsor or the client institution then controls the budget but the project owner or user client has to specify their requirements or needs. The consulting engineers then need to consider the "project owner's" requirements as well as the "user client's" needs when they design.

7.3.2 Community leaders

Communities could also demand to be involved in government and municipal based projects. Community liaison could therefore become critical to the success of a project. Engineer D reported that one would find that project steering committees consisting of councillors and a few community members become part of the project team. A community liaison officer is then appointed to liaise with the community to "ensure how best you can proceed that you are addressing their particular needs" [Engineer D]. Engineer D further explains that any miscommunication could result in an unhappy community and service delivery strikes, which could have an impact on the successful completion of the project.

7.3.3 Appointments to engineering projects

Project teams tend to "change because the client has more say in the appointment of the team … but you will find that, especially in private developers … they appoint the same team … But with government, they appoint the team and tell you here is the team you have to work with" [Engineer D]. One of three methods could be followed when an engineering project team is appointed [Engineers C & I]. It can be a direct appointment, an appointment based on the outcomes of a tender, or an appointment by a contractor, where the contractor is the client. When it is a direct appointment, the appointment could come from "continuous clients for whom we have done good work and who then re-appoint us … Around 30% or 40% of … projects is a direct appointment, or a reference, or an extension of an existing project" [Engineer I].

Engineer D offered an explanation of how a reference landed him an appointment. He related that he and Engineer A are “from the same stable. We basically give them support … So we have a partnership. So that is how I ended up in the project that you got the list of consultants for …” Engineer G gave a different description of how he became involved in a project. He related that a client or a client’s agent called him and asked whether he was interested in a certain project. He also recalled instances where the caller informed him that he had been appointed to a project and then asked “are you interested?” Engineer E reported similar experiences. He got involved in a project because a member of the development team trusted him and knew he could do the work. He therefore insisted that Engineer E be appointed. Engineer G explained the reason for this trusting relationship as follows: “You work with the project team for the next few years. I know this guy and I know how they work …”

Generally when a project starts, “the client first engages with the architect because of the vision of what he wants to do ... and only after this vision has been put into a building form, they would engage other things, like electrical” [Engineer M]. This indicates that not all engineering disciplines are appointed at the inception stage of an engineering project. However, “… once we get appointed, then on fee basis we will then look at the building design and will then start putting, asking questions to the client or the architect trying to understand how many people are we looking at that are going to use the building, what is the use” [Engineer J].

7.3.3.1 Principal agent

The “principal agent” (PA) is defined by ECSA (2014: 9) as “the entity, person, or professional services provider named or appointed with full authority and obligation to act in terms of the contract between the client and the contractor. Depending on the form of contract applicable, the term ‘agent’ or ‘engineer’, or ‘project manager’ shall have the same meaning as ‘principal agent’”.

The principal agent is appointed by the client and could be a professional engineer, an architect or, in rare instances, a quantity surveyor (QS) [Engineers C, D, I, M & O]. The role of the principal agent is described by Engineer I as the “team leader”. Engineer C notes that “all communications on a project goes through the principal agent whereas other team members are copied”. Engineer D describes this as follows: “ [The architect] would basically act in that role to filter information to all the consultants and act as a link to the client, the project manager from the client’s side.” As the principal agent on a fire station project, Engineer D noted that “whatever approval or statutory requirements that we need to address comes through us … so I have to seek that information”.

Engineers are generally the project leaders or principal agents on civil engineering projects [Engineer E]. Engineer E also noted that building projects generally involve a much larger consulting team than civil engineering projects.

Architects are generally the principal agents on building projects. Based on his own experiences, Engineer O believes there are three types of architects: “those who have nothing to say [i.e. they often ignore the different engineering design requirements when they produce their designs], those who would go to a lot of trouble with their designs but who do not attempt to micro manage; and architects who micro manage the project.” Engineer O’s observation was supported by Engineers D and M’s views of architects. According to Engineer D, “the architect is the boss and whatever you are doing must speak to what he wants”. In turn, Engineer M described architects as being “so influential in terms of the decisions, even if I have to choose the type of light fitting to be used, I need their approval. And they do reject it, they can say no, [Engineer M], I don’t want that light, because it will not look nice on my ceiling. Unless now I have to fight in terms of a technical thing like this light can’t give us enough light for this room and it cannot be anything better than this. That is the only way we can challenge it. Other than that, whatever they say goes.”

7.3.3.2 Project manager

Project managers are generally the team leaders on projects that do not involve an architect (i.e. smaller projects); whereas a principal agent would be appointed to building projects [Engineer O]. Furthermore, not all engineering projects involve an architect. Examples of such projects include infrastructure development projects such as roads, municipal services, electrical networks or even the fire station that was mentioned by Engineer D in section 7.3.3. Therefore, in the absence of an architect or in instances where clients appoint project managers as principal agents, Engineers F, I and N noted that an engineer or a quantity surveyor could be appointed to this position.

The consulting engineers' narratives revealed that project managers are mainly appointed to coordinate engineering projects. Engineer N explained the coordination role as follows: "Project managers have several roles to make things happen, the coordination." He believes communication is the "key factor" of his role. He notes that "communication here means the sharing of relevant information timely and accurately making sure that the discipline[s] interlink with the project as a whole … to see that each side talks to each other, because they are on the same building and that they don't clash. Now mine is to find out, is everybody on schedule. If they are not on schedule, what is the impact? What is going on? What is wrong? What do I need to do to get them back on schedule?"

7.3.3.3 Quantity surveyor

The quantity surveyor (QS) is the project accountant. As Engineer I noted, "They keep the money." Engineer D described the quantity surveyor's role as follows: "He does the costing for the project. So whatever we do, we feed to the QS to build up his budget or his cash course … He would tell you my budget is so much. So whatever you design needs to fit into this particular budget. … It is not carte blanche."

7.3.3.4 Consulting engineers

Consulting engineers design projects but do not build the projects themselves. Engineer F noted that consulting engineers have certain functions throughout the project. He used the following description to explain a consultant's role on an engineering project: "The client wants to build a structure. This structure could be anything, for example a road, or a building. Once appointed, the engineers need to initiate the project and determine the client's needs (i.e. the scope of works). Thereafter they need to do the designs, prepare tender documents, adjudicate the tenders, appoint a contractor and manage the project. This involves quality control, financial control and risk control."

Engineers K and O offered similar descriptions of consulting engineers' roles. Engineer O described his role as follows:"… design, get the design approved by the client, to call for tenders and get a contractor on site, to ensure the work is completed correctly and on time and to verify the quality thereof before signing the project off".

These two descriptions of consulting engineers' roles are supported by Engineer K when he stated: "I am a project manager and project designer, responsible for developing a project from the inception up to the final handover to the client. The project has got stages that are coupled to the maturity of each stage or sort of milestones determining the project status, progress as we are developing it, constructing it." The project managing component of a consulting engineer's role in this instance is not the same as when the engineer is the appointed project manager. It means that the individual consulting engineers have to manage the work for which they have been appointed. The projects that need to be managed by the consultants responsible for the different engineering disciplines on a building project are as follows:

a. Structural engineers

Civil engineering is a broad engineering discipline which includes structural engineering. Civil or structural engineers are generally the principal agents or project leaders on civil engineering projects [Engineer E]. They could even act as quantity surveyors. Engineer E further explained that the consulting team is rather large on a building project and they are only responsible for the structural design and to oversee the construction work. More than one engineer from the same engineering discipline could also be appointed to the same project. For example, Engineers D and E are structural engineers who were both appointed to the same project. In this project Engineer D focused on the steelwork and Engineer E on the concrete work.

Engineer A is also a structural engineer. All three responding structural engineers have been in the industry for more than thirty years and they work for different companies.

b. Civil engineers

Civil engineers are generally involved in infrastructure creation such as roads, paving, and municipal services (e.g. sewerage lines, water and storm-water drainage).

Engineers F, H and I are civil engineers. Engineers F and I have been in the industry for more than thirty years, whereas Engineer H has only two years' experience. He works for Engineer F.

c. Resident engineers

Resident engineers (RE) are members of the consulting team who are tasked with the management of staff on a building site. Engineer A is a resident engineer and he described his role as follows: "I form a link between the contractor, the principal agent and the rest of the professional team. I have regular meetings with the contractor and report the progress to the project team." Engineer F described this link between the resident engineer and the rest of the professional team. He expects the resident engineer to report to him on a regular basis. "And he must talk to me even though there is nothing to report on." He needs to know for a fact that everything on site is fine; he must not assume it is fine. This explanation is supported by Engineer I when he described the role of a good resident engineer as one of "asking questions". He must ask whether the tests had been completed, whether the diary had been updated, etc. Engineer I believes that, from a construction point of view, around 70% of the project administration is the residential engineer's work.

It is expensive to appoint a resident engineer to a building project. Resident engineers are therefore not appointed to all projects. But when one is appointed, Engineer I believes that it must be an experienced engineer.

Engineer A is a structural engineer and has 38 years of experience. He forms part of the structural engineering design team and oversees the construction work on a building site. As per agreement, he would also oversee the mechanical engineers' work. Engineer B, an electrical engineer, also reported on the support that a resident engineer (a civil engineer) renders him on township development projects. He explained that the resident engineer generally contacts him if problems occur with the “ground work” on site, which affect his electricity network.

d. Electrical engineers

Engineer B is involved in electrical infrastructure development for new townships, refurbishment projects, where old buildings are renovated and the electricity supply and wiring needs to be upgraded, as well as new buildings. When involved in the development of a new building, these engineers need to do infrastructure establishment, and plan and design the electrical services for the building.

Engineers B, C, J, K and M are electrical engineers. Engineer J is the youngest with five years’ experience and Engineer C has 40 years of experience. With the exception of Engineer M, all the responding electrical engineers work for the same company.

e. Electronics engineers

Engineer O is the only electronics engineer who participated in the study. He has two years’ experience. He is generally responsible for access control systems, security systems, closed-circuit television (CCTV) systems, audio-visual requirements, fire detection systems and information technology (IT) networks.

f. Acoustical engineers

Acoustical engineering is not regarded as an engineering discipline in South Africa [Engineer L]. According to Engineer L, acoustical engineering involves building acoustics and noise control. Building acoustics is about ensuring that the acoustical requirements in a building are met and the noise made by air conditioning is controlled. Unlike the other engineering consultants, the acoustical engineer does not produce engineering drawings and does not prepare tender documents. He works closely with the architect, the structural engineer and the mechanical engineer. His advice is then reflected on the architect’s and mechanical engineer’s designs and drawings.

Engineer L was the only responding acoustical engineer. He studied electronics engineering and had been in the industry for 31 years. He has no business partners. He noted that he enjoyed working on projects where he had previously worked with the architect and mechanical engineer. As he put it, “one has been on the ‘road’ for 20-25 years with some of these people”. These people know the nature of his needs and timeously call him for advice.

g. Mechanical engineers

Mechanical engineers generally look at the mechanical services of a project [Engineer N]. This involves air conditioning, ventilation, gases, lifts and, in some instances, fire protection systems [Engineer G]. There are two components to fire protection systems: fire detection and fire extinguishing. The fire detection component is usually the electronics engineer’s responsibility, but could also be the mechanical engineer’s area of responsibility [Engineer C, G & O].

Engineer G has been in the industry for 35 years and has two young engineers working for him. Engineer N works in the same company as Engineer M and has around 20 years of experience.

To summarise, building projects have the largest project teams and include engineers from various engineering disciplines, namely, civil, structural, electrical, mechanical, acoustics and electronics engineering. In addition to consulting engineers, a building project also includes an architect and a quantity surveyor and in some instances could include a project leader. The client, that is the entity for whom the building is being constructed, is also represented on the project team. Depending on the client’s own organisation, the client’s representative(s) can assume the roles of a project leader as well as the different engineering disciplines that are represented by the consulting engineers. The story of an engineering project now follows.

7.4 ENGINEERING PROJECT STAGES

Engineering projects are broken up in stages during which certain work must be concluded. Furthermore, “each stage has client acceptance” (i.e. the client’s approval of the work completed during a specific stage of the project) [Engineers F & I]. In addition to the client's acceptance, Engineer F also noted that external approval is also required. For example, building projects that fall within a municipal area need to be approved by the local authority. However, the local authority's representatives could reject the designs, due to elements in the design that they believe do not comply with their regulations. Therefore, as Engineer F explained, the approval process could involve technical discussions where the consultant has to convince the local authority's representative (e.g. a building inspector) of the correctness of the design.

The project stages that were identified by Engineers F and I are the same stages that were identified by ECSA (2014). These are the inception stage, concept viability stage (or preliminary design), detail design, documentation and procurement, contract administration and inspection, and the close-out stage.

7.4.1 Inception stage

The beginning of a project is an inception. Engineer N described the inception stage as follows: "There has to be a need. And a need has to be identified either by the people who fill that need [i.e. the potential client or community] or people who are doing feasibility studies …" [i.e. the architect and the consulting engineers]. As a result, "… a project's starting has quite a lot of dynamics around it" [Engineer K]. The dynamics of the inception stage is summarised by ECSA (2014: 12) as establishing "client requirements and preferences, refine user needs and options, appointment of necessary consultants, establish the project brief including project objectives, priorities, constraints, assumptions aspirations and strategies". During this stage, the project team needs "to get the parameters [scope of works] from the client, do a feasibility study and write a feasibility [inception] report" [Engineer F].

The inception report consists of mainly two components. "Firstly, what does the client want? In other words, what is the scope of works and what are the client's requirements. Secondly, what are we going to give the client and what are the deliverables, in other words, the scope of works?" [Engineer I]. As Engineers F and I explained, determining the scope of works requires establishing whether the client wants a “Ferrari or a Volkswagen Golf”. It also involves ensuring that the client is clear on what he will be getting when he chooses a “Volkswagen Golf”.

Engineer E explained that the inception report is a brief report in which the consultant indicates the viability of the project. It also includes some estimated costs. The cost estimates are based on the architect’s draft design [Engineers E & M]. Engineer O explained that they would base the cost estimates for a new project on the cost and tender values from previous projects. In turn, the quantity surveyor uses the consulting engineer’s cost estimates to prepare a provisional budget. Also, clients often use cost estimates to acquire funding for a project [Engineer O]. Engineer E also stressed the importance for engineers to do their “homework” properly before writing inception reports. He provided an example of a quantity surveyor who provided the client with a rough cost estimate for a project. However, the geotechnical engineers’ reports showed that the soil conditions required additional support for the building, which resulted in additional costs, not originally budgeted for.

Consulting engineers need to collect certain project-related information to complete their inception reports. Some of the information is generic and is required by most of the project team members. The generic information is collected by the principal agent or the architect. This includes information on clients’ budgets and needs (the size of the building, for what the building will be used, the building site, etc.). The inception report therefore also includes general information which is related to the engineering “trade”. “We would normally say this is what we will be using” [Engineer M].

Engineer G noted that the project team seldom gets any information on the “scope of works” when they are first approached to become involved in a project. They therefore visit the project site to establish what is available on site and what the client’s needs are. This is because the availability or non-availability of services could affect the scope of works. Some of the questions that need to be answered during this stage were identified by Engineer N, including the following: “What kind of services are around that site? Is there electricity nearby? Are you going to collect it locally or are you going to collect it from 100 kilometres? … The same is with water and sewerage.” The engineers therefore need to establish how they can integrate or adapt existing services [Engineer G].

Engineer I also identified wind grids and topographical information as being important. He explained that wind grids are used to ensure that a mining administration building is placed above the dust source or sewerage works are placed below the wind.

Around 5% of the work involved in an engineering project is completed during the inception stage, and the work is done at the risk of non-payment [Engineer C]. This means “the engineer may never be paid for the work that was done if the project does not continue” [Engineer C]. Also, a project usually starts with a few core team members, although all engineering disciplines should ideally be involved during the inception stage. The engineers from other engineering disciplines are appointed as the project develops [Engineer C]. Engineer C believes this is “not necessarily the most cost effective method, as money could have been saved if decisions that were taken considered the inputs that could have been made by other engineers”.

“If they [the clients] are happy with that [the inception reports], then we do our preliminary design” [referring to client acceptance] [Engineer M].

7.4.2 Concept viability

Concept viability is the second stage in an engineering project. This stage is often called the preliminary design stage (ECSA 2014: 12; Engineer M) or provisional design stage [Engineer F]. ECSA (2014: 12) defines the work to be completed during this stage as: “prepare and finalise the project concept in accordance with the brief, including project scope, scale, character, form and function, plus the preliminary programme and viability of the project”. According to Engineer C, about 15% of the consulting engineer’s work on a building project is completed during this stage.

The project team has regular meetings (e.g. once every two weeks) from this stage onwards to plan, share information and coordinate the design and development process. Engineer E noted that all tasks affecting the other engineering disciplines are discussed during these meetings. As the project leader or principal agent, the architect collects all the information from the different engineering disciplines that could affect the other engineering disciplines [Engineer E]. Meetings are minuted and serve as a frame of reference for decision-making [Engineer I].

Certain supporting information is required during this stage. This includes, for example, the architect's preliminary design and the quantity surveyor's budget. The consulting engineers also require discipline-related information.

7.4.2.1 Structural engineers

During the concept viability stage, structural engineers generally require the architect's information [Engineer D]. This is because the architect summarises all the information that is required for the project and he would have paid attention to the environmental impact study [Engineer E]. The environmental impact study is completed by an environmental practitioner [Engineer D]. This report also includes a report on heritage-related issues, social impacts, etc.

However, architects also require inputs from structural engineers as they require estimates on column sizes and the spacing between columns [Engineer E]. In order for structural engineers to provide the architects with this information, they need a geotechnical report and a land survey [Engineers D & E]. This is because "your design needs to speak to what is in the ground so that you make optimal use of what is in the ground. So, the geotechnical investigation gives you information on what the soil condition is like" [Engineer D]. Similarly, the land survey will determine what the building would look like on the outside, the excavations that will be required to level the soil, the best position for parking and storm-water drainage [Engineer E].

Structural engineers do not really require information from the client. Engineer E indicated that industrial projects are the exception and the structural engineer would then act as the "architect" or principal agent. He then has to liaise with the client to determine his needs as well as the needs of the industrial processes which will be housed in the building.

7.4.2.2 Civil engineers

During the concept viability stage, engineers focus on “determining the sizes and all those stuff” [Engineer I]. For this purpose they do a preliminary design and base their budgets on the preliminary design [Engineer F]. Apart from land surveys and geotechnical reports, Engineer F bases his designs on information acquired through his studies and from his 40 years’ experience in the industry.

For a road building project, civil engineers would also need to do an economic analysis [Engineer F].

In order to provide water and link the building to municipal sewerage services, Engineer H requires information on the existing services in the area. He gets a lot of this information from the local municipality and city planners. In addition to information on existing services, Engineers F and H also require local municipalities’ design specifications so that their designs are compliant with the local municipality’s requirements.

7.4.2.3 Electrical engineers

Electrical engineers require information on a number of issues related to electricity supply. Firstly, they need to know what the size of the planned building will be and for what it will be used [Engineer J]. This information is generally sought from the client and the architect. Engineer J explained that this information is required to assist them in establishing how much “power should be given to the building”. Secondly, the electrical engineers need to determine whether there is an electrical connection to the site and whether the local municipality has the capacity to provide electricity to the site [Engineer M]. Engineer B knows most of the people at his local municipality who could provide him with information. However, he noted that these people move around and may not always be there when he seeks the information.

In order to provide electricity to a building, engineers need to determine where the closest power substations or transformers are [Engineers B & J]. If there are no substations or transformers close to the building site, the electrical engineers could be required to have additional transformers built [Engineer B]. Engineer J further noted that he needs to share information on electricity supply with the architect, the quantity surveyor and the civil engineer, as they would rely on that information for their designs and to finalise the rezoning of a new stand [Engineer B]. The streamlining of the different engineering disciplines' responsibilities therefore depends on the timeous sharing of this kind of supporting information.

Thirdly, electrical engineers also need to engage with "the client … and the agent of the equipment that we use, for example, the light switching, or trunking, we get them from the manufacturer" [Engineer M]. Engineer B stressed the importance of discussing the project with the client to acquire an understanding of the client's expectations of the project. Engineer B explained that this is especially necessary in projects that involve building management systems. Understanding clients' needs ensures that clients get what they pay for.

Clients could also have design specifications. According to Engineer C, the "client specifies the type and nature of the equipment to be installed". Examples are the design requirements that are specified by the Department of Public Works and local authorities [Engineers B, C, D, F & H].

Lastly, electrical engineers need to engage with the mechanical engineer and the electronics engineer. The mechanical engineer must provide them with information on the air conditioning system's load to enable the calculation of the amount of power that is required for the building [Engineer M]. Electrical engineers also need to provide for the information technology (IT) infrastructure [Engineers B & M]. The electronics engineers must therefore provide them with information on their cable routes and conduit needs [Engineer M].

Engineer M noted that when they do their preliminary designs "you do your calculations of your equipment. You have given the client roughly what kind or things we are likely to use, and what likely methods are going to be used."

7.4.2.4 *Electronics engineers*

When he prepares his preliminary design, Engineer O requires the floor layout of the building and information from the user client. He gets information on the building's layout from the architect. The architect generally establishes the user client's needs for the other engineering disciplines but the electronics engineer cannot rely on the architect to collect the correct information on the user client's needs. Engineer O explained that electronic systems are complex and the architect does not necessarily understand them. Also, the client does not always know exactly what is needed. "To get the ball rolling," Engineer O would suggest some possible solutions to the client. When he discusses the solutions with the client, the client has the opportunity to decide which solution would best suit his needs. It is during these discussions that the client often identifies other needs he had not thought of previously.

Engineer O relies on his previous experience and the experience available in his organisation to do the cost estimations for the project. He also bases his cost estimations on previous tender values by adding on for possible escalations.

7.4.2.5 *Acoustical engineers*

The acoustical engineer engages most with the architect and the mechanical engineer. His engagement with the architect is about the building's acoustics, whereas his engagement with the mechanical engineer is about air conditioning. His inputs on the project are included in the architect's and mechanical engineer's drawings and documentation. Engineer L could recall only a few projects in his 31 years as acoustical consultant where the client knew what was needed. Clients are therefore not a source of acoustical information.

7.4.2.6 *Mechanical engineers*

During the concept viability stage, mechanical engineers need to establish the objectives of the work. Engineer G noted that the client very seldom provides written confirmation on what the scope of works is. As an example, he discussed the extension to an existing medical clinic where the clinic group required the implementation of concept designs. The engineers therefore had to visit the site to establish what was already there and to determine the scope of works. Once the scope of works is known, it is possible to produce the preliminary designs and do the load calculations as well as the cost estimates. For this project, the mechanical work involved air conditioning, ventilation, gases, lifts and fire protection. Engineer G also stressed the importance to determine the client's needs. According to him, the client has a concept but cannot define his exact needs. He believes it is the task of the consulting engineer to define the client's needs and advise him on the best solution to the problem and to motivate this with costs.

The mechanical engineer needs to share certain information with the other team members. This includes sharing the electrical requirements of the mechanical plants with the electrical engineer. He also needs to share his plant information with the acoustical engineer who should advise him on how to minimise the mechanical plants' noise output levels. Lastly, he needs to share the dimensions of the mechanical plants with the structural engineers as they need to provide for it in their designs [Engineer D].

7.4.3 Detail design

Detail design is the third stage in an engineering project. Engineer F noted that they "prepare their designs of what needs to be built and how it must be built. This includes all the drawings and specifications." He further noted that they would start preparing tender documents while they are busy with their designs. His description is supported by ECSA's (2014: 13) definition of the detailed design stage. That is to "develop the approved concept to finalise the design, outline specifications, cost plan, financial viability and programme for the project". Engineer C noted that 50% of the work is completed during this phase.

Engineer N noted that the detail design stage requires a lot of "input also from the stakeholders". The consulting team members also need to provide the quantity surveyor with information, such as the bills of quantities, which must be included in the tender document [Engineer E].

7.4.3.1 Architect and consulting team members

The architect and the structural engineer need to work closely together during this stage to design the building's structure. As Engineer D puts it: "The architect is the principal source of information … This is because you have to build on his designs." Engineer E supports this view when he states: "We need to support each other's designs." Other consulting team members who are important sources of information at this point include the mechanical and electrical engineers. Engineer D explains this as follows: "… whatever they are doing, affects my design." According to Engineer G, this is mainly about "spatial needs". Engineer E also listed the chemical engineer as an important source of information on an industrial project. He needs a lot of information on the functional aspects of the machine he has to design for use in an industrial project.

Since electrical engineers' designs must be adjusted to suit the architect's design, these engineers require a lot of information "inputs" from the architect [Engineer C]. For example, electrical engineers require information on the building's structure in order to place distribution boards, plugs and light fittings [Engineer C]. They also need information on the services that are required, for example, lifts, air conditioning, fire protection and electronic systems [Engineers B & J]. In order to provide for these services, electrical engineers also need infrastructure requirements from the mechanical, electrical and electronics engineers [Engineer B & K]. It was with these requirements in mind that Engineer G noted that he has to work closely with the electrical engineers. Engineer G would send the mechanical drawings to the electrical engineer. These drawings include all the "electrical needs" of the mechanical equipment.

During the design stage, the acoustical engineer will sit with the architect and the mechanical engineer to advise them on how to control noise and improve the acoustics of the building.

Information sharing is vital in order to coordinate the different engineering designs. Engineer G illustrated this when he explained that, "you now have three pictures: a building picture, an air conditioning picture and a picture with cables and other stuff. And these pictures need to get together and the architect should coordinate it. But he does not know my stuff …"

7.4.3.2 Clients

Since clients' needs must be addressed, clients are another important source of information [Engineers B & C]. As Engineer B noted, the consulting engineer can suggest the use of certain products. However, if what has been installed is not according to the client's expectations, the client can insist that it be removed.

When involved in a government project, Engineer D would liaise with the client's engineer and have them critique his design to ensure "that costs are not unnecessarily blown-up or also just check or making sure that whatever we are doing is as per guidelines".

7.4.3.3 Persons not directly involved in the project

Persons who are not directly involved in an engineering project are sometimes important sources of information. For example, Engineer J appreciates the inputs of other colleagues who are not intimately involved in the project since they could provide him with a different perspective on his design. Engineer O reported that, when he first started working as a consultant, his senior engineer discussed all his designs with him to ensure they are compliant. This support provided him with the "peace of mind that I am right".

When he is busy with designs concerning information technology (IT), Engineer O often discusses certain aspects of the design with persons who are specialists in the field. Most of these issues are related to the identification of possible cable routes – especially in projects where electronic services must be provided in existing buildings.

Consulting engineers generally have a draughtsperson who does their drawings. Engineer J noted it is not always necessary to provide the draughtsperson with a detail design as the draughtsperson is able to fill in the gaps, provided he/she understands the reasoning behind the design. This is slightly different to Engineer O's experiences in refurbishment projects. He noted how difficult it sometimes is to describe the reality in a two-dimensional design to the draughtsperson who does not already have a clear picture of the reality. He would therefore need to provide additional detail to his designs to ensure that the draughtsperson has a better understanding of his design.

7.4.3.4 Environmental information and permissions

Civil engineers require a detailed survey of an area to determine the depth of sewerage lines and the routes that have to be followed [Engineer H]. They also need to acquire permissions (way leaves) as well as approvals from local authorities [Engineer F & H]. The products civil engineers use are mainly determined by the local authorities.

7.4.3.5 Specifications and regulations

The information from specifications and regulations is “information that you can use from one project to another” [Engineer D]. When they need specifications, engineers would use the South African Bureau of Standards (SABS) for design specifications, the government for statutory regulations and the different engineering bodies (e.g. ECSA, CESA and contractor bodies) [Engineer D].

When they do work for a local authority, such as a municipality, or work in a local municipal area, civil engineers’ designs must adhere to certain specifications. As Engineers F and H noted, they may only use certain types of products, each local authority determines the types of products that may be used and have their own requirements for the building of manholes and the connection of pipes. This information can only be acquired from the local authority.

7.4.3.6 Product information

Engineers would generally seek product information, such as product specifications, from the manufacturers [Engineers D & E]. Engineers E and I noted that, in the past they had *Specifiles* – files that included product brochures and were regularly updated by the company compiling the *Specifiles*. *Specifiles* are no longer available and Engineer E would now phone suppliers for product information. Suppliers are also able to provide him with technical guidelines. Some company representatives are also important sources of information. As Engineers B, E, J and I noted, some of the representatives are technically knowledgeable and can advise them on the best products for specific applications. These representatives and contractors can also provide engineers with current information on product prices. Engineer M therefore stressed the importance of building relationships with suppliers.

When it comes to the use of new products, Engineer F noted that one needs to design for each product and "as a designer he cannot experiment with his client's money as his client holds him responsible for the product". This generally does not allow them the freedom to experiment with new products that have not yet proved to be successful under local circumstances.

7.4.3.7 Conferences and forums

Conferences and forums are also important sources of information that support engineers in their designs [Engineer F]. In order to develop relationships with colleagues in their companies and to enable colleagues to learn from each other Engineers B, C and I reported that they have regular social networking sessions. Engineers are then able to interact informally with one another and discuss their projects. Engineer F indicated that a colleague would attend a conference or workshop and then share what was learnt at that forum with the rest of the company.

7.4.3.8 Design software

Some of the responding engineers indicated that they use design software to simulate their designs, namely Engineers H, M and O. Engineer O indicated that design software supports him in optimising his designs and in producing designs faster. He believes that he will rely less on design software as his experience grows. His senior engineer, for example, knows from experience what a CCTV camera lens's output is and does not need design software to optimise his designs. Engineer O still needs to "build that experience".

7.4.3.9 Previous designs

Certain information (and designs) can be reused for a number of projects. Engineer D illustrated this when he notes that the requirements for housing projects in Limpopo and KwaZulu-Natal are similar and it is easy “for you to just borrow from the one project for the other”.

Using previous designs save consulting engineers time, especially when they are “handling more than one project at any point” [Engineer J].

7.4.4 Documentation and procurement

Once engineers had completed their designs and it was approved, they prepare the drawings and specifications [Engineers F & M]. As part of this process they prepare a tender document [Engineer F]. They thereafter continue with the tender process [Engineer G]. This is the fourth stage in an engineering project and it is defined by ECSA (2014: 14) as the documentation and procurement stage. ECSA (2014: 14) stipulates that the following work should be completed during this stage: “prepare procurement and construction documentation, confirm and implement the procurement strategies and procedures for effective and timeous procurement of necessary resources for execution of the project”. According to Engineer C, 25% of the work is completed during this stage.

Engineers F, M and N explained that a tender document includes tender drawings, general and detailed specifications and the bill of quantities. As explained by Engineer M, the general specification includes general information and also references to the applicable South African National Standard (SANS). The detailed specification provides details on the specific installation and provides information on the type of light fittings or circuit protection [Engineer K]. As Engineer J explained, “you need to know what it is that makes this product unique as compared to that one. And then you specify that uniqueness which is then acceptable on the regulations code.” As a rule, engineers will not include specific product brand names in their specifications for public tenders, to ensure that everybody has a fair chance to tender [Engineer M]. However, private clients could require that only a specific product is used and then engineers would include a specific product name in their specifications [Engineer M].

The Bill of Quantities is the second component of the tender document. This is a detailed list of the items that need to be procured, which is used for tender purposes. Engineer M reported that he would generally draw up the Bill of Quantities while he is preparing a design.

In order to prepare the tender document, Engineers H and J noted that they would generally keep to the same template that had previously been used for other projects and adapt it where necessary. As Engineer D explains, “It is very easy for you to just borrow from the one project for the other because it is basically the same situation … in special cases that you will find this information belongs to a particular project only.”

Once the tender documents have been completed, engineers call for tenders and it is the consultant’s task to evaluate the tenders and make a recommendation [Engineer F]. Tenders can be open or invited tenders [Engineers C & F]. Government or public projects generally have open tenders whereas private developments could have invited tenders. In invited tenders, potential contractors are invited to tender. This invitation is based on these contractors’ experience, previous work completed, and costs [Engineers C & J]. Engineer F noted that he would usually invite tenders from contractors he had previously worked with.

Tenderers may suggest alternative designs at this point [Engineer F]. If they do, they must provide details for the alternative design, which must then be evaluated along with other tenders [Engineer F]. No changes are allowed once the tenderer had been appointed.

When evaluating tenders, consultants need to establish whether the equipment that is offered by the tenderer is the same as what was specified. The engineers would also check the performance of the product on offer [Engineer K]. Following the tender evaluation, Engineer J noted they would give their clients professional advice on whom to appoint. This advice is presented to the client as a tender evaluation report and the client then appoints the contractor. The lowest tender is not necessarily the best tender. Engineer C noted that problems could arise when the client assigns a tender to a contractor based on the lowest price, without considering the design specifications and the specifications of the products that are being offered – especially if this appointment is in contrast to the recommendations that were made by the consulting engineer.

Engineer M noted that some clients could adjudicate the tenders themselves and the consulting engineer merely receives a phone call to inform him who the appointed contractor is. According to him, this could be problematic as the appointed contractor might not be the best person for the job.

Another scenario is posed by Engineer O. His main client employs term contractors for some of the institution’s inherent systems. There are also lone suppliers for those systems. He therefore does not go out on tender for contracts that involve term contractors. He bases his cost estimates on the fixed values that have been agreed on for the work these contractors do. He would only get quotations for audio-visual equipment as the costs for this equipment is volatile.

7.4.5 Contract administration and inspection

Construction begins once the main contractor has been appointed. This stage is known as the contract administration and inspection stage. The work to be completed during this stage is defined by ECSA (2014: 14) as: “manage, administer and monitor the construction contracts and processes including preparation and coordination of procedures and documentation to facilitate practical completion of the works”. Engineer C indicated that 25% of the work is completed during this stage.

The main contractor (also referred to as the main builder) uses the first two weeks after construction starts to establish the site. As Engineer M explained, this involves getting equipment to the site, setting up a container which serves as a site office, and preparing his safety files. The resident engineer, for example Engineer A, now joins the construction team on site – that is if the client is prepared to pay for a resident engineer. The resident engineer is the consulting engineer’s “eyes and ears on site” [Engineer E].

When the project does not allow for a resident engineer, consulting engineers need to visit the site more often to ensure the work is completed as specified [Engineer E].

In order to implement the engineer's designs, the resident engineer [Engineer A] and the contractor require a complete set of construction drawings. These drawings act as a contract of what has to be built and how it should be built. Also, the contractor and subcontractor "will be working to the programme of the builder" [Engineer J]. When changes to the original designs are required, consulting engineers need to issue written instructions [Engineer E]. These instructions are included in the site instruction book or in an email [Engineer E]. This need to document everything that happens on site, and to document instructions, is summarised by Engineer F when he states that communication on a construction site is about documentation.

Changes could be required during the construction stage. Engineer F distinguished between "material changes" and "immaterial changes". He explained immaterial changes as changes that are required to accommodate some unexpected problems on site. An immaterial change then requires that the design be adapted to bypass the problem. A "material change" is when something is dropped or added to the contract – that is a change in the scope of works. Such changes could have an effect on the designs of the other engineering disciplines. Engineer C believes most of the material changes that arise during the construction stage can be put to bad planning. As Engineer G noted, 25% of all changes are things that were never thought through properly or could not be incorporated earlier due to time restrictions.

This stage requires a lot of coordination and there is a certain chronology according to which tasks need to be completed. As Engineer N explained, "We cannot install electrical services until the walls are up. We cannot install the lights until the ceilings are in place." For this reason Engineer A requires the subcontractors' planning. This then enables him to coordinate the different subcontractors' "works" [activities or tasks]. He also requires certain certification before he can allow the contractor to pour concrete. These certifications include a safety and security officer's certificate that the supporting props are in place and would be able to carry the weight of the structure. He also requires confirmation from the electrical and electronics engineers that the conduits (cable routes) are in place and a confirmation from the mechanical engineer that the mechanical equipment's routes are correct. Despite these confirmations, it happens that some things, like a conduit, are missed or forgotten. When this happens, the consulting engineer needs to do crisis management by "put[ting] up a red flag" [Engineer O]. Engineer C supported this when he indicated that the electrical engineer needs to work closely with the structural engineers when concrete is being poured.

When the contractor pours the concrete, the resident engineer does "slump tests" to ensure the concrete mixture is correct [Engineer A]. He also orders that concrete cubes [samples] are taken. These cubes are allowed to age and are used to test the concrete's strength at certain intervals.

In order to complete their work on time, contractors sometimes have to work in the evenings and over weekends. However, when they do need to work over weekends, they need permission from the principal agent and the responsible consulting engineer [Engineer M]. This rule is governed by the Occupational Health and Safety Act (OHS), the constructional regulations and municipal by-laws which determine working hours. This is to ensure that there is standby support if something goes wrong on site.

Information generally flows from the contractor to the consultants during the construction stage [Engineer F]. He also noted that it could involve a flow of information from the consultants to the contractor and subcontractors. A site instruction book is kept for this purpose and all instructions and variations to the construction drawings are recorded in the site instruction book [Engineer A]. There is also a "site diary" and a "request for information" book on site [Engineer I]. According to Engineer I, the "request for information book" is used by the contractor to request information from the consulting engineer when the construction drawings don't include enough detail and more detailed instructions are required.

7.4.5.1 Communication structures

Communication is a key factor in an engineering project [Engineers A & N] and "it takes all forms of communication" [Engineer N]. Engineer N regards communication as "the sharing of relevant information timely and accurately, making sure that the discipline interlinks with the project as a whole”. Certain communication protocols need to be followed during the construction stage. Consultants’ communication is always via the principal agent (PA) [Engineer B]. Engineer A explained that communication on the construction site generally flows from the contractor (builder) to the foremen and subcontractors. Engineer D supported this when he explained, “You will find the line of communication is dotted … ” He further explained that it is sometimes necessary to discuss design details with the subcontractor. Once they have agreed on the best solution, “we can approve and give the information to the main contractor and the architect as well. If it has financial implications, it has to be communicated to the quantity surveyor as well … ” [Engineer D]. Engineer F also indicated the need to communicate approved changes to the residential engineer.

The reverse line of communication also applies. The foremen and subcontractors will generally communicate with the consulting engineers via the main contractor and principal agent (PA, e.g. the architect). For example, when the contractor “does something wrong, he has to tell the principal agent, and then the PA can tell the engineers” [Engineer M]. This example partially explains the information flow on site and that all communications on site need to go through the main contractor. He is the person that needs to do the construction according to the consulting engineers’ specifications. However, the main contractor does not do all the work and subcontractors are appointed for tasks. All communication to the subcontractors must also go through the main contractor and the architect (the principal agent) [Engineer D].

7.4.5.2 Engineering drawings

Engineering drawings, now referred to as construction drawings, provide the contractor (builder) with the instructions of what has to be built and how it should be built. Engineer I noted that the drawings can be issued electronically. However, he also noted that this protocol could be different for each project and some of his clients require that the contractor may only work from drawings that were signed off by the draughtsperson, the consulting engineer, the project leader and the client.

7.4.5.3 Personal communication

Communication between team members and contractors or subcontractors is “mostly verbal, that is, face-to-face or telephonically” [Engineer B]. All the responding engineers prefer face-to-face communication. Engineer D explained that certain issues are best dealt with in face-to-face meetings. Face-to-face communication is generally used to explain why something needs to be installed in a certain manner. Engineer L believes the contractor should understand why he should do certain things. Therefore, Engineer L would demonstrate to the electrician the acoustical implications of back-to-back wall plugs. Similarly, Engineer O liaises with the contractor and his subcontractor to find a solution to a problem that arose on site.

However, the engineers indicated that they would communicate telephonically when a face-to-face meeting is not possible – this is especially the case when the project is far away and the engineer is only able to visit the construction site in a few days’ time. Engineer F indicated that he would rather “pick up a phone than send an email. Then I sort things out more easily.” He and Engineer I believe this is contrary to what some of the younger engineers would do. They had observed that younger engineers preferred writing emails to telephonic conversations to sort out problems. However, all the responding engineers indicated that they would confirm in an email whatever decisions were taken during face-to-face meetings or telephonic conversations. This is to ensure that the decision is documented and can be referred to at a later stage, should that be required. Furthermore, “the contractor will only act on written instructions” [Engineer J].

When an instruction is issued by email, engineers must at all times send a copy to other important stakeholders, such as the contractor and the principal agent (architect), as well as to the quantity surveyor if the instruction has a financial implication.

Social media, such as WhatsApp messages, are generally not accepted as official communications, but could be used in engineering communications. Engineer O indicated that he would use WhatsApp to communicate with his subcontractors to confirm something, for example to confirm that a certain task had been completed or that equipment had arrived on site. This type of information is then later verified through a site visit or an email.

7.4.5.4 Meetings

Meetings and meeting minutes are important sources of engineering information [Engineer I]. Engineer I noted that meetings form the basis for decision-making. Preconstruction meetings are focused on project coordination and design meetings. These meetings are attended by consultants and the client. The meetings during the construction stage involve the client, the team of consultants and the main contractor [Engineer I]. These meetings are known as planning or technical meetings and site meetings [Engineers G & K]. Planning meetings involve the professional team and the client. During these meetings the architect provides the client with feedback on the project's progress. All the client's additional needs or changes are discussed during planning meetings. Changes that are made to designs at this point affect the designs of the other consultants as well [Engineer J].

Not all projects continue to have planning meetings during the construction stage and what would have been discussed in a planning meeting is then discussed during the site meeting.

Clients seldom attend site meetings. Site meetings are held fortnightly [Engineer M] and Engineer C regards site meetings as the most important coordination meetings on a project. This is when the professional team walks through the project to see whether all the work is being completed as specified. During these meetings the main contractor gives his feedback on the project to the architect [Engineer G]. He then discusses his progress, the effect of events, such as strikes or excessive rain, on the project's progress and other contractual aspects requiring attention. If the project team includes a resident engineer, the resident engineer will present the progress report. Engineer A indicated that he would have a meeting with the contractor a week before the site meeting so that they can report back on the latest developments on site.

In addition to the monthly site and planning meetings, the professional team also has site inspections. The progress and quality of the completed work are assessed during site inspections and these meetings form the basis of the monthly feedback reports that are issued by the consulting engineers. Based on the work that has been completed, the consultants issue payment certificates [Engineers G & I].

Site inspections have a second function as well. Engineer J explained that things happen on site and consultants pick up problems during site inspections that affect their designs. The example he gave is the inclusion of a crossbeam where electrical and electronic services are supposed to run. The engineers will then alert the principal agent and contractor to the problem and an alternative route for their services needs to be found [Engineers J & O].

Site inspections are not restricted to the bi-weekly site meetings and, if necessary, the consulting engineers could have more regular site meetings with their subcontractors. For example, the resident engineer is on site 24/7. “He would inspect and if it doesn’t comply with the design, he would notify me and say: ‘There is this particular problem.’ If the contractor requires an alternative approach, then I would go to site and sit down with [the resident engineer] and the contractor and discuss what alternative approach we can use without necessarily changing much of the project” [Engineer D]. The electrical engineer also expects his subcontractors to call him once they have laid the electrical cables, before they close them up, so that he can inspect the quality of their work.

7.4.6 Close-out

The close-out stage is the final stage in an engineering contract. The work that has to be completed during this stage is defined by ECSA (2014: 16) as follows: “Fulfil and complete the project close-out including necessary documentation to facilitate effective completion, handover and operation of the project.” Engineer B believes 5% of the work is completed during this stage.

Some clients require a completion report at the end of the construction phase. This report is a summary of the work that was completed and the history of the project. This will include reasons for delays, reasons for budget changes, reasons for contractor's claims if there were any, design changes, etc. [Engineers F, I & M]. Engineers then also need to complete the "as-built drawings" – these drawings reflect what was built [Engineers E, F, H, I]. Engineer M noted that he generally requests his subcontractor to update the construction drawings as changes are made. His draughtsperson then finalises the as-built drawings.

The client could also require certain completion certificates [Engineer E]. Engineer F explained that he would create a completion certificate, which is signed by him and the contractor. In order to issue completion certificates, engineers test the systems to ensure they comply with the design requirements [Engineer O]. Some clients also want to be present when these tests are done and they therefore also sign the completion certificates. To prove that the electrical installation is compliant with the Electrical Contractors Board's regulations, the electrical contractor should also provide the electrical consultant with a certificate of compliance.

The use of some systems may require training. The consulting engineers would then collect the training manuals from the subcontractor or the supplier and organise user training [Engineer M].

There usually is a twelve months maintenance period after which the systems are tested again and latent defects are corrected [Engineer F]. Hereafter the final accounts can be settled [Engineer I].

7.5 REFLECTION

This story of an engineering project is a reconstruction of the responding engineers' personal stories of engineering projects. The story contextualises the consulting engineers' information behaviour. It also shows the interaction between context and the consulting engineer's personal dimension and how these give rise to information needs, which in turn prompt specific information activities. Furthermore, this story endorses T J Allen's (1977) diagram of the flow of engineering information (section 3.3.5.4) and shows how an engineering project starts with an idea and the development of a product.

In this process, engineers use information from various sources and documents throughout the design process. From the narratives it is evident that the engineering documents, tender documents and construction reports are the outcomes of these processes. These documents are not only used throughout the engineering project, but could in turn also be used as sources of information on a different project or for extensions on the same project.

7.5.1 Context

The story also provides insight into how different contextual elements that are present in an engineering project affect the information behaviour of consulting engineers.
The contextual elements that seem to influence consulting engineers' information behaviour include the client, the principal agent or project manager, the team of consultants, the contractors, the project budget, the project timeline, the consulting engineers' work roles and their tasks. When considering the story of an engineering project, it is evident that each one of these contextual elements set certain requirements for the information that is needed and used. It also sets requirements in terms of the activities that are required to obtain the required information. Therefore, the set requirements that derive from the context can be viewed as contextual factors shaping information behaviour.

In addition to the collaborative information activities, these contextual elements also seem to affect consulting engineers' chosen form of communication on engineering projects. For example, the responding engineers prefer face-to-face meetings or telephonic conversation to writing emails when they need to sort out an engineering problem. This behaviour especially manifests itself during the contract administration stage when communications with contractors are mostly verbal communication. The preference for verbal communication is to save time and to ensure that the engineer and the responding person are on the same level of understanding. The decisions taken during these meetings or conversations are then confirmed by email for future reference – this behaviour provides them with some form of certainty.

As shown in the story, engineering projects are unique and are completed in stages. Each project stage sets its own information requirements in terms of what information is needed and from where or whom it is sought. Therefore, project stages can also be viewed as a contextual element that exists within a context. The information that is required during each project stage could be discipline-specific information or supporting information. The supporting information is that what is needed by all the engineering disciplines (e.g. the availability of water and electricity to the construction site) and it is one of the purposes of the reconnaissance tasks completed during the inception stage to collect this information. The collected supporting information in turn supports engineers' designs at later stages in engineering projects. Lastly, from the narratives it seems evident that the preconstruction stages are information rich stages and consulting engineers experience diverse information needs during these stages.

Furthermore, certain specific information activities could be observed during each of the project stages. For example, the concept viability stage is characterised by data collection activities. Information creation and information use activities are most prominent during the detail design and document procurement stages, whereas the contract administration stage requires all forms of communication. Information sharing is the one information activity that is always present throughout an engineering project, that is, irrespective of the project stage. These information sharing and communication activities support consulting engineers in building relationships with team members and contractors and contribute to the development of their social networks.

The consulting engineers' narratives revealed that engineers are often reliant on people, especially clients, project team members and contractors, for engineering information. This reliance on people as sources of engineering information also reflects a kind of interdependency among engineers, for example their dependency on the resident engineer for information on what is happening on the construction site.

People who are not directly involved in the project could also be important sources of information. This is especially during the preconstruction stages. These people include persons who provide consulting engineers with environmental information (e.g.

geotechnical engineers, environmental management consultants, social liaison consultants) or with permissions (e.g. local authorities), and sales persons or representatives who provide them with product information. Other persons who are important during these stages include the consulting engineers' colleagues within their own organisations, as well as more experienced engineers or experts in the field. The persons who provide consulting engineers with information throughout the engineering project can vary according to the project stage. For example, contractors and subcontractors do not provide consulting engineers with information during the preconstruction stages of the project. However, once they start implementing the consulting engineers' designs, they seek information from and exchange information with these consulting engineers.

Consulting engineers' need to collaboratively seek, share and communicate information, as well as their need to coordinate their designs and construction work, form the basis for their social networking activities. Therefore, it is evident that social networking is an imperative information behaviour activity for consulting engineers.

Certain information that is needed by consulting engineers is project-specific (e.g. the project budget and time frame) whereas other information can be shared between engineering projects. These include the sharing of certain documents (e.g. regulations, specifications and previous designs) and basing cost estimates on old tenders, as well as the experience gained from their involvement in engineering projects to solve engineering problems.

7.5.2 Personal dimension

The story of an engineering project also provides insight into how elements in consulting engineers' personal dimension affect their information behaviour. For example, consulting engineers are appointed to project teams for their knowledge, personal experience and the trust the client places in their abilities to find the best solution to the engineering problem at hand. The trust the client places in their abilities is often based on previous work experiences or references from team members who had previously worked with the consulting engineer. Also, the engineering project will determine consulting engineers' roles and tasks on the project. This is especially the case when more than one consulting engineer is appointed for the same engineering discipline, for example two structural engineers where one is responsible for the steel structure and the other for concrete work.

Collaboration with team members is only possible where team members are dependent on one another for information that is needed from different engineering disciplines to complete their individual tasks. The responding engineers' information sharing, communication and transfer activities reflect their interdependency on fellow team members to ensure successful task completion. Interdependency on people as sources of information is therefore another example of an element that derives from consulting engineers' personal dimension, which could affect their collaborative activities and their information behaviour.

7.5.3 Information activities

The narratives revealed that engineers are involved in various information activities throughout an engineering project. These include information seeking (e.g. the data collection in the concept viability stage), information use as well as information creation during the detail design stage and documentation and procurement stages of the project. Consulting engineers also seem to be involved in information reporting activities, especially during the procurement (construction) and close-out stages of the project. However, information communication and sharing activities seem to be the most prominent activities throughout the engineering project.

As noted by one of the responding engineers, engineers use all forms of communication to seek, share and communicate information. These include engineering drawings, telephone calls, face-to-face discussions, email and meetings. Some engineers even use social media platforms such as WhatsApp to communicate with their contractors and with each other, even though this medium is not regarded as an official form of engineering information. Using these media saved the responding engineers time and supported them in managing the construction work.

Certain communication protocols need to be adhered to on engineering projects. For example, all communications need to go through the principal agent (the architect or project manager). In addition to these activities, the narratives also revealed an awareness of fellow team members' information needs, as well as a need to remain aware of project-related developments and how these affect their own work.

With this story of an engineering project in mind, the collaborative information behaviour of consulting engineers can be described as an interactive network which includes people as well as printed and electronic sources. It can be illustrated as depicted in Figure 7.1 below:

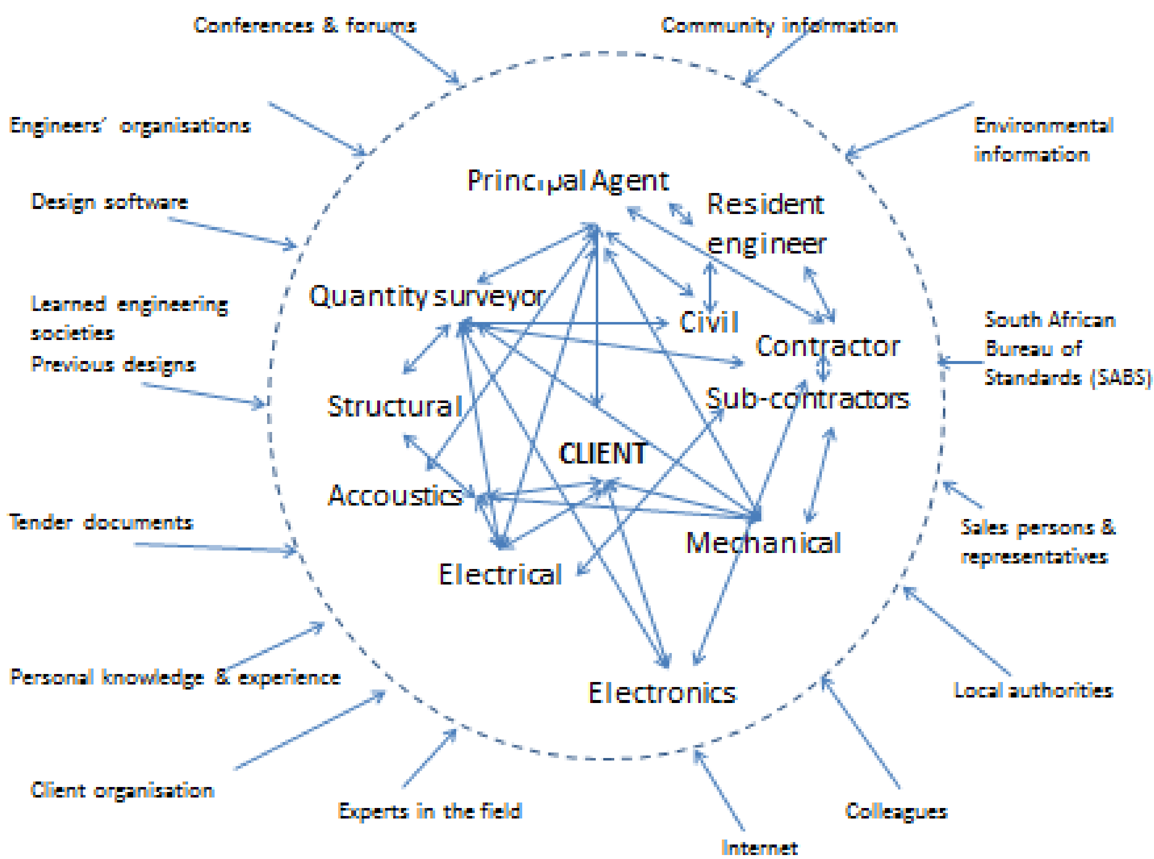


Figure 7.1: Depiction of consulting engineers' collaborative information behaviour

As explained in section 2.3.3 and illustrated with Figure 2.1, context is one of the core components of the information behaviour framework. Context acts as a frame of reference in which information behaviour can be observed. Thus, for the purpose of this investigation, Figure 7.1 illustrates an engineering project as a real life context in which a group of people, that is the project team, interact with information while simultaneously collaborating with one another to achieve their mutual goal. The people participating in the project are identified according to their roles (i.e. the architect, quantity surveyor and client), as well as the engineering disciplines that are represented by the consulting engineers. The double-headed arrows linking the different project team members show the bi-directional flow of engineering information among the individual team members. In addition to this bi-directional flow of information, the flow of all other information is also directed at the principal agent (or architect and sometimes the quantity surveyor). This information flow is depicted by single-headed arrows.

Dotted lines were used to draw the circle in Figure 7.1. This is an attempt to show that the context boundaries of an engineering project are not rigid, but act as a "semi-permeable membrane", which allows for a flow of information from outside the project boundaries to the project team. This is because consulting engineers also need information that is not available within the project team. These types of information include information from client organisations, the individual engineers' own organisations, colleagues, local authorities, personal social networks, etc. The single-headed arrows on the outside of the circle illustrate the flow of this "external" information through the circle's membrane to the individual project team members.

When considering that consulting engineers are simultaneously involved in multiple engineering projects, the consulting engineer can be visualised as being in the centre of a number of engineering projects (Figure 7.2). These can be current as well as previous projects, since each project bears on the engineer's personal experiences and knowledge. Also, relationships develop among team members during an engineering project. These relationships have the potential to affect engineers' information behaviour on other projects, where project team members are appointed to act as expert advisors on a different project. Therefore, the relationships that develop as a result of engineers' collaboration in different engineering projects contribute to the development of their social networks. In turn the consulting engineers' social networks can become sources of engineering information. A consulting engineer's project-related social network can be illustrated as follows:

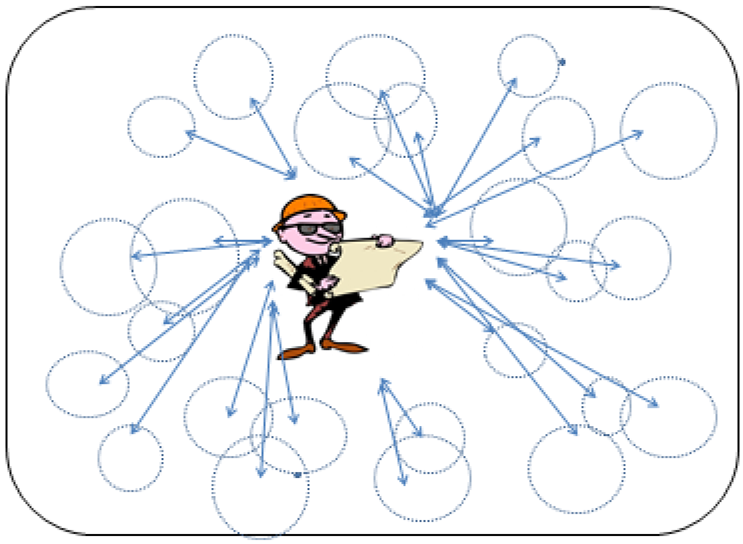


Figure 7.2 *Consulting engineer's network of projects*

The man in the middle of Figure 7.2 represents a consulting engineer. He is depicted as being in the centre of various engineering projects in which he is involved. These projects have either been completed or are still in progress. The circles represent different engineering projects. Some of the circles overlap and they show engineering projects involving team members who have previously been (or are currently) co-appointed to multiple projects. Furthermore, each project circle represents the consulting engineer's collaborative behaviour, illustrated in Figure 7.1.

However, the story of an engineering project also indicated that information could be transferred from one project to another. This implies that the information and experiences gained from earlier engineering projects could be applied to newer projects. These information sources could include previous tender documents or involve advice from former team members. It is possible that some former team members could be appointed to a new project. This suggests that there could also be a transfer of

information sources between different projects. It is not possible to illustrate the transfer of information sources between projects in Figure 7.2, since it is a one-dimensional figure.
Figure 7.2 is indicative of the complexity of consulting engineers' network of projects and it also shows how their involvement in other projects necessitates the development of their own social networks.

The story of an engineering project superimposed on the four components of the suggested information behaviour framework (Figure 2.1 and Figure 3.1). These components will serve as a point of departure for the thematic analysis of the empirical data in Chapter 8.

7.6 CONCLUSION

Narrative inquiry is a research approach and a data collection method. Narrative data can be analysed in various ways. One way is to re-story the data. This was the purpose of this chapter. Re-storying the data by telling the story of an engineering project supported the researcher in contextualising consulting engineers' collaborative information behaviour, which in turn can support a thematic analysis of the data. Re-storying can therefore also be utilised as a data collection method which enables the researcher to contextualise the data for the purpose of information behaviour research. The different project stages that are prescribed by ECSA (2014) provided the framework for the reconstructed story.

In order to summarise consulting engineers' collaborative information behaviour, Figure 7.1 was developed. This figure illustrates engineering projects as a collaborative information behaviour context. It also illustrates the complexity of consulting engineers' collaborative information behaviour. Since consulting engineers are involved in multiple projects simultaneously and, since former project information can be used on current projects, consulting engineers develop complex social networks. To show this development, Figure 7.2 was designed to illustrate the consulting engineer as being in the centre of a complex network of engineering projects.

The story of an engineering project provides a contextual point of departure for the thematic analysis of consulting engineers' collaborative information behaviour discussed in Chapter 8.

CHAPTER 8

REPORTING ON CONSULTING ENGINEERS' INFORMATION BEHAVIOUR

8.1 INTRODUCTION

Whereas the purpose of Chapter 7 was to provide a literary orientation to the analysis of the empirical data by developing a story of an engineering project, the purpose of this chapter is to analyse the empirical data thematically. The four components of the proposed information behaviour model discussed in Chapter 2, and which is illustrated in Figure 4.1, will provide the framework for the thematic analysis in this chapter. These components include the context, the personal dimension of consulting engineers, their information needs and collaborative information activities.

8.2 BACKGROUND

While reviewing the literature on the information behaviour of engineers, the researcher realised that the reported research focused on specific aspects of engineers' information behaviour. Although the contributions in the literature review of Chapter 3 to Chapter 5 were valuable, they did not really explain engineering projects and what engineering work entails. It seemed as if there was a gap in the understanding of why engineers interact with information in a particular manner. Telling the story of an engineering project provided the researcher with a real life situation, which could be compared to the proposed generic information behaviour framework in Chapter 2. In this manner it was possible to observe, identify and describe the interaction between elements in the work context of engineers and elements in their personal dimension that give rise to their information needs and subsequent information activities. In turn the discussions support the development of a framework that could be used to explain engineers' information behaviour as envisaged in Figure 8.1.

8.3 THE INFLUENCE OF CONTEXT ON INFORMATION BEHAVIOUR

Context is the first component in the proposed information behaviour framework that could affect consulting engineers' information behaviour. Throughout the literature review it was shown that engineers can have different work contexts. It became evident that the work context of consulting engineers, in particular, constitutes the engineering profession, the consulting industry, and engineering projects. Their involvement in engineering projects requires of consulting engineers to work in teams. Work teams are therefore important contexts which shape consulting engineers' collaborative information behaviour. Furthermore, as shown in section 5.3, certain contextual elements related to work teams influence the work team's collaborative information behaviour. These elements include organisations, work roles, tasks, a common goal and a common ground (section 5.3.1). Apart from these contextual elements, Borgatti and Cross (2003: 433) (as reported in section 5.3.1), identified certain contextual factors that are not team-related, which influence collaborative information behaviour. These factors include social networks, social relationships and access to information as factors influencing information behaviour.

In consideration of the story of an engineering project in Chapter 7, the following discussion will show the ways in which contextual elements, deriving from the engineering profession and the consulting industry, influence consulting engineers' project-related information behaviour. That is the engineering profession, organisational contexts, engineering projects, work roles and tasks.

8.3.1 Engineering profession

The engineering profession is an important context that influences engineers' information behaviour. In section 3.3 it was shown that engineering as a profession sets certain requirements in order to adhere to the objectives of a profession. These objectives require of engineers to act responsibly and ethically, render a high quality service and to adhere to safety standards. An analysis of the empirical data provided some evidence of how this is achieved through membership of statutory bodies and learned societies, engineering education and service delivery.

8.3.1.1 Statutory bodies and learned societies

With the exception of Engineer L, the collected data provided evidence of the responding engineers registration as members of the Engineering Council of South Africa (ECSA). The reason Engineer L gave for not being a registered engineer is because acoustic engineering is not officially regarded as an engineering discipline in South Africa and an ECSA registration is not required for acoustical engineering work.

While discussing the use of new products, for example tar, Engineer F explained that some clients would allow them to experiment with new products. When allowed some experimentation, Engineer F would then build "a test section" and write an article on their experiment and discuss it in forums where other experts are present. In this manner consulting engineers contribute to the development and transfer of engineering knowledge. He also referred to conferences and training opportunities that are offered by the forums in which he is involved. All the responding engineers indicated that they also attended conferences and went for training. As Engineer D noted, "So some of these conferences, they become a source of information, especially when you are sharing with your peers and when you discuss and people share from their experiences." Engineer D supports this view when stating, "You also get other information from our bodies."

Furthermore, engineers are required to attend such forums in order to accumulate CPD (continuous professional development) points in order to maintain their ECSA registration [Engineers D & G]. However, the narratives proved that engineers seem to have a problem in finding time to attend forum meetings. As Engineer I explained, "… and you only have so many hours". In order to solve this problem, engineers subscribe to courses presented on videos, which are then completed in their own time, "… and then you get your points" [Engineer I].

As discussed in section 3.3.4, engineering is a regulated industry and engineers' designs need to adhere to certain standards and regulations. It was with these requirements in mind that Engineer D noted: You would find that government is a big source of information because you have to comply to legislation, statutory regulations, you get from government." He further noted: "If I am looking at design specifications then I use SABS [South African Bureau of Standards]." Engineer E also indicated that he would get design codes and standards from the SABS. The regulations that building projects must adhere to are available from the local municipality within which the building site falls (section 7.4).

It thus seems that statutory bodies and learned societies not only regulate the engineering industry, but also ensure that registered engineers remain current by organising conferences, creating subject forums and requiring engineers to accumulate CPD points. Therefore, through the requirements they set for engineering work, statutory bodies can be considered as influential factors shaping consulting engineers' use of information.

8.3.1.2 Engineering disciplines

Various engineering disciplines were identified in section 3.3.2. Similarly, a number of engineering disciplines that are normally involved in a building project were identified in section 7.3.3. These disciplines include civil engineering, geotechnical engineering, mechanical engineering, electrical engineering, electronics engineering and acoustical engineering. Certain subdivisions in some of the engineering disciplines can also be identified. For example, civil engineering can be subdivided into civil and structural engineering, which in turn can be subdivided into steel and concrete engineering.

The responding engineers' narratives in Chapter 7 showed that some of the information that is required for an engineering project is supporting information, whereas the rest of the information is discipline specific. This finding is similar to the findings reported by Du Preez (2008) and Korobili, Malliari and Zaounidou (2011) in section 3.3.2. They reported that engineering disciplines only affect the selection of engineering sources.

8.3.1.3 Service delivery

The service delivery requirements that were discussed in section 3.3.5.2 include ensuring adherence to safety standards, accepting responsibility for their work and adhering to project time frames and budgets. An analysis of the responding engineers' narratives revealed the following measures taken to ensure the safety of their designs and the built product:

- The engineers' designs need to comply with local regulations and national specifications. In section 7.4.3.4, Engineer F explained that building projects need to be approved by the local authorities within which jurisdiction they fall. He also noted designs could be rejected, should certain elements in the design not comply with these regulations.
- The contractor has to keep certain documentation on the construction site. Engineer M referred to a safety file in which safety-related incidences are recorded. Engineer A discussed the role of a site diary in which all activities on the construction site are recorded for future reference. He also indicated that he would survey the construction site again before construction starts to ensure that all the measurements are correct. Lastly, Engineers F and I referred to "request for information" books and site instruction books in which instructions to contractors are recorded.
- A safety officer needs to certify that all the props (support structures) are in place before concrete may be poured. Engineer A further explained that engineers do slump tests to ensure the concrete mixture is as specified and to test the maturity of the concrete before the props are removed.
- Contractors are not allowed to work over weekends or after hours without the required permissions. This rule is enforced by the Occupational Health and Safety Act, the constructional regulations and municipal by-laws determining working hours (section 7.4.5).
- Only a professional engineer may sign technical reports [Engineer M]. As explained by Engineer M, the person signing the report takes responsibility for the report.
- Certificates of compliance (CoCs) are required for the electrical work and fire protection systems before the electricity may be switched on [Engineer M]. For this purpose, a person who is certified to sign the CoCs tests the installations to ensure the safety thereof. Engineer O also noted that some clients wish to be present when these tests are done and they then also sign the CoCs.

In addition to the afore-mentioned requirements, consulting engineers are also required to report safety issues they observe on the construction site. Engineer J shared the following: “If I see something that I think is incorrect, even if it is not impacting on me and my profession, but it doesn’t look right, I am going to raise it and say: ‘You have to check what they are doing on site’. That also goes with the indemnity we have, towards the public.” This example is supported by the following comment made by Engineer H: “At the end of the day I have the responsibility to ensure that the right thing happens.” However, all the responding consulting engineers noted that they act in an advisory role and cannot be held accountable for something that goes wrong should the client not accept their advice and install products that are not suitable for the specific application.

Apart from this adherence to safety issues and local authority regulations, the engineers also reported on their need to remain within the projects’ set time frames and budgets. This reporting is consistent with Czarniawska and Mazza (2003) and Glűckler and Armbrűster’s (2003) findings, showing time frames and budgets as being boundary service delivery parameters. This was reported on in section 4.3.1.2.

Based on this analysis of the responding engineers’ narratives, it is evident that the requirements set by the engineering profession are focused on high service delivery standards and ethical conduct, which give rise to information behaviour. For example: these requirements prompt certain needs for information (e.g. regulations and budget information), which in turn give rise to certain information activities. For example, the need to keep site diaries, report things that go wrong on the construction site and eventually sign documents (e.g. certificates of compliance) to confirm they had attended to all the requirements.

8.3.2 Organisational context

Organisations were identified in sections 4.3.1.1 and 5.4.1 as contextual elements in the consulting industry, as well as in work teams, which could affect consulting engineers’ collaborative information behaviour. In order to learn more about how organisations influence their collaborative information behaviour, the consulting engineers were asked to share some contextual information about their own organisations. The following is a summary of their responses:

- **Engineer A** works for himself and has an office at his home. He does contract work for other structural and concrete engineers. He has a partnership agreement with Engineer D's company but also does work for other structural and civil consulting companies, such as Engineers E and F's company.
- **Engineers B, C, J and K** work for the same electrical consulting engineering company. Engineers B and C are business partners. The company also employs a few draughtspersons. The engineers socially interact with each other and discuss their projects. "I design and finish my design and have somebody look over my shoulder and say that design is fine. … You can't work only on your own stuff" [Engineer K].Engineers can be involved simultaneously in five or more projects [Engineer K].
- **Engineer D** is a senior partner in what he describes as a relatively small multidisciplinary engineering company and is involved in structural engineering (especially steelwork) and electrical engineering. The company employs five civil and structural engineers and two electrical engineers, as well as six technicians and three electricians. Engineer D explains that "everybody is involved in everybody's project and the senior engineers check the junior engineers' designs". The company is ISO certified (ISO certification refers to the measures the company is employing to ensure the availability of project information within the company). "So, whatever information we have, there is a server and the information is made available on the server where everybody can get access to it." He also noted: "We are also required by our [professional] bodies, like ECSA, to build towards your [sic] development. So you will find that, within a given period you are required to accumulate a certain number of CPDs [continuing professional development points]." His company therefore has a training policy and budgets so that at least somebody attends a conference or two in a given year. He noted that they make a point of sending the junior engineers because "they are the ones that need to go, also for networking purposes". The reason he gives is that, "conferences, they become a source of information. Especially

when you are sharing with your peers and when you discuss and people share from their experiences, by saying this is how we handled this situation, or in terms of approaching certain situations, so they [conferences] also become sources of information."

- **Engineers E, F and H** work for a civil engineering company which employs around 50 engineers and technicians. Engineers E and F are company directors and Engineer H is a junior engineer who generally works under Engineer E. The company is subdivided into three directorates or sections: structural engineering (both structural steel and concrete engineering), civil engineering and road engineering. They also do land surveying. Each engineer is simultaneously involved in five or six projects where four or five persons work together with a senior engineer. Engineer E believes this arrangement allows for interaction among engineers and for mentoring. This view is supported by Engineer H when he states that, "I walk into my director's office and ask him when I don't know something". Engineer H also confirmed that he would generally be required to seek the information that is required from the local authorities, etc. – that is, he has to do the legwork. Also, Engineer H noted that Engineer E goes to a lot of trouble to bring him into contact with clients by involving him in smaller projects so that he can acquire experience. Engineer F noted the value of subject forums and conferences for the sharing of information. He also noted that he would send a junior engineer to do training on something new in their field of work. The junior engineer is then required to share the training information formally with the rest of the company, or at least with the engineers in the same directorate.
- **Engineer G** has his own mechanical engineering company. He used to work alone, but at the time of the interview he employed two young engineers. The three engineers in this company work on the same projects and are therefore always aware of what is happening. The young engineers act as design engineers, whereas Engineer G manages the projects and is also their clients' first point of contact with the company. He gradually introduces the junior engineers to clients and contractors so that they can develop their expertise and build trusting relationships with clients, other consulting engineers and contractors. He uses a tablet to communicate project-related information with his

colleagues in the office while he is away on site visits. In this manner they can always be updated on the latest developments regarding a specific project.

- **Engineer I** is a senior partner in a large engineering company. His company has offices in Pretoria, Durban and Cape Town and employs quantity surveyors, three architects, structural, civil, mechanical and electrical engineers. Engineer I has 40 engineers working for him and these engineers collaborate in groups, where each group has a team leader. They focus on industrial projects such as warehouses and infrastructure development. The engineers work in teams on projects and each team includes an experienced engineer, a junior engineer and two technicians. Engineer I further noted that the engineers in his company are involved in five to six projects simultaneously. The number of projects in which they are involved depends on the individual engineers' knowledge and personal capacity as well as the size of the project. The company is an ISO accredited company and has an IT network. The company uses FTP (File Transfer Protocol) sites and "Dropbox" to share information with their branch offices that do not have access to the central server in the head offices. Each project has a folder on a central server. All the information that is collected for the project is then saved on the server so that any person in the company can access that information should the need arise. They also have a checklist of documents that project team members must have collected and addressed during a project. The company has a library and a librarian. The librarian is also involved in maintaining the company's knowledge management system. The company holds regular "network evenings" (at least once a month) where the engineers can share their "lessons learnt" experiences and "learn from their elders".
- **Engineer L** is an acoustics engineer. He noted that he is not required to be a registered ECSA engineer to do his work. He works on his own and has an office at home. He generally meets the architect and individual consulting engineers at their offices when they need to collaborate. He has an extensive collection of textbooks and journal articles which he has collected over the years. Since acoustics is not tangible, he relies on textbooks and research reports to support his designs. He is always on the lookout for information that could be useful in his work.

- **Engineers M and N** are colleagues working for the same engineering company. This company is involved in structural, electrical, mechanical and civil engineering projects. The company is ISO accredited. All project-related information is therefore available to all the engineers in the company. The engineers work together on projects.
- **Engineer O** is an employee in an electrical and electronic consulting engineering company owned by two partners. The company also employs a draughtsperson and an office administrator. He often discusses his designs with his two senior engineers who also advise him. The company also sends him to various workshops to empower him.

From the responding engineers' narratives regarding their respective organisations, it seems evident that their organisational backgrounds vary. This includes variations in the knowledge and experience as well as the information resources (e.g. old tender documents that could be used as templates) that are available in the organisation. These findings endorse the findings by Aldrich (2006: 5) and Prekop (2002: 536) discussed in section 5.3.1. They found that organisations provide natural boundaries and have their own knowledge and other important elements that shape the information behaviour of individuals working in those organisations.

Furthermore, the data shows that the contextual elements influencing information behaviour that were identified as being present in organisations in Chapter 4 and Chapter 5 are also present in the consulting engineers' own organisations. These information-related contextual elements include information resources, social networks, contractual agreements, work teams, access to information and communication infrastructure, as identified below.

8.3.2.1 Resources

As reported on in section 4.3.1.1, Allen and Wilson (2003: 40), Rosenbaum (1993; 1996) and Solomon (1997: 1110-1111) noted that organisational resources shape information practices. In section 5.4.5, Attfield and Dowell (2003) subdivided organisational resources into cognitive and physical or external resources. This subdivision will be used to report on the resources that are available in the responding consulting engineers' organisations and how the available resources shape their information behaviour.

a. Cognitive resources

The concept "cognitive resources" refers to the cognitive knowledge and expertise that is available in an organisation or work team (Attfield & Dowell 2003). This was also discussed in section 5.4.5. An analysis of the empirical data on the organisational context in section 8.3.2 endorses their findings as it includes references to the knowledge and expertise resources that are available in consulting engineering organisations. For example, with the exception of Engineers A and L who work for themselves, all the responding engineers described ways in which younger and less experienced engineers are supported and knowledge is shared in the individual organisations. The means employed in supporting younger engineers varied from having a young engineer work in the same team as a more experienced engineer or by looking over the younger engineers' shoulders to see how they are doing. Peer reviewing each other's designs or having designs signed off by a senior partner is another example of how engineering organisations employ cognitive resources that are available to support their staff. The peer reviewing of designs and the means employed to support younger engineers are examples of expertise sharing. This was reported on by Tiwana and Bush (2005) in section 5.7.3.

All the consulting engineering companies, described in section 8.3.2, create opportunities where all staff members can be updated on new developments. For example, Engineers D, F and I told of information sessions their companies or work groups organise to share the knowledge they had gained from an external training programme with colleagues who could not attend these sessions. These practices are further examples of the expertise and knowledge sharing practices that were reported on by Tiwana and Bush (2005) and shows how social networks can be used to exchange new information, as it was reported on by Von Seggeren (1995) in section 5.4.4.

b. Physical resources

Physical resources are important information resources. This was reported on in section 5.4.1.5. In section 7.4.4 the engineers referred to making use of information sources that are available in their organisations' electronic archives. For example, Engineers D, H and J described using old tender documents when they prepare new tender documents. Engineer O also explained how old tender documents could be used to prepare cost estimates and budgets for the inception and concept viability stages of a project.

More examples were provided by Engineers D and I. They noted that project-related information is stored on central servers in their organisations. As Engineer D explained, "this also allows colleagues to learn from the project files what is happening on a project and enables them to use the same information on their own projects". The information saved on the central servers therefore has a dual purpose. It allows engineers to get access to information that could support them in current projects. It also supports engineers in the company in knowing what is happening on a project. Engineer H reported that he had to step in on projects where a former colleague had resigned and such files supported him in ascertaining what had happened on the project. The responding engineers' activities that are focused on the creation and sharing of documents endorse the findings on the document sharing and creation activities reported on by Hansen and Järvelin (2005) and O'Day and Jeffries (1993) in section 5.7.3.

Cognitive resources in organisations are therefore related to the knowledge and expertise that are available in the organisation. The available cognitive resources also contribute to the development of the engineers' social networks, which in turn act as an informal "database" of work-related information. The physical resources that are available in an organisation are the products of the engineers' cognitive output and are reused in an engineering organisation. Membership of an organisation and a social network therefore determine the access that engineers have to certain cognitive resources.

In consideration of this discussion on information resources, it seems as if the consulting engineers' use of cognitive sources is also characteristic of their information sharing activities. In turn these activities can also be linked to the engineers' tendency to communicate (and share) information informally in their social networks. Informal information communication and information sharing can therefore be viewed as information behaviour activities that are characteristic of engineers' information behaviour.

8.3.2.2 Social networks and social relationships

Social networks are further contextual elements that are present in organisations. As discussed in section 5.4.4, social networks not only shape information practices (Courtright 2007: 282), but also provide the foundation for collaboration and socialisation that may span organisational boundaries (Cho, Lee, Stefanone & Gray 2005: 430; Sonnenwald 1999: 180; 2008: 655). In section 7.3, the respondents confirmed that projects are performed by people and in section 7.5 that relationships develop among team members during an engineering project. The respondents' narratives showed that social networks are important for various reasons, for example:

- Acquiring information. Engineer D noted the importance of other consultants as sources of information. The reason he gives is that "the mistakes made by other people is a source of information for you". Engineer E provided some different examples. He indicated that he would phone suppliers for product information. Engineer M (in section 7.4.3.5) not only stressed the importance of building relationships with suppliers but he also indicated that "obviously when we start you depend a lot on your seniors. As you go, you also build your own relationships." Two conclusions can be drawn from Engineer M's comment. Firstly, it stresses the importance of social networks and, secondly, it shows the importance of social networks in an organisation.
- Learning to do one's work. Engineers B, C, E, F and I reported that networking opportunities were organised in their organisations. The purpose of these opportunities is to encourage social interaction among the engineers and to create opportunities to share experiences and learn from colleagues. Engineer

O also reported that he would discuss his designs with his senior engineer to ensure the correctness of his designs and that he had designed optimally.

- Collectively solving cognitive complex tasks. As shown throughout section 7.4, consulting engineers need to coordinate their designs and collectively find a solution to problems arising during the project development process. This is achieved through information sharing.
- Creating potential work opportunities. Engineer I noted that between 30% and 40% of engineering work are direct appointments that come from continuous clients – that is, clients with whom they have built up a positive relationship over time. Engineer A supports this view when he stated: “People get to know you through the work you do and that can lead to new work.”

From the above it seems evident that, in an organisational context, consulting engineers’ social networks tend to develop naturally to provide in a need for an appropriate information resource. Engineer I supported this view when he stressed the importance of maintaining contact with former colleagues, former student friends and persons from different disciplines. He also noted that social networks are important to retain existing clients. This view was supported by Engineer D when he noted, “You need to keep your clients very close so that if there is more work then they can think of you.”

In order to support the development of trusting relationships between contractor and consulting engineer, Engineer A occasionally organises social events after the site meetings that are held during the construction stages of the project. These events promote a more amicable relationship between consulting engineers and contractors. He organises these events after one of the regular site meetings. These social networking and social relationship building opportunities endorse Borgatti and Cross’s (2003: 433) observations on the value of social networks and social relationships in a collaborative work environment, discussed in section 5.2. They stressed the importance of social relationships in a collaborative environment for acquiring information, learning to do one’s work and to solve problems collectively.

It was suggested in section 3.8 that the shared experiences and relationships that develop from the social interaction in work teams contribute to the development of social networks and to social networks as sources of information. Furthermore, as observed by Nardi, Whittaker and Schwartz (2002: 207) and reported on in section 5.4.4, the relationships that develop in this manner may form the basis for future work. The reasons provided by the responding engineers to promote the development of social networks support this notion.

8.3.3 Projects

Engineering projects, as shown in the discussion on the engineering profession and practice in section 3.3.6, as well as the consulting industry in section 4.4.1, arecontextual elements which affect the information behaviour of engineers. The narrative of an engineering project in Chapter 7 revealed how an engineering project acts as a context affecting consulting engineers' information behaviour. It also shows the effect of certain project-related elements on the consulting engineers' information behaviour. These elements include the project team, contractual agreements or service delivery requirements (e.g. scope of works), the project stages, social access to information, and communication infrastructure. These elements are similar to the elements identified in the discussion on collaborative information behaviour in Chapter 5 and provide the framework for the following discussion.

8.3.3.1 Project team

As shown in Chapter 7, building projects are about people who are appointed to achieve a specific objective: the completion of some construction to the satisfaction of their client. This involves transforming someone's vision or ideas into something tangible irrespective of whether that vision or idea is a house, a road, or an office building, etc. A project team is therefore appointed to achieve this objective. As shown in section 7.3, they are appointed for their individual skills and knowledge and are often employed by different organisations.

In section 5.3, it was highlighted that team members have different expectations and perceptions of quality and success. The empirical data of this investigation revealed that, despite these differences, engineers “need to support each other’s designs” [Engineer E in section 7.4.3.1]. They also have different organisational constraints and priorities. In order to accommodate these differences, it is important that team members arrive at a common goal and a common ground.

Arriving at a common goal involves responses from the engineers’ personal dimension such as group learning, group problem-solving and group decision-making (Allen 1996: 57). Similarly, a common ground is a “shared cognitive understanding that allows collaborators to successfully coordinate their effort to accomplish joint work” (Finholt 2002). Considering the engineers’ narratives, arriving at a common goal can be challenging and can involve various activities.

A common goal activity requires of team members to establish what is wanted for the project. Since the architect is the “boss and whatever you are doing must speak to what he wants” [Engineer D], consulting engineers first need to learn what the architect wants. As observed by Engineer O, there are different “types of architects”. Some architects are prepared to accept the consulting engineer’s advice on how to approach the problem, whereas other architects are set on having their designs implemented as they visualise it. In order to adhere to the architect’s design requirements, engineers often have to redesign to find a different solution to their problem and in the process compromise their own designs. From the findings it seems that this autocratic kind of behaviour, exhibited by architects set on having their designs implemented as they visualise it, can apparently challenge the project team’s ability to arrive at a common goal and a common ground. This type of autocratic behaviour is contrary to the democratic processes that are required to arrive at a common ground, as observed by Shah (2012). Gray (1989) also noted that a democratic approach is designed at producing solutions to problems that cannot be achieved if team members had to work independently. As a result, the project team members’ responses to information are determined by the architect’s preparedness to negotiate design needs. These findings therefore support the views of Cheimets et al. (2009) and Lappalainen (2009), indicating engineers' need for technical negotiating skills, which is an element in the personal dimension of engineers. They also indicated that the application of these skills supports engineers in exploring the best solutions to the problem with which they are confronted. The reviewed information behaviour literature did not report on this need for negotiation skills.

A second common ground activity is learning fellow team members' needs and understanding how they work. Engineer I indicated his preference for working on projects involving project team members with whom he had previously worked. One of the reasons he gives is that they understand the nature of each other's needs. His preference was supported by Engineer D when he stated that, "If you have a core team that you work with where you know how things are done, it is much easier to work with ... there is not that learning curve to say what we are doing here is not the way that I want my things to be done …" These findings endorse the findings by Hyldegård (2006: 287) and Olson, Olson and Hofer (2005: 1) that people who had previously collaborated are likely to achieve a common ground when working on a different project.

A third common goal activity is to acquire an understanding of the context in which the product or system will be used (Rasmussen, Pejtersen & Goodstein 1994; Sonnenwald & Lievrouw 1996). The manner in which consulting engineers ascertain the context in which the system will be used is by establishing the client's needs. As explained by Engineer G, the client often has a concept (an idea) but is unable to define his exact needs. It is then the task of the consulting engineer to advise the client on the best solution to his problem and motivate his solution with costs. Engineer O provided a similar description of how he establishes his clients' needs. He explained that he provides his clients with different solutions to the problem. These solutions often prompt clients to express their needs, which in turn supports him in optimising his designs. The activities described by Engineers G and O are aimed at acquiring an understanding of the context in which the systems they are developing will be used, as well as activities aimed at arriving at a common ground.

In addition to establishing clients' needs, arriving at a common ground also requires that the "scope of works" is established – that is establishing the parameters within which the engineers will be working (section 7.4.1). It also involves establishing the deliverables – that is what the client will be getting once the project is completed. The scope of works is determined by the client's needs and what the client is prepared to pay. However, there are certain things that are not related to the client's needs that can affect the scope of works. These include the availability or non-availability of services such as water and electricity to the proposed building site. In order to ascertain the non-client-related factors affecting the scope of works, engineers also visit the proposed building site. Consulting engineers can only start creating their preliminary designs once they have determined the scope of works. Ascertaining client expectations and other things that affect the "scope of works" are examples of non-organisational or non-team-related factors that influence engineers' information practices. This was also identified by Lamb, King and Kling (2003) as factors affecting information practices and reported in section 4.3.1.1.

8.3.3.2 Contractual agreements

As discussed in section 4.3.1.2, the contractual agreements signed by consulting engineers and their clients set the parameters within which they work. The three parameters that were identified in section 4.3.1.2 and 4.4.1 are "level of effort", budget and time frame. The consulting engineers also identified the "scope of works" as an element that forms part of the contractual agreements they sign with their clients.

a. Level of effort and scope of works

In section 4.3 it was shown that the agreed "level of effort" determines the amount of time the consulting engineers need to expend on the project. Although not mentioned as being the "level of effort", Engineer F provided an example of how clients' requirements affected the "level of effort" he would expend on a project. The example he gave was related to road building projects. According to him, township developers want to save on costs and are generally not interested in paying for roads that would last longer than three years. This is different when compared to a national road agency who wants roads to last longer and whose roads are required to carry heavier traffic than roads in urban areas. As a result, township developers expect the consulting engineer to expend the minimum time and effort on the project. On the other hand, the National Roads Agency expects of the engineer to expend the maximum time and effort on the project. This example also shows how cost as a factor is linked to the engineer's "level of effort".

The "level of effort" to be expended is generally captured in the "scope of works" component of the contractual agreements they need to sign with their clients. As explained by Engineer I in section 7.4.1, the "scope of works" sets the parameters for the contract. Also, as noted by Engineer G in section 7.4.2.6, engineers can only prepare their preliminary designs and do cost estimates for the project once the "scope of works" is known. The "scope of works" therefore also influences the project budget and will determine whether the engineers can design for a "Ferrari or a Volkswagen Golf" as it was explained by Engineers F and I in section 7.4.1.

b. Time and cost

It was evident from the literature review, discussed in sections 3.3.5.2, 4.4.1.1 and 5.4.5, that time and cost influence engineers' decisions to select and use specific information. The responding engineers' narratives support this view. Engineer J provided the following explanation of how engineers view time and cost. He believes that time and knowledge is consulting engineers' biggest commodity and that they make money when they are able to "sell the same amount of knowledge in a little amount of time". This organisational need requires of consulting engineers to be involved in multiple projects simultaneously. In order to cope with the time restrictions that arise due to this requirement, consulting engineers "borrow [designs] from one project to another" [Engineer D]. This then also allows engineers to save time on their project designs and "to make a profit" [Engineer I]. The use of design software also supports engineers in saving time and in optimising their designs. This was reported on by Engineers H, M and O.

Another example of how time and cost affect consulting engineers' information behaviour comes from their preference for face-to-face communication. In section 7.4.5.3, Engineer F reported that he would rather phone than send an email as he is able to sort things out more easily. Phoning therefore saves consulting engineers' time in ascertaining the problem and its solution. Their decisions are then confirmed in an email.

Unfortunately, the challenges that consulting engineers experience in arriving at a common goal and a common ground also have time and cost implications. For example, the need to redesign continuously to comply with continuous changes in other team members' designs. Time spent on such changes results in having engineers spend more time on the project than what is "logically" viable [Engineer L].

The consulting engineers' responses to time as a factor in task completion also endorse the findings reported on by Case (2007: 154), which were discussed in section 3.3.5.2. He found that cost affects information behaviour as a "trade-off" between the efforts that are required to employ a specific strategy.

From the above it seems evident that contractual elements such as the "scope of works" and "time and cost" are determining contextual factors that trigger a cognitive response (i.e. level of effort) in the engineers' personal dimension. These responses reflect the existing relationship between the contextual and personal dimension components of the consulting engineers' information behaviour framework.

8.3.3.3 Engineering designs

From the responding engineers' stories in Chapter 7, it is evident that two stages in engineering projects are dedicated to engineering design. These stages are the concept viability and detailed design stages. The story in Chapter 7 shows how engineers start with a concept, collect information, and coordinate designs from various engineering disciplines to eventually produce a purposeful engineering structure. This description endorses the definition for engineering design provided by Hubka and Eder (1987: 123) in section 3.3.5.1. The responding engineers' stories show the process in which engineers make connections between seemingly unrelated ideas. The following description and comments made by Engineer D is illustrative of such connections:

The architect (or the project leader or principal agent) "is the boss and whatever you are doing must speak to what he wants". Although designs need to speak to [comply with] what the architect wants, “you must also give a bit of advice from your own experience as to say, ‘If we do things this way I think it can work out this way.’ And they can accept that or they can say no I want it this way. … Whatever they are doing, affects my design ...”

These comments, drawn from Engineer D’s story, illustrate the collaborative design process for a building in a similar manner as Alisantoso, Khoo, Lee and Lu (2006) described the design process of a vacuum cleaner, reported on in section 3.3.5.1.

A set of drawings and a tender document (sources of information) are the products of engineers’ work during the two design stages. In section 7.4.4 it was indicated that tender documents include the engineers’ design specifications and the bill of quantities. These documents are important sources of information and, as noted by the consulting engineers, they are legal documents which guide the implementation of the engineers’ designs. Furthermore, engineers also use tender documents’ “templates” from previous contracts [Engineers H & J] when preparing their tender documents for a new project. Therefore, tender documents are examples of both cognitive and physical resources that are available in engineers’ organisations and access to these documents are restricted to members of the organisation.

8.3.3.4 Access to information

Successful collaboration is dependent on access to information and the timeous exchange of information (section 5.4.5.2). As shown in sections 7.4.1 to 7.4.3, certain supporting information is required to complete an engineering project. This includes reports on the geological survey and the environmental impact study. Also, engineers require information on the client’s needs, the project budget and time frame.

In Chapter 7, it was shown that some of this information is collected by the principal agent, who could be the architect. Also, some of the individual engineering disciplines collect other generic information. For example, civil engineers collect information on the availability of civil services on the building site, structural engineers employ a geologist to conduct the geotechnical survey and electrical engineers determine the availability of electricity. Engineer I also indicated that his company have checklists to support the junior engineers in remembering that they have to access these documents when working on their designs. This requirement for supporting information also indicates interdependency among engineers for information, as well as a dependency on persons who are not formal members of the project team. The discussion in section 5.3 also identified interdependency as a prerequisite for collaboration.

However, successful collaboration is dependent on the timeous exchange of information. This was noted by Engineer N (section 7.3.3.2) and reported on by Sonnenwald (2008: 666) and Sonnenwald and Pierce (2000: 463). An example of the importance of timeous information exchange is provided by Engineer M in section 7.4.2.3. In this section he noted his dependence on information from the mechanical and electronic engineers to complete his design. Engineer J provided similar reasons why he has to share information with fellow project team members.

The flow of engineering information on a project is through the principal agent (often the architect). As Engineer I explained in section 7.4.2, the architect or principal agent is tasked with collecting the information from the different engineering disciplines that could affect the other engineering disciplines. However, despite this flow of project information, some engineers still need to communicate personally with the client to establish the client's needs. Engineer O explained the reason for this in section 7.4.2.4. According to him, clients do not necessarily know what they want and the principal agent also does not understand these complex systems. Therefore, even though the principal agent is supposed to share this information with the project team, some team members are compelled to seek the required information directly from the client.

In section 5.4.5.2, it was noted that information politics could prohibit the exchange of information. The forms of information politics that were identified by the respondents of this investigation included hoarding, distortion and blocking – these are all factors that develop in the personal dimension component of the information behaviour framework. For example, although the consulting engineers' stories did not reveal any information politics per se, Engineer I did raise concerns about hoarding. The effects hoarding has on information communication will be discussed in more detail in section 8.6.4.6.

In consideration of this discussion on the access to information, it becomes evident that engineers are interdependent on fellow team members, as well as persons external to the project team, for information. It is also evident that the principal agent is an important link in the flow of engineering information and that some blockage or distortion in this flow of information can have a negative impact on the engineering project. This is another example of the existing relationship between the context and personal dimension components of the information behaviour framework of consulting engineers.

8.3.4 Work roles

The discussion in section 3.3.7.1 identified work roles and associated tasks as two contextual elements affecting information behaviour. In section 7.3.3.4, the responding engineers described their roles as being project managers, designers and project developers, from its inception stage to the final handover. Since the responding engineers have to advise their clients throughout the project, they are also advisors. Furthermore, the associated tasks they are required to complete are representative of the different roles they fulfil throughout the project. For example, the resident engineer starts off as a member of the structural and concrete engineering design team, but when construction starts he becomes the structural and concrete engineers' eyes and ears on the construction site.

Two junior engineers were interviewed in this regard. Engineer H described his role as doing a lot of background work, engineering design and collecting information for projects. He also does a lot of site visits where he has to collect data. Decision-making is left to his senior engineer. Engineer G reported similar roles applicable to his junior engineers. Engineer O is the second junior engineer that was interviewed. He is responsible for his own projects but he continuously seeks his senior engineers' advice, who also "look over his shoulder" as a quality control measure. These two responding engineers reported work roles and information behaviour that are similar to the information behaviour reported on by Gralewska-Vickery (1976) in section 3.3.7.1. She reported that junior engineers did the footwork, sought advice from their supervisors and observed their behaviour.

8.3.5 Tasks

The concept “tasks” refers to the activities an individual needs to complete and which are governed by their work roles (section 3.3.7.2). The different stages in the engineering project dictate which tasks have to be completed during each stage (section 7.4), where “… a project’s starting has quite a lof of dynamics around it” [Engineer K]. Section 7.4 also shows that the tasks requiring completion during the preconstruction stages (the critical design stages) vary and involve activities such as planning, negotiation and design. These tasks therefore require information from various sources of information. This includes information from both formal and informal sources of information. Du Preez (2008: 321-322) and Freund et al. (2005: 16) reported similar findings.

However, tasks deriving from the construction phases evolve around managing the construction of the project and the implementation of the engineers’ designs. The information that is required for these stages comes from the engineers’ own designs and information from the contractors and sub-contractors. This supports Thomas Allen’s (1977) and Ellis and Haugan’s (1997) findings that engineers’ information needs varied as they progressed through an engineering project and that they took different courses of action to provide in their information needs. This was reported on in section 3.5.1.2.

8.3.6 Reflection on the influence of context in information behaviour

The discussion on the engineering context showed the importance of context when examining the information behaviour of consulting engineers. Furthermore, it also highlighted the complexity of consulting engineers’ information behaviour by showing the influences various elements within the different engineering contexts have on their information behaviour. These elements include the engineering profession, organisations and engineering projects. Other elements that were discussed include the work roles and tasks of consulting engineers. Although these elements can act as contexts on their own, they are also elements of the organisational context. This is especially the case with projects where projects could arise in an organisation but can also be external to the consulting engineers’ organisation and involve team members from various organisations. Furthermore, consulting engineers have certain work roles and tasks as members of their own organisations, as well as tasks and work roles they have to fulfil as members of an engineering project team. This discussion only focused on the responding consulting engineers' project-related work roles and tasks.

Social networks are other examples of organisational contexts but they can also be viewed from an individual engineer's perspective. Although social networks were discussed as part of the organisational context, the focus in this discussion was on the role of social networks as information resources in engineering projects. This is irrespective of whether the social network developed within the consulting engineers' organisations or whether it is a personal network that was developed and maintained over a period of time. This view was supported by Engineer I when he stressed the need to maintain contact with former colleagues, friends, existing clients and persons from other disciplines. This was reported on in section 8.3.2.2.

In the suggested information behaviour framework, Figure 2.1 (section 2.3.2), the personal dimension was identified as the second component of the information behaviour definition. The following discussion will now focus on how the personal dimension affects consulting engineers' information behaviour.

8.4 PERSONAL DIMENSION

As shown in Figure 2.1 (section 2.3.2), certain inner mental states can be associated with information behaviour. The states that were identified in that discussion include cognitive, conative and affective phenomena. The following paragraphs focus on how these phenomena manifest in consulting engineers' information behaviour.

8.4.1 Cognitive element

The cognitive phenomena that affect engineers' information behaviour, which were identified by B.L. Allen (1991: 7) and reported on in section 3.4.1, include conceptual knowledge (i.e. subject knowledge), task knowledge and knowledge of the resources that are used. All the responding engineers commented in their narratives on the value of their own personal knowledge and experience when they participate in a project. For example, contractors seek Engineers A's advice because of his experience and knowledge obtained as a resident engineer. Engineer F noted that he has an Honours degree and forty years of work experience: "As you grow older and continue to work with construction, then you know of the problem. Sometimes you see a problem coming. It starts in the design stage. You know when you do a design that you will not have problems because it worked previously." Engineer E provides a similar explanation when he stated: "It helps to know that a specific product didn't work on a similar project and you don't want to have the same problem again." These comments were endorsed by Engineer B when he regarded the experiences of older engineers as being "invaluable on project work". These examples of engineers' reliance on their own experience and other engineers' personal knowledge support the findings by Ellis and Haugan (1997), Fidel and Green (2004), Shuchman (1981) and Ward (2001), as discussed in section 3.4.1.

An observation made by Engineer L shows the possible effect of inexperience on consulting engineers' information behaviour. He observed that inexperienced engineers tend to prefer emails as a form of communication. This then provides the engineer with a record "to cover our backs" [Engineer M]. A more experienced engineer might not feel the need to keep a paper trail [Engineer D]. Engineer L believes "keeping a paper trail" does not necessarily solve the engineering problem at hand.

It is not only the cognitive phenomena of consulting engineers that affect their information behaviour. Their clients' knowledge could also have an effect. For example, Engineer E observed that a knowledgeable client knows best practices and would be prepared to pay for it even if they cost more. However, a client who does not know, would rather choose to follow the advice of a so-called "expert" who has a seemingly cheaper solution to the problem without realising that he could end up paying more. In order to solve this potential problem, consulting engineers then provide their clients with different solutions and simultaneously inform them what the implications for their choices would be. This was also explained in section 7.4.1 by Engineers F and I and by Engineers C and J in section 7.4.4.

8.4.2 Conative element

Conative phenomena are the second personal dimension element in Figure 2.1 requiring discussion. Two conative phenomena that affect information behaviour were identified in section 2.3.1.2. They are self-efficacy and learning styles and have been mentioned in the narratives of the responding engineers as reported below.

8.4.2.1 Self-efficacy

Self-efficacy (i.e. personal beliefs) seems to be very important for considerations of how individuals approach their tasks (section 2.3.1.2). In the field of engineering, self-efficacy is manifested through the questions raised by engineers at the onset of an engineering project (section 3.4.1.2). It is also reflected in engineers' ability to convert visual perceptions, ideas and technology into physical products. For example, the responding engineers' information activities, reported on in the inception and concept viability stages of a project (sections 7.4.1 and 7.4.2), are aimed at establishing their clients' needs. These activities are examples of their attempts to get an idea of what is required for the project and to enable them to convert these ideas into a physical product. The layering of the individual engineering disciplines' designs into one final product is a further example of engineering self-efficacy.

The conversion of ideas and technology into physical products is a complex process. The complexity thereof is captured in a comment made by Engineer J. He noted, "It is one thing to study something in theory and understand the theory perfectly and something else to go out to site and see how these things work together. How is it applied, and maintained and what they are supposed to do." Similarly, Engineer O described how difficult it is to describe something "in two dimensions" to someone (e.g. the draughtsperson) who only sees the engineering drawing and who cannot visit the construction site to see what the actual situation is. This is especially a problem in projects where new facilities are being installed in an old building. Engineer O explained that he then has to include extra detail to the drawing and "say okay, this thing should be there. … It cannot follow this route because there is no ceiling at this point …" This description offered by Engineer O endorses Allen's (in Veshosky 1998: 59) suggestion that communication with non-team members created a need to convey contextual information to ensure the colleague understood the problem. This was reported on in section 4.6.1.

Engineer E provided the following practical example which is evident of how self-efficacy affects information behaviour:

“We have the SABS codes, design codes. There are guidelines. … You use the guidelines as an alert for things you need to be looking out for. The important thing is, it remains guidelines. You are a professional engineer and you must apply the guidelines. You must use your own judgement. They [i.e. the architect and client] will tell you, you must design an office for 50 kilograms per square meter. However, this office’s dimensions will be different as less [sic] or more people will be working there. In the end, you need to decide whether you will follow the general guidelines, or use different guidelines or make your own assumptions. You just need to document your decision.”

The ability to make the decisions described by Engineer E is indicative of engineers’ personal beliefs of how a specific task should be approached. It is also indicative of engineers’ ability to visualise the problem and convert this into a physical product.

8.4.2.2 Learning styles

The discussion in section 2.3.1.2 showed that learning styles as a conative phenomenon can affect information behaviour in various ways. A comment made by Engineer M best expresses one of the most important ways in which learning styles affect engineers’ information behaviour. He noted: “Obviously when we start you depend a lot on your seniors.” Engineers H and O also confirmed their reliance on senior engineers for advice.

Engineers also learn through repetition. Engineer K best captured this learning style in his following comment: “You have been doing this repetitively. Even though it is not the same type of project, the philosophy [principle] is the same.” Engineer E confirms this view when he explains that “it is not necessarily a direct transfer of information. It is experience. … We know with this type of thing this is the case. … It is knowledge you have accumulated over years of experience."

Keeping in mind the value of repetitive work in ensuring high quality of work, Engineer I noted that his company's policy is to guide clients in using "tried and tested best practices". This then allows engineers to apply principles, standards and techniques they are familiar with and which they have used successfully in the past. This kind of behaviour also reduces uncertainty (an affective phenomenon). Similarly, Engineers B and C noted that the problems experienced and solved in one project become part of their personal experience and knowledge. In turn this experience and knowledge can then be applied to a different project when a similar problem arises.

The responding engineers' reports on how they learn through repetitive work endorse the findings by Gralewska-Vickery (1976), Rosenberg (1967), Taylor (1991) and Ward (2001), reported on in section 3.4.2.2.

8.4.2.3 Coping skills

Based on the literature review in section 5.5.2.2, it was observed that there are two conative phenomena that affect the information behaviour of project teams. These are motivation and coping skills. An analysis of the empirical data did not reveal the effect motivation has on the responding engineers' information behaviour. However, Engineer M gave an example of how feelings of being "overwhelmed" (coping skills) pressurised him in accepting the correctness of information included in as-built drawings, without confirming the actual situation on site. As a result, an electrical cable was broken and the electrical services to the construction site were interrupted. Engineer M's decision shows how his coping skills affected the quality of the service that was rendered. This was also reported on by Chowdhurry, Gibb and Landoni (2014).

8.4.3 Affective element

Trust and uncertainty are affective elements in the personal dimension that were reported on in section 5.5.3.

8.4.3.1 Trust

As defined in section 5.5.3.1 by Rousseau, Sitkin, Burt and Camerer (1998: 395), trust is a psychological state where people do not take advantage of each other's vulnerability and act positively towards one another. Engineer I provided a very practical example of what a trusting relationship entails. According to him, "engineering is about trusting relationships. Engineering projects are huge capital investments. When a person says 'I trust Mr X', more than persons or individuals are at stake. It could be a … [Company A] person or a … [Company B] person, at the end of the day he liaises with a person within a company. It is that person who serves him, helps him to sort a personal problem" [Engineer I]. Engineer G believes that liaising with the same person makes the client "feel safer". The relationship described here by Engineers G and I is a reflection on the trusting relationship that should exist between a client and a consulting engineer. Engineer I believes it is hard work to build a trusting relationship with a client.

It is with this trusting relationship between client and engineer in mind, that Engineer F noted that he could not experiment with his client's money when he designs, since the client holds the engineer responsible for the product. He would therefore use products he trusts and knows will work. It is when consulting engineers give their clients what they want and deliver quality products that they receive continuous appointments, as it was noted in section 7.3.3.

Engineers also build trusting relationships with their fellow team members. For example, Engineer L noted that he had worked with some consulting engineers for 25 years and those engineers know his needs and contact him when they start their designs. Engineer A supported this notion when he stated that there is a measure of understanding of how the former project team members approach their tasks and of what their personal preferences are. These findings endorse Borgatti and Cross's (2003: 432) findings, namely that collaborative information behaviour is promoted by trusting relationships where collaborators know what the other person knows, value that person's knowledge and timeously get to know what the other person is thinking. Furthermore, this kind of understanding makes it easier for team members to arrive at a common ground and a common goal, which in turn is a prerequisite for trust, as found by Olson and Olson (2000) and discussed in section 5.5.3.1.

It is also important to build a trusting relationship with the contractor [Engineer O]. When there is a good relationship between the contractor and the consulting engineer, “there is really no need to write down trivial things and try and always have a paper trail. But if you feel okay, this is critical and there needs to be a paper trail, you will put it in writing” [Engineer D].

From the above it seems evident that trusting relationships between clients and consulting engineers, among team members and between consultant and contractor are important for successful collaboration.

8.4.3.2 Uncertainty

Uncertainty was identified in sections 3.4.3 and 4.5.3 as an affective element of the personal dimension, which could also shape information behaviour. The narratives also provided examples of how engineers deal with task uncertainty. Working with a new project team, as opposed to working with team members the responding engineers know from previous projects, could contribute to or reduce the consulting engineers' feelings of uncertainty. The reason Engineer G gave in section 7.3.3 for the reduction of uncertainty when working with persons he knows is “I know how they work”.

The respondents confirmed that to provide some certainty that an engineering design is correct, they usually have someone else look at their designs and approve them. As explained by Engineer J, “*The advice from the next engineer who is not intimately involved in the project, will give a different perspective.” Engineer M noted: “I want someone to check how I worked my prices out, and for grammar.”* Engineer K regards this as a good practice to have somebody look over his shoulder to say the design is fine. He believes “you can’t work only on your own stuff”. Engineer O summarised the reasons for this practice when he indicated that he has some “peace of mind” when his senior engineer had approved his designs.

In addition to their own task uncertainty, contractors' uncertainty also shapes the responding engineers' information behaviour. For example, in section 7.4.5.3 it was reported that the responding engineers prefer face-to-face meetings with their contractors when the contractor is uncertain of how to proceed with the implementation of the engineers' designs. These meetings provide engineers with the opportunity to "explain" or "demonstrate" aspects in their designs that require clarification, to ensure that the contractor clearly understands what is required. However, when it is not possible to meet face-to-face, the responding engineers call the contractor telephonically to discuss the problem and find a solution. This preference for face-to-face communication and telephonic discussions (i.e. informal communication) is an example of how the responding engineers use informal communication to reduce the task uncertainty of contractors. Informal communication also supports the responding engineers in avoiding misunderstandings of how a design should be implemented.

8.4.3.3 Interdependency

In sections 7.5.1 and 8.3.3.4 it was shown that the responding engineers are reliant on people for information, especially fellow project team members. It was also shown that consulting engineers are often unable to proceed with their tasks without the information they require from fellow team members. This reliance on others for information reflects a kind of interdependency among project team members. As discussed in section 5.3, Gray (1989) identified interdependency as a prerequisite for work teams' ability to settle on a common goal. It was also reported in section 5.3 that Cleal, Andersen and Albrechtsen (2004) found that the degree of collaboration is determined by the degree of interdependency among team members to complete their tasks. According to them, interdependency is also reflected in the need of engineers for diverse information from other engineering disciplines. Interdependency could therefore also be a contributing factor to the development of engineers' social networks.

8.4.4 Reflection on the personal dimension

In summary, the discussion on the personal dimension of consulting engineers showed the interconnectedness between engineers' cognitive and conative abilities and skills.

The personal knowledge they had acquired through their formal education and from their involvement in repetitive tasks (i.e. repetitive learning) was highlighted by the responding engineers as important cognitive abilities. From the findings it appeared that the responding engineers' conative abilities (i.e. their self-efficacy, learning styles and coping skills) also play a prominent role when they are involved in decision-making tasks. This is reflected in the responding engineers' ability to apply their cognitive knowledge and experience to an engineering task.

Certain affective phenomena, such as trust and uncertainty, also have an effect on the responding engineers' information behaviour. Having trusting relationships with their contractors, clients and fellow project team members is the one affective phenomenon the responding engineers regarded as very important. Trusting relationships seem to affect the responding engineers' decision-making and project teams' ability to arrive at a common goal. Trusting relationships therefore also affect the responding engineers' reliance (interdependability) on fellow team members for information and support them in reducing uncertainty. This is especially true in instances where engineers trust a colleague to provide them with advice and confirm the validity of their designs. Furthermore, trusting relationships also seem to support the responding engineers in developing and maintaining their social networks.

The responding engineers' comments on trust also reflected their feelings of responsibility towards their clients and towards society. Their feelings of responsibility are further reflected in their reactions to feelings of uncertainty. Whenever the responding engineers are uncertain of the correctness of their designs or the solution to a problem, they seek advice from a more experienced engineer. Keeping a paper trail of decisions is another way in which the responding engineers reduce feelings of uncertainty.

8.5 INFORMATION NEEDS

From the discussion of information needs in sections 2.3.4, 3.5, 4.6 and 5.6 it was evident that information needs arise from the interaction between certain elements and situations in the context of the information user and certain elements of the cognitive phenomena in the information user's personal dimension. The following paragraphs will report the empirical findings on how the interaction between elements from the engineers' context and personal dimension gives rise to consulting engineers' information needs.

8.5.1 Information needs arising from the context

The contextual factors that give rise to information needs were identified by Savolainen (2012) and were discussed in section 3.5.1. These factors include situation of action, tasks and dialogue. From the narratives of the responding engineers it became evident that these factors are also present in the work context of consulting engineers and manifest themselves as identified below.

8.5.1.1 Situation of action

The concept "situations of action" refers to those circumstances that determine the conditions and requirements of action (section 5.6.1.1). The responding engineers' narratives revealed that multiple contexts and situations of action are present throughout an engineering project. Some examples of contexts and situations of action were reported on in sections 7.3.1.1, 7.3.3, 8.3.1.3 and 8.3.3.3 and include the following:

- The need to work in teams that include engineers from different engineering disciplines and other professionals such as architects and quantity surveyors.
- Team members come from different organisations with varied organisational requirements, support and resources (as shown in section 8.3.2).
- The project's time frame and budget.
- The client's needs and requirements. This includes a need for the timeous and comprehensive communication of client needs and requirements. This need was also discussed in section 5.6.1.2.
- The different engineering disciplines' needs and the need for individual engineering designs to adhere to the regulations and requirements that apply to the engineering discipline.

- The different solutions to the engineering problems posed by the architectural design. This is especially a problem when the architect's solution to the problem is different from the engineers' solutions to the same problem.
- The engineers also need business information, for example, product information, the costs thereof, and from where it can be procured.

These findings on situations of actions are indicative of the complexity of engineering projects and the various situational activities that contribute to the responding engineers' information needs. The responding engineers' information needs, although deriving from the project itself (i.e. the situation of action), are also embedded in the engineering profession (i.e. the need for designs to adhere to regulatory requirements), the consulting industry (i.e. clients' needs) and a collaborative work environment (i.e. the need to work with team members from different organisational backgrounds). The discussion in section 5.3.1.6 supports these findings on the complexity of engineering project-related information environments.

8.5.1.2 Tasks and related project stages

Tasks are a second contextual element that affects information needs. An analysis of the empirical data and the story of an engineering project (Chapter 7) show that the tasks requiring completion are determined by the project stage. Both the project-related tasks as well as the project stages therefore become factors that determine information needs.

In support of the finding on project stages as factors affecting information needs, evidence from the narratives showed that information needs are more diverse during the pre-construction stages of a project than during the construction stages. However, information needs are focused on solving engineering problems that arise during each stage of the project. These findings endorse the findings by Friedel and Liedtka (2007), Mueller, Sorini and Grossman (2006) and Ward (2001), as well as the findings reported on by Bruce, Fidel, Pejtersen, Dumais, Grudin and Poltrock (2003: 142), discussed in sections 3.5.1.2 and 5.6.1.2.

The project stages also determine the persons that consulting engineers need to approach for information. For example, consulting engineers need information from the client during the initial stages of the project, which is then implemented in their designs. In bigger organisations where junior engineers produce the designs and the company directors deal with clients (for example in the cases of Engineer H and the junior engineers employed by Engineer G), the director needs to provide the design engineers with information regarding client needs. In these examples, the design engineer has very little contact with the client during these stages and a gap could occur between what is required and their own visualisation of the solution to the problem.

The narratives also showed that information needs vary as a project advances. For example, the responding engineers need information from other engineering disciplines to complete their engineering designs. The engineering discipline will determine what information is needed from which engineering discipline – that is which team member should provide the information. These findings endorse Thomas Allen's (1977) and Ellis and Haugan’s (1997) findings that information needs vary as engineers progress through an engineering project and that different courses of action provide in their information needs.

The scheduling of tasks, especially during the construction stages of the project, also seems to affect engineers’ information needs. The narratives discussed in section 7.4.3.1 showed that information sharing is vital for the coordination of engineering designs. This was also previously reported on by Bryce Allen (1997) in section 5.6.1.2.

Lastly, the story of an engineering project also showed that the project team’s collaborative information needs do not replace the individual engineer’s information needs. Furthermore, the team’s information needs and the individual engineer’s needs occur concurrently. This was also reported on by Bryce Allen (1997) and discussed in section 5.6.1.2.

8.5.1.3 Dialogue

As indicated in section 3.5.1.3, information needs that arise from the dialogue in context are needs that arise within a social environment. It was also highlighted in section 4.6.1.3 that consulting engineers need to communicate project-related information. A comment made by Engineer D in this regard reflects the importance of a social relationship in his dialogue with a contractor or fellow team member. He said:

"[It] also depends on your relationship that you build. Because at times it is like when you have built a certain relationship there is really no need to write down trivial things and try and always have a paper trail. But if you feel okay, this is critical and there needs to be a paper trail, you will put it in writing."

As a result of Engineer D's good relationship with a specific person, he does not need to have a paper trail of everything. A need to build good relationships is also reflected in consulting engineers' need for social networks and their resulting need to network, as it was discussed in section 8.3.2.2. However, Engineer D also noted the value of keeping a paper trail when decisions are queried and to avoid misunderstandings. He argued that, "Fortunately we had also written [to the client's representatives] and the client's people ignored our advice in a way … the client … had not realised that this was the case." In this instance, the paper trail restored the client's trust in the engineer and their relationship.

8.5.2 Information needs arising from the personal dimension

The information user's personal dimension is the second component of the proposed information behaviour framework and it also manifests itself in the responding engineers' information needs. In sections 3.5.2, 4.6.2 and 5.6.2, the engineers' cognitive and affective elements were identified as being important in discussions on their information needs.

8.5.2.1 Cognitive element-

The cognitive traits of consulting engineers that give rise to their information needs, as identified in section 8.4.1, include their personal knowledge and experience, as well as their clients' knowledge of the problem. For example, Engineer B noted his need to spend more time with a client who doesn't know what his [information] needs are to ascertain his expectations of the project.

The responding engineers' cognitive traits also support them in remaining updated, reduce their uncertainty and to build trusting relationships, which in turn are manifestations of the affective structure of the personal dimension. Therefore, a lack of knowledge or experience can give rise to information needs that would reduce their uncertainty. This was also reported on in sections 3.5.2, 4.5.2 and 5.5.2.

8.5.2.2 Affective element

The responding engineers' narratives discussed in section 7.4.4 and 8.4.1 revealed that certain affective phenomena give rise to their information needs. The same phenomena were identified in the literature review (sections 3.5.2, 4.6.2 and 5.6.2) and include:

- Seeking advice. For example, Engineers H and J would consult a more senior person or the next engineer for advice or a different perspective on their designs.
- A need to build a trusting relationship with their clients and project team members.
- Interaction with others.
- Individual's approach. This need is reflected in the different approaches of architects and consulting engineers regarding the solution to an engineering problem.
- Perceptions of situations. Individual versus the project teams' perceptions of situations.

When viewed from an information needs perspective, the affective phenomena that were identified and discussed in section 8.4.1 now become factors that give rise to consulting engineers' information needs. Furthermore, it seems evident that the interaction between the cognitive and affective elements of the personal dimension also gives rise to information needs.

8.5.3 Reflection on information needs

The analysis of the responding engineers' narratives revealed that factors in both the context and the personal dimension of engineers give rise to their information needs. The most important information needs that were highlighted in the discussion on contextual needs showed the effect of organisational backgrounds and limited resources on consulting engineers' information needs. Organisations, social networks, projects, project stages and tasks are contextual determinants of information needs. This is due to the fact that the tasks requiring completion are determined by the project stage, and in turn determines the nature of the information that is required and from whom it is sought. From the narratives it is also evident that consulting engineers generally need information from people and the persons they approach are either members of the consulting engineers' social networks or are project team members. For this purpose team members include contractors. The findings highlighted two dialogue needs, namely, a need for good social relationships and negotiation skills.

Not much was reported by the responding engineers on their personal information needs, except for needs that can also be related to their contextual needs. These include a need for trusting relationships, a need to reduce uncertainty and to deal with their own information needs as well as with the group's needs. However, when considering the discussions on context and personal dimension, as well as engineers' contextual needs, a need for personal knowledge and experience is evident. Also, the extent of engineers' personal knowledge and experience determines the extent of their information needs in a project. The focus in the following discussion is on the responding engineers' information activities.

8.6 INFORMATION ACTIVITIES

As shown in the discussion on needs, certain elements in the consulting engineers' contexts and their personal dimension give rise to information needs, which in turn prompt them to become involved in various information activities. An analysis of the literature review chapters and the empirical data showed that certain information activities are important in a collaborative information environment such as that of consulting engineers. These activities include collaborative information seeking, communication, sharing, use, awareness of information and information gathering. The following discussion will focus on these activities as reflected in the narratives of the responding engineers.

8.6.1 Collaborative information seeking

As shown in section 5.7.1, the concept "collaborative information seeking" refers to the information-seeking activities performed by a team of users to inform their collaborative work. Furthermore, the activities can be performed by either individuals or by the group. The literature review chapters showed that elements from both the context and the personal dimension affect consulting engineers' collaborative information-seeking behaviour.

8.6.1.1 Contextual elements

The elements affecting collaborative information seeking in consulting engineers' contexts that were identified in section 5.7.1 include collaborative grounding, information sources and resources.

a. Collaborative grounding

The concept "collaborative grounding" refers to those activities aimed at constructing a shared understanding among collaborators (section 5.7.1.1). It became evident from the narratives of the responding engineers in section 8.3.3 that certain contextual elements in an engineering project can affect collaborative grounding. These elements include the principal agent, team members' needs, and understanding the context in which a system (e.g. a security system) will be used. These elements determine what type of information is sought and from whom it is sought.

b. Information sources and resources

The findings showed that consulting engineers seek information from a variety of sources. These include printed sources (i.e. textbooks, standards, regulations, codes of practice and journals), the construction site, the World Wide Web and personal contacts. The South African Bureau of Standards (SABS) showed to be an important resource for standards and codes of practice. Also, Google is an important search engine when seeking information from the Web. As Engineer F believes, “Professor Google is very knowledgeable and he is very patient.” He further stressed the importance of teaching engineering students information literacy skills so that they can differentiate between relevant and irrelevant sources of information.

According to Engineers D, F, L and O, conferences, workshops and discussion forums offered by engineering societies and industry, as well as networking opportunities within organisations, showed to be important sources of engineering information. Engineer D pointed out the value of other consultants as a source of information, stating as follows: “The mistakes made by other people is a source of information for you.”

Another source of information identified by the responding engineers – shown in sections 7.4.3.8, 7.4.4 and 8.3.3.3 – is the consulting engineers’ reuse of old tender documents, either as templates or to support them when budgeting for a new project. The availability and accessibility of these sources, as well as the availability of sources such as standards and regulations, does have an affect on the consulting engineers’ information-seeking behaviour. Engineer J believes that “Good engineering companies will keep a library and we will keep a template. Projects of similar nature will always be grouped together and we can always go back and say, ‘What went wrong on that project that we must try and cut down now?’” Engineer J’s explanation not only stresses the importance of keeping an archive of previous projects, but also provides a rough indication of their information organisation strategies.

A different example of how the availability of project information affects engineering design and the preparation of budgets and tender documents is provided by Engineer G. He noted that, due to the volatile exchange rate of the South African Rand, contractors in the air conditioning industry are reluctant to quote. This makes it very difficult to prepare budgets for projects as they now have to provide for this escalation in price over a period of time. For this purpose the responding engineers use business information that is published in the Department of Trade and Industry's consumer price indexes.

c. Projects

Engineering projects provide a context within which collaborative information-seeking takes place. Project-related contextual elements that were identified in section 8.3.3 as affecting consulting engineers' collaborative information-seeking behaviour include project teams, contractual agreements (i.e. level of effort, time and cost, etc.) and engineering designs.

d. Social networks

The responding engineers' narratives revealed that they purposefully create social networks for various reasons. Acquiring information was one of the reasons that were identified in section 8.3.2.2. Although the individual engineers' networks do not solely derive from their project work and their organisations, the information that is available in their networks does reflect the network members' personal knowledge and expertise.

8.6.1.2 Personal elements

The findings described in 8.3.2.1 showed that personal knowledge and expertise, as well as the knowledge and expertise of others, are typical sources of engineering information. Therefore, the knowledge and expertise that are available within a project team will also affect engineers' information-seeking behaviour. In turn this is also affected by the knowledge and expertise available in the consulting engineers' organisations and their social networks that have developed from project work.

8.6.2 Awareness and encountering

As shown in section 3.7.3, the concept "awareness" merely refers to being aware of information, whereas information encountering entails finding information accidentally.

In the case of the responding engineers, Engineer L drew attention to his information awareness when he noted that he would always be on the lookout for useful pieces of information. For example, he would follow up on references he picked up in conversations involving similar situations as the ones he encountered in his projects, which could be useful for his subject field. Engineer E provided a similar example. He related that his awareness of potential problems with a product is based on his experiences of having used the product on a different project. Not only are these descriptions of information awareness reflective of consulting engineers' personal knowledge and expertise, but it is also a means they apply to remain current. These findings endorse the discussion on information awareness in section 3.7.3.

An awareness of their team members' information activities updates consulting engineers on the current status of their team's activities (section 5.4.4). A comment made by Engineer J reflects the consulting engineer's creation of information awareness activities, which could also be described as alerting certain team members to his activities. He noted that he would send a copy to the main contractor when he issues an instruction to his sub-contractor in an email, "so that the main contractor is also aware of the situation". The main contractor needs to be updated on instructions as these could affect his building program as well as his budget for the work that has to be completed. Engineer D provided similar reasons for copying stakeholders in emails. The copying of stakeholders in emails can also serve as an example of the responding engineers' collaborative information gathering activities.

8.6.3 Information gathering

Apparently consultants generally have a streamlined process of information gathering (Mueller et al. 2006). As shown in section 4.7.2, the concept information gathering refers to the ways and means that are used to collect information. An analysis of the empirical data also showed examples of consulting engineers' information gathering activities. These include the information collection activities for their inception reports, to create their designs, to prepare tender documents, and to manage the implementation of their designs during the construction stages. These activities were described in section 7.4.

In addition to the activities that were described in section 7.4, Engineer G also reported on a "records for future" system which is kept up to date by the architect he is working with on a project. These activities resemble a personal information management system (PIM), which is intended for use by the project team. Similarly, Engineer I reported on the creation of project files on their server in which all documents that are related to the project are saved and made available in their organisation. Although the reviewed literature reported on the use of archived material, no evidence was found of engineers' activities in organising and archiving information for future use. These activities that are focused on making project information centrally available also show how information technologies have influenced engineers' information gathering and organising activities.

Lastly, one of the young responding engineers, Engineer H, reported that he is generally tasked to gather information for projects. His reporting endorses Ward's (2001) findings (in section 4.7.2) that junior engineers generally do the legwork.

8.6.4 Information use

Information use can be understood as the manner in which people handle information when they collect, search, access and communicate information (Meyer 2003). In section 3.7.4, it was indicated that the factors affecting information use can be subdivided into the context and the personal dimension of the user.

8.6.4.1 Contextual factors affecting information use

In the context of an engineering project, consulting engineers use different types of information. In addition to the project-specific information that has to be collected (e.g. the client's needs, geology survey results, environmental impact study reports and services available to the construction site), the responding engineers' information use is shaped by the information that is available in their own organisations and from the project team. This information includes previous project documentation which could be used for budgeting purposes or as “templates” to prepare new specifications and tender documents. These findings are similar to the findings reported on by Du Preez (2008) and Gralewska-Vickery (1976) in section 4.7.4. Also, the sources available in the responding engineers’ organisations, and which are used by them, are sources that are readily available and easily accessible. These findings concur with the findings reported on by Bin Guo (2007), Kwasitsu (2003) and Shuchman (1981).

In addition to the identification of the use of specific sources of information, the discussion in section 7.4 showed that different project stages can be associated with different patterns of information use. These findings endorse the findings reported on in section 3.3.6 indicating that engineers follow different patterns of information use as the project progresses.

8.6.4.2 Personal factors affecting information use

Elements in the personal dimension that affect the responding engineers’ information use derive from the cognitive and affective structures in their personal dimension. For example, the responding engineers’ personal knowledge and experience is one such element from their cognitive structures. This can be illustrated by observing the reasons why Engineers H, M and O use design software when they create designs. Engineer O explained that design software saves him time and supports him in optimising his design. He further explained that his senior engineer does not use design software as he already knows from experience what performance he can expect from the equipment he specifies.

Affective elements that were identified in section 3.6.4.2, which seem to be important when selecting information sources for use, include personal preferences and trust. Unfortunately none of the responding engineers explicitly indicated the role of these elements in their selection and use of information. They did, however, indicate their preferred means of communication (i.e. face-to-face meetings and email) and their preferences for products they have used and trust because of the positive experiences they have had with these products.

8.6.5 Communication

The responding engineers used the concept communication when they referred to the interpersonal communication among team members and the different forms of communication they employ to communicate information. In section 3.6.5 it was noted that some of the communication activities are also information sharing activities.

For responding engineers A, F and N communication is a key factor in engineering and “if there is not sufficient communication, things get mixed-up” [Engineer A]. This comment not only refers to interpersonal communication but also to the different forms of communication that are employed on an engineering project. According to Engineer D, it takes all forms of communication. These include formal communications such as engineering drawings and tender documentation, written communication such as email or instructions in the site instruction book, meetings, and informal communications such as telephonic discussions. The responding engineers’ narratives also revealed that formal communication structures exist in project teams.

8.6.5.1 Communication structures

An analysis of the empirical data, reported on in section 7.4.5.1, showed the communication structures in a building project. In that discussion it was shown that all communication flows via the architect (or the principal agent) to the project team and the contractor. The architect then filters (and disseminates) the information to all the consultants and acts as a link to the client [Engineer D]. Engineer N explained the need to filter information. According to him, sending documents to persons who are not involved with those documents “might blind” them. This is one way in which the principal agent attempts to avoid individual project team members from being overloaded with information.

On the construction site all information is rerouted via the main contractor to the principal agent and the respective consulting engineers. As Engineer D noted, "When I have done a design, I submit the design to the contractor who in turn submits it to the sub-contractor." When a resident engineer is appointed to the project, construction information is forwarded to the resident engineer who then submits the information to the contractor. However, some of the engineers did report communicating directly with the sub-contractor, but then they would always follow up the communication with an email of which the main contractor is sent a copy.

On a smaller project that does not involve a principal agent or a project manager, the information flows directly between the consulting engineer and the contractor.

It seems as if the communication activities of engineers and the means they employ to communicate are intended to avoid any miscommunication among team members. Furthermore, the communication structures and flow of engineering information on engineering projects act as control mechanisms to ensure that the main contractor and the principal agent are at all times aware of what is happening on the project. It also enables them to trace the responsible person if something goes wrong on the project. With the exception of Thomas Allen (1977: 291), who addressed the importance of organisational structures in communication, the reviewed literature did not seem to address communication structures on an engineering project.

8.6.5.2 Meetings

From the narratives it became evident that meetings form the basis for decision-making and are also a means through which information is shared among the responding engineers. Therefore, Engineer I holds the view that meetings form part of the contractual agreement with the client. All the responding engineers reported that they have regular bi-weekly meetings, of which the preconstruction meetings are focused on project coordination and planning, as well as design meetings. The meetings during the implementation stage are focused on site visits and progress meetings. All meetings are minuted and, as Engineer I explained, they are legal technical documents that support the implementation of the project. This implies that these documents are used to communicate and record design decisions, problems experienced on site (e.g. the effect of the steel strike in South Africa during 2014) and the project's progress. This information is later used to explain why the project was not completed on time or why it could not be completed within its budget. Apart from being an information communication activity, the minuting of meetings can also be viewed as an example of information gathering activities.

8.6.5.3 Formal communication

Engineers regard engineering designs and related documentation (e.g. tender documents, specifications, site instructions, etc.) as formal communication. Due to its written format, emails are also regarded to be formal communications [Engineer D]. As Engineer F noted, “A construction site is about documentation.” This is because documented instructions can be used to avoid disputes [Engineers A & H].

Emails are reliant on information communication technologies and can be used for both formal and informal communication. All the responding consulting engineers indicated emails as a preferred form of formal communication when confirmation or a brief answer is required. However, they all noted that they would write an email to confirm informal communications to ensure that all decisions are documented. They would also send the architect a copy, and in instances where the decisions have cost implications, they would send the quantity surveyor a copy as well. Sending email copies of these communications to the architect and quantity surveyor provides them with a budget control tool and alerts them to changes in the current state of the engineer’s budget for the project.

Keeping record of everything that happens on an engineering project is important. As Engineer J explained, these records support them in justifying additional costs on the project. Engineer G’s R&F (records for future) system, reported on in section 8.6.3, is another example of record keeping. Record keeping is an information gathering activity and it supports consulting engineers in reducing their uncertainty.

8.6.5.4 Informal communication

Face-to-face communication, telephone calls and short messages, using social network platforms such as WhatsApp and SMS (short message services), are regarded as informal communication. From the narratives discussed it became evident why informal communication plays such an important role in consulting engineers' communication behaviour. Although all the responding consulting engineers confirmed the importance of formal communication, they all indicated a need for informal communication. This is because "certain issues are best to deal with face-to-face" [Engineer D]. Engineer L explained this from an acoustics engineering point of view. He noted that acoustics do not form part of most people's environment and that a face-to-face discussion supports him in explaining what is required in a better way. He would even demonstrate the use of certain products to support his explanations. In this way misunderstandings can be avoided. This is also the reason Engineer O gave for his preference for face-to-face meetings. Furthermore, all the responding engineers indicated that face-to-face communication also supports them in collaboratively finding a solution to a specific problem and to answer other questions that may arise from the discussion.

Due to time and distance-related factors, face-to-face meetings are not always possible. In such instances the responding engineers would make a telephone call to discuss the problems at hand. In addition to making a telephone call, Engineer O also noted the use of WhatsApp to communicate with his contractors. Since WhatsApp communications are not generally accepted as being legally binding, Engineer O always follows up WhatsApp communications with a site visit or a formal email. None of the other responding engineers admitted to using WhatsApp as a means of communication. In fact, Engineer I noted that he requested a client to stop using WhatsApp when communicating with one of his junior engineers because it is not an accepted practice. These findings endorse the findings by Finholt (2002) and Kakihara and Sørenson (2004: 181), discussed in section 5.4.5.3, on the use of mobile technologies for virtual communication with a large range of people.

In addition to being an important form of communication during projects, Engineer G provided another reason for informal communications. He noted that informal communications support him in building relationships. Considering the importance of personal relations and social networks for engineering work, this is a very important reason and a good example of an engineer's social networking activities. This reason for informal communications was not revealed in the reviewed literature.

8.6.5.5 Information communication technologies

Certain information communication technologies are utilised to communicate project-related information and as a result support information sharing. For example, Engineer G reported that he acquired a tablet to communicate information and decisions deriving from meetings via email with his two colleagues in the office who had to implement those decisions. His reasons for using a tablet concur with the reasons reported on by Burford and Park (2014) in section 5.4.5.3. They found that mobile devices are valuable access points for digital information such as email.

The use of photographs is another communication-related technology that was reported on by the responding consulting engineers. Although photographs and photography are not generally associated with information communication technologies, it is discussed here since the responding consulting engineers generally use their cell phone cameras to photograph developments and problems on a construction site. They do this for record-keeping purposes as well as for communication purposes. Engineer M explained that, in instances where he could not go to a site and assistance was required, he would request the contractor to take a number of pictures showing the trench or installation from different angles. This then enables him to evaluate the situation and suggest solutions to the problem.

Other evidence of the role of information technologies that were reported on, but which will be discussed under information sharing (section 8.6.6), include Dropbox and FTP sites.

Engineer L raised some concerns about the use of electronic communication tools. He advocates the value of face-to-face meetings and believes that electronic communication tools could have a potentially negative impact on engineering communication. According to him, some engineers don't do their work by timeously sorting out issues with the correct person. They then hide behind emails. It was noticed in the narratives that all the older responding engineers commented on the younger engineers' preference for email as a communication tool. Engineer I also reported that he would at times instruct his younger colleagues to have face-to-face discussions on aspects of their designs, and have all communications documented, rather than sending each other emails. A possible reason for these concerns was highlighted in section 8.6.5.4, where the value of informal communication for relationship building was discussed. The older engineers' concerns on the use of electronic media were not reported on in the reviewed literature and it could be an indication of how modern technology is changing the manner in which people communicate.

8.6.5.6 Factors inhibiting communication

Certain aspects in consulting engineers' contexts and personal dimensions also act as factors that inhibit communication. For example, Engineer I expressed concerns about team members hoarding information and not making it available. He noted the implications this has during the design stages and in instances where the engineer resigns from his company and by implication from the project. This example supports Allen and Wilson's (2003: 33) findings on information politics that were discussed in section 5.4.5.2.

In sections 7.3.3.1 and 8.3.3.1 it was reported that some architects are set on having their creative designs executed as they have visualised it and then tend to ignore the consulting engineers' suggested solutions and requirements. This finding endorses Thomas Allen's (1977: 232-233) finding on social norms, where work roles can undermine communication. It was also reported in section 5.4.3 that this kind of conduct inhibits creativity and information sharing.

8.6.6 Information sharing

As shown in section 5.6.3, information sharing is a social act and includes activities that are undertaken to identify and resolve shared information needs. As reported on in section 7.4.5.1, the purpose of information sharing in engineering projects is to ensure that the information deriving from the different engineering disciplines interlinks with the project as a whole. This view endorses the discussion in section 5.7.3 indicating that the context determines the type of information that is sought and shared.

A further reason for information sharing was reported on in section 7.4. This is to avoid the duplication of information-gathering activities. The specific project-related information that is shared is discussed in section 8.6.6.1. This reason was also reported on by Cross, Rice and Parker (2001: 440) and Olson, Grudin and Horvitz (2005: 1985) in section 5.7.3. Activities that were previously regarded to be information transfer or communication activities are also characteristic of information sharing (section 3.7.6). This supports Talja's (2002: 3) view that information sharing is an umbrella term for many collaborative information behaviour activities. However, the discussion in section 3.7.6 highlighted that the concept "information sharing" incorporates explicit and implicit information exchanges (Talja & Hansen 2006: 114). It also denotes "information exchanges among those involved in solving a problem" (Fidel, Pejtersen, Cleal & Bruce 2004: 944). The empirical findings on information communication, reported on in 8.6.4, endorse these views. This is because information communication activities such as meetings, and informal communication such as face-to-face communication, are also information-sharing activities. As shown through the responding engineers' stories in Chapter 7 and the discussion in 8.6.4, meetings and other forms of informal communication are focused on exchanging project information and solving engineering problems. These findings also endorse Ellis and Haugan's (1997: 392) findings on the role of meetings and electronic systems in both the communication and sharing of information.

Other informal information-sharing activities that were not discussed in section 8.6.4, but which were reported on by the responding consulting engineers, include conference and workshop attendance as well as participation in discussion forums (section 8.6.1.1b). In addition to these, Engineer I reported that the librarian in his organisation organises monthly social networking evenings for the purpose of information sharing. Similar activities were also reported on by Engineers B, C, J and K as well as Engineers E, F and H. These activities are examples of "less goal oriented" information sharing that was also reported on by Talja and Hansen (2006: 114). Furthermore, as stressed by Engineers D and I, these information activities are also focused on relationship building and networking.

8.6.6.1 Project information that is shared

Apart from the information that is communicated to team members and contractors, the responding consulting engineers also reported on project information that needs to be shared with the project team. For example, Engineer J indicated that he needs to share information with the architect, quantity surveyor and civil engineer on the availability of electricity services to a construction site and when it will be connected. They rely on that information for budgeting and coordination purposes. This was also reported on in section 7.4.2.3. In addition to sharing information with project team members on the services that are available, Engineer H also reported that he would often share civil services information with the local municipality. This is especially in instances where services were installed before the municipality recorded the position and nature of such services. The as-built drawings discussed in section 7.4.6 are used for this purpose. These drawings are also examples of records for future use as they become important sources of information when a building is renovated or changed after some period of time.

Other project-related information that needs to be shared with certain team members, that were reported on in section 7.4, includes civil services, environmental impact reports, geotechnical reports, and engineering drawings. Although regarded as a resource, tender documents and specifications are also documents that are shared in companies, especially when engineers use them as “templates” to prepare new tender documents. This was discussed in section 8.3.3.3.

8.6.6.2 Electronic information sharing

Information is shared through communication and through the use of technology. Information communication technologies make it easier to transfer information and make information resources available to project team members who come from different organisational backgrounds. As discussed in section 5.4.5.3, information technologies support engineers in bridging time and distance barriers. The responding engineers described (in section 8.3) how they use servers to store information so that it is accessible to everybody in the organisation. Engineer I also referred to using Dropbox and FTP sites to share information between their different branch offices. Engineer J noted that FTP sites are also created for specific projects and are mainly used to share engineering drawings. Engineer I indicated that they would also upload Bill of Quantity lists and project specifications. The information that is available on the FTP site cannot be changed, but it can be downloaded and used for other purposes.

8.6.7 Reflection on collaborative information activities

This discussion on information activities focused on the responding consulting engineers' collaborative information seeking, awareness, information gathering, information use, communication and information-sharing activities. The discussion showed the influence that elements in the context and in the responding consulting engineers' personal dimension have on their information behaviour. It also provided reasons for the engineers' involvement in specific activities.

Meetings, formal and informal communications and information sharing are important information activities of consulting engineers. Some of the activities that were discussed as information communication activities are also information-sharing activities. In turn, information-sharing activities support the interlinking of designs emanating from the various engineering disciplines. These activities also avoid the duplication of information-gathering activities.

This discussion on communication as an information activity stressed the importance of information communication for engineering work. Informal communication such as face-to-face meetings and telephone calls are not only used to communicate and share information. These activities also contribute to relationship building and in turn are subconsciously aimed at expanding consulting engineers' social networks. This was shown to be an important contextual resource and source of information. Furthermore, the discussion in section 8.6.1.1d also suggested that the engineers' social networks are a reflection of the knowledge and expertise that are available in the network.

8.7 MANIFESTATION OF CONSULTING ENGINEERS' INFORMATION BEHAVIOUR

As in Chapter 2 and the consecutive three literature review chapters, the information behaviour framework that was based on Wilson's (1999; 2000) encapsulating definition of information behaviour provided the framework for this chapter. The empirical data was therefore analysed according to the responding engineers' context, personal dimensions, information needs and information activities. The findings from the narratives support the views expressed in the literature review chapters that information needs evolve due to the interaction between elements in the contexts in which they originate, as well as elements in the personal dimensions of individuals. In turn, information needs give rise to information activities such as seeking, awareness and encountering, gathering, use, communication and sharing. Elements in the individual's context and personal dimension also shape these activities.

The findings showed that factors in consulting engineers' contexts that influence their information behaviour are a combination of elements or situations of action that derive from both the engineering profession and the consulting industry. The situations of action include engineering projects, their social networks, work roles and tasks. A comparison of the literature review chapters, the story of an engineering project and the empirical data in this chapter confirms the importance of social networks as an information resource. The consulting engineers' reliance on people (interdependency) for certain engineering information was shown to be the reason for the evolving of social networks. To further stress the importance of social networks, the findings also revealed that consulting engineers are highly dependent on information from their social networks. They therefore purposefully use certain communication and information-sharing activities to develop their personal relationships and social networks. These activities include face-to-face communication, meetings, social networking sessions and the attendance of professional forums such as conferences and workshops.

The experiences gained from engineering projects contribute to consulting engineers' personal knowledge and to their experiences of working with certain people, or of using certain products. It seems evident from the findings that the acquired knowledge that can be derived from consulting engineers’ experiences then becomes a resource for future engineering projects, which results in more appointments to other engineering projects.

Consulting engineers’ experiences of working with people support them in developing trusting relationships. It also develops their awareness of what can be expected when working with a certain person, especially when they work together on consecutive projects. This then saves them time in that they already have an understanding of how the other person works and what his design needs are. It similarly creates an awareness of the potential design problems they could encounter when working with certain individuals. In this manner, engineers’ social networks have a cohesive role that supports them in streamlining their activities.

The information activities that were considered in this discussion include collaborative information seeking, awareness, information gathering, use, communication and sharing. The consulting engineers’ involvement in each of these activities was not only prompted by events in the context in which their information needs arose, but was also shaped by certain aspects in the consulting engineers’ personal dimension. These include the engineers’ subject knowledge and experience, their subjective intuition, their ability to apply their knowledge to the problem at hand and the trust they place in their project team members. Some of the activities were also aimed at reducing their uncertainty, for example, their need to keep record of decisions that were made.

The creation and sharing of documents were not discussed in this study as an information activity per se, and have received very little attention in the information behaviour literature focusing on engineers. This study also did not pay much attention to engineers’ archiving and information organisation activities. These activities also did not receive much attention in the information behaviour literature focusing on engineers. However, an analysis of the narratives in this chapter does include references to “creation” activities, as well as archiving and information organisation activities. These are aspects that should receive more attention in future research.

The data analysis in this chapter shows that the four identified components that underlie Wilson's (1999) information behaviour definition give rise to information activities such as information seeking, use, sharing and information communication. In the instance of consulting engineers, the findings showed that the interaction between the found components also gives rise to the creation of a social network exclusive to the members of the team. The information behaviour definition of engineers was illustrated graphically in Figure 4.1. Following the story of an engineering project in Chapter 7, and with the thematic analysis of the empirical data, it is now possible to adapt the framework depicted in Figure 4.1 to include more detail of the consulting engineering context, as illustrated below:

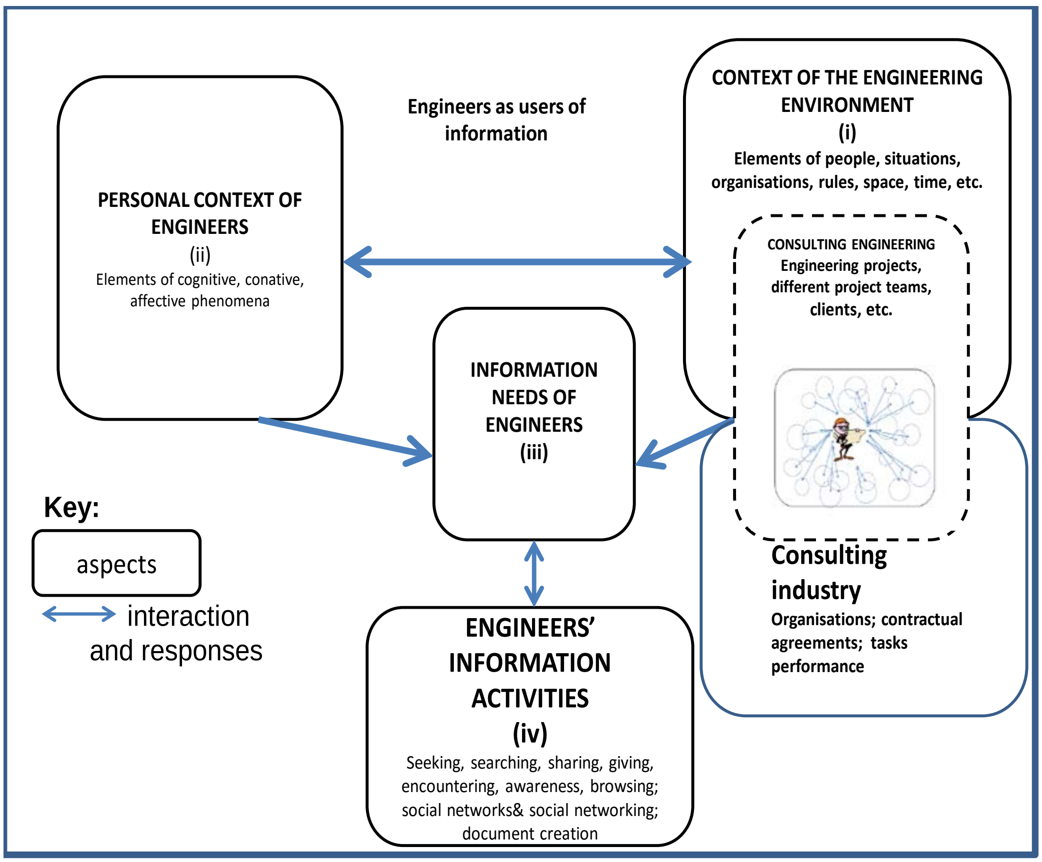


Figure 8.1: Framework of consulting engineers' collaborative information behaviour

In order to provide more detail to the consulting engineers' context in the framework illustrated in Figure 8.1, Figure 7.2 was used. This figure shows the complexity of the consulting engineer's network of projects and visualises the consulting engineer in the centre of various engineering projects. Figure 7.2 also visualises each project as a context which, along with several other factors such as consulting engineers' personal dimensions and interdependency on people, shape collaborative information behaviour. In the explanation of Figure 7.2 (section 7.5.3), it was suggested that Figure 7.2 can also be illustrative of the contributions project work makes to the development of engineers' personal knowledge, experience and social networks. Figure 7.1 illustrates the manner in which projects as a context shape consulting engineers' information behaviour. Although it is not possible to include all possible elements of the different components in the framework, this figure can therefore also be used to provide even more graphic detail to Figure 8.1.

8.8 CONCLUSION

The purpose of this chapter was to analyse the empirical data thematically. For this purpose, the information behaviour framework that was developed throughout the literature review chapters served as a template to test the findings and eventually develop and propose the new framework, depicted in Figure 8.1. The latter reflects the role of social networks in the information behaviour of consulting engineers.

The findings confirmed that social networks are important sources of engineering information. In addition to being important sources of information, the findings also showed that consulting engineers are highly dependent on their social networks to streamline their work and for information control among team members. Since social networks are so important to consulting engineers, the creation of their own social networks follows naturally.

Chapter 9 will address the conclusions, limitations and recommendations of this study.

CHAPTER 9

CONCLUSIONS, LIMITATIONS AND RECOMMENDATIONS

9.1 INTRODUCTION

The purpose of this chapter is to discuss the conclusions to the research questions that were formulated in Chapter 1. The limitations of the study will follow the conclusions to the research questions. Thereafter suggestions for further research will be made and the value of the study will be discussed. The final summary and comments will conclude the chapter.

9.2 CONCLUSIONS TO THE RESEARCH QUESTIONS

In Chapter 1 it was suggested that consulting engineers rely on persons for information. It was also suggested that engineers develop social networks to support them and that consulting engineers' social networks could play an important role in their information behaviour. With this in mind, the research question was formulated as follows:

> What is the role of social networks in consulting engineers' information behaviour – with special reference to consulting engineers in South Africa?

In order to answer the research question, the following sub-questions were identified:

1. What are the key concepts contributing to the information behaviour of consulting engineers?
2. Which elements are typical of consulting engineers' work environment?
3. Which elements in the personal dimension of consulting engineers affect their information behaviour?
4. Which information needs necessitate collaboration among team members of a consultancy engineering project?
5. What information activities arise from the interaction between the engineering context and the personal dimension of consulting engineers?

6. Which sources of information take preference during task completion of a consulting engineering project?

These research questions were addressed theoretically and empirically in order to acquire an understanding of consulting engineers' information behaviour and to learn more about the information activities in which they are involved. By learning more about consulting engineers' information behaviour, it was possible to learn more about the role social networks play in their information behaviour. The following paragraphs will answer the research questions.

9.2.1 Research question one: What are the key concepts contributing to the information behaviour of consulting engineers?

The purpose of the first research question was to establish a conceptual framework for the study. The conceptual framework for this study is based on Wilson's (1999; 2000) encapsulating definition of information behaviour and the contributions other researchers made to the different components that make up the information behaviour framework (section 2.3). The same components were used to formulate the operational information behaviour definition for the study (section 2.5). Four components were chosen for the discussion, as they seemed to be most important for this study. These components include context, personal dimension, information needs and information activities.

9.2.1.1 Context

The context component of the conceptual framework was described as a setting or an information use environment which included a combination of elements such as social environments and situations of action, in which information activities are embedded. Furthermore, contexts also have boundaries and some of the boundaries that were identified include space, time, organisations, goals and tasks. The different elements of context also become factors affecting information behaviour.

9.2.1.2 Personal dimension

The personal dimension component refers to engineers' inner mental structures that are associated with their information behaviour. Three inner mental states were identified in the literature. These are consulting engineers' cognitive, conative, affective and/or sensorimotor structures. The findings and the literature review showed how elements in the personal domain, as well as the interplay between these elements, shape consulting engineers' information behaviour.

9.2.1.3 Information needs

Information needs are the acknowledgement of a knowledge gap which requires information to achieve a goal. In order to acknowledge a knowledge gap, the current levels of knowledge are compared with the goal states. However, certain conditions are required to give rise to information needs. These are the reduction of uncertainty and making sense of something. Therefore, as a result of the interaction between the condition and the acknowledgement of a knowledge gap, information needs prompt information activities that are observable information behaviour. Information needs can be cognitive or social needs.

The findings and the literature review revealed that the context or situation in which a problem originates seems to be the root cause for the development of information needs. The contextual elements that were identified as being important to consider include the following: the nature of the engineering task, the frequency with which the need arises, the importance of the need, and the complexity of the task from which the information need arose. Lastly, the findings also showed that certain contextual information is task or project-specific and it is not applicable to a different project. This implies that certain contextual information can seldom be re-used on a different project.

9.2.1.4 Information activities

The literature review and the findings revealed that information activities are prompted by information needs that arise in the work environment of consulting engineers. These activities can be observable or unobservable and can take place in a social context. The observable activities that were identified include information seeking and use. The unobservable activities that were identified include serendipitous encountering of information and awareness. The information activities that are restricted to a specific context, requiring collaboration with fellow team members, involve information sharing, giving and communication. The findings revealed that consulting engineers are involved in all of the mentioned information activities.

9.2.1.5 Summary of key concepts

The focus of this question was merely to identify the key concepts that needed to be considered to enable the exploration of engineers' information behaviour and which were used to develop the conceptual framework for the study. The findings revealed that the existing interaction between different components in the framework, such as the context and personal dimension, give rise to information needs. In turn, information needs can prompt certain information activities. Furthermore, each of the four components consists of a number of elements, where the different elements can also be factors affecting information behaviour.

9.2.2 Research question two: Which elements are typical of consulting engineers' work environment?

Various elements that shape their collaborative behaviour could be identified in the work environment of consulting engineers. The findings and literature review showed that the elements typical in the work environment of consulting engineers differentiate them from engineers working in other environments. These elements derive from the engineering profession and the consultancy industry. Furthermore, it was also shown that the engineering profession and the consulting industry are two different contexts that, in combination, influence consulting engineers' information behaviour.

9.2.2.1 Engineering profession

From the literature review and the empirical findings it is evident that the engineering profession sets certain requirements to adhere to the objectives of a profession. The elements that could be identified in the engineering profession include membership of statutory bodies and learned societies, engineering disciplines, and service delivery requirements. These elements were shown to affect the professional conduct and information behaviour of consulting engineers. The reason that could be derived from the findings is that the requirements set by the engineering profession are focused on high service delivery standards and ethical conduct. In order to comply with these requirements, it was found that consulting engineers keep diaries, report incidents on construction sites and sign documents to confirm that they have attended to all the requirements.

In addition to these elements, the literature review showed that the engineering profession also includes engineering projects. The reason that was highlighted in the literature review, and confirmed by the empirical findings, is that engineering is about projects and these projects involve work teams. The literature review also revealed that engineers' work roles and tasks are determined by their work environment. This view was supported by the empirical findings. The consulting engineers' work environment therefore becomes the second context that influences consulting engineers' information behaviour.

9.2.2.2 Consultancy industry

The literature review and the findings showed that the consultancy industry includes a number of elements. These elements include organisations, engineering projects, work roles and tasks.

a. Organisations

Organisations were identified in the literature review as a contextual element in the consulting industry that could affect consulting engineers' information behaviour. Both the literature review and the responding engineers' narratives revealed that the consulting engineers' organisations determine the information resources that are available to them. These include the cognitive resources (knowledge and expertise available in the organisation) and the physical resources available in the organisations' archives. From the literature review and findings it seems evident that the use that engineers make of the available cognitive resources, and their tendency to communicate this kind of information informally, is characteristic of their information sharing activities.

When considering the findings reported in Chapter 7 and Chapter 8, consulting engineers' social networks develop naturally in their organisations and their social networks provide in their need for appropriate information resources. The engineers' shared experiences and the relationships that develop from their teamwork further contribute to the development of their social networks.

b. Engineering projects

As shown in the literature review and the findings, engineering projects are elements in consulting engineers' organisational contexts. It was also shown that each engineering project reflects a context in which a group of people collaborate to achieve a common goal. The findings revealed that arriving at a common goal (a prerequisite for collaboration) can be challenging and requires activities such as establishing the needs of clients and fellow team members. Consulting engineers also need to understand the context in which the product or system they are designing will be used.

From the literature review and the findings it became evident that the contractual agreements that are signed for the projects are important. These agreements include the project's time frame and budget (cost) as well as the service delivery requirements, which are the "scope of works". As suggested in the literature review and confirmed by the findings, contractual agreements determine the "level of effort" that consulting engineers will expend on a contract. The contractual agreements also stipulate the specific role the individual engineer will fulfil in the contract.

Engineering projects are completed in stages, where the project stage determines the information that is required. Also, the project stages determine the information that is needed and from whom the information is sought. The findings also confirmed that consulting engineers' information needs are most diverse during the initial stages of the project.

It is evident that the engineering project and the project team determine the cognitive resources that are available to project team members. These elements also determine the access team members have to certain information. Also, the principal agent (often the architect in a building project) is an important link in the flow of engineering information on the project. Any blockage or distortion in this information flow can affect the engineering project negatively.

c. Work roles

The consulting engineers' appointment to engineering projects is determined by their subject discipline, knowledge and expertise, and often the trust their clients have in their abilities. However, their roles can vary between projects and their roles are determined by the engineering project. The responding consulting engineers described their roles as being advisors, project managers, designers, and project developers. Depending on their own organisational structures, the decision-making tasks are often left to the senior engineers who then also look over the junior engineers' shoulders to ensure they are applying the correct engineering principles and are following the correct procedures. Junior engineers are often tasked with data collection (i.e. information gathering) and they depend to a large extent on their seniors' advice.

d. Tasks

It has been learnt that consulting engineers' tasks are linked to their work roles. The tasks during the preconstruction stages of the project vary and involve activities such as planning, negotiating and design. Consulting engineers also require information from both formal and informal sources to complete their tasks successfully during these initial stages of the project.

During the construction stages of projects consulting engineers manage the construction and implementation of their designs. The required information during these stages comes from the project itself and the contractor and sub-contractors are the consulting engineers' most important sources of information.

9.2.2.3 Summary of the context component

As far as the contextual component of information behaviour is concerned it can be confirmed that at least two contexts affect consulting engineers' information behaviour. The first context is the engineering profession and the second context is the consulting industry. Each context harbours elements which act as factors affecting consulting engineers' information behaviour. These include engineering projects, the engineers' work roles and tasks. In addition, the organisations employing consulting engineers are also an important contextual element. The latter not only determines the information sources and resources that are available to consulting engineers in their own organisations, but also specifies the contractual agreements that are signed with clients. They also determine the engineering projects that consulting engineers are involved in, as well as the level of their involvement. Organisations also contribute to the development of consulting engineers' social networks.

9.2.3 Research question three: Which elements in the personal dimension of consulting engineers affect their information behaviour?

As shown in Chapter 2 and the subsequent literature review chapters, the personal dimension component of the proposed information behaviour framework has three elements. That is the cognitive, conative and affective phenomena. All three of these elements manifest themselves in consulting engineers' information behaviour.

9.2.3.1 Cognitive phenomena

The narratives confirmed that consulting engineers not only rely on their personal knowledge and experience in engineering work, they also rely on the experience and knowledge of other experts in their field of engineering. For example, young engineers approach their seniors and peers for advice on their engineering designs. Senior engineers also look over the shoulders of junior engineers to ensure the correctness of their designs.

The literature review suggested, and it was confirmed by the findings, that consulting engineers' appointments to engineering projects are based on their personal knowledge and experience. Evidently consulting engineers' appointments could also be affected by their clients' knowledge and expertise, since certain clients are aware of best engineering practices and are prepared to pay for expert advice.

Technical negotiation skills are required that could support consulting engineers in exploring the best solution to the problem they are confronted with. This endorses suggestions made by engineers in the literature review.

9.2.3.2 Conative phenomena

It can be confirmed that the conative structure makes the connection between consulting engineers' personal knowledge and their recognition of an information need, which in turn prompts certain information activities. Self-efficacy, learning styles and coping skills are three conative elements that were identified in the literature review, and are also factors present in the personal dimension of consulting engineers' information behaviour.

a. Self-efficacy

Self-efficacy manifests in the consulting engineers' ability to make decisions that are based on their personal beliefs of how a task should be approached. It can be confirmed that self-efficacy is indicative of the consulting engineers' ability to visualise a solution to an engineering problem and convert this into a physical product.

b. Learning styles

The narratives revealed that consulting engineers learn through repetitive work and, as they grow in their knowledge and experience, they tend to rely less on their senior engineers for advice. They also prefer using "tried and tested best practices" as these then allow them to apply principles, standards and techniques they are familiar with and have used successfully in the past.

c. Coping skills

Consulting engineers' information behaviour can be affected by their coping skills. For example, decisions taken while under pressure to not verify certain information, can affect the quality of the service that is rendered negatively.

9.2.3.3 Affective phenomena

Evidently there seem to be three outstanding affective phenomena influencing consulting engineers' information behaviour. These are trust, uncertainty and interdependency.

a. Trust

Trusting relationships were shown to be very important for successful collaboration. The responding engineers stressed the importance of trusting relationships with their clients, their team members and their contractors as contributing to successful task completion. They also confirmed receiving appointments to new projects due to established trusting relationships.

b. Uncertainty

It can be concluded that task uncertainty shapes consulting engineers' information behaviour. Consulting engineers confirmed that they ask a colleague or an expert's advice when uncertain about something. However, contractors' task uncertainty also affects the consulting engineers' information behaviour. In order to reduce the uncertainty of contractors, consulting engineers prefer face-to-face or telephonic discussions.

c. Interdependency

Interdependency emerged in this study as a prominent element in the affective structures of consulting engineers' personal dimensions and evidently plays an important role in collaborative information behaviour in consulting engineers' teamwork. It serves as a contributing factor in the natural forming of their social networks.

d. Frustration

Frustration is often experienced among consulting engineers working in a team capacity. Frustration could potentially affect their collaborative information behaviour.

9.2.3.4 Summary of the personal dimension

It can be concluded that collaboration among consulting engineers working in a team has a profound effect on their information behaviour. The interplay among cognitive, conative and affective phenomena is instrumental in decision-making and initiating specific information activities such as network forming.

Consulting engineers expand their personal knowledge and experience through repetitive work and they therefore show a preference for "tried and tested best practices" in their engineering designs. Evidently, their knowledge and expertise become the reason why they are appointed to certain engineering projects.

9.2.4 Research question four: Which information needs necessitate collaboration among team members of a consultancy engineering project?

The findings revealed that consulting engineers' information needs arise from the situation of action (i.e. an engineering project), the engineers' tasks and dialogue (i.e. communication). However, not all information needs necessitate collaboration among team members of a consultancy engineering project. It can also be confirmed that consulting engineers' collaborative information needs do not replace their individual information needs.

9.2.4.1 Situation of action

The literature review and the empirical findings confirmed that arriving at a common ground is a prerequisite for successful collaboration among project team members. Collaborative grounding involves ascertaining clients' needs and expectations of the project and ascertaining the scope of works. Furthermore, consulting engineers need to collaboratively find solutions to the problems posed by the architectural designs. Lastly, consulting engineers need to coordinate their designs. For these reasons, they need information from other engineering disciplines and they often need to negotiate their technical needs with fellow team members.

9.2.4.2 Tasks

It can be concluded that consulting engineers' information needs vary as the project advances and that their information needs are diverse during the initial stages of the project. Project stages determine the tasks requiring completion during each stage of the project. The need to coordinate their designs and tasks during the construction stages also gives rise to information needs.

9.2.4.3 Dialogue

Teamwork in engineering projects creates a need to communicate project-related information with fellow team members. The findings confirm suggestions made by engineers in the literature review that consulting engineers also have to negotiate their technical needs with team members. They often need to employ their communication skills to explain why work should be executed in a certain manner. Consulting engineers therefore also have a need for good relationships with their team members and with contractors.

9.2.4.4 Personal dimension

Not all information needs arise from the consulting engineers' working context. The literature review and the findings showed that cognitive needs arise from an individual member's personal knowledge and experience. However, the interaction with fellow team members can also give rise to cognitive needs. Such needs then give rise to collaborative information activities such as information communication and sharing.

In order to satisfy information needs originating in the personal dimension, consulting engineers seek advice from experts or senior engineers. They therefore need to develop trusting relationships with team members and contractors. Their perceptions of a situation or tasks also give rise to information needs.

9.2.4.5 Summary of information needs

It can be concluded that the findings on information needs support the view that, although context is an important determinant of information needs, the interaction with elements in the personal dimension determines whether the need will give rise to an information activity. Also, the interaction between context and elements in the personal dimension determine the route that will be followed to acquire the information that is needed.

9.2.5 Research question five: What information activities arise from the interaction between the engineering context and the personal dimension of consulting engineers?

From the literature review and findings it is evident that consulting engineers are involved in both personal as well as collaborative information activities. Most of these activities derive from the interaction among elements in either the context, the consulting engineers’ personal dimension, or from the interrelationships between their contexts and their personal dimensions. Both personal information and collaborative information activities in which consulting engineers are involved include information seeking, awareness, serendipitous information encountering and information use.

9.2.5.1 Information seeking

The findings revealed that the interaction between elements in the engineering and consulting industry contexts, as well as elements in engineers’ personal dimensions, give rise to their information-seeking behaviour.

It can be concluded that consulting engineers seek information from formal sources such as textbooks, standards and regulations to provide in individual information needs. However, in a collaborative environment such as their work teams, they seek information from their individual social networks, which include colleagues, fellow team members, contractors, and suppliers. Evidently available information sources are determined by the information available in the consulting engineers' organisations. It is also determined by the knowledge and expertise that are available in the individual engineers' social networks as well as in the project team.

9.2.5.2 Awareness and encountering

The findings revealed that consulting engineers are always on the lookout for useful pieces of information that they could apply in their projects. As with information seeking, the consulting engineers' awareness is stimulated through certain contextual elements and perceptual elements in their personal dimension.

The findings confirmed that the consulting engineers' awareness of information is prompted by their constant awareness of potential problems they could encounter on a project when certain products are used. Furthermore, their involvement in engineering projects and teamwork requires an awareness of developments on the project.

Since consulting engineers need to remain current in their subject field they are continuously on the lookout for useful information. This behaviour is focused on expanding their personal knowledge.

9.2.5.3 Information gathering

Consulting engineers are involved in various information gathering activities that are project-related. Junior engineers are often tasked with these activities. These activities give rise to information organisation activities such as the archiving of information for future use.

9.2.5.4 Information use

It can be concluded that consulting engineers' information use activities are shaped by the information that is available in their own organisations and the information available from members of the project team. These sources include former project documentation and the expertise that is available in the organisation. The different project stages are also associated with different patterns of information use.

Information use is also affected by factors such as the consulting engineers' personal knowledge and experience and personal preferences. The findings also showed the importance of trust in the selection and use of certain sources of information.

9.2.5.5 Communication

It can be concluded that consulting engineers utilise all forms of communication. This includes formal communication (e.g. tender documentation, engineering drawings, email communications and written instructions) and interpersonal communication (i.e. telephone discussions or face-to-face meetings). Communication, as opposed to information sharing, is used by consulting engineers to communicate information with their fellow team members or contractors. The findings revealed that when consulting engineers communicate task information, some action is required from the team member or the contractor.

Certain communication structures are required for the purpose of project coordination. For example, in project management all information flows via the principal agent or the main contractor to the rest of the project team or to the sub-contractors. However, it is evident from the findings that social norms deriving from work roles can inhibit engineering communication.

In project management the communication activities are focused on avoiding miscommunication among team members and contractors. Communication activities also ensure that all team members remain updated on developments in the project.

Information communication technologies (ICTs) have an important role in engineering information communication. Various technological devices are employed by consulting engineers, such as tablets, cell phones, cameras and social media, such as WhatsApp. There are concerns that young engineers' preferences for information communication technologies might compromise the role of personal discussions in project communication practices.

9.2.5.6 Sharing

It can be concluded that information sharing can only take place in a social environment and it is focused on solving problems collaboratively. Usually it is employed to share project-related information. This includes information on the project budget and time frames, the scope of works, and individual engineering disciplines' designs and technical needs. Formal (tender documents, reports and engineering designs) and informal methods (meetings and face-to-face communications) are employed for this purpose.

Information communication technologies are also employed to share information and to bridge time and distance barriers. For this purpose, consulting engineers employ technological devices such as Dropbox, FTP sites, emails and even social media such as WhatsApp.

Evidently information sharing can also be less goal orientated. The findings reported less goal orientated information sharing, such as sharing of personal knowledge and experience with fellow team members of colleagues and contractors. This kind of information sharing is generally shared informally at organised social networking opportunities, and formal information sharing sessions in an organisation or at conferences.

9.2.5.7 Summary of information activities

It can be concluded that consulting engineers engage in a number of information activities. Different contextual elements, such as the project stage and specific tasks, give rise to very specific information activities. Meetings, formal and informal communications and information sharing are important information activities. These activities not only support engineers in completing their various tasks successfully, but also contribute to relationship building. In turn these activities are also aimed at expanding consulting engineers' social networks.

In addition to the contextual elements prompting information activities, consulting engineers' personal knowledge and expertise are another factor determining whether they will become involved in certain activities.

9.2.6 Research question six: Which sources of information take preference during task completion of a consulting engineer's project?

It can be concluded that consulting engineers utilise a variety of information sources throughout an engineering project. These include both formal and informal sources of information. The formal sources of information include information retrieved from learned societies, engineering standards and regulations, textbooks, conferences and subject forums. The most important informal sources include their clients, contractors, community liaison officers, environmental information, sales persons and representatives, local authorities, project team members and the engineers' social networks. Furthermore, the responding engineers indicated a preference for face-to-face communication and telephone calls, as compared to more formal means of communication, such as emails. Informal communication supports engineers in building relationships and developing their social networks.

The empirical findings revealed that consulting engineers rely on their own personal knowledge and experience during task completion. The importance of personal knowledge and experience is evidenced in younger engineers' information-seeking activities when they seek advice and guidance from their seniors and other experts in their respective fields of interest.

It can be confirmed that consulting engineers' social networks serve as sources of engineering information. The responding engineers' narratives revealed that consulting engineers' social networks act as their collective memory. The narratives also included proof that engineers actively develop their social networks.

9.2.7 Concluding answer to the overall research question

The proposed conceptual framework that was developed in Chapter 2 was shown to be suitable for a study focusing on the information behaviour of consulting engineers.

Throughout the discussions in both the literature reviews and the empirical study, it became evident that it is important to consider the context in which an information need arises when exploring individuals' information behaviour. In this study, there are especially two contexts that affect consulting engineers' information behaviour. These are the engineering profession and the consulting industry.

It also became evident that the cognitive, conative and affective phenomena from the personal dimension need to be considered when studying the information behaviour of people. The study further confirmed findings in the literature review that the interaction between elements in the context and in the personal dimension gives rise to information needs, which in turn could prompt specific information activities. Consulting engineers' personal knowledge and experience determine whether a need arising in the context is perceived as an information need and whether it will prompt an information activity. When this happens, the elements in the context and personal dimension components of the information behaviour framework become the factors that affect consulting engineers' information behaviour.

Information communication and sharing are important information activities. Also, engineers prefer informal or face-to-face communication as opposed to formal means of communication, such as emails. These informal communication activities not only save engineers time in sorting out engineering problems, but are also purposefully employed to build interpersonal relationships and develop their social networks. Engineers actively maintain and develop their social networks for various reasons. These include potential work in future and for learning how to do their work. Their networks also reflect the expertise and knowledge at their disposal and seem to act as a collective memory which could be accessed for information when needed.

9.3 LIMITATIONS OF THIS STUDY

The study has certain limitations that could be identified concerning both the literature review as well as the empirical component of the study.

9.3.1 Limitations of the literature study

A comprehensive literature review was conducted that addressed all aspects of engineers' information behaviour. As a result much was learnt from the literature about engineers' information behaviour. However, the focus of the study was on the role of social networks in consulting engineers' information behaviour. The literature review did not explore this in much depth. Despite this limitation, an in-depth study of consulting engineers' information behaviour revealed the important role of social networks as sources of engineering information. A literature study exploring only social networks and social networking might have revealed different results. Future studies on the role of social networks in engineers' information behaviour need to address this limitation.

9.3.2 Limitations of the empirical study

Two limitations regarding the empirical component of the study could be identified, namely, the sample and engineering contexts.

9.3.2.1 Sample

Engineering work is about teamwork and could involve various types of projects. This also applies to consulting engineers. Some of the types of projects that were identified by some of the responding engineers include office buildings and other types of buildings, infrastructure development, mining projects, retrofit (renovation) projects and industrial processes. This study only explored the information behaviour of consulting engineers involved in building projects and did not explore their information behaviour on other types of consulting engineering projects. A study focusing on a different type of project could have included a different sample of responding engineers. It could also have yielded different results since information needs and communication processes on other types of engineering projects could be different.

9.3.2.2 Engineering contexts

Not all aspects within the consulting engineers' contexts and not all their information activities were studied in depth. An in-depth study of specific information activities may yield more detailed results.

9.4 RECOMMENDATIONS

The recommendations relate to the objectives of the study set in Chapter 1. It is recommended that the effects that the key components in the conceptual framework have on consulting engineers' information behaviour be compared with the information behaviour of other professional groups. A wider application of collaboration and social networking in other communities of practice also needs to be explored.

It is also recommended that the results from this study be used to guide the development of an information system that would assist engineers in finding people who could provide them with information. Such a development would support Fidel and Green's (2004: 579) and Hertzum and Pejtersen's (2000: 75) call for such a system. Fidel and Green (2004: 578) reckoned that, encouraging engineers to create and maintain such networks will increase the number of people the engineer knows, both inside and outside an organisation.

9.5 FUTURE RESEARCH

Some suggestions for future research could be identified from the findings. These include the following:

- **Interdependency**. The narratives revealed an interdependency for information among project team members. Although the literature review included references to interdependency, no information behaviour studies were reported that solely focused on interdependency as a factor affecting collaborative information behaviour. Therefore, information behaviour studies focusing on interdependency are needed to learn more about this phenomenon.

- **Frustration**. The narratives revealed that the consulting engineers experience feelings of frustration during an engineering project. However, this study did not explore the effect frustration has on their information behaviour and this is something that needs to receive attention in future studies
- **Technical negotiation skills**. The engineering literature and the findings showed a need for technical negotiation skills. However, it seems as if the effect that technical negotiation skills have on information behaviour has not yet been addressed in information behaviour studies
- **Communication structures**. With the exception of Thomas Allen (1977: 291), who addressed the importance of organisational structures in communication, the reviewed literature did not address communication structures in an engineering project. With this in mind, a future study could address the communication structures and flow of engineering information in a specific engineering project.
- **Sharing.** Information sharing has been addressed as a collaborative information behaviour activity by a number of researchers. However, none of these studies addressed the sharing of documents, knowledge and experience across different engineering projects.
- **Document creation, organisation and archiving**. The narratives revealed that consulting engineers are involved in document creation, information organisation and archiving activities. These activities were not explored in depth in this study. The literature review did include references to document creation, information organisation and archiving activities. However, none of the reviewed studies solely addressed engineers' activities in relation to these activities. This therefore also requires further investigation.
- **Electronic communication technologies**. The narratives revealed that the older engineers were concerned about the extensive use of electronic media by younger engineers. Some even believed that technological developments could have a negative impact on engineering communication. With these concerns in mind, a future study focusing on the influence of electronic communication technologies on engineering communication could be useful to ascertain whether these engineers' concerns were justified or not.

- **Social network analysis (SNA).** The study addressed social networks and social networking within a work team as an instrument to access engineering information. However, the engineers' social networks were not analysed. A study that purposefully analyses consulting engineers' social networks may provide insightful information on the flow of information in an engineering project team.

9.6 VALUE OF THIS STUDY

The contributions that are made by this study are twofold: methodologically and in the development of a conceptual information behaviour framework.

9.6.1 Methodological contribution

The current study is an interpretive study and it is based on the lived experiences of consulting engineers. Narrative inquiry was used as both a research approach and research method. This is not a research approach or research method that is generally used to study the information behaviour of individuals or a group of people. As such, narrative inquiry is a relatively new information behaviour data collection and analysis technique. It allowed the researcher to collect in-depth and richer information than would have been possible if a semi-structured interview schedule or a survey questionnaire had been used. It also allowed the researcher to observe the role of interdependency in teamwork and collaborative information behaviour. Although discussions on collaborative information behaviour included references that could resemble interdependency, interdependency as concept has not received attention in information behaviour research.

Furthermore, the thematic analysis of narrative inquiry data provides researchers with the opportunity to generalise their empirical findings to a broader application of collaborative information behaviour research. This is contrary to case study research where the research is restricted to one or two engineering projects and does not allow for the exploration of information behaviour issues that are not project-specific.

9.6.2 Conceptual framework for consulting engineers' information behaviour

As set out in Chapter 1 (section 1.6), Cibangu (2013) and Vakkari (2008) were concerned with the lack of theoretical contributions that are made in the field of information science. Julien and Duggan (2000: 303) also observed an increase in the publication of information needs and use research in scholarly journals. However, most of these publications were atheoretical. Therefore, Wilson's (1999; 2000) encapsulating information behaviour definition was used as a point of departure to develop an information behaviour framework. The proposed framework (i.e. Figure 2.1 and Figure 3.1) was used to guide the literature review and could be refined after the completion of the empirical study (i.e. Figure 8.1). The conceptual framework depicts the context within which information behaviour takes place, the individual's personal dimension, information needs and information activities as components in the framework. The existing interaction between the first three components then prompts information activities such as information seeking, use, communication, and sharing.

The context component of the framework illustrates the complexity of consulting engineers' contexts which should be considered when studying their information behaviour.

9.6.3 Social networks as sources of engineering information

As indicated in Chapter 1 (section 1.2), information behaviour studies focusing on engineers did not consider the engineers' project related work environment where project team members socially interact to ensure task completion. This study addresses this gap by showing how important engineers' social networks are as a source of engineering information.

Throughout the study, it was shown that each engineering project represents an engineering context within which specific project information is exchanged and shared among team members. It was also shown that the engineers could also seek information from persons within their own social networks who are not necessarily a member of a specific project team. It is for this important role social networks have as a resource of engineering information that the engineers actively develop and maintain their social networks.

9.7 SUMMARY AND FINAL COMMENTS

This study explored the role of social networks in consulting engineers' information behaviour in a South African context. An extensive literature review supported in establishing the theoretical framework for the study and provided some insight into aspects of both engineers' and consulting engineers' information behaviour. Narrative inquiry was used as both a research approach and research method to collect and analyse data for the study. The findings revealed that social networks are important resources for engineering information. It was also evident that consulting engineers actively develop and maintain their social networks.

LIST OF REFERENCES

Aguillar, FJ. 1967. *Scannning the business enviornment.* New York: MacMillan.

Aldrich, HE. 2006. *Organizations evolving.* 2nd ed. London: Sage.

Alisantoso, D, Khoo, LP, Lee, IB & Lu, WF. 2006. A design representation scheme for collaborative product development. *International Journal of Advanced Manufacturing Technology* 30(1-2): 30-39.

Allard, S, Levine, K & Tenopir, C. 2009. Design engineers and technical professionals at work: observing information usage in the workplace. *Journal of the American Society for information Science and Technology* 60(3): 443-454.

Allen, BL. 1991. Cognitive research in information science: implications for design. *Annual Review of Information Science and Technology* 26: 3-37

Allen, BL. 1996. Information needs. In, *Information tasks: toward a user-centered approach to information systems*. San Diego, CA: Emerald Group: 55-107.

Allen, BL. 1997. Information needs: a person-in-situation approach. In, Vakkari, P, Savolainen, R & Dervin, B (eds). *Information seeking in context: proceedings of an International Conference on Research in Information Needs, Seeking and Use in Different Contexts, 14-16 August 1996, Tampere, Finland.* London: Taylor Graham: 111-122.

Allen, BL & Kim, KS. 2001. Person and context in information seeking: interactions between cognitive and task variables: paper presented at ISIC 2000: Information Seeking in Context: the 3rd International Conference on Information Needs, Seeking and Use in Different Contexts, 2000 August 16-18, Gothenburg, Sweden*. New Review of Information Behaviour Research* 2: 1-16.

Allen, D & Wilson, TD. 2003. Information overload: context and causes. *New Review of Information Behaviour Research* 4(3): 31-44.

Allen, D, Karanasios, S & Slavova, M. 2011. Working with activity theory: context, technology, and information behavior. *Journal of the American Society for Information Science and Technology* 62(4): 776-788.

Allen, TJ. 1977. *Managing the flow of technology: technology transfer and the dissemination of technological information within the R&D organization.* Cambridge, MA: MIT Press.

Anderson, CJ, Glassman, M, McAfee, RB & Pinelli, T. 2001. An investigation of factors affecting how engineers and scientists seek information. *Journal of Engineering and Technology Management* 18(2): 131-155.

Atkin, C. 1973. Instrumental utilities and information-seeking. In, P. Clarke (ed). *New models for mass communication research*. Beverly Hills: Sage: 205-242.

Attfield, S & Dowell, J. 2003. Information seeking and use by newspaper journalists. *Journal of Documentation* 59(2): 187-204.

Audunson, R. 1997. Can institutional theory contribute to our understanding of information seeking behaviour? In, Wilson, TD & Allen, DK (eds). *Exploring the contexts of information behaviour: proceedings of the second International Conference on Research in Information Needs, Seeking and Use in different Contexts, 13/15 August 1998, Sheffield, UK.* London: Taylor Graham: 67-81. http://www.informationr.net/isic/ISIC1998/98_Audunson.pdf (Accessed 12 October 2015).

Aurisicchio, M, Bracewell, R & Wallace, K. 2010. Understanding how the information requests of aerospace engineering designers influence information-seeking behaviour. *Journal of Engineering Design* 21(6): 707-730.

Babbie, E. 2010. *The practice of social research.* Belmont, CA: Wadsworth.

Balmaceda, JM, Schiaffino, S & Godoy, D. 2014. How do personality traits affect communication among users in online social networks? *Online Information Review,* 38(1): 136-153.

Bandura, A. 1995. *Self-efficacy in changing societies.* Cambridge: Cambridge University Press.

Bates, MJ. 2009. Information behavior. In, *Encyclopedia of library and information science.* 3rd ed. New York: Taylor and Francis.

Baumeister, R, Bratslavsky, E, Muraven, M & Tice, D. 1998. Ego depletion: is the active self a limited resource? *Journal of Personality and Social Psychology* 74(5): 1252-1265.

Bawden, D. 2006. Users, user studies and information behaviour: a three decade perspective on Tom Wilson‘s “On user studies and information needs”. *Journal of Documentation* 62(6): 671-679.

Bawden, D. 2011. Encountering on the road to Serendip?: Browsing in new information environments. In, Foster, A & Rafferty, P (eds). *Innovations in information retrieval*. London: Facet: 1-22.

Beldad, A, De Jong, M & Steehouder, M. 2011. A comprehensive theoretical framework for personal information: related behaviors on the Internet. *Information Society* 27: 220-232.

Belkin, NJ, Oddy, RN & Brooks, HM. 1982. ASK for information retrieval: Part 1. Background and theory. *Journal of Documentation 38*(2): 61-71.

Bertelotti, F & Tagliaventi, MR. 2007. Discovering complex interdependencies in organizational settings: the role of social network analysis in qualitative research. *Qualitative Research in Organizations and Management* 2(1): 43-61.

Bigdeli, Z. 2007. Iranian engineers' information needs and seeking habits: an agro-industry company experience. *Information Research* 12(2): 1-8.

Bin Guo, HL. 2007. Information seeking behaviour of R&D professionals in new product development. In, *IEEE International Conference on Industrial Engineering and Engineering Management*. Singapore: IEEE: 1980-1984.

Birnholz, JP. 2005. When do researchers collaborate?: towards a model of collaboration propensity in science and engineering research. Doctor of Philosophy – University of Michigan.

Blom, A. 1983. The task performance of the scientist and how it affects an information service. *Mousaion* 3(1): 3-26.

Borgatti, S & Cross, R. 2003. A relational view of information seeking and learning in social networks. *Management Science* 49(4): 432-445.

Brashers, DE. 2001. Communication and uncertainty management. *Journal of Communication 51*(3): 477-497.

Brown, JS & Duguid, P. 1991. Organizational learning and communities-of-practice: toward a unified view of working, learning and innovation. *Organization Science* 2(1): 40-57.

Bruce, H, Fidel, R, Pejtersen, A, Dumais, S, Grudin, J & Poltrock, S. 2003. A comparison of the collaborative information retrieval behaviour of two design teams. *The New Review of Information Behaviour Research* 4(1): 139-153.

Burford, S & Park, S. 2014. The impact of mobile tablet devices on human information behaviour. *Journal of Documentation,* 70(4): 622-639.

Burnett, G. 2000. Information exchange in virutal communities: a typology. *Information Research* 5(4).

Burnett, G & Jaeger, PT. 2008. Small worlds, lifeworlds, and information: the ramifications of the information behaviour of social groups in public policy and the public sphere. *Information Research* 13(2).

Burnett, G, Besant, M & Chatman, E. 2001. Small worlds: normative behavior in virtual communities and feminist bookselling. *Journal of the American Society for Information Science and Technology* 52(7): 536-547.

Business dictionary. 2013. Sv “Problem solving.” http://m.businessdictionary.com/definition/problem-solving.html (Accessed 9 July 2013).

Byström, K. 1996. Municipal administrators at work: information needs and seeking (INandS) in relation to task complexity: a case study amongst municipal officials. *Proceedings of an International Conference on Research in Information Needs, Seeking and Use in Different Contexts.* London: Taylor Graham: 125-146.

Byström, K. 2002. Information and information sources in tasks of varying complexity. *Journal of the American Society for Information Science and Technology* 53(7): 581-591.

Byström, K. 2007. Approaches to "task” in contemporary information studies. Proceedings of the sixth International Conference on Conceptions of Library and Information Science: "Featuring the Future". *Information Research* 12(4).

Byström, K & Hansen, P. 2005. Conceptual framework for tasks in information studies. *Journal of the American Society for Information Science and Technology* 56(10): 1050-1061.

Byström, K & Järvelin, K. 1995. Task complexity affects information seeking and use. *Information Processing and Management* 31(2): 191-213.

Cairns, R & Compton, B. 1970. The SATCOM report and the engineer's information problem. *American Society for Engineering Education* 60: 375-376.

Case, DO. 2006. Information behaviour. *Annual Review of Information Science and Technology* 40: 293-327.

Case, DO. 2007. *Looking for information: a survey of research on information seeking, needs and behaviour.* 2nd ed. Amsterdam: Elsevier.

Case, DO. 2012. *Looking for information.* 3rd ed. Bingley: Emerald.

Charon, R. 2001. Narrative medicine: a model for empathy, reflection, profession and trust. *JAMA* 286(15): 1897-1902.

Charon, R. 2006. *Narrative medicine: honoring the stories of illness.* Oxford: Oxford University Press.

Chase, S. 2005. Narrative inquiry: multiple lenses, approaches, voices. In, Denzin, NK & Lincoln, YS (eds). *The Sage handbook of qualitative research.* 3rd ed. Thousand Oaks, CA: Sage: 651-679.

Chatman, EA. 1991. Life in a small world: applicability of gratification theory to information-seeking behaviour. *Journal of the American Society for Information Science* 42(6): 438-449.

Chatman, EA. 1996. The impoverished life-world of outsiders. *Journal of the American Society for Information Science* 47(3): 193-206.

Chatman, EA. 1999. A theory of life in the round. *Journal of the Amercian Society for Information Science* 50(3): 207-217.

Chatman, EA. 2000. Framing social life in theory and research. *The New Review of Information Behaviour Research* 1: 3-17.

Cheimets, Pl, Gordon, J & Tull, J. 2009. Technical negotiation: product development today is often about teamwork, and there are teachable skills to give engineers more influence in group decisions. *Mechanical Engineering* 131(8): 26-29.

Cherry, K. 2013. *What is motivation?* http://psychology.about.com/.od.mindex/g/motivation-definition.htm (Accessed 16 December 2013)

Cheuk Wai-Yi, B. 1998. An information seeking and using process model in the workplace: a constructivist approach. *Asian Libraries* 7(12): 375-390.

Cho, H & Lee, JS. 2008. Collaborative information seeking in intercultural computer-mediated communication groups: testing the influence of social context using social network analysis. *Communication Research* 35(4): 548-573.

Cho, H, Lee, JS, Stefanone, M & Gray, G. 2005. Development of computer-supported collaborative social networks in a distributed learning community. *Behaviour and Information Technology* 24(6): 435-447.

Chowdhurry, S, Gibb, F & Landoni, M. 2014. A model of uncertainty and its relation to information seeking and retrieval (IS&R). *Journal of Documentation* 70(4):575-604.

Cibangu, SK. 2013. A memo of qualitative research for information science: toward theory construction. *Journal of Documentation* 69(2): 194-213.

Clandinin, DJ & Caine, V. 2008. Narrative inquiry. In, Given, LM. *The Sage encyclopedia of qualitative research methods.* Thousand Oaks, CA: Sage: 542-545. DOI: http://dx.doi.org/10.4135/9781412963909.n275

Clandinin, DJ & Connelly, FM. 1995. *Teachers' professional knowledge landscapes.* New York: Teacher's College Press.

Clandinin, DJ & Connelly, FM. 2000. *Narrative inquiry: experience and story in qualitative research.* San Francisco, CA: Jossey-Bass.

Clandinin, DJ, Murphy, MS, Huber, J & Orr, AM. 2010. Negotiating narrative inquiries: living in a tension-filled midst. *Journal of Educational Research* 103(2): 81-90.

Clark, HH & Brennan, SE. 1991. Grounding in communication. In, Resnick, L, Levine, J & Teasley, S. *Perspectives on socially shared cognition*. Washington: American Psychological Association: 127-149.

Cleal, BR, Andersen, HH & Albrechtsen, H. 2004. Collaboration, communication and categorial complexity: a case study for collaboratory evaluation. *Journal of Digital Information Management* 2(1): 13-20.

Cole, C. 2011. A theory of information need for information retrieval that connects information to knowledge. *Journal of the American Society for Information Science and Technology* 62(7): 1216-1231.

Connelly, FM & Clandinin, DJ. 2006. Narrative inquiry. In, Green, J. Camilli, G & Elmore, P (eds). *Handbook of complementary methods in education research*. Mahwah, NJ: Erlbaum: 477-487.

Consulting Engineers South Africa (CESA). 2003a. The essence of the client-consulting engineer relationship. *Advisory note 85/18*, 1-5.

http://www.cesa.co.za/_f1l3z_/advisroynotes/85_18.pdf (Accessed 11 September 2011).

Consulting Engineers South Africa (CESA). 2003b. Guideline for consulting engineers and their clients on the correct procedures for implementing complex multidisciplinary projects. *Advisory Note* 81/4. http://www.cesa.co.za/_f1l3z_/advisorynotes/81_4.pdf (Accessed 11 September 2011).

Consulting Engineers South Africa (CESA). 2003c. Some thoughts on the engineer's obligations and responsibilities. *Advisory Note*(86/9): 1-5. http://www.cesa.co.za/_f1l3z_/advisroynotes/86_9.pdf (Accessed 11 September 2011).

Cool, C. 2001. The concept of situation in information science. *Annual Review of Library and Information Science and Technology* 35: 5-42.

Cool, C & Xie, H. 2000. Patterns of information use, avoidance and evaluation in a corporate engineering environment. In, Kraft, D (ed). *ASIS 2000: proceedings of the 63rd ASIS Annual Meeting 13-16 November 2000* 37: 462-472. https://pantherfile.uwm.edu/hiris/www/IrisArticles/Articles/2000patternofinformationuse.pdf (Accessed 25 May 2015).

Court, AW. 1997. The relationship between information and personal knowledge in new product development. *International Journal of Information Management* 17(2): 123-138.

Courtright, C. 2007. Context in information behaviour research. *Annual Review of Information Science and Technology* 41(1): 273-306.

Cox, A. 2013. Information in social practice: a practice approach to understanding information activities in personal photography. *Journal of Information Science* 39(1): 61-72.

Cox, AM. 2007. Beyond information: factors in participation in networks of practice: a case study of web management in UK higher education. *Journal of Documentation* 63(5): 765-787.

Creswell, JW. 2013. *Qualitative inquiry & research design: choosing among five approaches.* 3rd ed. Los Angeles, CA: Sage.

Cross, R, Parker, A, Prusak, L & Borgatti, SP. 2001. Supporting knowledge creation and sharing in social networks. *Organizational Dynamics* 30(2): 100-120.

Cross, R, Rice, RE & Parker, A. 2001. Information seeking in social context: structural influences and receipt of information benefits. *IEEE Transactions on Systems, Man and Cybernetics. Part C: Applications and Reviews* 31(4): 438-448.

Czarniawska, B. 2004. *Narratives in social science research.* Thousand Oaks, CA: Sage.

Czarniawska, B & Mazza, C. 2003. Consulting as a liminal space. *Human Relations* 56(3): 267-290.

De Smet, E. 1992. Information behaviour in a scientific-technical environment: a survey with innovation engineers. *Scientometrics* 25(1): 101-113.

Denzin, NK. 2004. Interpretive biography. In, Lewis-Beck, MS, Bryman, A & Liao, TF (eds). *Sage encyclopedia of social science research methods*. Newbury, CA: Sage: 508-509.

Denzin, NK & Lincoln, YS. (eds). 1994. *Handbook of qualitative research.* Thousand Oaks, CA: Sage.

Dervin, B. 1983. Information as a user construct: the relevance of perceived information needs to synthesis and interpretation. In, Ward, S & Reed, L (eds). *Knowledge structure and use: implications for synthesis and interpretation*. Philadelphia, PA: Temple University Press: 153-184.

Dervin, B. 1997. Given context by any other name: methodological tools for taming the unruly beast. In, Vakkari, P, Savolainen, R & Dervin, B (eds). *Information seeking in context. Proceedings of an International Conference on Research in Information Needs, Seeking and Use in Different Contexts, Tampere, Finland 14-16 August 1966*. London: Taylor & Francis: 13-38.

Dictionary.com. 2015. Sv “component.” http://dictionary.reference.com/browse/component (Accessed 3 June 2015).

Dictionary.com. 2015. Sv “element.” http://dictionary.reference.com/browse/element (Accessed 3 June 2015).

Dourish, P. 2008. What we talk about when we talk about context. *Personal and Ubiqutous Computing* 8(1): 19-30.

Dourish, P & Belotti, V. 1992. Awareness and coordination in shared workspaces. *Proceedings of the 1992 ACM Conference on Computer Supported Cooperative Work (CSCW'92)* New York: ACM: 107-115.

Du Bruyn, K. 2004. Die inligtingsbehoeftes van ingenieursdosente verbonde aan die Vaal Universiteit van Tegnologie*.* Masters' dissertation – University of Potchefstroom. Potchefstroom.

Du Preez, M. 2008. The information needs and information-seeking behaviour of consulting engineers in South Africa*.* Masters' dissertation – University of South Africa. Pretoria.

Du Preez, M & Meyer, HWJ. 2011. Exploring conceptual models to study consulting engineers' social networks. Proceedings of the Progress in Library and Information Science in South Africa (ProLISSA): sixth biennial DISSANET Conference, University of South Africa (UNISA) 9-11 March 2011. Pretoria: Dept of Information Science, University of South Africa 78-101.

Dunn, WN. 1983. Social network theory. *Science Communication* 4(3): 453-461.

Eisenberg, M & Berkowitz, R. 1990. *Information problem solving: the big six skills approach to library & information skills instruction.* Norwood, NJ: Ablex.

Ellis, DG & Fisher, BA. 1994. *Small group decision making: communication and group process.* 4th ed. [New York]: McGraw-Hill.

Ellis, D & Haugan, M. 1997. Modelling the information seeking patterns of engineers and research scientists in an industrial environment. *Journal of Documentation* 53(4): 384-403.

Endsley, MR. 1995. Toward a theory of situation awareness in dynamic systems. *Human Factors* 37(1):32-64.

Engel, D, Robbins, S & Kulp, C. 2011. The information seeking habits of engineering faculty. *College and Research Libraries* 72(6): 548-567.

Engineering Council. 2011. *Chartered Engineer (CEng).* www.engc.org.uk/professional-qualifications/chartered-engineer/about-chartered-engineer (Accessed 29 October 2011).

Engineering Council of South Africa (ECSA). 2006. Rules of conduct for registered persons: Engineering Profession Act, 2000 (Act no. 46 of 2000). *Government Gazette* (28605): 1-5.

Engineering Council of South Africa (ECSA). 2010. Board notice 175 of 2010: guideline scope of services and tariff of fees for persons registerd in terms of the Engineering Profession Act, 2000 (Act no. 46 of 2000). *Government Gazette = Staatskoerant, 535* (32851).

Engineering Council of South Africa (ECSA). 2014. *ECSA guideline for services and processes for estimating fees for registered persons 2014.* https://www.ecsa.co.za/regulation/RegulationDocs/Guideline_Fees_2014.pdf (Accessed 3 June 2014).

Engineers' Council for Professional Development. 1941. *Science,* 94(2446): 456.

Erdelez, S. 1997. Information encountering: a conceptual framework for accidental information seeking. *Information seeking in context: proceedings of an international conference on research in information needs, seeking and use in different contexts, Tampere, Finland, 1996*. Los Angeles: Taylor Graham: 412-421.

Erdelez, S. 2005. Information encountering. In, Fisher, KE, Erdelez, S & Meckechnie, EF (eds). *Theories of information behavior.* Medford, NJ: Information Today: 179-184.

Ernst, H & Vitt, J. 2000. The influence of corporate acquisitions on the behaviour of key inventors. *R&D Management* 30(2): 105-119.

Espinosa, JA, DeLone, W & Lee, G. 2006. Global boundaries, task processes and IS project success: a field study. *Information Technology and People* 19(4): 345-370.

Fernàndez, J, Lòpez, I, Rubio, R & Marco, F. 2009. An assessment of behavioural variables implied in teamwork: an experience with engineering students of Zaragosa University. *European Journal of Engineering Education* 34(2): 113-122.

Fidel, R. 1993. Qualitative methods in information retrieval research. *Library and Information Science Research* 15(3): 219-247.

Fidel, R & Efthimiadis, E. 1999. Web searching behaviour of aerospace engineers. *Proceedings of SIGIR '99: 22nd International Conference on Research and Development in Information Retrieval*. New York: ACM: 319-320.

Fidel, R & Green, M. 2004. The many faces of accessibility: engineers' perception of information sources. *Information Processing and Management* 40(3): 563-581.

Fidel, R & Pejtersen, AM. 2004. From information behaviour research to the design of information systems: the cognitive work analysis framework. *Information Research,* 10(1). http://www.informationr.net/ir/10-1/paper210.html (Accessed 25 May 2015).

Fidel, R, Pejtersen, AM, Cleal, M & Bruce, H. 2004. A multidimensional approach to the study of human-information interaction: a case study of collabborative information retrieval. *Journal of the American Society for Information Science and Technology,* 55(11): 939-953.

Finholt, TA. 2002. Collaboratories. *Annual Review of Information Science and Technology,* 36*:* 73-107.

Finn, B & Johnston, P. 2004. Index use by engineering faculty and students. *Georgia Library Quarterly* 41(3): 5-15.

Fisher, KE & Julien, H. 2009. Information behavior. *Annual Review of Information Science and Technology* 43: 317-358.

Fisher, KE & Naumer, CM. 2006. Information grounds: theoretical basis and empirical findings on information flow in social settings. In, Spink, a & Cole C (eds). *New directions in human information behavior.* Dordrecht: Springer: 93-111.

Ford, N, Wood, D & Walsh, C. 1993. Cognitive styles and online searching. *Information Research News* 4(1): 6-13.

Fosmire, M. 2012. Information literacy and engineering design: developing an integrated conceptual model. *IFLA Journal* 38(1): 47-52.

Foster, J. 2009. Understanding interaction in information seeking and use as a discourse: a dialogic approach. *Journal of Documentation* 65(1): 83-105.

Free Dictionary. 2015. Sv "dependability". http://www.freedictionary.com/dependable (Accessed 21 April 2015).

Freund, L, Toms, E & Waterhouse, J. 2005. Modelling the information behaviour of software engineers using a work-task framework. *Proceedings of the American Society for Information Science and Technology* 42(1): 1-28.

Friedel, R & Liedtka, J. 2007. Possibility thinking: lessons from breakthrough engineering. *Journal of Business Strategy* 28(4): 30-37.

Gazan, R. 2010. Microcollaborations in a social Q&A community. *Information Processing and Management,* 46(6): 693-702.

Gerstberger, PG & Allen, TJ. 1968. Criteria used by research and development engineers in the selection of an information source. *Journal of Applied Psychology* 52(4): 272-279.

Gill, P, Stewart, K, Treasure, E & Chadwick, B. 2008. Methods of data collection in qualitative research: interviews and focus groups. *British Dental Journal* 204(6): 291-295.

Glückler, J & Armbrüster, T. 2003. Bridging uncertainty in management consulting: the mechanisms of trust and networked reputation. *Organization Studies* 24(2): 269-297.

Gorman, GE & Clayton, P. 1997. *Qualitative research for the information professional: a practical handbook.* London: Library Association Publishing.

Gralewska-Vickery, A. 1976. Communication and information needs of earth science engineers. *Information Processing and Management* 12(4): 251-282.

Granovetter, MS. 1973. The strength of weak ties. *American Journal of Sociology* 78(6): 1360-1380.

Gray, B. 1989. *Collaborating: finding common ground for multiparty problems.* San Francisco: Jossey-Bass.

Gross, M. 1999. Imposed queries in the school library media center: a descriptive study. *Library & Information Science Research* 21: 501-521.

Gross, M. 2001. Imposed information seeking in public libraries and school library media centers: a common behaviour? *Information Research,* 6(2).

Guba, EG. 1981. Criteria for assessing the trustworthiness of naturalistic inquiries. *Educational Communication and Technology* 29(2): 75-91.

Haas, MR & Hansen, MT. 2007. Different knowledge, different benefits: toward a productivity perspective on knowledge sharing in organizations. *Strategic Management Journal* 28(11): 1133-1153.

Hackos, JT & Redish, JC. 1998. *User and task analysis for interface design.* New York: Wiley.

Hansen, MT. 2002. Knowledge networks: explaining effective knowledge sharing in multi unit companies. *Organization Science* 13(3): 232-248.

Hansen, MT & Haas MR. 2001. Competing for attention in knowledge markets: electronic document dissemination in a management consulting company. *Administrative Science Quarterly* 46: 1-28

Hansen, P & Järvelin, K. 2005. Collaborative information retrieval in an information-intensive domain. *Information Processing and Management* 41(5): 1101-1119.

Havelock, RG. 1986. Modeling the knowledge system. In, Beal, GM, Dissanayake, W & Konoshima, S (eds). *Knowledge generation, exchange and utilization*. Boulder: Westview Press: 77-104.

Hayter, S. 2006. Exploring information worlds in a disadvantaged community: a UK perspective = Exploration des mondes de l'information dans une communauté défavorisée: une perspective du Royaume-Uni. *Canadian Journal of Information and Library Science* 30(1/2): 21-35.

Haythornthwaite, C. 1996. Social network analysis: an approach and techniques for the study of information exchange. *Library and Information Science Research* 18(4): 323-342.

Heisig, P, Caldwell, NH, Grevbici, K & Clarkson, PJ. 2010. Exploring knowledge and information needs in engineering from the past and for the future: results from a survey. *Design Studies* 31(5): 499-532.

Henning, E, Van Rensburg, W & Smit, B. 2004. *Finding your way in qualitative research.* Pretoria: Van Schaik.

Hepworth, M. 2007. Knowledge of information behaviour and its relevance to the design of people-centred information products and services. *Journal of Documentation* 63(1): 33-56.

Hersberger, JA. 2003. A qualitative approach to examining information transfer via social networks among homeless populations. *New Review of Information Behaviour Research: Studies of Information Seeking in Context* 4(1): 95-108.

Hertzum, M. 2002. The importance of trust in software engineers' assessment and choice of information sources. *Information and Organization* 12(1): 1-18.

Hertzum, M. 2008. Collaborative information seeking: the combined activity of information seeking and collaborative grounding. *Information Processing and Management* 44(2): 957-962.

Hertzum, M. 2010. Breakdowns in collaborative information seeking: a study of the medication process. *Information Processing and Management* 46(6): 646-655.

Hertzum, M & Pejtersen, A. 2000. The information-seeking practices of engineers: searching for documents as well as for people. *Information Processing and Management* 36(5): 761-778.

Hiller, S. 2003. *How scientists and engineers find information and use libraries.* http://www.lib.washington.edu/assessment/conferences/STSjune2003Hiller_files/frame.htm (Accessed 4 November 2010).

Hirsh, SG. 1999. Information needs, information seeking, and communication in an industrial R&D environment. *Proceedings of the ASIS Annual Meeting* 37: 473-486.

Hirsh, SG & Dinkelacker, J. 2004. Seeking information in order to produce information: an empirical study at Hewlett Packard Labs. *Journal of the American Society for Information Science and Technology* 55(9): 807-817.

Hofstede, G. 1984. National cultures and corporate cultures. In, Samovar, LA & Porter, RE (eds). *Communication between cultures.* Belmont: Wadsworth.

Holland, MP & Powell, CK. 1995. A longitudinal survey of the information seeking and use habits of engineers. *College and Research Libraries* 56(1): 7-15.

Holland, MP, Pinelli, TE, Barclay, RO & Kennedy, JM. 1991. Engineers as information processors: a survey of US Aerospace Engineering Faculty and students. *European Journal of Engineering Education* 16(4): 317-336.

Hubka, V & Eder, WE. 1987. A scientific approach to engineering design. *Design Studies,* 8(3): 123-137.

Huemer, L, Von Krogh, G & Roos, J. 1998. Knowledge and the concept of trust. In, Von Krogh, G, Roos, J & Kleine, D (eds). *Knowing in firms: understanding, managing and measuring knowledge.* London: Sage: 123-145.

Huit, W. 1999. Connation as an important factor of mind. In, *Educational Psychology Interactive.* Valdosta: Valdosta State University. http://www.edpsycinteractive.org/topics/conation/conation.html (Accessed 10 February 2012).

Hurd, JM, Weller, AC & Curtis, KL. 1992. Information seeking behavior of faculty: use of indexes and abstracts by scientists and engineers. *Proceedings of the American Society for Information Science* 29: 136-143.

Huvila, I. 2006. *The ecology of information work: a case study of bridging archaeological work and virtual reality based knowledge organisation.* Abo: Abo Akademi University Press.

Huvila, I. 2008. Work and work roles: a context of tasks. *Journal of Documentation* 64(6): 797-815.

Hyldegård, J. 2006. Collaborative information behavior: exploring Kuhlthau's information search process model in a group-based educational setting. *Information Processing and Management* 42(1): 276-298.

Ikeya, N, Awamur, N & Sakai, S. 2011. Why do we need to share information?: analysis of collaborative task management meetings. In, Foster, J (ed). *Collaborative information behavior: user engagement and communication sharing*. Hershey: Information Science Reference: 89-108.

Ileperuma, S. 2002. Information gathering behaviour of arts scholars in Sri Lankan universities : a critical evaluation. *Collection Building* 21(1): 22-31.

Ingwersen, P & Järvelin, K. 2005. *The turn.* Dordrecht: Springer.

International Technology Education Association. 2007. *Standards for technological literacy.* Reston, VA: ITEA.

Jackson, WK. 2001. *Information overload and managerial roles: a naturalistic study of engineers.* Austin.

Jaeger, PT & Burnett, G. 2010. Information worlds: social context, technology and information behavior in the age of the Internet. New York: Routledge.

Jagtap, S & Johnson, A. 2010. Requirements and use of in-service information in an engineering redesign task: case studies from the aerospace industry. *Journal of the American Society for Information Science and Technology* 61(12): 2442-2460.

Johnson, J. 1997. A frameworks for interaction (FINT) scale: extensions and refinement in an industrial setting. *Communication Studies* 48(2): 127-141.

Johnson, J. 2003. On contexts of information seeking. *Information Processing and Management* 39(5): 735-760.

Julien, H & Duggan, LJ. 2000. A longitudinal analysis of the information needs and uses literature. *Library and Information Science Research* 22(3): 391-309.

Julien, H & Michels, D. 2004. Intra-individual information behaviour in daily life. *Information Processing and Management* 40: 547-562

Karamuftuoglu, M. 1998. Collaborative information retrieval: toward a socia informatics view of IR interaction. *Journal of the American Society for Information Science* 49(12): 1070-1080.

Kakihara, M & Sørensen, C. 2004. Practising mobile professional work: tales of locational operational, and interactional mobility. *Info* 6(3): 180-187.

Kari, J. 2010. Diversity in the conceptions of information use. *Information Research* 15(3).

Katz, R & Tushman, M. 1979. Communication patterns, project performance and task characteristics: an empirical evaluation and integration in an R&D setting. *Organizational Behavior and Human Performance* 23(2): 139-162.

Katz, R & Tushman, M. 1981. An investigation into the managerial roles and career paths of gatekeepers and project supervisors in a major R&D facility. *R&D Management* 11(3): 103-110.

Kent, J. 2005. Cognitive phenomena: expanded consciousness, lifting the veil. In, *Psychedelic information theory.* Seattle: PIT Press. www.tripzine.com/listing.php?id=pit15 (Accessed 30 January 2013).

King, DW, Casto, J & Jones, H. 1994. *Communication by engineers: a literature review of engineers' information needs, seeking processes and use.* Washington, DC: Council on Library Resources.

Korobili, S, Malliari, A & Zapounidou, S. 2011. Factors that influence information-seeking behavior: the case of Greek graduate students. *Journal of Academic Librarianship* 37(2): 155-165.

Kraaijenbrink, J. 2007. Engineers and the web: an analysis of real life gaps in information use. *Information Processing and Management* 43(5): 1368-1382.

Kratzer, J, Leenders, R & Van Engelen, J. 2008. The social structure of leadership and creativity in engineering design teams: an empirical analysis. *Journal of Engineering Technology Management* 25(4): 269-286.

Kraut, RE & Streeter, LA. 1995. Coordination in software development. *Communications of the ACM* 38(3): 69-81.

Kramer, MG. 1988. Approaches and practices: Caveat Vendor: packagain rhetoric for the corporate marketplace. *Journal of Business and Technical Communication* 2: 71-77.

Kremer, JM. 1980. Information flow among engineers in a design company*.* PhD thesis, University of Illinois, Urbana-Campaign.

Krikelas, J. 1983. Information-seeking behavior: patterns and concepts. *Drexel Library Quarterly* 19(6): 5-20.

Kuhlthau, CC. 2004. *Seeking meaning : a process approach to library and information services.* 2nd ed. Westport: Libraries Unlimited.

Kuhlthau, CC. 2005. Kuhlthau's information search process. In, Fisher, KE, Erdelez, S & McKechnie, EF (eds). *Theories of information behavior* . Medford: Information Today: 230-234.

Kvale, S (ed). 2007. *Doing interviews: introduction to interview research.* London: Sage.

Kvale, S & Brinkmann, S. 2009. *Interviews: learning the craft of qualitative inquiry.* Los Angeles, CA: Sage.

Kwasitsu, L. 2003. Information seeking behavior of design, process, and manufacturing engineers. *Library and Information Science Research* 25(4): 459-476.

Lamb, R, King, J & Kling, R. 2003. Informational environments: organizational contexts of online information use. *Journal of the American Society for Information Science and Technology* 54(2): 97-114.

Lappalainen, P. 2009. Communication as part of the engineering skills set. *European Journal of Engineering Education* 34(2): 123-129.

Leckie, GJ, Pettigrew, KE & Sylvain, C. 1996. Modelling the information seeking of professionals: a general model derived from research on engineers, health care professionals and lawyers. *Library Quarterly* 66(2): 161-193.

Lee, JS & Cho, H. 2011. Factors affecting information seeking and evaluation in a distributed learning environment. *Educational Technology and Society* 14(2): 213-223.

Lee, KJ & Thomas, JO. 2008. Understanding consultants' information-seeking practices: knowledge management's touchpoint. *2008 Conference on Human Factors in*

Computing Systems (CHI'08). Florence: Association for Computing Machinery (ACM): 3543-3548.

Leenders, RT, Van Engelen, JM & Kratzer, J. 2003. Virtuality, communication, and new product team creativity: a social perspective. *Journal of Engineering and Technology Management* 20(1/2): 69-92.

Lera, S, Cooper, I & Powell, JA. 1984. Information and designers. *Design Studies* 5(2): 113-120.

Lievrouw, LA. 2001. New media and the "pluralization of life-worlds". *New Media & Society* 3(1): 7-28.

Lincoln, YS & Guba, EG. 1985. *Naturalistic inquiry.* Beverly Hills: Sage.

Lowe, A, McMahon, C & Culley, S. 2004. Characterising the requirements of engineering information systems. *International Journal of Information Management* 24(5): 401-422.

Lundh, A. (2010). Studying information needs as question-negotiations in an educational context: a methodological comment. *Information Research,* 15(4).

Makri, S & Warwick, C. 2010. Information for inspiration: understanding architects' information seeking and use behaviors to inform design. *Journal of the American Society for Information Science and Technology* 61(9): 1745-1770.

Marshall, MN. 1995. Sampling for qualitative research. *Family Practice* 13(6): 522-525.

Mascitelli, R. 2000. From experience: harnessing tacit knowledge to achieve breakthrough innovation. *Journal of Product Innovation Management 17*(3): 179-193.

Maslow, AH. 1943. A theory of human motivation. *Psychological Review* 50: 370-396.

Mason, H & Robinson, L. 2011. The information-related behaviour of emerging artists and designers: inspiration and guidance for new practitioners. *Journal of Documentation* 67(1): 159-180.

McCreadie, M & Rice, RE. 1999. Trends in analyzing access to information. Part 1: Cross-disciplinary conceptualizations of access. *Information Processing & Management* 35: 45-76.

McDonald, DW & Ackerman, MS. 1998. Just talk to me: a field study of expertise location. In, Poltrock, S & Grudin, J (ed). *Proceedings of the 1998 ACM Conference on Computer Supported Cooperative Work (CSCW '98)*. New York:

ACM Press: 312-324. http://pensivepuffin.com/dwmcphd/papers/McDonald.CSCW98.pdf (Accessed 14 July 2013).

McKenzie, PJ. 2004. Positioning theory and the negotiation of information needs in a clinical midwifery setting. *Journal of the American Society for Information Science and Technology* 55(8): 685-694.

Mench, JW. 2002. Electrical education for construction engineers. *Proceedings IEEE SoutheastCon 2002, 5-7 April 2002*. [Columbia]: [IEEE]: 147-151.

Meyer, HWJ. 2003. Information use in rural development. *New Review of Information Behaviour Research* 4(1): 109-125.

Milewski, AE. 2007. Global and task effects in information-seeking among software engineers. *Empirical Software Engineering* 12(3): 311-326.

Montesi, M & Navarrete, T. 2008. Classifying web genres in context: a case study documenting the web genres used by a software engineer. *Information Processing and Management* 44(4): 1410-1430.

Mowshowitz, A. 1997. Virtual organization: a vision of management in the information age. *Communications of the ACM* 40(9): 30-37.

Mueller, BK, Sorini, G & Grossman, E. 2006. *Information seeking behavior of engineers in the corporate environment: implications for information delivery.* Apaper presented at the Special Libraries Association (SLA) Annual Conference in Toronto, 5-8 June 2005. http://www.sla.org/documents/conf/toronto/Mueller.doc (Accessed 6 May 2010).

Nahl, D. 2001. A conceptual framework for explaining information behavior. *Studies in Media & Information Literacy Education* 1(2): 1-15.

Nardi, BA, Whittaker, S & Schwarz, H. 2000. It's not what you know, it's who you know: work in the information age. *First Monday 5*(5). http://www.firstmonday.org/issues/issue5/nardi/index.html (Accessed 20 June 2005).

Nardi, BA, Whittaker, S & Schwarz, H. 2002. Networkers and their activity in intensional networks. *Journal of Computer Supported Cooperative Work* 11(1-2): 205-242.

Naumer, CM & Fisher, KE. 2009. Information needs. In, *Encycopledia of Library and Information Sciences.* 3rd ed. London: Taylor & Francis: 2452-2458.

Nichols, D & Twidale, M. 2011. Recommendation, collaboration and social search. In, Ruthven, I & Kelly, D (eds). *Interactive information seeking behaviour and retrieval.* London: Facet: 205-220.

Nunkoosing, K. 2005. The problems with interviews. *Qualitative Health Research* 15(5): 698-706.

Nwagwu, WE & Segilola, MO. 2013. Information needs, information sources and information seeking behaviours of engineers in breweries in Nigeria. *Libri* 63(2): 159-178.

O'Day, VL & Jeffries, R. 1993. Information artisans: patterns of result sharing by information searchers. *COCS'93: Proceedings of the ACM conference on organizational computing systems, 1-4 November 1993*. Milpitas, CA: ACM Press: 98-107. http://www.hpl.hp.com/techreports/93/HPL-93-19.pdf?jumpid=reg_r1002_zaen_c-001_title_r0003 (Accessed October 15, 2010)

Olson, GM & Olson, JS. 2000. Distance matters. *Human-Computer Interaction* 15(2): 139-178.

Olson, JS & Teasley, S. 1996. Groupware in the wild: lessons learned from a year of virtual collocation. *Proceedings of the ACM 1996 Conference on Computer Supported Cooperative, Boston, MA, 16-20 November 1966.* New York: ACM Press: 419-427.

Olson, JS, Grudin, J & Horvitz, E. 2005. A study of preferences for sharing and privacy. *CHI 2005: CHI'05 extended abstracts on human factors in computing systems.* New York: ACM Press: 1985-1988.

Olson, JS, Olson, GM & Hofer, EC. [2005?] What makes for success in science and engineering collaboratories? http://citeseerx.is.psu.edu/viewdoc/download?doi=10.1.1.118.1417&reptype=pdf. (Accessed 15 August 2011).

Palmer, M. 1993. Role of information technology in addressing the information needs of engineers operating in a developing country. Masters' Dissertation - Rand Afrikaans University. Johannesburg.

Pendleton, VE & Chatman, EA. 1998. Small world lives: implications for the public library. *Library Trends* 46(4): 732-752.

Pepe, A. 2010. Structure and evolution of scientific collaboration networks in a modern research collaboratory. PhD thesis - University of California. Los Angeles.

Pettigrew, KE. 1997. The role of community health nurses in providing information and referral to the elderly: a study based on social network theory. PhD thesis, University of Western Ontario, London, ON.

Pettigrew, KE. 1999. Waiting for chiropody: contextual results from an ethnographic study of the information behaviour among attendees at community clinics. *Information Processing and Management* 35(6): 801-817.

Pettigrew, K, Fidel, R & Bruce, H. 2001. Conceptual frameworks in information behaviour. *Annual Review of Information Science and Technology* 35: 43-77.

Pilerot, O & Limberg, L. 2011. Information sharing as a means to reach collective understanding: a study of design scholars' information practices. *Journal of Documentation* 67(2): 312-333.

Pinelli, TE. 2001. Distinguishing engineers from scientists: the case for an engineering knowledge community. *Science and Technology Libraries* 21(3/4): 131-161.

Pinelli, TE, Barclay, R, Kennedy, J, Glassman, N & Demerath, L. 1991. The relationship between seven variables and the use of US government technical reports by US aerospace engineers and scientists. *ASIS Proceedings* 28: 313-321.

Pinelli, T, Bishop, A, Barclay, R & Kennedy, J. 1992. The electronic transfer of information and aerospace knowledge diffusion. *International Forum on Information and Documentation* 17(4): 8-16.

Pinelli, T, Glassman, M, Oliu, W & Barclay, R. 1989. *Technical communications in aeronautics: results of Phase 1 Pilot Study: Report 1.* National Aeronautics and Space Administration (NASA). Washington, DC: NASA.

Polkinghorne, DE. 1995. Narrative configuration in qualitative analysis. *Qualitative Studies in Education* 8(1): 5-23.

Poltrock, S, Grudin, J, Dumais, S, Fidel, R, Bruce, H & Pejtersen, AM. 2003. Information seeking and sharing in design teams. *Proceedings of the 2003 International ACM SIGGROUP Conference on Supporting Group Work*. New York: Association for Computing Machinery: 239-247.

Prekop, P. 2002. A qualitative study of collaborative information seeking. *Journal of Documentation* 58(5): 533-547.

Project Management Institute (PMI). Standards Committee. 1996. *A guide to the Project Management body of knowledge,* WR Duncan (Ed). Newtown Square: The Institute.

Punch, K. 1998. *Introduction to social research: quantitative and qualitative approaches.* London: Sage.

Rasmussen, J, Pejtersen, AM & Goodstein, LP. 1994. *Cognitive systems engineering.* New York: Wiley.

Rouse, M. 2006. Social networking. http://whatis.techtarget.com/definiton/social-networking (accessed April 1, 2015).

Reddy, MC & Jansen, BJ. 2008. A model for understanding collaborative information behavior in context: a study of two healthcare teams. *Information Processing and Management* 44(1): 256-273.

Reddy, MC, Jansen, BJ & Spence, PR. 2011. Collaborative information behavior: exploring collaboration and coordination during information seeking and retrieval activities. In, Foster, J (Ed). *Collaborative information behavior: user engagement and communication sharing*. Hershey: Information Science Reference: 73-89.

Rieh, SY. 2004. On the Web at home: information seeking and web searching in the home environment. *Journal of the American Society for Information Science and Technology* 55(8): 743-753.

Riessman, CK. 2008. *Narrative methods for the human sciences.* Los Angeles, CA: Sage.

Robbins, S, Engel, D & Kulp, C. 2011. How unique are our users? Comparing responses regarding the information-seeking habits of engineering faculty. *College and Research Libraries* 72(6): 515-532.

Robertson, M & Swan, J. 2003. Control, what control? Culture and ambiguity within a knowledge intensive firm. *Journal of Management Studies* 40(4): 831-858.

Robinson, MA. 2010. An empirical analysis of engineers' information behaviours. *Journal of the American Society for Information Science and Technology* 61(4): 640-658.

Robson, A & Robinson, L. 2013. Building on models of information behaviour: linking information seeking and communication. *Journal of Documentation* 69(2): 169-193.

Rosenbaum, H. 1993. Information use environments and structuration: towards an integration of Taylor and Giddens. *Proceedings of the 56th Annual Meeting of the American Society of Information Science, Columbus, OH, 24-28 October 1993:* 235-245. http://ils.indiana.edu/faculty/hrosenba/www/Papers/ASIS962.html (Accessed on 21 September 2013).

Rosenbaum, H. 1996. Structure and action: towards a new concept of the information use environment: ASIS 1996 Annual Conference: contributed paper. *ASIS 1996 Annual Conference Proceedings October 19-24, 1996.* Https://scholarworks.iu.edu/dspace/bitstream/handle/2022/1804/wp96-04B.html?sequence=1 (Accessed 14 March 2012).

Rosenberg, V. 1967. Factors affecting the preferences of industrial personnel for information gathering methods. *Information Storage and Retrieval* 3(3): 119-127.

Rosenbloom, R & Wolek, F. 1970. *Technology and information transfer: a survey of practice in industrial organizations.* Boston: Harvard University.

Rosenthal, G. 1993. Reconstruction of life stories: principles of selection in generating stories for narrative biographical interviews. In, Josselson, R & Lieblich, A (Eds). *The narrative study of lives.* London: Sage: 59-91.

Rousseau, DM, Sitkin, SB, Burt, RS & Camerer, C. 1998. Not so different after all: a cross-discipline view of trust. *Academy of Management Review* 23(3): 393-404.

Rubin, HJ & Rubin, RS. 1995. *Qualitative interviewing: the art of hearing data.* Thousand Oaks, CA: Sage.

Salancik, GR. 1995. Wanted: a good network theory of organisation. *Administrative Science Quarterly* 40(2): 345-349.

Sandstrom, PE. 1994. An optimal foraging approach to information seeking and use. *Library Quarterly* 64(4): 414-449.

Savin-Baden, M & Van Niekerk, L. 2007. Narrative inquiry: theory and practice. *Journal of Geography in Higher Education* 31(3): 459-472.

Savolainen, R. 1993. The sense-making theory: reviewing interests of a user-centered approach to information seeking and use. *Information Processing and Management* 29(1): 13-28.

Savolainen, R. 2006. Time as a context of information seeking. *Library and Information Science Research* 28(1): 110-127.

Savolainen, R. 2007. Information behavior and information practice: reviewing the "umbrella concept" of information-seeking studies. *Library Quarterly* 77(2): 109-132.

Savolainen, R. 2009. Small world and information grounds as contexts of information seeking and sharing. *Library and Information Science Research* 31(1): 38-45.

Savolainen, R. 2012. Conceptualizing information need in context. *Information Research* 17(4).

Savolainen, R. 2014. Emotions as motivators for information seeking: a conceptual analysis. *Library and Information Science Research* 36(1): 59-65.

Schutz, A & Luckman, T. 1974. *The structures of the life-world,* translated by T. Engelhard & R. Zaner. London: Heinemann.

Schwarzwalder, R. 2001. The implementaion of information technology in the corporate engineering library. *Science and Technology Libraries* 19(3/4): 189-205.

Shah, C. 2012. *Collaborative information seeking: the art and science of making the whole greater than the sum of all.* Berlin: Springer.

Shapira, B, Kantor, PB & Melmed, B. 2001. The effect of extrinsic motivation on user behavior in a collaborative information finding system. *Journal of the American Society for Information Science and Technology* 52(11): 879-887.

Shenton, AK. 2004. Strategies for ensuring trustworthiness in qualitative research projects. *Education for Information* 22(2): 63-75.

Shepherd, A. 1998. HTA as a frameword for task analysis. *Ergonomics* 41(11): 1537-1552.

Sheppard, S, Colby, A, Macatangay, K & Sullivan, W. 2006. What is engineering practice? *International Journal for Engineering Education* 22(3): 429-438.

Shuchman, HL. 1981. *Information transfer in engineering.* Glastonbury: Futures Group.

Smith, RJ. 2011. *Engineering.* http://www.britannica.com/EBchecked/topic/187549/engineering (Accessed 9 September 2011).

Solomon, P. 1997. Discovering information behavior in sense making. II. The social. *Journal of the American Society for Information Science* 48(12): 1109-1126.

Solomon, P. 2002. Discovering information in context. *Annual Review of Information Science and Technology,* 36(1): 229-264.

Sonnenwald, DH. 1995. Contested collaboration: a descriptive model of intergroup communication in information system design. *Information Processing and Management* 31(6): 859-877.

Sonnenwald, DH. 1996. Communication roles that support collaboration during the design process. *Design Studies* 17(3): 277-301.

Sonnenwald, DH. 1999. Evolving perspectives of human information behaviour: contexts, situations, social networks and information horizons. In, Wilson, T & Allen, D (eds). *Exploring the contexts of information behaviour: proceedings of the 2nd International Conference on Research in Information Needs, Seeking and Use in Different Contexts, 1998 August 13-14, Sheffield*. London: Taylor Graham: 176-190

Sonnenwald, DH. 2003. Expectations for a scientific collaboratory: a case study. *Proceedings of the 2003 International SCM SIGGROUP Conference on Supporting Group Work*. New York: ACM: 68-74.

Sonnenwald, DH. 2006. Challenges in sharing information effectively: examples from command and control. *Information Research* 11(4).

Sonnenwald, DH. 2008. Scientific collaboration. *Annual Review of Information Science and Technology* 41(1): 643-681.

Sonnenwald, DH & Iivonen, M. 1999. An integrated human information behaviour research framework for information studies. *Library and Information Science Research* 21(4): 429-457.

Sonnenwald, DH & Lievrouw, LA. 1996. Collaboration during the design process: a case study of communication, information behaviour and project performance. *Information seeking in context: proceedings of an international conference on research in information needs, seeking and use in different contexts, Tampere, Finland 1996.* Los Angeles: Taylor Graham: 179-204.

Sonnenwald, DH, Maglaughlin, KL & Whitton, MC. 2004. Designing to support situation awareness across distances: an example from a scientific collaboratory. *Information Processing and Management* 40(6): 989-1011.

Sonnenwald, DH & Pierce, LG. 2000. Information behaviour in dynamic group work contexts: interwoven situational awareness, dense social networks and contested collaboration in command and control. *Information Processing and Management* 36(3): 461-479.

South African Bureau of Standards. 2005. *Catalogue: 2005.* Pretoria: Standards South Africa.

South African concise Oxford dictionary. 2002. Sv. “boundary”. Cape Town: Oxford University Press: 133.

South African concise Oxford dictionary. 2002. Sv. “profession”. Cape Town: Oxford University Press: 931.

South African concise Oxford dictionary. 2002. Sv “project”. Cape Town: Oxford University Press: 932.

South African concise Oxford dictionary. 2002. Sv. "role". Cape Town: Oxford University Press Southern Africa: 1012.

Stryker, SC. 2011. *Principles and practices of professional consulting [online].* Lanham: Rowman & Littlefield.

Sturdy, A, Handley, K, Clark, T & Fincham, R. 2009. *Management consultancy: boundaries and knowledge in action.* [S.l]: Oxford Scholarship Online.

Su, C & Contractor, N. 2011. A multidimensional network approach to studying team members' information seeking from human and digital knowledge sources in consulting firms. *Journal of the American Society for Information Science and Technology* 62(7): 1257-1275.

Su, C, Huang, M & Contractor, N. 2010. Understanding the structures, antecedents and outcomes of organisational learning and knowledge transfer: a multi-theoretical and multi-level network analysis. *European Journal of International Management* 46(6): 576-601.

Sutton, B. 2009. Qualitative research methods in library and information science [ELIS Classic]. In, Bates, M (ed). *Encyclopedia of library and information sciences.* 3rd ed. New York: Taylor and Francis: 4380-4393.

Symon, G, Long, K & Ellis, J. 1996. The coordination of work activities: cooperation and conflict in a hospital context. *Computer Supported Cooperative Work* 5(1): 1-31.

Tackie, S & Adams, M. 2007. Information needs and seeking behaviour of engineers in Ghana: a case study of the Volta River Authority. *African Journal for Library, Archives and Information Science* 17(2): 69-78.

Talja, S. 2002. Information sharing in academic communities: types and levels of collaboration in information seeking and use. *New Review of Information Behavior Research* 3(1): 143-159. http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.96.163&rep=rep1&type=pdf (Accessed 12 June 2011).

Talja, S & Hansen, P. 2006. Information sharing. In, Spink, A & Cole, C (eds). *New directions in human information behavior.* Dordrecht: Springer: 113-134.

Tan, BC, Wei, KK, Watson, RT, Clapper, DL & McLean, ER. 1998. Computer-mediated communication and majority influence: assessing the impact in an individualistic and a collectivistic culture. *Management Science* 44(9): 1263-1278.

Taylor, RS. 1968. Question negotiation and information seeking in libraries. *College and Research Libraries* 29(3): 178-194.

Taylor, RS. 1991. Information use environments. In, Dervin, B & Voigt, M. *Progress in communication sciences.* 10: 217-255.

Tenopir, C & King, DW. 2004. *Communication patterns of engineers.* [Piscataway, NJ]: IEEE Press.

Thilmany, J. 2005. It's a steel zoo out there. *Mechanical Engineering* 127(9): 14.

Tiwana, A & Bush, AA. 2005. Continuance in expertise-sharing networks: a social perspective. *IEEE Transactions on Engineering Management,* 52(1): 85-101.

Toms, EG. 2011. Task-based information searching and retrieval. In, Ruthven, I & Kelley, D (eds). *Interactive information seeking behaviour and retrieval.* London: Facet: 43-59.

Tseng, S & Fogg, BJ. 1999. Credibility and computing technology. *Communications of the ACM* 42(5): 39-44.

Tushman, ML. 1977. Special boundary roles in the innovation process. *Administrative Science Quarterly* 22(4): 587-605.

Tushman, ML. 1978. Technical communication in R&D laboratories: the impact of project work characteristics. *Academy of Management Journal* 21(4): 624-645.

Tushman, ML. 1982. Managing communication networks in R&D laboratories. In, Tushman, M & Moore W (eds). *Readings in the management of innovation.* Marshfield: Pitman: 261-274.

Twidale, MB, Nichols, DM & Paice, CD. 1997. Browsing is a collaborative process. *Information Processing and Management* 33(6): 761-783.

Urquhart, C. 2011. Meta-synthesis with information behaviour research. In, Spink, A & Heinstrom, J (eds). *New Directions in information behaviour*. London: Emerald: 37-66.

Vakkari, P. 1997. Information seeking in context: a challenging metatheory. *Information seeking in context. Proceedings of an International Conference on Research in Information Needs, Seeking and Use in Different Contexts,* Tampere, Finland, 14-16 August 1996. London: Taylor & Francis: 451-464. www.informationr.net/isic/ISIC1996/96_Vakkari.pdf (Accessed 29 February 2012).

Vakkari, P. 1999. Task complexity, problem structure and inforamtion actions: integrating studies on information seeking and retrieval. *Information Processing and Management* 35(6): 819-837.

Vakkari, P. 2003. Task-based information searching. *Annual Review of Information Science and Technology* 37(1): 413-464.

Vakkari, P. 2008. Trends and approaches in information behaviour research. *Information Research* 13(4). www.informationr.net/ir/13-4/paper361.html (Accessed 15 March 2014).

Van House, NA, Butler, MH & Schiff, LR. 1998. Cooperative knowledge work and practices of trust. *ACM Conference on Computer Supported Cooperative Work, Seattle, Washington*. New York: Association for Computing Machinery: 335-343.

Veshosky, D. 1998. Managing innovation information in engineering and construction firms. *Journal of Management in Engineering* 14(1): 58-66.

Vicenti, W. 1990. *What engineers know and how they know it: analytical studies from aeronautical history.* Baltimore, MD: Johns Hopkins University Press.

Von Krogh, G, Ichijo, K & Nonaka, I. 2000. *Enabling knowledge creation: how to unlock the mystery of tacit knowledge and release the power of innovation.* New York: Oxford University Press.

Von Seggern, M. 1995. Scientists, information seeking, and reference services. *Reference Librarian* 23(49/50): 95-104.

Wang, P. 1999. Methodologies and methods for user behavioral research. *Annual Review of Information Science and Technology* 34: 53-99.

Wang, P. 2011. Information behavior and seeking. In, Ruthven, I & Kelly, D (eds). *Interactive information seeking behaviour and retrieval*. London: Facet: 15-41.

Ward, M. 2001. A survey of engineers in their information world. *Journal of Librarianship and Information Science* 33(4): 168-176.

Watson-Manheim, MB, Chudoba, KM & Crowston, K. 2002. Discontinuities and continuities: a new way to understand virtual work. *Information Technology and People,* 15(3): 191-209.

Weiten, W & Lloyd, MA. 2008. *Psychology applied to modern life.* 9th ed. Wadsworth: Cengage Learning.

Wellman, B & Berkowitz, SD. 1988. *Social structures: a network approach*. Cambridge: Cambridge University Press.

Westbrook, L. 208. Understanding crisis information needs in context: the case of intimate partner violence survivors. *Library Quarterly* 78(3): 237-261.

Whittaker, S & Sidner, C. 1997. E-mail overload: exploring personal information management of e-mail. In Kiesler, S. *Culture of the Internet*. New Jersey: Lawrence Erlbaum: 277-295.

Widén-Wulff, G, Ginman, M, Perttilä, R, Södergård, P & Tötterman, AK. 2008. Information behaviour meets social capital: a conceptual model. *Journal of Information Science* 34(3): 346-355.

Wildemuth, BM & Case DO. 2009. Early information behavior research. *Bulletin of the American Society for Information Science and Technology.* 36(3): 35-38.

Wilson, P. 1973. Situational relevance. *Information Storage and Retrieval* 9(8): 457-471.

Wilson, TD. 1981. On user studies and information needs. *Journal of Documentation* 37(1): 3-15.

Wilson, TD. 1999. Models in information behaviour research. *Journal of Documentation* 55(3): 249-270.

Wilson, TD. 2000. Human information behaviour. *Informing Science* 3(2): 49-55.

Wilson, TD. 2005. Evolution in information behavior modeling: Wilson's model. In, Fisher, K, Erdelez, S & McKechnie, L (eds). *Theories of information behavior*. Medford, NJ: Information Today: 31-66.

Wilson, TD. 2006. On user studies and information needs. *Journal of Documentation* 62(6): 658-670.

Wilson, TD. 2008. Activity theory and information seeking. *Annual Review of Information Science and Technology* 42(1): 119-161.

Wilson, TD. 2010. Information sharing: an exploration of the literature and some propositions. *Information Research* 15(4). www.informationr.net/ir/15-4/paper440.html (Accessed 15 February 2014).

Wilson, TD, Ellis, D, Ford, N, Foster, A & Spink, A. 2000. *Uncertainty and its correlates.* http://www.informationr.net/tdw/publ/unis/app4.html (Accessed 11 January 2014).

Wilson, TD, Ellis, D, Ford, N, Foster, A & Spink, A. 2002. Information seeking and mediated searching. Part 2. Uncertainty and its correlates. *Journal of the American Society for Information Science and Technology* 53(9): 704-715.

Wolek, FW. 1969. The engineer: his work and needs for information. *Proceedings of the Annual Meeting of the American Society for Information Science* 6: 471-476.

Your Dictionary. 2015. Sv “sharing”. http://www.yourdictionary.com/sharing (Accessed 3 June 2015).

Zhang, P & Benjamin, RI. 2007. Understanding information related fields: a conceptual framework. *Journal of the American Society for Information Science and Technology,* 58(13): 1934-1947.

Zipperer, L. 1993. The creative professional and knowledge. *Special Libraries* 84(2): 69-78.

Zucker, LG, Darby, MR, Brewer, MB & Peng, Y. 1996. Collaboration structure and information dilemmas in biotechnology: organizational boundaries as trust production. In, Kramer, RM & Tyler, TR (eds). *Trust in organizations: frontiers of theory and research*. London: Sage: 90-113.

APPENDIX A

FORM FOR RESEARCH SUBJECT'S PERMISSION

1. Title of research project: The role of social networking in the information seeking and sharing of consulting engineers.

I…………………………………………. …………………………………….

hereby voluntarily grant my permission for participation in the project as explained to me by Mrs Madely du Preez (Department of Information Science, University of South Africa). Participation will include an in-depth individual interview. I agree to interviews being tape-recorded.

2. The nature, objective, and implications have been explained to me and I understand them.

3. I understand that the project is aimed at understanding social networks and their role in providing task-related information to consulting engineers. The intention at this stage is not to provide consulting engineers and significant others with the actual information required or to introduce them to social networks, etc.

4. I understand my right to choose whether to participate in the project and that the information furnished will be handled confidentially. I am aware that the results of the investigation may be used for the purpose of publication or conference presentations.

5. Upon signature of this form, I will be provided with a copy.

Signed: ……………………………………………….. Date:………………

Researcher:……………………………………………. Date:……………….

VORM VIR TOESTEMMING DEUR DEELNEMERS AAN DIE NAVORSINGSPROJEK

1. **Titel van die navorsingsprojek: Die rol van sosiale netwerke in die inligtingsoeke en deel van inligting van raadgewende ingenieurs.**

   Ek………………………………………… …………………………………….. gee hiermee vrywilliglik toestemming tot my deelname aan die projek soos deur mev. Madely du Preez (Department Inligtingkunde, Universiteit van Suid-Afrika) aan my verduidelik. Deelname sal ’n in diepte persoonlike onderhoud beteken. Ek gee toestemming dat die onderhoud opgeneem mag word.

2. Die aard, doel, en implikasies van die projek is aan my verduidelik en ek verstaan dit.

3. Ek verstaan dat die projek daarop gerig is om die rol van sosiale netwerke in die inligtingsoeke en deel van inligting van raadgewende ingenieurs te bepaal. Die doel op hierdie stadium is nie om inligting as sodanig beskikbaar te stel nie of om die ingenieurs aan sosiale netwerke, ens. bekend te stel nie.

4. Ek verstaan my reg om te kies om deel te neem aan die projek en dat die inligting wat ingewin word vertroulik hanteer sal word. Ek is bewus daarvan dat die resultate van die ondersoek gebruik kan word vir publikasies of vir konferensie-aanbiedings.

5. Met die ondertekening van hierdie vorm sal ek van 'n kopie voorsien word.

Geteken: ……………………………………………….. Datum………………

Navorser:…………………………………………… Datum……………….

APPENDIX B

INTERVIEW SCHEDULE

PERSONAL INFORMATION

1. What is your engineering discipline?
2. For which organisation do you work and how is the organisation structured?
3. Please select a project in which you are currently involved or which has just been completed and tell me your story of the project.

PROJECT INFORMATION

The answers to the following questions should be derived from the story. If not, ask the questions:

4. What is the nature of the project?
5. Which engineering disciplines are represented on the project team?
6. Who is the project team leader and what is his/her occupation? For example, engineer / architect / quantity surveyor?
7. What is your task or role in the selected project team?
8. How does your role fit in with the roles of other team members?
9. What are the team leaders' roles or tasks in this project?

CLIENT NEEDS

10. Which team members are tasked with determining clients' needs?

COMMUNICATION

11. How do you generally communicate or share information with fellow team members? What methods or technologies are used to share information (cell phones, email, Dropbox). Are the same technologies used on all the projects in which you are involved?
12. What problems do you experience with information communication and information sharing on the project you described?

PERSONAL CONTACTS

13. What is the nature of the information you need from team members for each stage of the project?
    i. Reporting stage
    ii. Preliminary design stage
    iii. Design and tender stage
    iv. Working drawing and construction stage
    v. Target procurement stage

Other questions that could be asked, if not addressed in the story of the project:

1. Have you previously worked with any of the team members? Or, are you currently working with any of the team members on a different project?
2. If you need information for a project that cannot be provided by a team member, where do you look for that information? Which sources do you use? Who are possible contacts whom you would approach?
3. Can persons you know in the industry provide you with project-related information, even though they are not involved in the project themselves?
4. What is your preferred method of communication with team members?
5. How does the information that is available in your organisation support your information needs on the selected project?