INFORMATION NEEDS AND INFORMATION-SEEKING BEHAVIOUR OF CONSULTING ENGINEERS: A QUALITATIVE INVESTIGATION

by

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LIST OF ACRONYMS

CSIR	Council for Scientific and Industrial Research
ECSA	Engineering Council of South Africa
ESC	Electrical Supply Company
FIDIC	International Federation of Consulting Engineers
GPS	global positioning system
ISAP	Index to South African Periodicals
ISP	information search process
ISU	information-seeking and using
mms	multimedia message service
NLSA	National Library of South Africa
RE	residential engineer
QS	quantity surveyor
SAACE	South African Association of Consulting Engineers
SACPE	South African Council of Professional Engineers
SAISC	South African Institute for Steel Construction
SPE	Society for Professional Engineers
TEF	Technical Evaluation Forum

SUMMARY

This study involved a qualitative investigation of consulting engineers' information needs and information-seeking behaviour within the context of their project-related work roles and tasks. The research design includes a study of various information behaviour models, a systematic review of the subject literature and the exploration of relevant qualitative research methods. Data was collected through time-line interviews. The findings show how consulting engineers' work roles and tasks determine their information needs during various engineering project stages. These factors also determine the use of various sources during information seeking. Consulting engineers use a variety of information sources but rely mainly on interpersonal communication to gather information. Digital cameras are used by consulting engineers to record progress in a project. They also use Internet technologies such as email and FTP sites to communicate project related information. Recommendations were put forward for the development of an Internet-based information service for consulting engineers.

Keywords: Consulting engineers; Information behaviour, Information-seeking, Information needs; Qualitative studies

CHAPTER 1

GENERAL INTRODUCTION

1.1 BACKGROUND TO THE PROBLEM

The overriding purpose of engineering is to design technological devices or structures which are either based on new concepts or are modifications of existing concepts (Wolek 1969:471). Engineering development may also aim at the satisfaction of a new need or one which has not yet been met (Wolek 1969:471). With this purpose of engineering in mind engineers can be described as practising an applied science and can be characterised as subject specialists performing rather complex tasks (Hertzum & Pejtersen 2000:2). These tasks include all the required activities of the engineering project with which the engineer is involved. These activities include reporting, designing, supervising or the construction of an engineering device.

The Engineering Council of South Africa (ECSA) (2007:3) defines consulting engineers as “any professional registered in terms of the Engineering Professions Act, 2000 (Act no. 46 of 2000), or a juristic person who employs such a professional, engaged by a client on a project”. To be an ECSA registered engineer, the engineer should have completed an engineering degree in the discipline of his choice or interest, for example, civil, chemical, mechanical, or electrical engineering. The description of consulting engineers provided by

Gralewska-Vickery (1976:266) expands the ECSA definition by describing the work roles of consulting engineers as follows:

> "A consulting engineer is called in when the opinion of an expert is needed. He needs to be a good communicator, has relationships with his clients and their staff, frequently represents his client in dealings with government agencies, works with contractors, manufacturers and material suppliers, [and] is in contact with all of them to obtain the information needed in order to perform the task entrusted to him. He also communicates with other engineers, which include competitors and scientists. Consultants have nothing to sell except service, time, knowledge and judgement. They rely on contacts with prospective users of their services."

It is clear from the above that the engineering tasks, work roles and professional status of consulting engineers could determine their information needs and information-seeking behaviour. A study into the professionalism, work roles and tasks of consulting engineers might contribute to information scientists' knowledge of how these factors influence consulting engineers' information needs and their selection of information sources.

Apart from their statutory membership of ECSA, consulting engineers can also be members of the South African Association of Consulting Engineers (SAACE), the Society of Professional Engineers (SPE) and of the relevant discipline's engineering societies or institutes. Each of these professional bodies publishes regular newsletters and journals to update their members on the latest developments and trends in their respective fields. Some institutes, such as the South African Institute for Steel Construction (SAISC) provide an information service to their members.

Some multi-disciplinary engineering firms in South Africa have their own libraries and information services while other consulting engineering firms do not have the resources available to employ information workers. For example, a consulting engineering firm located in the Pretoria region, would have to rely on the information services offered by the Council for Scientific and Industrial Research (CSIR), the University of Pretoria, the University of South Africa (UNISA), public libraries, the National Library of South Africa (NLSA) and the libraries of the relevant professional bodies to which the engineering firm belongs. However, these information services charge fees for their services and may not necessarily be able to meet the needs of consulting engineers. The latter may therefore be more dependent on their own information sources as well as other formal information resources, such as bookstores and the Internet to provide for their specific needs. Consulting engineers in other parts of the country may meet their specific needs for information from similar types of information sources or services.

Despite the fact that consulting engineers appear to experience difficulties in retrieving useful and relevant information to suit their needs, specific research on this user group has not been done in South Africa.

Allen (1988:6) notes that free communication of technical information among engineers from different organisations is greatly inhibited. This is because proprietary information must be protected to preserve a firm's position in a highly competitive marketplace and may therefore not be published. However, a good proportion of truly important engineering information is considered proprietary or is published within the organisation. The informal documentation system of the employing organisation is therefore an important source of information for the engineers working for a specific organisation (Allen 1988:6-7). This situation is more clearly explained in the guidelines of the International Federation of Consulting Engineers (FIDIC) (1998:11) which stipulates that the consultant retains copyright of all documents prepared by him and that he or she will be entitled to use them or copy them only for the works and the purpose for which they are intended. However, information is not available in textual or other recorded form unless someone has felt a need to write or record it in writing and spent time doing so (Bikson, Quint & Johnson in Holland Pinelli, Barclay & Kennedy 1991:321; Hertzum & Pejterson 2000:7). These factors would also influence engineers' information behaviour because the required information might not be available to the engineers when they need it. Research reported by Pinelli (1991:12) and Leckie, Pettigrew and Sylvain (1996:165) correspond with Allen's (1988) findings and the FIDIC guidelines.

The lack of freely available documented engineering information explains research findings indicating that a vacuum exists in the production, effective dissemination and acquisition of scientific and published or recorded technical information. Leckie *et al.* (1996:164) quote studies indicating that engineers need far more information than they generate. Whereas scientists use information primarily to produce similar information, engineers consume information primarily to reproduce physically encoded information with documentation being a by-product. Bikson, Quint and Johnson (in Holland *et al*. 1991:321) found that

> "…. dissemination activities were afterthoughts, undertaken without serious commitment by those whose primary concerns were with [knowledge] production and not with knowledge transfer"; [therefore], "much of what has been learned about how knowledge is diffused has not been incorporated into data, information, and knowledge diffusion activities."

The completion of an engineering task and the final report which consulting engineers need to submit to their clients is the outcomes of the engineers' use of information as well as the result of the information-seeking process. It is at this stage that information dissemination activities could take place, provided the engineers committed the time and acquired the necessary permissions to publish their reports to a wider engineering audience.

Keeping abreast of the latest engineering developments involves acquiring and using information about events, trends and relationships in an organisation's internal as well as external environment (Choo 2001:1). This is termed "environmental scanning".

Engineers also receive their ideas from informal sources, such as, colleagues, customers, vendors, and potential suppliers (Allen 1988:10). A personal observation is that consulting engineers have, for example, discussions with possible suppliers or contractors. These discussions provide the engineers with information about specific products that could be suitable for use in a specific project. Research on environmental scanning could therefore be of great value to the current study since consulting engineers may have to rely on information sources of information because of the lack of freely available published or recorded technical information.

Computers and telecommunications have opened up new methods of disseminating scientific information and primary publications in electronic format, including electronic newsletters (Allen 1991:32-33). However, the ability and willingness of consulting engineers to utilise and gain access to these information resources could affect the use they make of these resources. If library and information scientists could build up a body of knowledge about the information needs and information-seeking behaviour of consulting engineers, it could be possible to design a unique information system on the Internet that suits their specific information needs.

It is clear that various determining factors such as work roles, engineering tasks, professional status or membership of a professional group, the availability and accessibility of formal and informal information sources, systems and services, and the communication of engineering information are related to engineers' information needs and information-seeking behaviour An examination of the present state of research may reveal gaps in our body of knowledge in regard to these aspects.

1.1.1 Present state of research

King, Casto and Jones (1994) compiled a useful guide to the literature reporting research on the ways engineers seek and use information. In their literature review, King *et al* (1994) found that scientific and technical information (STI) communication research performed by engineers is based on five kinds of models or research approaches:

a. Research and development projects and tasks

Studies on research and development projects and tasks make it possible to determine the relative importance of various personal, interpersonal, published and other information sources. Allen (1977), Shuchman (1981), Tushman (1982), and Pinelli *et al.* (1991) and his colleagues conducted such research.

b. The exchange or flow of information among individual engineers or scientists

This type of research determined the extent to which specific individuals are used as information sources and the extent to which intra-unit, intra-organisation and external information sources are utilised. For instance, Allen (1977), Shuchman (1981) and Tushman (1982) relied on this approach.

c. Life cycle of information

This approach examines newly created information and follows it through its life cycle and use through communication channels such as internal discussions, reporting in meetings, formal publication of meeting procedures, journal articles, books etcetera. Various studies by Garvey (in King *et al.* 1994:7) and his colleagues conducted during the period from 1967 to 1972 focused on the life cycle of information research.

d. Amount of information-related activity and information use

Researchers who focused on the amount of information-related activity and information use are Garvey (1960-1970) and King (1960-1980). These studies examined either specific communication functions (e.g. authorship, publishing, identification) or the participants or users who perform the functions (e.g. authors, publishers, and libraries).

e. The amount and characteristics of the flow of information among functions or participants

These kinds of studies examine the flow of information among authors and publishers; publishers and engineers; libraries and engineers and so on. Garvey (1960-1970), King (1960-1980) and various studies by Pinelli and his colleagues (1980,1989-1994) adopted this research approach.

Since 1980, Pinelli and his colleagues (in King *et al.* 1994:37) have performed a series of studies of technical communications in the aerospace field. Pinelli's (1991) study and King *et al.*'s (1994) literature review indicates that much research has been done on the information-seeking behaviour of engineers as well as the types of information sources consulted by them.

Various studies of engineers' information-seeking behaviour determined that they are crucially dependent not only on documents but also on people and experimentation as sources of information. These include studies conducted by Anderson, Glassman, McAfee and Pinelli (2001), Case (2002), Case (2007), Gralewska-Vickery (1976), Hertzum (2002), Hertzum and Pejterson (2000), Holland, Pinelli, Barclay and Kennedy (1991), Holland and Powell (1995), Mueller, Sorini and Grossman (2006),Katz and Tushman (1979), Kremer (1980), Taylor (1991) and Ward (2001). Tenopir and King (2004:181) indicate that the reasons for this may be the nature of engineering work, but that engineers' inherent personalities, ways of addressing problems, and learning styles could also play a role.

Engineers spend a lot of their time communicating technical information and they choose to do so because their performance depends on communicating (King *et al.* 1994:9). This is done despite the restrictions imposed on the free communication of information amongst engineers from different organisations previously reported.

Engineers also seldom find all the information they need to solve a technical problem in one source as is the case with many other types of information seekers (Bates 1989:10; Kaufman in Pinelli *et al.*1991:20). Leckie *et al.* (1996:279) indicate that studies of diverse professional groups (including engineers) have all concluded that professionals are frequently frustrated in their search for relevant and necessary information due to the large number of complex and interacting factors that may influence information-seeking. This could be attributed to the complexity of the engineering tasks with which the engineers are involved. The engineers' information needs are also characterised by the context of the information need, the frequency or recurrence of the need and whether the engineers can predict or anticipate a need for information (Leckie *et al.* 1996:182-183).

Some personal observations of the information-seeking behaviour of consulting engineers have shown that they prefer buying a new book to visiting a library. Various research findings indicate that engineers are reluctant to use a library (Ellis & Haugan 1997:401; Fidel & Green 2004:12; Gralewska-Vickery 1976:281; Leckie *et al.* 1996:165-166; Taylor 1991:227). These observations and research findings in fact could be regarded as a tentative confirmation of Tenopir and King's (2004:181) contention that engineers tend to be self-sufficient and more direct in their approach to work.

Therefore, knowledge of engineers' information-seeking behaviour could contribute to the creation and development of viable information retrieval systems for engineering companies (Hertzum 2003:1-2). Studies on engineers' use of electronic databases and various information technologies have found that these professionals either fail to take advantage of electronic information access and retrieval systems or, when they do use online databases, they stick to one or two paid access resources (Hurd, Weller & Curtis 1992:183; Mueller, Sorini &

Grossman 2006:3). A recent study conducted by Kraaijenbrink (2007:9) further determined that engineers using the Internet to find information, found numerous gaps concerning the availability of suitable information.

However, the possibility exists that older consulting engineers may be reluctant to use the Internet, or may not have the necessary skills required to gain access to Internet-based information systems. Since the average age of consulting engineers in South Africa is 56 years, according to a study by the SAACE (2005c:1), this was a factor that had to be taken into account in this study.

Previous studies on engineers' information needs and their use of information were mainly conducted within specific companies, and mostly within the same discipline. No studies appear to have been conducted on engineers in different independent companies and different disciplines. Nor have any South African studies been conducted on engineers' information needs and information-seeking behaviour. Ward (2001) appears to be the only researcher to have conducted a study on the information behaviour of consulting engineers. In view of the limited research involving consulting engineers, engineers who work in different engineering disciplines and different independent companies, a study on the information needs and information-seeking behaviour of South African consulting engineers could be of value.

Gralewska-Vickery (1976) also reported on some aspects of consulting engineers' information usage behaviour. However, the main purpose of her study was to investigate the information needs of earth science engineers rather than that of consulting engineers.

The indications are that engineers have unique information needs that are not easily satisfied by the use of conventional sources and library or information services. These needs also seem to be influenced by the engineers' work roles, tasks and the particular characteristics of their information needs such as context, frequency of use, and anticipated information needs (Leckie *et al.* 1996:183).

1.1.2 Aspects that require further research

Aspects that require further research have been identified by various researchers who studied engineers' information needs and information-seeking behaviour.

- Further examination of electronic media such as email, video conferencing, computerised databases, and Internet access in retrieving relevant information as well as the extent to which the selection of information sources in various formats is affected by organisational culture is required (Anderson *et al.* 2001:16).
- Studies on the specific factors that motivate an engineer to prefer one source over another are required according to Fidel and Green (2004:13). These authors are of the opinion that such studies will enrich information scientists' knowledge of the factors that influence engineers' decisions about selecting information sources. The findings from such studies could also assist library and information practitioners in the design of viable

information systems that could meet consulting engineers' information needs.

- Studies aimed at bridging the gap between the qualities of individual information systems and their interfaces, the use made of the information systems and the features work tasks are required (Järvelin & Ingwersen 2004:11). Considering the overall objective of engineering and the explanation of their work roles and tasks offered by Gralewska-Vickery, already reported, these tasks could involve the design of a system or structure, or the provision of a service or communication with contractors.

Kraaijenbrink (2007:14-15) identified gaps which engineers face when they try to find and use information on the Internet, some of these gaps have also been addressed by Cheuk Wai-Yi (1998a):

- A gap exists between the engineers' initial information need when their information-seeking process starts and the final information need when the information-seeking process ends. A gap also exists between the amount and quality of information provided and needed.
- Gaps related to forward and backward chain links (identification) to switching between websites containing relevant information and to translation from application through function to form (utilisation) also exist. Studies identifying these gaps would suggest opportunities for website designers to modify websites to meet the needs of engineers, as well as opening up new opportunities for research.

A research method designed to conduct an in-depth study of information gaps which are related to the engineers' tasks is required that would enable the researcher to identify the gaps between the engineers' initial information need and their final information need. A study of this nature could also assist the researcher in identifying the gap between the amount and the quality of the information that is provided and the quality of the information that is needed. Cheuk Wai-Yi's (1998a) study and Kraaijenbrink's (2007) are of the few in-depth studies that have been conducted to determine gaps in engineers' information needs.

A study identifying the gaps between consulting engineers' initial and final information needs could also assist in determining which sources of information that were selected by the engineers to solve their information problems. Initial information needs refer to those instances when the consulting engineers first identify a gap in their existing knowledge to complete a task and require general information to acquire an understanding of the concepts involved. Final information needs on the other hand, refer to the need for specific information in order to complete the task for which the initial information need was identified (Wolek 1969:471).

The studies reported in the subject literature do not seem to address aspects such as the work roles of consulting engineers and their engineering tasks and how these lead to initial and final information needs. Aspects such as the factors influencing the consulting engineers' preferences for specific sources of information also need to be addressed.

1.2 RESEARCH PROBLEM

In view of the identified aspects requiring research, the purpose of this study is to determine the information needs and information-seeking behaviour of consulting engineers with particular reference to their work roles and tasks, the kinds of information sources and services they consult and the various factors that influence their information needs and selection of information sources. This will enable the researcher to make recommendations for the design of information systems that could meet the information needs of consulting engineers. In view of this purpose the following main problem can be formulated:

What are the information needs and information-seeking behaviour of consulting engineers, and what are the factors that influence or shape their information needs and information-seeking behaviour? This problem was then divided into two sub-problems. These were:

1. How does the individual consulting engineer's work role and engineering task influence his or her information needs and information-seeking behaviour?

1.1 What are consulting engineers' work roles?

1.2 How do engineering tasks influence consulting engineers' information needs and information-seeking?

1.3. What are the characteristics of consulting engineers' information needs and how does it influence or shape their information-seeking?

2 What are the characteristics of consulting engineers' information-seeking behaviour and how do these factors affect the outcomes of information-seeking?

2.1 How do the factors related to various types of information sources affect consulting engineers' information-seeking?

2.2 How does an awareness of information sources, perceptions of the value of the information sources and the types of information required influence the consulting engineers' information-seeking?

2.3 What are the outcomes of engineers' information-seeking?

1.3 AIMS OF THE STUDY

The aim of the study is to propose recommendations in respect of an Internet-based information service that would suit the consulting engineers' specific needs. The study will also aim at developing a suitable model which could be used in future studies on the information behaviour of consulting engineers.

1.4 IMPORTANCE OF THE STUDY

An in-depth understanding of the information needs and information-seeking behaviour of consulting engineers could assist providers of engineering information in designing effective information systems that could meet consulting engineers' information needs.

1.5 RESEARCH METHODOLOGY

The research methodology includes a literature study and an empirical investigation. A qualitative research approach was adopted.

1.5.1 Literature study

A literature study of theoretical and empirical research findings on the information needs and information-seeking behaviour of engineers was conducted. These findings contribute to an understanding of the information needs and information-seeking behaviour of engineers in general. Research models that have been developed to explain information needs and information-seeking behaviour were studied in order to identify the research approach that could be used for this study. One of these models is used as a framework to systematise and interpret the empirical findings on the information needs and information-seeking behaviour of consulting engineers in Central and North Gauteng.

1.5.2 Empirical research

1.5.2.1 Research design and data collection method

A qualitative research design was used in view of the fact that qualitative rather than quantitative data is needed to conduct an in-depth investigation of information needs and information-seeking behaviour. The intention was to collect information rich data.

Questioning was the data collection method used. An open-ended time-line questionnaire served as an interview schedule. Fidel and Green (2004:13) demonstrated that detailed, open-ended interviews with engineers are a promising approach to uncover interviewees' information needs and information-seeking behaviour.

Personal interviews are the most convenient and most cost-effective method for both the researcher and individual responding engineers particularly in view of the fact that the study is restricted to consulting engineers residing in Central and North Gauteng. The intention was to collect information rich data. The data collection method is discussed in section 4.6

1.5.2.2 Sampling

For the purposes of this research, purposive and convenience sampling was deemed the best method. A small sample would enable the researcher to study the phenomenon in-depth.

Samples for qualitative investigations tend to be small and an appropriate sample size for a qualitative study is one that adequately answers the research question (Marshall 1996:523). Convenience sampling involves the selection of the most accessible subjects. A convenience sample is also the least costly to the researcher, in terms of time, effort and money (Marshall 1996:523).

The sample of engineers interviewed for this study was taken from 76 engineering companies registered with the South African Association of Consulting Engineers (SAACE 2005a). The sample represents civil, structural, electrical, electronic, mechanical, asset management and acoustical consulting engineering disciplines.

1.6 DEMARCATION OF THE FIELD

The unit of analysis is consulting engineers working for various consulting engineering firms in different engineering disciplines within Central and North Gauteng. None of these consulting engineers have a formal library or information system available within their organisation. Only engineers registered with the Engineering Council of South Africa (ECSA) and engineers who are employed by, or are directors of member companies of the South African Association of Consulting Engineers were approached to participate.

The aspects investigated are the information needs and information-seeking behaviour of consulting engineers. This will include an investigation into the factors that influence or shape their preferences for specific information sources and systems.

1.7 DEFINITIONS

1.7.1 Information behaviour

Information behaviour is the term which best encompasses the focus of the current study. Ingwersen and Järvelin (2005:384) define information behaviour as the "human behaviour dealing with generation, communication, use and other activities concerned with information, such as, information-seeking behaviour and interactive IR [information retrieval]." According to this definition, information behaviour will include all aspects of human behaviour (such as work roles and tasks) that require users to generate, communicate and seek information that is relevant to their information needs. This term also embraces information retrieval activities.

The information behaviour of engineers can be described and explained by studying those factors that influence engineers in the generation and communication of engineering information. In this study, engineers' information behaviour is explained by investigating those factors that influence the engineers' information-seeking behaviour such as their work roles and tasks. The information sources they use reveal their patterns of information-seeking and enable one to describe their information behaviour.

1.7.2 Information needs

An information need arises when an individual senses a problematic situation or information gap, in which his or her internal knowledge and beliefs, and model of the environment fail to suggest a path towards the satisfaction of his or her goals (Case 2007:333). Such an identified information need may lead to information-seeking and the formulation of requests for information (Ingwersen & Järvelin, 2005:20). The term "information need" therefore does not necessarily imply that people are "in need of" information as such but that the use of information can lead to the satisfaction of a more basic need (Wilson 1981:5-6).

When considered from a task performance point of view, information needs are the requirements for information as they are necessary to fulfil a task (International Organisation for Standardisation (ISO) in Blom 1983:4).

1.7.3 Information requirements

The terms "information needs" and "information requirements" are often used for the same concept. Information requirements are however user specifications that apply when information is requested or exchanged and include aspects such as accessibility and relevance of information (Gericke 2001:57). These aspects further influence the consulting engineers' awareness of information. This study will use the term "information needs."

Consulting engineers' information needs can be determined by studying the situation, work roles, type of work roles and tasks they are engaged in, or have to complete. For example, if the task is the construction of a building, then the engineer would have to ask, what are the client's specifications and which building regulations have to be met?

1.7.4 Work roles

Consulting engineers' work roles can be defined as the role of a professional person providing a service (Leckie *et al.* 1996:181) to a client who engaged him on a project (ECSA 2007:3). Certain tasks are "embedded" in the consulting engineers' work roles such as assessment, advising and supervising works (Leckie *et al.* 1996:181).

The work roles of consulting engineers can be derived by determining the specific roles the consulting engineers have during the completion of an engineering project, such as advising the client on the most suitable equipment to use in a particular project.

1.7.5 Tasks

A task may be assigned to an engineer, or group of engineers by an external agent (client) or may be self-generated. It consists of a complex set of instructions which specify what has to be done. The instructions indicate what operations are performed by the subjects (in the current study the consulting engineers) with respect to what goal is to be achieved (Hackman 1969:113). Each task has a recognisable beginning and end (Byström & Järvelin 1995:193).

Consulting engineers' tasks can be derived from a study of the various individual tasks the engineers have to complete in order to successfully complete the project in which they are involved. For example, if the task is the construction of a building the consulting engineer has to ask, what type of foundations would be needed to support the building?

1.7.6 Information-seeking

An information need may lead to a decision to seek information. *Information-seeking* is a form of human behaviour that involves seeking for information by means of the active examination of information sources or information retrieval systems to satisfy the information need, or to solve a problem (Ingwersen & Järvelin 2005: 386). In order to acquire information the user has to select information from a particular source, system, channel or service. According to Ellis (2005:138) the information-seeking process involves the activities of

- starting
- chaining
- browsing
- differentiating
- monitoring

In this study the concept information-seeking also refers to the consulting engineers' use of information services and systems, such as, libraries and computerised databases as well as personal and formal sources of information, such as, textbooks and technical journals. The concept also refers to the consulting engineers' use of informal information sources such as personal contacts through telephoning or sending emails to colleagues or suppliers to find information, seeking personal files, conferences attendance, searching the Internet, and visits to construction sites or similar installations to see what others have done.

1.7.7 Engineering information

The World Federation of Engineering Organisations' Committee on Engineering Information (WFEO/CEI) (1979:8) defines engineering information as "that information which is used, needed, or generated by engineers in the practice of their profession." The major part of such information is scientific or technical by nature, but also includes other kinds of information such as economic, marketing, commercial, social, managerial and legal information (Leckie *et al.* 1996:165-166).

The kinds of engineering information used by consulting engineers can be derived by studying engineers' use of specific information sources.

1.7.8 Information sources

Information sources can be defined as the physical (or digital) entities in a variety of media providing potential information (Ingwersen & Järvelin 2005:387). From an engineers' point of view, information sources could contain relevant information (Byström & Järvelin 1995:193). Sources of engineering information can also be classified in various ways, namely technical or non-technical, oriented to project or to profession, public or private, printed or generated on site, and of continuing or ephemeral value (Gralewska-Vickery 1976:267). Information sources can also be distinguished as external and internal sources, human and documentary sources, or formal and informal sources of information.

Information is accessed through various channels (e.g. colleagues, and the Internet) from various sources (e.g. colleagues, and text books). An information source contains relevant information whereas a channel guides the user to pertinent sources of information (Byström & Järvelin 1995:193).

For the purposes of the current study information sources are classified as internal sources (i.e. sources available in the consulting engineers' company) and external sources of information (i.e. sources available externally to the consulting engineers' company). The study also distinguishes between formal sources of information (librarians, libraries, and other information services) and informal sources of information (colleagues, clients, contractors and suppliers).

1.8 RESEARCH PROGRAMME

This chapter provided a general introduction to the study. The research programme gives an indication of those aspects that will be discussed in subsequent chapters. These are:

- Chapter 2 analyses information behaviour models. Research models that were developed to study information behaviour are used as a point of departure and as a reference framework to study the information needs, characteristics and circumstances of consulting engineers. A model was selected from this study to systematise information collected from the literature study. This analysis of information behaviour models also formed part of the literature review for the study.
- Chapter 3 provides a review of the research that has been conducted into the information needs and information-seeking behaviour of engineers reported in the subject literature.
- Chapter 4 describes the research methodology adopted for the study. The different qualitative research approaches that are relevant to a study of the information-related behaviour of engineers are explored to determine which kinds of investigative methods and strategies have already been used. The qualitative research methods that were used for the study are explained. The interview sample is described and the method of sampling is explained. The data collection method is also described.
- Chapter 5 reports and discusses the results of the empirical investigation into consulting engineers' information needs which are determined inter alia by work roles and associated tasks. Needs for various information sources

during various project stages are identified. The chapter also deals with the influence of personal and environmental factors and the engineering discipline.

- Chapter 6 reports and discusses the results of the empirical investigation into the information needs and information-seeking behaviour of consulting engineers, including the use of various information sources and the factors influencing these facets of information behaviour.
- Chapter 7 concludes the study by providing a summary of the research findings. Based on these findings recommendations for the design of a information system that could suit consulting engineers' information needs are made. Suggestions for future research are also made.

CHAPTER 2

AN ANALYSIS OF INFORMATION BEHAVIOUR MODELS

2.1 INTRODUCTION

The information needs and information-seeking behaviour of engineers has interested information scientists over the past decades and numerous studies have been undertaken to learn more about their specific needs and the resources that meet those needs. As indicated in chapter 1, most of these studies focused on the exchange or flow of information among individual engineers, the life cycle of information and information use. Some of the more recent studies seem to focus on tasks as a factor influencing information behaviour.

As indicated in chapter 1, little research seems to have been conducted on the information needs and information-seeking behaviour of consulting engineers, particularly in South Africa. Furthermore, consulting engineers who are employed by small companies and who do not have access to libraries as well as other traditional information services and systems do not appear to have been studied.

Some structure or framework is needed to research information users and their information behaviour. Wilson (1999:250) describes information behaviour models as frameworks for thinking about a problem that may evolve into a statement of the relationship among theoretical propositions. Models can therefore provide the required frameworks for information user behaviour research and contribute to a better understanding of users' information behaviour. Ellis (1989) for example, developed a model which was later used by Ellis and Haugan (1997) to study the information-seeking behaviour of engineers. This chapter therefore describes models that are relevant to engineers' information behaviour with the object of selecting the most suitable model for studying consulting engineers' information needs and information-seeking behaviour.

The models that have been developed to date by information behaviour researchers are not necessarily applicable to all user groups. Research seems to indicate that various factors influence specific information needs and information-seeking behaviour that are often context-specific, such as, the users' work role. Some models comprehensively study users from information behaviour, information-seeking and information needs perspectives whereas other models only focus on aspects of information retrieval. Furthermore, a model intended for a study of information behaviour should allow for a description and explanation of user behaviour and should focus on the user.

In this chapter some of the models that apply to information users in general and some models that have been tested on engineers are examined. These models are identified and summarised in table 2.1 and then discussed individually.

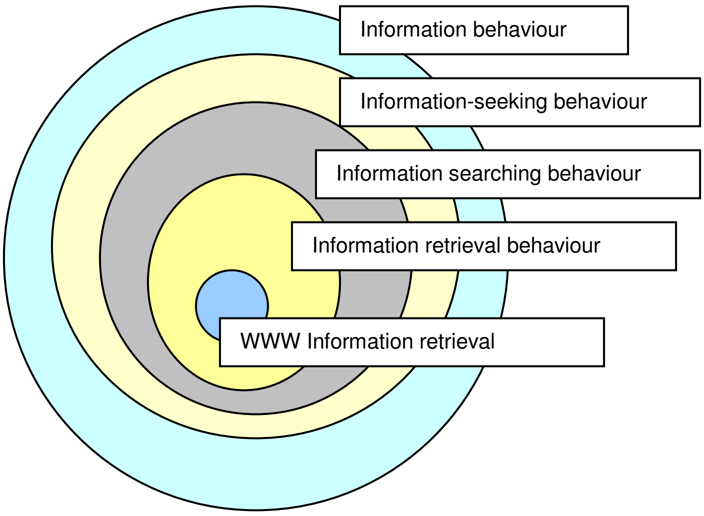
2.2 MODELS FOR STUDYING INFORMATION BEHAVIOUR

Kraaijenbrink (2007:4) and Wilson (1999:250) state that most models attempt to describe information-seeking activity, the causes and consequences of that activity, or the relationships among stages in information-seeking behaviour. Models study, for example, information behaviour from a general, behavioural or a task performance perspective. According to Wilson (1999:250) theoretical models seldom advance to the stage of specifying relationships among theoretical propositions.

The information behaviour models that have been developed to date address user's information behaviour from different perspectives. Wilson (1999:250-251) explains that models of information behaviour and information-seeking are related. This relatedness is well illustrated in Fourie's (2002:52) adaptation of Wilson's' (1999:263) Nested Model of Information Behaviour. Figure 2.1 is a graphic representation of Fourie's adaptation of the model and clearly shows the positions of the conceptual areas of information behaviour and information-seeking behaviour in relation to the conceptual areas of information searching behaviour and information retrieval behaviour.

FIGURE 2.1

Wilson's (1999) nested model of conceptual areas



Source: Fourie (2002:52)

The different models that seem to be the most relevant models for this study are summarised in table 2.1 followed by a more detailed discussion on each model in sections 2.3 to 2.6. The following headings are used in the table:

- Model name. This column identifies each model and refers to the researcher who developed the model.
- Model type/focus. This column briefly indicates the general focus of the model.
- Summary. A brief summary of the main components of each model is provided in this column.
- Test group. This column provides an indication of the specific user group on which each model was tested.
- Review. This column refers to the various authors who reviewed and discussed each model.

TABLE 2.1

Summary of information behaviour models

MODEL NAME	MODEL TYPE/FOCUS	SUMMARY OF MODEL	TEST GROUP	REVIEW
Wilson's (1981) and (1996) Models of Information Behaviour	Wilson's model is a static, broad, general summary model (Ingwersen & Järvelin 2005:67). .	Wilson's Model offers a three-fold view of information-seeking (Wilson 2005:31): 1. The context of the seeker. 2. The 'system' employed (which might be manual or machine and navigated either personally or by an intermediary). 3 The information resources that might be drawn upon. Wilson developed various models over a period of time, e.g. 1981, 1996.	Not tested.	Wilson (1999) Wilson (2000:51-52) Case (2002:116-119) Niedwiedzka (2003) Ingwersen & Järvelin (2005:67-68,197-198) Wilson (2005:31-43)
Ellis' Behavioural Model of Information-Seeking	Ellis' Model is (Ingwersen & Järvelin 2005): 1. A process model. 2. A summary model, not directly suggesting analysable relationships. 3. A general model, claiming applicability and validity over a range of empirical domains.	This model identifies eight features of information-seeking behaviour which characterise the information-seeking patterns of social scientists, scientists and engineers: 1. Starting/surveying. 2. Chaining. 3. Browsing. 4. Differentiating. 5. Filtering. 6. Monitoring. 7. Extracting. 8. Ending.	1. Social scientists 2. English literature researchers. 3. Physicists and chemists. 4. Engineers and research scientists in an industrial environment.	Ellis (1984) Ellis & Haugan (1997) Wilson (1999) Kalbach (2000) Wilson (2000:52) Järvelin & Wilson (2003: 6-8) Meho & Tibbo (2003) Ellis (2005) Ingwersen & Järvelin (2005)
Kuhlthau's Information Search Process (ISP) Model	Kuhlthau's ISP Model is: 1. A process model. 2. An analytical model, suggesting a relationship between process stages and feelings, thoughts and actions. 3. A general model	The ISP Model incorporates three realms: the affective (feelings), the cognitive (thoughts), and the physical (actions) common to each stage (Kuhlthau, 2004:44). The stages of this model are: 1. Initiation. 2. Selection. 3. Prefocus exploration. 4. Focus formulation.	Field studies with actual library users: 1. 26 academic high school seniors. 2. High-, middle-, and low-achieving high school seniors. 3. Longitudinal surveys of the first group.	Kuhlthau (1993) Wilson (2000:52) Kuhlthau (2004) Kuhlthau (2005) Ingwersen & Järvelin (2005:65-67)

MODEL NAME	MODEL TYPE/FOCUS	SUMMARY OF MODEL	TEST GROUP	REVIEW
	(Ingwersen & Järvelin 2005:66).	5. Collection. 6. Search closure (Kuhlthau 2005:231).		
Dervin's Sense-making approach (also described by Dervin as a theory or a methodology)	The Sense-making approach is: 1. A process model. 2. An abstract model. 3. A summary model and does not directly suggest analysable relationships. 4. A general model (Ingwersen & Järvelin 2005:62). 5. An information-seeking model (Cheuk Wai-Yi & Dervin 1999b:4). 6. A metatheoretic tool (Dervin 1999b:728).	The approach consists of: 1.1 A set of assumptions about human reality. Includes assumptions on moving, process, discontinuity, situationality, gap-bridging, and information-seeking. 1.2 A theoretic perspective. 1.3 A methodological approach. 1.4 A set of research methods (Ingwersen & Jarvelin 2005:62). 2. The theory implements four constituent elements: 2.1 A *situation* in time and space. 2.2 A *gap* - the difference between the contextual and the desired situation. 2.3 An *outcome* - the consequences of the sense-making process. 2.4 A *bridge* – the means of closing the gap between the situation and the outcome (Cheuk Wai-Yi & Dervin 1999b:4).	Professional groups tested: 1. Auditors 2. Engineers 3. Architects	Dervin (1983) Cheuk Wai-Yi (1998a & 1998b) Dervin (1998) Cheuk Wai-Yi & Dervin (1999) Dervin (1999b) Wilson (2000:52) Kuhlthau (2004:4) Ingwersen & Järvelin (2005:59-63) Tidline (2005:113-122)
Information-Seeking and Using (ISU) Process Model (Cheuk Wai-Yi)	ISU Process Model employs the Sense-making approach.	The model is made up of seven different situations: 1. Task initiating situation. 2. Focus forming situation. 3. Ideas assuming situation. 4. Ideas confirming situation. 5. Ideas rejecting situation. 6. Ideas finalising situation. 7. Passing on ideas situation.	1. Auditors 2. Engineers 3. Architects	Cheuk Wai-Yi (1998a)
Optimal Foraging Theory	The Optimal Foraging Theory is a deductive middle-range theory explaining particular behaviour. It is	1. Optimal Foraging Theory is a collection of methodologies or heuristic tools to clarify how and why individuals make the strategic choices they do" (Sandstrom 1994:415).	Generically tested on scholars, as if humanists, scientists, and engineers were a single class of information seekers and	Sandstrom (1994) Choo et al. (1998) Sandstrom (1999) Bates (2002:8-9) Jacoby (2005:259-264)

MODEL NAME	MODEL TYPE/FOCUS	SUMMARY OF MODEL	TEST GROUP	REVIEW
	generalising in approach.	2. Optimal foraging uses cost-benefit analysis to deconstruct complex processes of selection in component parts (Jacoby 2005:259-260). 3. Information foraging refers to activities associated with assessing, seeking, and handling information sources particularly in networked environments (Choo *et al.* 1998:2).	users.	
Aguilar's Modes of Environmental Scanning	A general approach to seeking information within an organisation by means of both formal and informal searches.	Environmental scanning involves an *exposure* to, and *perception of* information (Aguilar, 1967:18). The environmental scanning process comprises three activities (Aguilar 1967:19): 1. The gathering of information concerning the organisation's external environment. 2. The analysis and interpretation of this information. 3. The use of this analysed intelligence in strategic decision-making (Lester & Waters 1989:5). Aguilar differentiated four styles of environmental scanning: 1. Undirected viewing. 2. Conditioned viewing. 3. Information search. 4. Formal search.	Environmental scanning involves an *exposure* to, and *perception of* information (Aguilar, 1967:18). The environmental scanning process comprises three activities: 4. The gathering of information concerning the organisation's external environment. 5. The analysis and interpretation of this information. 6. The use of this analysed intelligence in strategic decision-making (Lester & Waters 1989:5).	Aguilar (1967) Daft & Weick (1984) Auster & Choo (1993) Costa (1995) Choo *et al.* (2000a & 2000b) Nardi, Whittaker & Schwarz (2000) Choo (2001) Choo (2002) Karim (2004)
Behavioural Model of Information-Seeking on the Web (Choo, Detlor & Turnbull)	Behavioural model	It is a combination and extension of Aguilar's modes of scanning and Ellis's seeking behaviour. It consists of four main modes (Choo *et al.* 1998:6-14): 1. Undirected viewing. 2. Conditioned viewing. 3. Informal search. 4. Formal search.	1. Managers. 2. Information technology (IT) specialists. 3. Information specialists.	Choo *et al.* 1998

MODEL NAME	MODEL TYPE/FOCUS	SUMMARY OF MODEL	TEST GROUP	REVIEW
Paisley's Conceptual Framework of the 'Scientist within Systems"	A systems model of the information user	Paisley sees the individual scientist operating within many systems that touch every aspect of his work. He has access to at least three sets of resources: mission-oriented resources (work team, work organisation); discipline oriented resources (scientists in his field and other workers in the same specialist area); the library and information sources of his general environment.	Not tested by Paisley.	Paisley (1965) Gralewska-Vickery (1976) Wilkin (1977) Leckie, Pettigrew, & Sylvain (1996)
Blom's Task Performance Model	Focuses on the research process as the context of information needs and the application of information to satisfy needs.	The task performance model sees the scientific discipline, environmental factors, and the scientist as an individual as three groups of variables. Each group affects the task performance of the scientist and his/her information needs. There is also a mutual influence of the different groups on each other (Blom 1983:8).	Not tested by Blom.	Blom (1983) Gericke (1996)
Byström-Jãrvelin Task-based Information-Seeking Model	An abstract and static model that is highly analytical and specific to professional task contexts (Ingwersen & Järvelin 2005:70).	The model considers task and information-seeking from the worker's viewpoint and in the cognitive domain. The model claims systematic relations between (Byström & Järvelin 1995): 1. Task complexity 2. Types of information sought 3. Type of information source.	Studied in the Public Administration context.	Byström & Järvelin (1995) Järvelin & Wilson (2003: 12) Ingwersen & Jãrvelin (2005:68-70)
Leckie et al's General Model of the Information-Seeking of Professionals	A general model	Assumes that the roles and related tasks undertaken by professionals in the course of daily practice prompt particular information needs, which in turn give rise to the information-seeking process. Information-seeking is greatly influenced by a number of interacting variables, which can affect the outcome of information use. The model comprises six components: 1. Work roles 2. Associated tasks	1. Engineers 2. Health Care professionals 3. Nurses 4. Physicians 5. Dentists 6. Lawyers	Leckie, Pettigrew, & Sylvain (1996) Case (2002:126-129) Leckie (2005)

MODEL NAME	MODEL TYPE/FOCUS	SUMMARY OF MODEL	TEST GROUP	REVIEW
		3. Characteristics of information needs and the factors affecting information-seeking 4. Awareness 5. Sources 6. Outcomes		
Bates' Berrypicking Model of Information Retrieval	Information Retrieval	The Berrypicking Model states that (Bates 1989:10): 1. Typical search queries are not static, but evolve. 2. Searchers commonly gather information in bits and pieces instead of in one 'grand best-retrieved set.' 3. Searchers use a wide variety of search techniques which extend beyond those commonly associated with bibliographic databases. 4. Searchers use a wide variety of sources other than bibliographic databases.	Not tested by Bates	Bates (1989) Bates (2002) Bates (2005:58-62) Ingwersen & Järvelin (2005:218-219)

The models that were summarised in table 2.1 are discussed in more detail according to particular categories, namely general process models, behavioural models, task performance and task based models, and an information retrieval model. These categories are distinguished in an attempt to provide some structure to the discussion and to proceed from more general models to task performance and task based models.

2.3 GENERAL PROCESS MODELS

General process models are those models that focus on micro-processes of daily life, in particular, cultural contexts and social settings (Leckie 2005:158). The models that are grouped into this category are Wilson's (1981) and (1996) Models of information behaviour (in Wilson 1999), Ellis's Model of information-seeking (in Ellis & Haugan 1997), Kuhlthau's Information search process model (in Kuhlthau 1993,2004, & 2005) ; Dervin's Sense-making approach (in Dervin 1983); and, Cheuk Wai-Yi's Information-seeking and using (ISU) process model (in Cheuk 1998a).

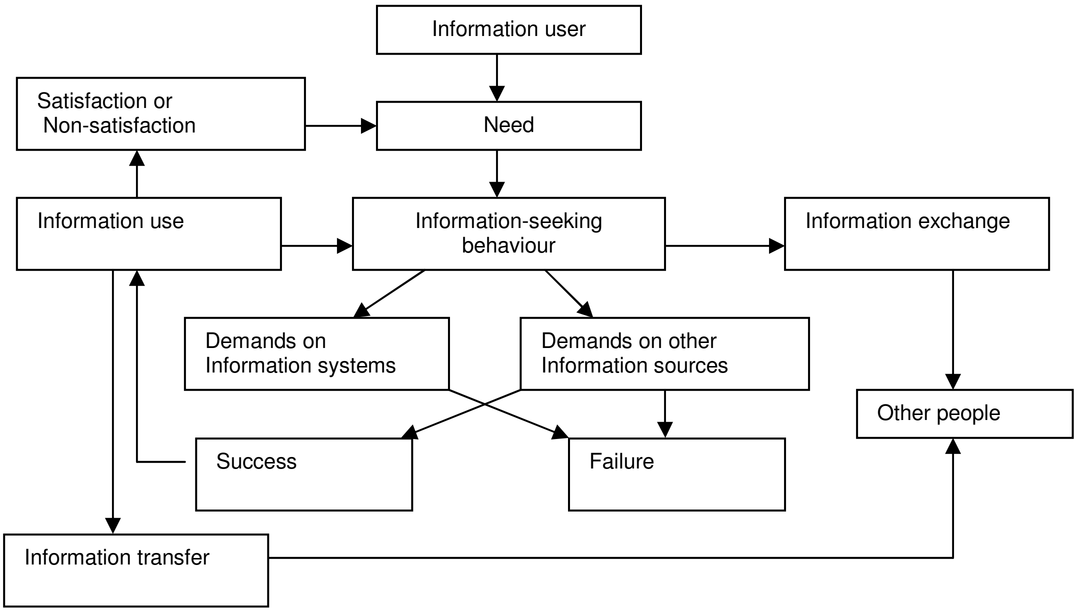
2.3.1 Wilson's (1981) model of information behaviour

Wilson (1999:257-258) labels his models 'information behaviour models' to distinguish them from the 'information search models' as they are understood by information retrieval researchers. These models are more concerned with user behaviour surrounding the actual initiation of information-seeking and have a broader perspective of the information search than the use of computer-based information retrieval systems.

The aim of Wilson's 1981 model shown in figure 2.2 was to outline the various areas covered by what he proposed as 'information-seeking behaviour' as an alternative to 'information needs'.

FIGURE 2.2

Wilson's (1981) model of information behaviour



Source: Wilson (1999:251)

Wilson's (1999:251) first 1981 model suggests that information-seeking behaviour arises as a consequence of a need perceived by an information user. In order to satisfy that need, the user then makes demands upon formal or informal information sources or systems. These demands for information result in success or failure in finding relevant information. The successful retrieval of information results in user satisfaction while failure would result in non-satisfaction and require the user to adapt his search using a different information system.

Wilson's first 1981 model shows that part of information-seeking behaviour may involve other people through information exchange. The information perceived as useful may also be passed on to other people as well as by the person seeking the information — a threefold view of information-seeking (Wilson 2005:31). Although Wilson's model only draws attention to gaps in research it continues to serve as a framework in present research with as much validity as at the time of its conception (Wilson 2005:32).

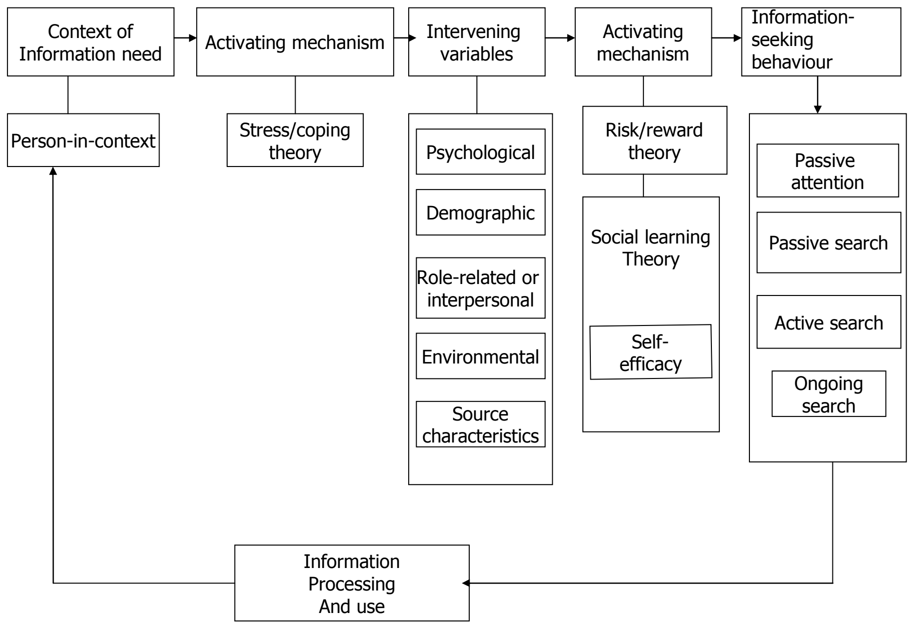
Wilson's second 1981 model (in Wilson 1999:252) proposes that an information need is not a primary need but rather a secondary need that arises out of a more basic kind of need. The model also proposes that the enquirer is likely to encounter different kinds of barriers in his effort to discover information to satisfy that need (Wilson 1999:252). This model suggests how information needs arise and what factors may prevent the actual search for information.

2.3.2 Wilson's (1996) model of information behaviour

Wilson made major revisions to his 1981 model of information behaviour. In his 1996 model (in Wilson 1999:257), shown in figure 2.3, he drew upon research from a variety of fields other than Information Science (Ingwersen & Järvelin 2005:67; Wilson 1999:256). These fields include decision-making theory, psychology, innovation, health communication and consumer research. The model pictures the cycle of information activities, from the rise of the information need (context of information need) to the phase when information is being used (information processing and use) (Niedzwiekzka 2003:5-6).

FIGURE 2.3

Wilson's (1996) model of information behaviour



Source: Niedzwiedzka (2003:6); Wilson (1999:257).

The basic framework of Wilson's 1981 model remains in the 1996 model. The 'intervening variables' (as illustrated in the third group of concepts in figure 2.3) now represent the information-seeking barriers, that is psychological, demographic, role-related or interpersonal, environmental and source characteristics.

The 1996 model now also identifies 'information-seeking behaviour' (in the fifth group of concepts in the figure), namely passive attention, passive search, active search and ongoing search. The suggestion is that the impact of the intervening variables may support and prevent information use while information-seeking behaviour consists of more types of information-seeking behaviour than identified in the 1981 model. If information needs are to be satisfied, ‘information processing and use’ becomes an essential part of the feedback loop shown at the bottom of the model.

The 1996 model also presents three relevant theoretical ideas as activating mechanisms to explain user behaviour (Wilson 1999:256). In the second and fourth group of concepts in figure 2.3 these mechanisms are represented as and the stress/coping, risk/reward, social learning theory and ‘self-efficacy’. The activating mechanisms are psychological factors which are explained by these different theories and which prompt the user to proceed with the information-seeking process. Thus, Wilson identified characteristics of a number of human behaviour models in his model. For example, the decision to seek information to satisfy an information need could be related to Folkman’s (in Wilson 2005:34) stress-coping theory while the decision to search information sources could be associated with Bandura’s (1977 in Wilson 2005:34) risk-reward theory. In this manner, the model draws attention to the interrelated nature of information behaviour theory, whether the theory is drawn from other disciplines or from the research traditions of Information Science (Wilson 2005:35).

Wilson also incorporated Ellis’ “behavioural characteristics” of information-seeking (Wilson 2005:34). These characteristics describe information-seeking activities such as “active search” and “ongoing search” while Erdelez’s (1997:412) “information encountering” is an elaboration of the “passive attention” or passive search mode. Kuhlthau’s (1993, 2004) information search process model is a detailed analysis of the cognitive and affective stages in the active search for information. One could also associate Dervin’s (1983, 1996) Sense-making approach for example with Wilson’s 1996 model, in that it deals with the perception of a need for information (Wilson 2005:335).

Niedzwiedzka (2003:2) used Wilson’s (1996) model of information behaviour as a conceptual framework for a study on the current information needs, preferences and the limitations of Polish health care managers as information users. The practical requirements of Niedzwiedzka’s (2003:3) research revealed some conceptual difficulties which the model imposes on researchers. Niedzwiedzka (2003:15) found the model only applies to information users who personally seek information which is not a predominant type of behaviour amongst the managers in the Polish health care system who mainly acquire information through intermediaries. The model also proved not to be general enough to encompass the predominant information behaviour of the group of managers investigated in Niedzwiekzka’s study.

In Wilson’s (2005:34) view, his 1996 Model of information behaviour remains a macro-behaviour or general model while the inclusion of other human behaviour and information behaviour models makes the model a rich source of hypotheses for further research.

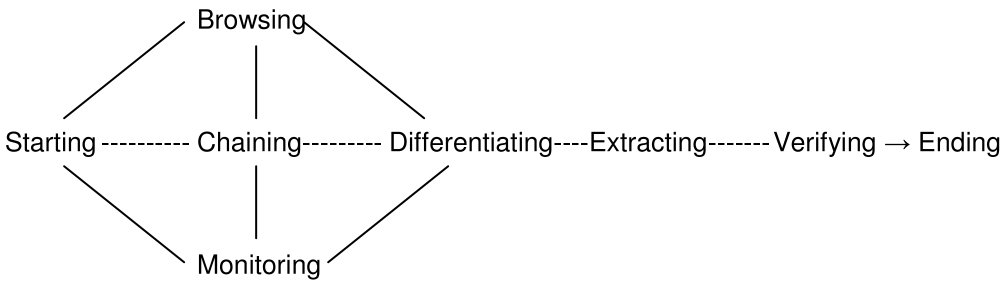
2.3.3 Ellis's (1994) model of information-seeking behaviour

Ellis' model of information-seeking behaviour was tested on engineers.

Ellis first described his model of information-seeking behaviour in 1984 and has since then developed the model in information-seeking studies of various groups of researchers, including engineers (Ellis 2005:138-139). Ellis (in Ellis & Haugan 1997:385; Ellis 2005:140; Ingwersen & Järvelin 2005:63) derived eight generic characteristics of the information-seeking patterns of social scientists. Ellis later extended this work to physicists, chemists and engineers. Figure 2.3 is a stage process version of Ellis' model.

FIGURE 2.4

A stage process version of Ellis' (1994) behavioural framework



Source: Wilson (1999:255)

The eight characteristics of Ellis' model of information-seeking behaviour represents types of activities, rather than stages that the users of information systems might want to accomplish through the systems and do not directly provide any design specifications for the systems (Ellis 2005:39; Ingwersen & Järvelin

2005:64). These are starting or surveying; browsing, chaining, monitoring, differentiating, extracting, filtering or verifying and ending.

a. Starting/surveying

Starting or surveying activities are characteristic of the initial search for information and involve identifying the initial materials to search through and select starting points for the search, for example, asking a colleague (Ellis & Haugan 1997:395; Kalbach, 2000:3; Wilson 1999:254; Wilson 2000:52). The identified sources often include familiar sources that have been used previously (Choo *et al.* 1998:5; Choo *et al.* 2000a:4). The perceived accessibility of the information source is a strong predictor of source use for many information users, especially engineers (Choo *et al.* 1998:5; Choo *et al.* 2000a:4; Fidel & Green 2004:564).

b. Browsing

Chang and Rice (in Erdelez 1997:413) identified browsing as "a rich and fundamental human behaviour." Browsing involves semi-directed searching in an area of potential interest as a monitoring activity through scanning of journals and tables of contents, etc, to find something of particular interest (Ellis & Haugan 1997:398; Wilson 1999:254; Choo *et al.* 2000a:4; Kalbach 2000:3; Wilson 2000:52). Browsing is also undirected and active searching while web browsing involves the following of links from one document to another (Bates 2002:5).

c. Chaining

Chaining is when the information seeker follows chains of citations or other forms of referential connection between materials to identify new sources of information (Ellis & Haugan 1997:396; Kalbach 2000:3). Chaining can be forward where the user is looking for new sources that refer to the initial source or follows footnotes and citations in an information source. It could also be backward when a pointer or reference from an initial source is followed (Choo *et al.* 2000a:4; Wilson 2000:52).

d. Differentiating or distinguishing

Differentiating or distinguishing is characterised by activities in which the user ranks the information sources based on their relevance and value to his or her information need (Ellis & Haugan 1997:399; Kalbach 2000:3; Wilson 2000:52).

e. Monitoring

Monitoring is similar to searching for information for current awareness purposes where the user maintains an awareness of developments in his field of interest through the monitoring of particular sources (Ellis & Haugan 1997: 397; Kalbach 2000:3; Wilson 1999:254; Wilson 2000:52). Monitoring also involves the exchange of information through contact with suppliers of technology, including participation in international conferences and other international forums, and is of great importance to most engineers (Ellis & Haugan 1997:397; Weiss 2005). This characteristic is also similar to 'being aware' in Bates' (2002:4) Modes of

Information-seeking and ‘undirected viewing’ in Aguillar’s (1967) Modes of Environmental Scanning (to be discussed in 2.4.2).

f. Filtering

Filtering involves the use of certain criteria or mechanisms when searching for information, to make the information as relevant and precise as possible, mainly through computerised literature searches (Ellis & Haugan 1997:399).

g. Extracting

The user systematically works through a particular source to locate material of interest in the extracting mode. This implies the selective identification of relevant material in an information source and represents a major feature of the information-seeking patterns of many researchers (Ellis & Haugan 1997:399; Wilson 1999:254; Wilson 2000:52).

h. Ending

Ending involves ‘tying up the loose ends’ through a final search (Ellis & Haugan 1997:400; Wilson 1999:254; Wilson 2000:52).

The strength of Ellis’ model lies in the fact that it is based on empirical research and has been tested in subsequent studies (Wilson 1999:254). Unfortunately there is no reported information about the specific tasks which the subjects in Ellis’ and other researchers' studies were performing when the data was collected, that is, it is not clear whether certain categories were more likely to be used with certain kinds of tasks (Ingwersen & Järvelin 2005:82).

2.3.4 Kuhlthau's (1993) information search process model

Kuhlthau's information search process (ISP) model focuses on the affective and cognitive aspects of the information search process. According to Pettigrew, Fidel and Bruce (2001:49) her study is "a landmark study" which set the scene for researchers "within the cognitive framework." Fidel (1993:224) maintains that "the study is one of the best examples of holistic research in which three realms were incorporated: the affective (feelings), the cognitive (thoughts) and the physical (actions) that are common to each stage of the information search process." The model has also been employed in a number of later empirical studies, most of them dealing with relevance criteria or web information retrieval (Ingwersen & Järvelin 2005:83).

Kuhlthau's ISP model is based on George Kelly's personal construct theory and as such depicts information-seeking as a process of construction (Kuhlthau 2005:230). The model was developed around the following hypothesis (Kuhlthau 2004:30):

- Is information-seeking a process of construction in which students may expect to be confused and anxious?
- Is the bibliographic paradigm inadequate for mediation within the constructive process?

A series of empirical studies provided the basis for Kuhlthau's ISP model. The first was a small-scale study to develop the model which was then tested and verified in longitudinal and large-scale field studies (Kuhlthau 1993; Kuhlthau 2004; Kuhlthau 2005; Ingwersen & Järvelin 2005:82). The ISP model inspired other researchers also concerned with interactive information retrieval during the 1990s (Ingwersen & Järvelin 2005:199).

Figure 2.5 is a graphic representation of Kuhlthau's ISP model.

FIGURE 2.5

Kuhlthau's (1993) information search process

Tasks	Initiation	Selection	Exploration	Search Formulation	Information Collection	Search Closure	Starting Writing
Feelings	Uncertainty	Optimism	Confusion Frustration Doubt	Clarity	Sense of direction / Confidence	Relief	Satisfaction or dissatis-Faction
Thoughts		Ambuigity		Increase interest	Specificity		
Actions		Seeking relevant information			Seeking pertinent information		

Source: Kuhlthau (2005:231)

2.3.4.1 Stages in Kuhlthau's information search process model

The different stages identified by Kuhlthau (2005:230-231) in the ISP model are task initiation, topic selection, prefocus exploration, focus formulation, information collection, search closure, and starting writing.

a. Initiation

The user becomes aware of an information need. Uncertainty and apprehension are common feelings at this stage.

b. Selection

The user identifies and selects the general topic for seeking information. The user experiences a brief sense of optimism and a readiness to begin the search.

c. Prefocus exploration

This stage involves the seeking and investigation of information on the general topic. Feelings of uncertainty, confusion and doubt frequently increase during this stage.

d. Focus formulation

The user is now able to structure the problem which needs to be solved. Feelings of uncertainty diminish as user confidence increases.

e. Collection

Pertinent information for the focused topic is gathered. Uncertainty subsides as the user's interest and involvement in the project deepens.

f. Search closure or presentation

The search is completed. This enables the user to put the information to use and report on his or her findings.

2.3.4.2 A comparison of Kuhlthau and Ellis' models

The ISP model complements Ellis' model (1997) in the sense that Kuhlthau attached the associated feelings, thoughts and actions, and the appropriate information tasks to the different stages of the 'information search process' (Wilson 1999:255). Kuhlthau's (1993) model is more general than Ellis' (1997) model. Kuhlthau's model in effect postulates a process of gradual refinement of the problem area throughout the information searching process (Wilson 1999:255-256). Kuhlthau's longitudinal study also supports the views that information seekers are learning during information-seeking and that their information needs are dynamic (Ingwersen & Järvelin 2005:82-83). Librarians also played a minimal role in the search process and participants expressed the need for a more proactive role for librarians (Kuhlthau 2004:80).

2.3.5 Dervin's (1983) Sense-making approach

Sense-making can be defined as behaviour, both internal (i.e. cognitive) and external (i.e. procedural), which allows the individual to construct and design his or her movement through time-space. It refers to the ways in which individuals perceive and bridge cognitive gaps in order to make personal sense of the world

(Schamber 2000:1). Sense-making behaviour, thus is communicating behaviour (Dervin 1992: 7; Dervin 1999b:729; Ingwersen & Järvelin 2005:60; Savolainen 1993:15). The central activities of sense-making are information-seeking, processing, creating and using (Savolainen 1993:16).

The Sense-making approach focuses on behaviour and as such assumes that the important things that can be learned about human use of information and information systems must be conceptualised as behaviour: the "step-takings", or "communicatings", that humans undertake to construct sense of their worlds (Dervin 1992:65). This kind of communicating behaviour is then the link between individuals and structures, institutions, and cultures (Dervin 1992:67).

As such the Sense-making approach can be used to acquire an understanding of information, communication, and meaningful relationships in these forms of behaviour (Tidline 2005:113). By using the Sense-making approach to study users' information behaviour, researchers are able to discover people's strategies, expectations, attitudes, and anxieties within their lives and work situations (Solomon 1997a:1098). When looking at the motivations that lead to information behaviour, researchers should be able to find the criteria users employ when seeking and using information that makes sense of their worlds (Nilan, Peek & Snyder 1988:153-154).

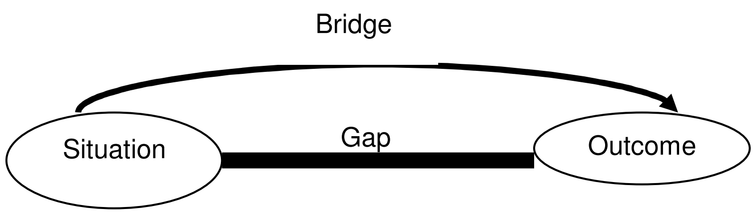
The Sense-making approach is, apart from being defined as a behaviour, it can also be referred to as a process model, a theory and a methodology.

2.3.5.1 Sense-making approach as a process model

The Sense-making approach has been used in various disciplines as a process model. The central ideas or concepts of the Sense-making approach is based on concepts relating to time, space, movement, and gaps. It "pictures the person as moving through time-space, bridging gaps and moving on" (Dervin 1999a:44; Dervin 2005:27; Dervin & Nilan 1986:21; Nilan, Peek & Snyder 1988:153; Pettigrew Fidel & Bruce 2001:65). Figure 2.6 graphically illustrates the central concepts in Dervin's (1983) Sense-making approach.

FIGURE 2.6

Dervin's (1983) Sense-making Approach



Source: Ingwersen & Järvelin (2005:60).

The sense-making gaps are cognitive gaps as perceived by individuals (Kraaijenbrink 2007:3) – "a situation in which people are unable to make sense of their experiences" (Choo, Detlor & Turnbull 2000b:4). To bridge this gap, individuals seek information to make new sense and use this information to help them continue on their journey. The outcome represents the use of information to complete a task. This makes the sense-making experience a holistic experience where the three time-space components (time-space, gaps, and moving on) are interacting and affecting one another (Cheuk Wai-Yi 1999:2).

Sense-making gaps can also be affective and situational (Choo *et al.* 2000b:5; Kraaijenbrink 2007:3). Affective gaps concern the fulfilment of emotional needs and are associated with uncertainty, anxiety, frustration, and stress (Kraaijenbrink 2007:3; Kuhlthau 1991:363; Kuhlthau 2004:6; Wilson 1997:557).

From a cognitive point of view, the Sense-making approach is an essential step forward in a study of information needs and information-seeking. The approach draws attention to individual sense-making (problem solving) in varying situations, and focuses on the information seeker and process viewpoints rather than on information systems or traditional viewpoints (Ingwersen & Järvelin 2005:62; Tidline 2005:114). This makes sense-making individual-centred without excluding the study of sense-making as social phenomenon while allowing researchers to discover certain systematic underlying features of information-seeking (Ingwersen & Järvelin 2005:62-63; Solomon 1997a:1098).

2.3.5.2 Sense-making as a theory

Sense-making is also a generalised approach to thinking about, and studying human sense making and "sense unmaking" in its variant forms (Dervin 2005:26). It rests on a fundamental set of philosophic assumptions about the nature of information, the nature of human sense-making (and "sense unmaking") which in turn ensures a specific set of methodological moves (Dervin 2005:27; Savolainen

1993:16). The Sense-making theory has defined information or knowledge as a product of, and “fodder” for sense making and “sense unmaking” (Dervin 1998:36).

The Sense-making theory conceptualises communication as gap bridging where each new moment in time-space requires another gap-bridging step. This is regardless of whether the gap-bridging step is “habitual and unconscious; capricious and accidental; or invented and planned.” Gap bridging can potentially be changed by time-space moments, but the time-space moments must then be “anchored in particular situational conditions with particular structural arrangements, experiential horizons, and flows of power or energy.” Gap-bridging can be seen as potentially responsive and potentially impervious to changing conditions as the information users move from one time-space moment to the next time-space moment (Dervin 1998:36; 2005:27; Ingwersen & Järvelin 2005:60).

It is not always easy to identify the gaps (Savolainen 1993:17). People might find it difficult to articulate the gaps in detail or they might evaluate the depth of the gap differently to other individuals. Alternatively, depending on the situation, the same individual can be very rigid or very flexible in the articulation or evaluation of his or her information gaps. Equal attention should be paid to both “human rigidities and flexibilities” in Sense-making research when it comes to information-seeking and use (Savolainen 1993:17; Dervin 1992:68).

Sense-making provides a theoretic perspective on information needs, but it is also a methodological approach that could be used to study information usage behaviour.

2.3.5.3 Sense-making as a method

As a methodological approach, Sense-making provides a set of research methods and a set of communication practices (Dervin 1999a:44; Dervin & Nilan 1986:20). The approach can lead to a way of questioning that can reveal the nature of a problematic situation, the extent to which information serves in bridging the gap of uncertainty and the nature of the outcomes from the use of information (Wilson 1999:253-254). This brings a shift in research emphasis from information sources to information users, offering an alternative approach to the study of human use of information and information systems (Dalrymple 2001;Savolainen 1993:16; Tidline 2005:113).

The Sense-making approach assumes that human use of information and information systems needs to be studied from the perspective of the "actor" or user and not from the perspective of the observer (Dervin 1992:64). It stresses an individual rather than a collective understanding of a user group (Tidline 2005:114-115).

When applied consistently in 'micro-moment or time-line interviews' sense-making questioning can lead to insights that could influence information service design and delivery. In this way the approach opens up alternative methods for questioning by allowing the researcher to ask: "under what conditions would habit or constancy be found across time-space versus under what conditions would time-space anchored situational variation be found?" (Dervin 2005:28). Sense-making studies can therefore identify when external forces (e.g. economics or infrastructure) constrain information behaviour. However, Dervin (2005:28-29) maintains that it would then not be possible to study the demographic attributes of users. Dervin conceptualises these attributes in sense-making as “indices of societal imposed structural conditions” (Dervin 2005:29).

2.3.6 Cheuk Wai-Yi’s (1998) information-seeking and using process model

The information-seeking and using (ISU) process model developed by Cheuk Wai-Yi (1998b; 1999) is based on Dervin’s Sense-making approach. The model was tested on different professional user groups, including engineers, making it a relevant model for this study.

Cheuk Wai-Yi (1998b:2; 1999:2) developed the ISU process model in the workplace context to illustrate the dynamic and diverse information-seeking behaviour exhibited by each “individual-in-situation”. The model proposes that “human information-seeking and using behaviour” are responses to the situations that prompt the information need (Cheuk Wai-Yi 1998b:4).

Cheuk Wai-Yi (1999:2) based the ISU Process Model on the Sense-making approach which allows the researcher to explore diversity at different time-space moments. It is possible to generalise information needs and information-seeking behaviour that are anchored in time-space moments and apply them to different professional groups.

The ISU Process model is made up of seven crucially different situations that participants experienced in their workplaces based on a study focusing on how auditors and engineers seek and use information. These situations then form the framework for the identification of information behaviour associated with each ISU situation. The seven situations are: task initiating, focus forming; ideas assuming; ideas confirming; ideas rejecting; ideas finalising; and the passing on of ideas.

In this study, Cheuk Wai-Yi (1998b:3) found a relationship between each of the seven abovementioned situations and the following information-seeking aspects: use and choice of information sources, information relevance judgement criteria, information organisation and information presentation strategies, feelings, and definition of information.

a. Use and choice of information sources

People are a more frequently consulted information source than secondary documents. There are differences in the choice of information sources in each situation and auditors switched from one source to another, and their persistence in using one source was extremely low. If the corporate library is not “visible’ at this stage of the process, auditors will not hesitate to use alternative sources (Cheuk Wai-Yi 1998a:7). However, in “ideas confirming” and “ideas rejecting” situations, people turned to use specific and authoritative information sources (Cheuk Wai-Yi 1998b:3).

b. Information relevance judgement criteria

Different criteria to judge information relevance are used in different situations (Cheuk Wai-Yi 1998a:7).

c. Information organisation strategies and information presentation strategies

Information organisation strategies are individual professionals' strategies to organise their own information while information presentation strategies could reflect aspects such as report writing.

d. Feelings

Kuhlthau (1993, 2004, 2005) has shown that students become more confident in the final stage of their information search. Cheuk Wai-Yi (1998a:7) however, determined the opposite occurred for auditors. They started their work with confidence but soon became stressed, frustrated and annoyed when ideas were contradicted by the information gathered, a feeling that remained until the end.

e. Definition of information

Auditors refer to information as different things at different stages of the process, for example, data, figures, events, words, opinions, comments and experience (Cheuk Wai-Yi, 1998a:8). Cheuk Wai-Yi did not report any similar findings for engineers.

A third important finding of the study by Cheuk Wai-Yi (1998a:8; 1998b:4), suggests that the ISU process in the workplace does not follow any specified sequential order. People move between the seven ISU situations in multi-directional paths. Because the ISU process model is a non-linear model, it suggests that although it is impossible to pre-determine what ISU situations (and in what order these situations) will be experienced, it is possible to associate distinctive sets of information behaviour with different ISU situations. Cheuk Wai-Yi (1998a:8; 1998b:4) contends that this makes the process of human information-seeking and use systematic and predictable.

Cheuk Wai-Yi (1999:2) also determined that "people-belonging-to-the-same-professional-group" do not have the same information needs, but use similar information sources and channels, as well as organise and evaluate information at all times.

The models discussed in section 2.3 focus on the micro-processes in the daily lives of users within particular contexts and social settings that could potentially influence users' information behaviour. The models developed by Ellis (1989) and Kuhlthau (1993) focus on the different activities involved in the information-seeking process. Dervin's Sense-making approach and Cheuk Wai-Yi's Information-seeking and using process model provide for the study of the way in which individuals perceive and bridge cognitive gaps to make sense of their world. An understanding of the sense-making process is very relevant to a study of consulting engineers' information behaviour in their quest to retrieve relevant information that could assist in problem-solving.

2.4 INFORMATION BEHAVIOURAL MODELS

Behavioural models are orientated research models focusing on users' information-seeking behaviour. These models include Sandstrom's (1994) Optimal foraging theory; Aguillar's (1967) Modes of environmental scanning, and Choo's (1999) Behavioural model of information-seeking on the Web.

2.4.1 Sandstrom's (1994) optimal foraging theory

In Sandstrom's (1994) optimal foraging theory the term "information foraging" refers to activities associated with assessing, seeking and handling of information sources, particularly in a networked environment (Choo *et al.* 1998:2). The theory was derived from evolutionary ecology for its potential to clarify and operationalise studies of scholarly communication (Sandstrom 1994:414).

Foraging includes both "hunting and gathering", thus encompassing a broad range of behaviour from organised, goal-directed searches to ongoing *ad hoc* background activities (Jacoby 2005:259). The key assumption of optimal foraging theory is methodological individualism where individuals are motivated by self-interest. These interests are defined in terms of some specific goal that highlights the content of the individual's choices (Sandstrom 1994:417).

Scholars tend to use a "core" of frequently cited sources that represent their area of research specialisation (Sandstrom 1999:19). Sandstrom (1994; 1999; Jacoby 2005:261) found a continuum of two types of foraging strategies:

- Specialists, who focus on a single high-density ‘patch’ of sources encountered via informal communication or routine monitoring and draw heavily on sources in their personal collections; and
- Generalists who gather sources from a wide variety of “patches”, a strategy that requires deliberate searching and other labour intensive techniques.

Jacoby (2005:262-263) maintains that the optimal foraging theory provides a rich framework for understanding information-gathering behaviour in online information environments and among academic researchers. The theory allows for the systematic examination of the interplay between the information environment, people’s perceptions of that environment and the strategies they use to retrieve information from the different information systems (“information spaces”).

A collection of methodologies or heuristic tools are used in the optimal foraging theory to clarify how and why individuals make the strategic choices they do (Sandstrom 1994:415). These include a cost-benefit analysis to deconstruct complex processes of selection into their component parts where a user (actor) chooses among alternative sources (Jacoby 2005:259; Sandstrom 1994:416,417). The user can then measure the alternatives in terms of costs (search and handlings costs such as the time spent seeking for usable information, time required to retrieve, read and process the information) and benefits (a set of constraints limiting the user’s behaviour), enabling the user to set a strategy specifying a range of viable options. This approach attempts to explain how scholars calculate where and when to exploit certain information resources and why they bypass potentially useful items to search and pursue alternative sources (Sandstrom 1994:419).

Sandstrom (1994:442) believes that the optimal foraging theory offers a behavioural and quantitative theory or approach for studying a complex social phenomenon. It operationalises concepts such as goals, currencies, alternative strategies and specific tactics in the context of scholars' pursuit and creation of information. The theory also provides a vehicle and an impetus to formulate and test hypotheses about scholars' decision-making and environmental constraints. The optimal foraging theory has provided a framework for research focused on understanding information-gathering behaviour in online information environments and offers a way to model both the information seeker and the information environment (Jacoby 2005:263).

2.4.2 Aguilar's (1967) modes of environmental scanning

Aguilar's Modes of Environmental Scanning is a behavioural model and is concerned with the way in which a company's top management gains relevant information about events occurring outside the company in order to guide the company's future course of action (Aguillar 1967:vii). Environmental scanning is also a management process in which environmental information is used in decision making and involves various information activities (Erdelez 1997:414; Lester & Waters 1989:6-8). Although not tested on engineers, this model is examined to determine whether environmental scanning is applicable to consulting engineers' information-seeking behaviour.

Scanning is the process of monitoring the environment and providing environmental data to managers (Daft & Weick 1984:286). As such, environmental scanning is concerned with data collection in order to gain information about events and relationships in the organisation's environment, a knowledge of which would assist management in planning future courses of action (Auster & Choo 1993:1). Environmental scanning is complementary to, but distinct from, information gathering activities such as competitor intelligence, competitive intelligence, and business intelligence (Choo 1999:1). An important effect of scanning is that it increases and enhances communication and discussion about future-oriented issues by people in the organisation (Choo 2001:8).

Environmental scanning includes both looking at information (viewing) and looking for information. This could range from gleaning information inadvertently from a casual conversation at the lunch table or by observing an angry customer by chance. It could also include gathering information by means of a formal market research program or a scenario-planning exercise (Choo & Auster 1993:280; Choo 1999:2; Choo 2001:2; Choo 2002:84; Daft & Weick 1984).

Aguilar (1967:19) differentiated between four modes of scanning. These are undirected viewing, conditioned viewing, informal search and formal search.

a. Undirected viewing

Undirected viewing is characterised by the individual's general unawareness as to what issues may be raised (Aguilar 1967:19) and takes place all the time (Choo

2002:84; Choo & Auster 1993:280). In this way the individual is alerted that 'something' has happened and that there is more to be learned (Aguilar 1967:20; Choo 2002:84). Undirected viewing makes information-seeking casual and opportunistic while undirected viewers rely more on irregular contacts and casual information from external people and sources (Choo 2001:14-15; Choo & Auster 1993:280). A considerable degree of orientation on the part of the scanner is required when selecting particular sources that are relevant to his or her general experience and interest (Aguilar 1967:20).

As a result of undirected viewing, general areas or topics may be identified as being potentially relevant to the organisation's goals or tasks, and the individual becomes sensitive to these areas (Choo *et al.* 2000b:151).

b. Conditioned viewing

Viewing is conditioned in the sense that "it is limited to the routine documents, reports, publications, and information systems that have grown through the years" (Choo 2001:16; Daft & Weick 1984:289). The user is therefore exposed to information about selected areas or certain types of information in this mode and ready to assess the significance of the information as it is encountered (Aguilar 1967:20; Choo *et al.* 2000b:151; Choo 2002:85). Cultural knowledge plays an important role in conditioned viewing by supplying the assumptions and beliefs about the business and the environment that the organisation is in (Choo 2001:17).

c. Informal search

This environmental scanning mode is relatively limited and unstructured. An informal search is an effort to obtain specific information or information for a specific purpose and can take many forms (Aguilar 1967:20; Choo 2002:85). These range from soliciting information to increasing the emphasis on relevant sources, or to acting in a way that will improve the possibility of encountering the desired information (Aguilar 1967:20). The overall purpose is to gather information to elaborate on an issue so as to determine the need for action by the organisation (Choo *et al.* 2000b:152). Informal searchers have determined the potential importance of specific developments, and embark on a search that would build up knowledge about those developments, and deepen understanding of their implications and consequences (Choo *et al.* 2000b:152).

d. Formal search

The overall purpose of formal searching is to systematically retrieve information which is relevant to an issue (Choo *et al.* 2000b:152). Formal searchers then make an effort to obtain specific information or information about a specific issue (Aguilar 1967:21; Choo *et al.* 2000b: 152; Choo 2002:85; Choo & Auster 1993:280**).**

Choo (2001:2) notes that various factors influence scanning behaviour. These are external factors (e.g. environmental turbulence and resource dependency), organisational factors (e.g. the nature of the business and the scanning strategy pursued), information-related factors (e.g. the availability and quality of information) and personal factors (e.g. the scanner's knowledge or cognitive style).

Environmental scanning is similar to other forms of information behaviour. It starts with an information need, and involves information-seeking, and information use (Choo 2001:2). In the context of environmental scanning, information needs are often studied by investigating the focus and scope of scanning, particularly the environmental sectors where scanning is most intense (Choo 2001:2; Choo 2002:98). When studying information-seeking within the context of environmental scanning, researchers need to examine the sources that are used to scan the environment as well as the organisational methods and systems deployed to monitor the environment (Choo 2001:2-3; Choo 2002:98). The use made of the information is usually studied within the context of whether the information was needed for decision making, strategic planning or for intended reduction of organisational activities (Choo 2002:98).

Correia and Wilson (2001:3) note that research on individual scanning has focused mainly on the individual scanning activities of managers, namely:

- the identification of the information sources used
- the environmental sectors scanned
- the scanning modes and methods
- the influence of the role played and the tasks performed upon the scanning activity.

Research typically attempts to account for patterns of source or system use and satisfaction by analysing users' demographic factors, their membership in social or professional groups, their life style, or their task requirements (Choo & Auster 1993:304). Choo and Auster (1993:305) and Roberts and Wilson (1988:285) found that most traditional studies on information needs and uses start with the information source or system and examine the user in relation to that system. These studies are further confined to the use of formal information sources, such as documents and computer-based information systems, in spite of the fact that most information exchange among businesses is verbal and informal.

2.4.3 Choo's (1998) behavioural model of information-seeking on the Web

Choo *et al's* (1998) Behavioural Model of Information-Seeking on the Web seems relevant to a study of the information behaviour of consulting engineers because of the model's focus on information-seeking on the Internet. The assumption is that engineers often use the Internet to retrieve information.

Considering the functional relatedness of the models in Fourie's nested model of conceptual areas illustrated in figure 2.1, Choo *et al's* (1998) behavioural model of information-seeking on the Web should be regarded as an information retrieval model. The model's name suggests it is a behavioural model. The model also has many elements similar to Aguillar's (1967) modes of environmental scanning.

Choo *et al.* (1998) combined and extended Aguilar's modes of environmental scanning (these were discussed in 2.4.3) and Ellis's information-seeking behaviour model (discussed in 2.3.3) into a new behavioural model of information-seeking on the Web. Choo *et al.* (1998:6-8; Turnbull 2005:397) identified undirected viewing, conditioned viewing, informal search and formal search as the four main modes of information-seeking on the Web.

a. Undirected viewing

This is an information viewing activity aimed at noticing developments or issues that then generate new information needs (Choo *et al.* 1998:6). The individual is exposed to information with no specific informational need in mind (Choo *et al.* 2000b:5). Starting occurs when users visit a favourite page or site to begin their viewing (Choo *et al.* 2000a:6). The users would then follow hypertext links (chaining) to find more information on items in which they are interested (Choo *et al.* 1998:6-7). Starting and chaining are the two activities that could dominate information searching on the Web (Choo *et al.* 1998:6-7).

b. Conditioned viewing

This would include activities such as browsing, differentiating, and monitoring. Differentiating will now occur when viewers select Web sites or pages that they expect would provide relevant information. Differentiated sites are often bookmarked (Choo *et al.* 1998:7). When visiting these sites, viewers browse the content by looking through tables of contents, site maps, or lists of items and categories (Choo *et al.* 2000a:9).

c. Informal search

An informal search is aimed at learning more about the issue in order to determine the need for action or response (Choo *et al.* 1998:7; Choo *et al.* 2000b:5). Differentiating, extracting and monitoring could be typical information-seeking activities in the informal search mode (Choo *et al.* 1998:7). Extracting could now probably involve the use of basic, search features of the commands of a local search engine, in order to get to the most important or most recent information (Choo *et al.* 1998:7). Monitoring could be more proactive if individuals were to set up push channels or software agents (such as alerting services or RSS feeds) that would automatically find and deliver information based on selections of keywords or topics (Choo *et al.* 1998:7).

d. Formal search

Individuals are now prepared to spend time and effort in order to gather information that will enable them to take action (Choo *et al.* 1998:6; Choo *et al.* 2000b:5). The information search follows some pre-established routine or method, elaborates the query in detail, and the retrieved information is used 'formally' as well (Choo *et al.* 1998:8). A formal search may be two-staged: multi-site searching that identifies significant sources followed by 'within-site' searching. The latter could involve intensive foraging while extracting could be supported by monitoring activities making use of services such as Web site alerts, push channels, and software agents (Choo *et al.* 1998:6).

Being a hybrid model based on Ellis (1989) and Aguillar (1967), the Behaviour Model of Information-Seeking on the Web demonstrates the value of using multiple methods to collect data and has the potential to be extended or mapped to other information-seeking activities such as an information search (Turnbull 2005:397). As such the model now also provides a systematic method to examine the relationship between information needs, search strategies and search tactics (Hsieh-Yee 2001:7).

Web search studies by Jansen, Spink, Bateman and Saracevic (1998) and Silverstein, Marais, Henzinger and Moricz (1998) show that users have particular patterns of searching for information on the Web that seem to differ significantly from users of traditional information retrieval systems. These studies yield insights into users' mental models of searching (Turnbull 2005:399).

The behavioural models studied in section 2.4 focus on human or organisational information-seeking behaviour. Since it is important for consulting engineers to remain current about developments in their field of interest, Aguillar's modes of environmental scanning could be useful in determining some scanning behaviour amongst consulting engineers.

2.5 TASK PERFORMANCE AND TASK BASED MODELS IN WORK-RELATED CONTEXTS

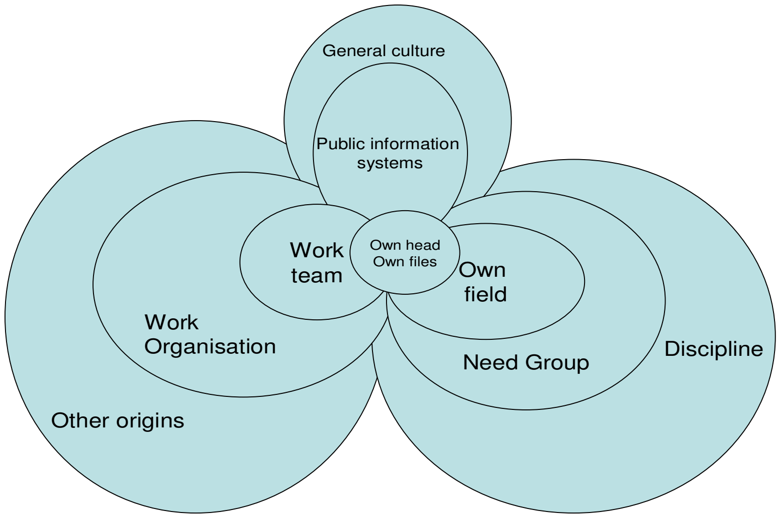
The task performance, task- based and work role models include Paisley's (1968) conceptual framework of the scientist within systems; Blom's (1983) task performance model; Byström and Järvelin's (1995) task-based information-seeking model*;* and Leckie *et al's* (1996) general godel of the information-seeking of professionals. Of these models, only Leckie *et al's* (1996) model was tested on engineers. The other three models can also contribute to a study that focuses on task-based information needs and information-seeking behaviour within a work-related context.

2.5.1 Paisley's (1968) conceptual framework of the scientists within systems

Paisley (1968:3-6) sees the individual scientist as standing at the centre of many systems that touch every aspect of his work. Wilkin (1977:265) graphically illustrated these systems as shown in figure 2.7. Certain systems are particularly relevant to the information user in a work context, for example, the scientists' work team and colleagues. However, other systems close to the scientists not represented in the model, such as religious groups, may not impact on their working habits and information use.

FIGURE 2.7

Paisley's (1968) framework of the scientist within systems



Source: Wilkin (1977:265).

Wilkin (1977:265) used a set of almost concentric circles in figure 2.7 to represent the different systems. The closer the system is to the scientist himself, the more influence is exerted on his information use behaviour. Thus the scientist within his own head is at the centre of the model. The systems affecting the scientist include:

- The scientist within his culture
- The scientist within a political system
- The scientist within a membership group
- The scientist within a reference group
  - The scientist within an invisible college
- The scientist within a formal organisation

    - The scientist within a work team
- The scientist within his own head
- The scientist within a legal/economic system
- The scientist within a formal information system

Apart from his own knowledge and imagination and personal fields, the scientist diagrammatically lies within, and has access to, at least three sets of resources, for example his work team, his subject field and public information systems. These resources could be mission-oriented resources that would include his work team, and his work organisation. Then there are discipline-oriented resources, which include other scientists in his field, and a "need group" of workers in the same specialist area, and outside them the wider discipline and discipline-oriented library and information services. Finally there are the library and information sources of his general culture (Wilkin 1977:264-264).

Although the social network was not included in Paisley's framework as part of the systems that affect the scientist's usage behaviour, the scientist within his working team, reference group or invisible college could be seen as being involved in forms of social networking. Social networking can also be viewed as a type of environmental scanning, since users who use the undirected viewing mode to scan their environments tend to rely more on casual information from external people and sources.

For this reason social networks have to be explored. As indicated in chapter 1, various studies have reported that engineers are crucially dependent on documents and people for information.

Nardi, Whittaker and Schwarz (2000:1) maintain that workers are “mining” (gathering information) from their own social networks rather than using traditional institutional information resources. One could argue that consulting engineers are workers who also gather information from personal external sources and networks rather than from institutional sources within the organisation. This is because employees work for long periods in different ‘communities of practice’ (such as a multidisciplinary team of engineers involved in a building project) where they build up considerable expertise in the details of their job for the duration of each of the projects in which they are involved (Nardi *et al.* 2000:3; Wenger 1998:72-85). Once the project is completed, the ‘community of practice’ dissolves and the members join a next ‘community of practice’ with the onset of a next project.

Nardi *et al.* (2000:4) found that workers are now replacing the organisational backdrop and predetermined work roles of old style corporate environments with their own personal network of people who come together to collaborate for short or long periods. Once the joint work is completed, the network has some persistence and the shared experience of the joint work serves to establish relationships that may form the basis for future joint work.

Johnson (2004:4-5) explains that social resources are the goods possessed by individuals in the social network and can consist of intangible goods. Access to these resources depends on the relationship with the individual possessing the resource and where one is located in the social structure. However, different resources not only lie outside one's social group, they reside in a different level of the social hierarchy.

2.5.2 Blom's task performance model

A study of the factors that influence the information needs and information-seeking behaviour of consulting engineers within the contexts of problem-solving and decision-making in work situations is also illuminated by studying Blom's (1983) Task Performance model since engineering is a task-related discipline.

Blom's (1983) Task Performance Model is based on Blom's research into scientists' information needs and use. The approach to the development of Blom's Task Performance model (Blom 1983:3-4) is based on the following hypothesis:

- the aim of an *information service* is to contribute to successful task performance of the potential users of such a service.
- *information* is an input to problem solving, decision making, planning, any planned activity, or to the increase of knowledge.
- *information needs* are the requirements for information as they are necessary to fulfil a task (as pointed out in chapter 1). Task performance needs and information needs are synonymous.
- the following factors are in interaction with each other:
    - the purpose, problem area, and methods of the scientific discipline

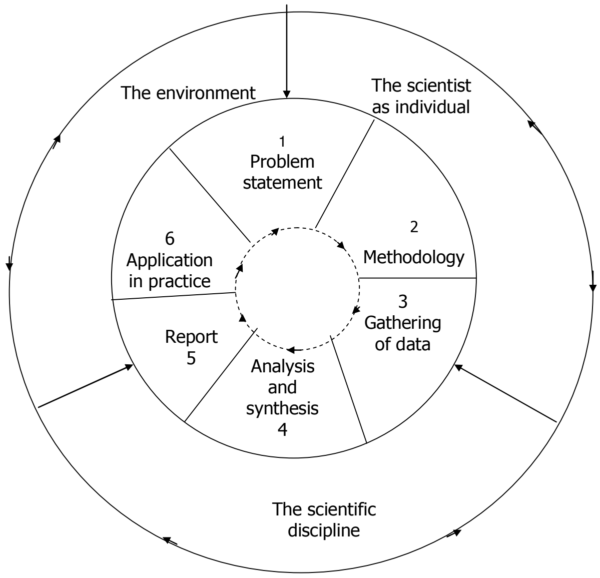
- the environmental factors, especially those pertaining to the employing organisation
- the personal attributes of the scientist.

This means that the demands placed on an information service by the performance of a task is given precedence over the demands of the user (Blom 1983:5-7). Figure 2.8 shows that the task of the scientist is always performed within the context of the particular scientific discipline which is being practised; within the context of the environment in which the task is performed; and within the context of the scientist as an individual.

The different steps in the research process illustrated in Blom’s model are the problem statement, methodology, gathering of data, analysis and synthesis, report and the application in practice. These steps can be equated with the steps in the information process.

FIGURE 2.8

Blom's (1983) scientific communication system



Source: Blom (1983:32).

The most important environmental factors influencing the task performance of the scientist and his information needs are those concerned with the employing organisation (Blom 1983:19). Another important influence on the mutual exchange of information is interpersonal relations and social intercourse, as well as patterns of friendship within the organisation (Blom 1983:21).

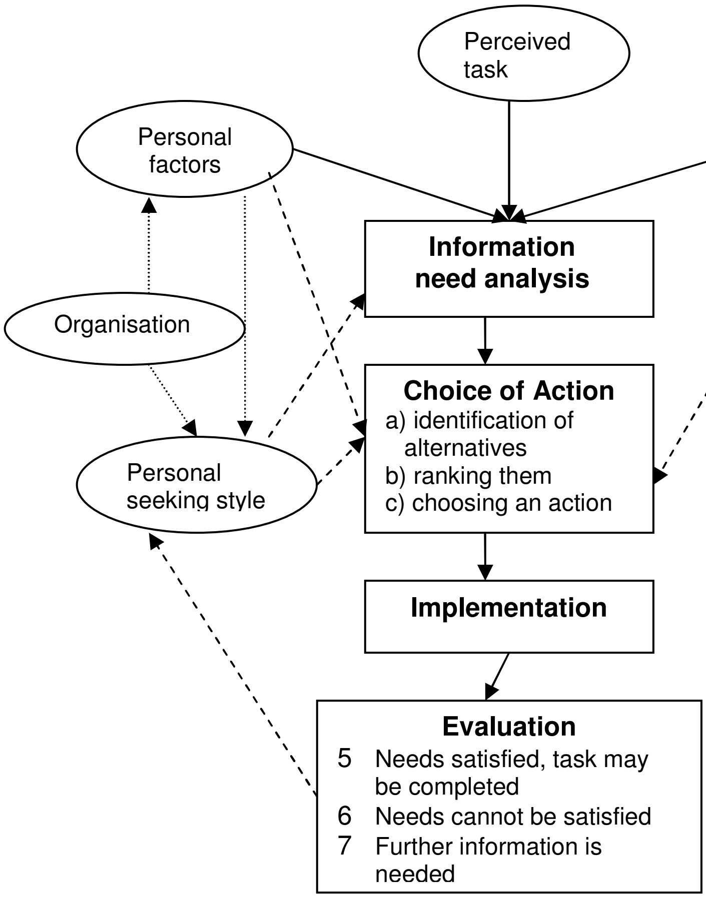
2.5.3 Byström and Järvelin's (1995) task-based information-seeking model

Byström and Järvelin (1995:191-192) consider task-based information-seeking as a problem solving process. At the surface level, they modelled information-seeking as a process consisting of needs analysis, selection of actions, implementation of seeking actions, and evaluation of the results. This process depends on a number of situational, personal, and organisational factors as well as the perceived task. This model claims systematic relationships between task complexity, type of information sought and type of information source (Byström 2005:175; Ingwersen & Järvelin 2005:68; Vakkari 1998:363). Figure 2.9 is a graphic representation of Byström and Järvelin's (1995) task-based information-seeking model.

The model in figure 2.9 indicates how the information need analysis, the choice of action, the implementation of the search and finally the evaluation of the outcomes or the information search is dependent on or influenced by the perceived task, personal and situational factors, the organisation and personal information-seeking style. According to Ingwersen and Järvelin (2005:69) this model illustrates the relationship between task complexity, the information needed and the information sources, and makes the Byström-Järvelin model most valuable for the integration of information-seeking and retrieval.

FIGURE 2.9

Byström and Järvelin's (1995) task-based information-seeking model



Source: Ingwersen & Järvelin (2005:69)

The tasks performed by a worker can be analysed and classified in many different ways. Task complexity or difficulty is one of the most essential factors affecting task performance (Byström & Järvelin 1995:192). Task complexity refers to the degree of uncertainty about the task inputs, process and outcome (Byström 2005:176; Byström & Järvelin 1995:194-195; Vakkari 1998:372). Byström and Järvelin (1995:194-195) divide the determinability of task complexity into five subcategories.

a. Automatic information-processing tasks

Automatic information processing tasks are completely determinable so that, in principle, they could be automated.

b. Normal information processing tasks

Normal information processing tasks are almost completely determinable, but require some case-based arbitration concerning the sufficiency of the information normally collected.

c. Normal decision tasks

Normal decision tasks are quite structured, but in them cased-based arbitration has a major role to play, such as when hiring an employee.

d. Known genuine decisions tasks

Known genuine decision tasks refer to tasks where the type and structure of the result is known, but permanent procedures for performing the tasks have not emerged yet.

e. Genuine decision tasks

Genuine decision tasks are unexpected, new, and unstructured. Neither the result, the process, nor the information requirements for the task can be characterised in advance.

The information required to complete a task is accessed through various channels (e.g. colleagues, directories and information retrieval systems) from various sources (e.g. colleagues, codes of practice and reports) (Byström & Järvelin 1995:193). From a worker's point of view, a source contains (or is expected to contain) relevant information, whereas a channel guides (or is expected to guide) the worker to pertinent sources (Byström & Järvelin 1995:193).

The specific problem studied by Byström and Järvelin (1995:196) was to determine the types of information that was sought while users use different types of channels (i.e. external, internal) and different kinds of sources (e.g. experts, literature, and official documents). Their empirical findings indicated that as task complexity increases, the following patterns emerged:

- complexity of information needed increases
- needs for domain information (this is information related to the specific field of expertise) and problem solving information increase
- the share of general-purpose sources, people in particular, increases and that of problem and fact-oriented sources decreases
- successfulness of information-seeking decreases

- use of internal information sources, especially people, increases and the use of documentary sources decreases
- number of sources used increases (Byström & Järvelin 1995:211; Ingwersen & Järvelin 2005:83; Vakkari 1998:375).

These findings suggest that both the task complexity and the information-type dimensions are needed in a general model of task-based information-seeking and retrieval (Ingwersen & Järvelin 2005:84). The opportunity the model offers to explain the relationship between task complexity, the information need and information sources, makes the Task-based information-seeking model valuable for research studying the integration of information-seeking and information retrieval (Ingwersen & Järvelin 2005:69).

2.5.4 Leckie *et al's* (1996) general model of the information-seeking of professionals

Although Leckie *et al.* (1996) regard this model as a general model, the researcher decided to group the model with task performance and task based models in work related contexts. The focus of Leckie *et al's* (1996) research is on the professional and how the professional's work roles and tasks influence his or her information-seeking and information usage-behaviour.

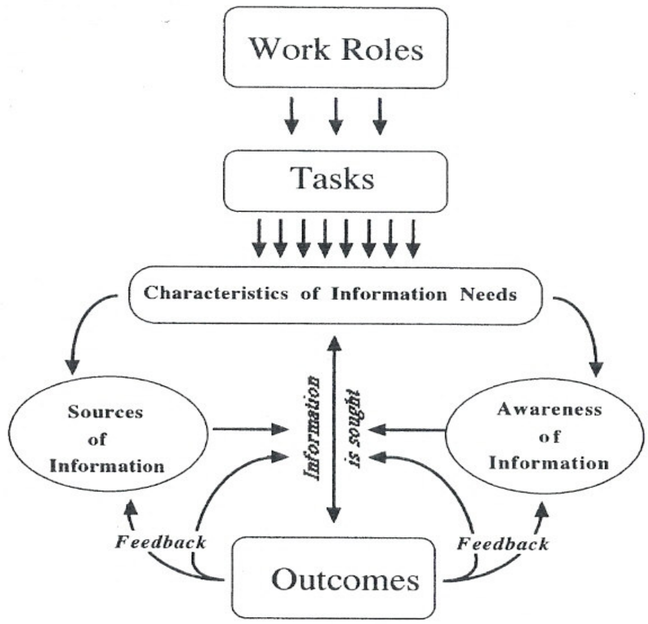
Leckie (2005:159) indicates that studies have been conducted to examine the information-seeking behaviour and information use of librarians, academics, researchers, doctors, nurses, dentists, engineers, lawyers, and many others. She notes that these studies examine the information practices embedded within professional work, how those information-related practices function to contribute to the professional's work, and whether or not those practices can be improved or changed for the better. Leckie *et al.* (1996) conducted an extensive meta-review of the Library and Information Services (LIS) literature and the literatures of a number of other professional fields with the aim of looking for patterns or trends in common across all these studies. Five key findings emerged from the literature review:

- Despite their training in a particular area of expertise, a professional often assumes a number of complex and different work roles.
- These roles have constellations of tasks associated with them.
- The tasks required in each role are likely to prompt information needs and information-seeking.
- There are intervening factors that may either facilitate or inhibit the finding and use of information for specific tasks.
- It often takes more than one attempt to find the appropriate information (Leckie *et al.* 1996:178-179; Leckie 2005:160).

Leckie *et al.*'s (1996) model of the information-seeking of professionals is graphically illustrated in figure 2.8 and shows the relationship between the different components in the model. These components are the professional's work roles, associated tasks, characteristics of information needs, an awareness of information, the information sources, and outcomes of information-seeking. Information–seeking is indicated as "information is sought". Feedback indicates satisfaction or non-satisfaction of the need (Case 2002:126-129; Case 2007:127-129; Leckie *et al.* 1996; Leckie 2005).

FIGURE 2.10

Leckie et al's (1996) general model of the information-seeking of professionals



Source: Leckie *et al.* (1996:180)

The six components of Leckie et al's model are interrelated and dependent on each other.

2.5.4.1 Work roles and associated tasks

Professionals lead complicated work lives and must assume a multiplicity of roles in the course of their daily work, such as, service provider, administrator or manager, researcher, educator, and student (Leckie *et al.* 1996:180-181).

Embedded in different roles are different tasks. For example, tasks in which engineers are involved include the technical responsibility for an operational unit as well as the supervisory responsibility for those who operate the unit (Kemper 1982:123). The impact on the roles undertaken by engineers could have a bearing on the types of information required and the ways in which such information are sought and used (Leckie *et al.* 1996:180-182; Leckie, 2005:161). The professional's status in the organisation, his or her years of experience and area of specialisation are other factors that could influence the professional's specific information needs (Leckie *et al.* 1996:180-182; Leckie 2005:161).

2.5.4.2 Factors influencing information needs

Information needs arise out of situations pertaining to a specific task that is associated with one or more of the work roles played by the professional (Leckie *et al.* 1996:182). The information needs of the engineer are determined or characterised by their context (situation-specific need, internally or externally prompted), frequency (recurring or new need), predictability (anticipated or unexpected need), importance (degrees of urgency), and complexity (easily resolved or difficult) (Ellis & Haugan 1997:401; Leckie *et al.* 1996:182-183). Other factors that influence professionals' information needs include individual demographics or attributes and circumstances, such as age, profession, specialisation, career stage, and geographic location.

2.5.4.3 Factors affecting information-seeking

The way in which "information is sought" is influenced by a number of factors. Leckie *et al.* (1996) used the phrase "factors affecting information-seeking" to refer to the "information is sought" process.

Factors related to, or associated with the sources of information, an awareness of information and the outcomes of the information-seeking process influence information-seeking. These factors make up the last three components in Leckie et al*'s* (1996:180) model.

a. Sources of information

Professionals seek information from various types of sources which can be characterised as formal (e.g. conferences, journals) or informal (personal conversations); internal or external (source within the organisation or outside); oral or written sources (written sources includes paper copies and electronic texts) and personal sources (these include personal knowledge and experience, professional practices) (Leckie *et al.* 1996:183-184). The choice of information sources is not necessarily confined to one or two sources. A combination of several sources may be required to fulfil an information need (Leckie *et al.* 1996:184). These sources have particular characteristics which appeal to the user and thus have an influence on his choice of a source.

b. Awareness of information

The professional's awareness of information sources and, or information content can determine the path information-seeking will take (Leckie *et al.* 1996:185). Various important factors are linked to information awareness.

- Familiarity and prior success. Engineers will often select a source based on authors they already know and have used before (Leckie *et al.* 1996:185).
- Trustworthiness. The professional's faith that a source will provide accurate information, a belief that the source is not socially risky when confidentiality is an issue (Leckie *et al.* 1996:185).
- Packaging is important when information is needed through a specific medium or in a specific format (Leckie *et al.* 1996:185).
- Timeliness. The engineers must obtain the required information immediately or within an acceptable amount of time. The information's usefulness will decrease if it is obtained too early or too late (Leckie *et al.* 1996:185).
- Cost. The importance of the information need, time factor and the monies available will determine the amount of effort and expense a professional will spend seeking information from any source. Cost need not only be calculated in terms of the money to be paid for the information, but can also be psychological and physical, for example the time and effort required to acquire the information (Leckie *et al.* 1996:186).
- Quality. The perceived quality and relevance of the information to the task ought to be primary criteria with which engineers select an information

product or service (Kaufman in Pinnelli *et al.* 1991:316; Pinelli *et al.* 1991:317).

- Accessibility. This could be physical proximity of the information (is the information available in the engineers' office or not) and other considerations such as whether the language used is known to the engineers. Most professionals perceive their own collections to be most accessible (Leckie *et al.* 1996:186).

2.5.4.4 Outcomes of information-seeking

The optimal outcome of information usage is that the information need is met and the professional accomplishes the task at hand (Leckie *et al.* 1996:187). In that sense it is a final stage in information usage. However, the possibility remains that the outcome of the information-seeking may not satisfy the information need and further information-seeking is required. In this way the outcome influences information usage. The 'feedback' loop in the model conceptualises these instances. The second round of information-seeking can now involve a totally different set of information sources and will be influenced by different awareness factors. The feedback loop also illustrates that an information-seeking outcome is not a one-dimensional event, and that information-seeking is not a linear occurrence.

The discussion in section 2.5 shows how tasks can influence users' information behaviour. These models can contribute to an understanding of how engineering tasks determine consulting engineers' information needs and information-seeking behaviour, and in particular how specific sources of information enable them to complete their tasks.

2.6 INFORMATION RETRIEVAL MODEL

Bates' Berrypicking model of information retrieval is the only information retrieval model that is summarised in table 2.1. The berrypicking model was selected amongst other information retrieval models because elements of the model can be applied to engineers' information-seeking behaviour. The model is therefore relevant to a study of the information needs and information-seeking behaviour of consulting engineers.

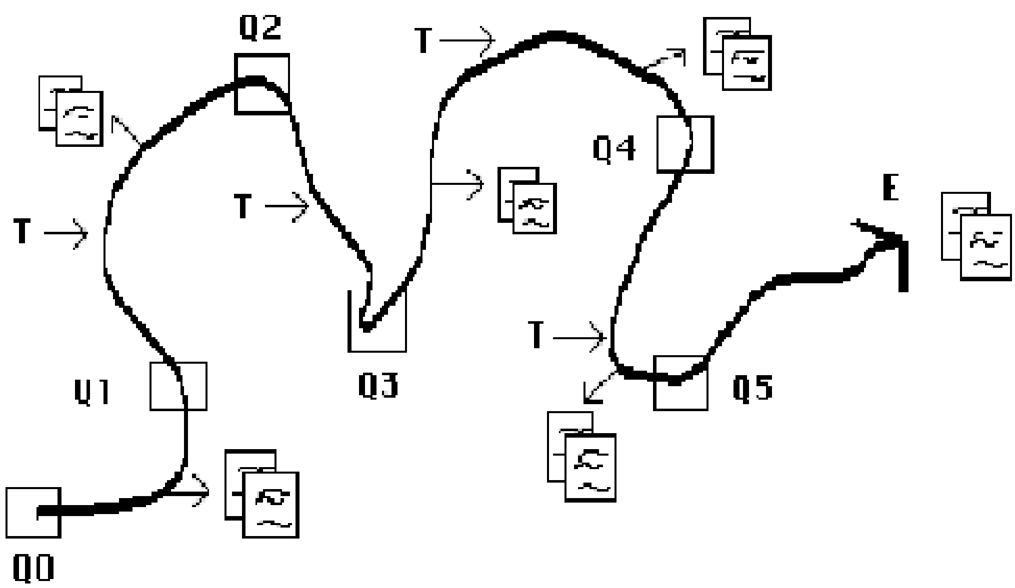
In the Berrypicking Model of Information Retrieval the term "berrypicking" is used by Bates as an analogy to picking berries in a forest. The berries are scattered in the forest and must be picked one at a time in the same way that information could be berry-picked from various information systems.

Bates (2005:59; Ingwersen & Järvelin 2005:218) developed Berrypicking as a principle for information retrieval behaviour because a one-stop model of online information searching seemed poorly fitted to the more gradual and complex information gathering associated with social scientists. Bates (2005:59) argues that real information searching does not always work in the one query or one use way that has formerly been assumed by researchers.

The berrypicking principle entails that each new piece of information that searchers encounter provides them potentially with new ideas and directions to follow, and consequently a new conception of their information need. At each stage of the search, the user may identify useful information items which could lead him or her to a next possible source of information. In this way the information search evolves to eventually satisfy the users' information needs (Ingwersen & Järvelin 2005:218). Figure 2.6 illustrates how a berrypicking search evolves. The "Q" in the illustration represents the query variation, "T" represents thought and "E" exit. Documents containing information are represented by small rectangles.

FIGURE 2.11

A berrypicking evolving search



Source: Bates (1989)

The Berrypicking Model of Information Retrieval differs from the traditional information retrieval models in four ways.

a. Nature of the query

Information queries change and evolve during the course of searching.

b. Nature of the overall search process

The user may identify useful information and references at each information retrieval stage and with each different conception of the query. This information retrieval pattern follows a berrypicking pattern where, instead of leading to a single best retrieved set, users retrieve information from different information systems as their searches evolve.

c. Range of search techniques used

Users' utilise a wide range of information-searching techniques to retrieve the required information. These techniques include:

- the traditional subject searching in bibliographies and abstracting and indexing services
- footnote chasing which involves the user in following up on footnotes found in books and articles of interest
- citation searching where the user would look citations up in a citation index

- journal runs where all relevant volumes of journals are searched for the information
- area scanning which involves the browsing of information sources physically collated with other information sources found earlier in the search
- author searching. This could also be an effective part of subject searching.

d. Domain searched

Users search in many other places besides bibliographic databases as their ever-shifting berrypicking search moves from source to source, technique to technique (Bates 2005:60-61).

According to Bates (2002:10) both browsing and berrypicking are types of sampling and selecting. However, browsing is undirected while berrypicking is more directed. This leaves most people, when left to their own devices, to resort to sampling and selecting techniques for both directed (berrypicking) and undirected (browsing) active information searching.

This model could contribute to an understanding of the techniques which consulting engineers apply to seek sources of information within a specific online environment such as the Internet.

2.7 CONCLUSION

Various information-seeking and information behaviour models that are relevant to a study on the information needs and information-seeking behaviour of consulting engineers were summarised and discussed. It is evident from the discussion above that each model represents a different but also an overlapping or similar approach to information-seeking behaviour research.

The models that were studied in this chapter were arranged systematically according to the following categories:

- General process models.
- Behavioural models.
- Task performance, task based and work related models.
- An information retrieval model.

Common elements or factors reflected in all the models are that information usage is a process involving multiple phases. These phases include the identification of information needs, the decision to use information, selecting and acquiring information sources, finding and gathering, interpreting and processing the information, and putting the information to use. The outcome of the information-seeking process is the utilisation of the required information to complete a task (i.e. the satisfaction of the original need or task accomplishment).

Ellis' (1989) model and Kuhlthau's (1993) information process model characterise the information-seeking patterns of information users. This characterisation of the different information-seeking processes such as browsing or monitoring can assist in acquiring an understanding of how engineers go about finding information.

Aguillar's (1967) modes of environmental scanning and Choo's (1998) behavioural model of information-seeking on the Web can further support an understanding of the information-seeking processes in that they better explain the *information-seeking* patterns in different information environments such as the business environment and the World Wide Web. Choo's model and Aguillar's modes have similar characteristics. The main difference between them lies in the fact that Choo's model contributes to research on information-seeking behaviour on the Web while Aguillar's model focuses on the information-seeking behaviour of managers within an organisation. Aguillar's modes are not restricted to a specific information system but also involve the scanning of the business environment to remain abreast of the latest trends and developments in the specific business field in which the manager is involved whereas Choo's model addresses information-seeking in a specific information system, namely the World Wide Web.

An aspect that needs to be addressed is that most environmental scanning research has been confined to studying the use of, or transfer of formal information sources even though most information exchange is informal and verbal. Although neither the behavioural model nor the environmental scanning model have been used to study engineers' information needs or information-seeking behaviour, they could contribute to a better understanding of how consulting engineers seek information and therefore need to be explored further. Although it is not possible to empirically test all aspects of environmental scanning, attempts are made to identify those facets of consulting engineers' information-seeking behaviour which resemble environmental scanning.

Dervin's (1983) Sense-making approach's focuses on the need for information experienced by users within the context of their personal situations. This shifts the focus from the information-seeking processes characterised by Ellis, Kuhlthau, Aguillar and Choo to the user and the context of the user's personal situation. The model highlights the existing gap between an information related problem that constitutes an information need and the information source that could provide the solution to the problem. Cheuk Wai-Yi's (1998) information-seeking and using (ISU) Process Model is based on Dervin's (1983) Sense-making approach. The strength of this model lies in the fact that the model stresses the relationship between different situations that participants experience in their workplaces and their use and choice of information sources. These models can contribute to an understanding of how different work situations or tasks influence the engineers' selection and use of specific sources of information.

Research that focuses on the relationship between different work-related situations that influence users' choice of information sources complements task-based information usage behaviour research. Four models that studied the information use of professionals within the context of their tasks are:

- Paisley's (1965) conceptual framework of the scientist within systems'
- Blom's (1983) task performance model
- Byström and Järvelin (1995) task-based information-seeking model
- Leckie *et al's* (1996) general model of the information-seeking of professionals.

These models stress the importance of studying information needs and information-seeking behaviour within the context of the user's work environments and the tasks in which they are involved. Paisley's conceptual framework of the scientist within systems contributes to an understanding of the different systems (or factors in Leckie *et al's* model) that influence users' information behaviour. Blom's task performance model stresses the context in which the task is performed and user satisfaction while Byström and Järvelin consider task-based *information-seeking* as a problem solving process. Leckie *et al's* model combines all these aspects in that the six components of the model contextualise the engineers' work roles and tasks also highlighted in Blom's model. These components comprise work roles, associated tasks, characteristics of information needs, information sources, awareness of information and outcomes. The model further incorporates Paisley's concept of the 'scientist within systems' in that the characteristics of information needs could be viewed as work role and task-related factors. The outcomes in Leckie *et al's* model show that task-based information-seeking is a problem-solving process. This makes Leckie *et al's* model a fairly comprehensive model that can be adapted for the purposes of studying consulting engineers' information needs and information-seeking behaviour.

As indicated in chapter 1, engineers seem to prefer personal contacts and verbal information communication to more formal sources of information. Engineers may not necessarily approach the same people for every information need. Social networks, which are reflected in, or corresponds with Paisley's "scientist within a reference group" and as a member of an invisible college should be taken into account. An understanding of the social networking process could explain why engineers would approach certain people to fulfill some information needs and a different group of people to meet other information needs.

Sandstrom's (1994) optimal foraging theory and Bates' (1989) berrypicking model are supplementary models. Whereas the optimal foraging theory provides a framework for understanding information gathering behaviour in an online information environment, the berrypicking theory highlights the specific techniques users follow to retrieve (sampling and selecting) information sources within a specific online information environment. These models can assist in explaining specific stages in information-seeking behaviours such as the selection of information from different information sources and information systems.

From the models studied in this chapter, the general model of the information-seeking of professionals developed by Leckie *et al.* (1996) is used to provide the framework for a discussion of research findings reported in the subject literature on the information needs and information-seeking behaviour of engineers in chapter 3. As shown above, it is a comprehensive model and when considering the research problem indicated in chapter 1, it also seems to be the best model to systematise the data collected in the current empirical study of consulting engineers.

As a method, Sense-making could be invaluable in identifying consulting engineers' specific information needs that arise from their work roles and associated work tasks and in investigating their selection of information sources. Sense-making questioning, through the use of 'micro-moment or time-line interviews' can lead to insights that could influence information service design and delivery. These reasons and the fact that Cheuk Wai-Yi's ISU Process Model was successfully tested on engineers, makes sense-making a suitable method for collecting and analysing the empirical data to be reported in chapters 5 and 6.

CHAPTER 3

INFORMATION BEHAVIOUR OF ENGINEERS: A LITERATURE REVIEW

3.1 INTRODUCTION

As indicated in chapter 1, engineers, and specifically consulting engineers, do not seem to use the conventional information systems available in libraries. The reason could be that they have specific information needs that are not easily satisfied by existing information systems or libraries. The complex nature of engineers' work may further contribute to the complexity of their information-seeking behaviour.

Some of the research models that have been used to study engineers' information needs and information-seeking behaviour include Ellis' (in Ellis & Haughan 1997); behavioural model of information-seeking; the information-seeking and using (ISU) process model developed by Cheuk Wai-YI (1998b), and Leckie *et al's* (1996) general model of professionals' information-seeking. This model studies professionals' information needs and information-seeking behaviour according to their different work roles and associated tasks, the characteristics of professionals' individual information needs, the factors affecting information-seeking ("information is sought") and finally, the outcomes of the information-seeking process.These and other information-seeking models were discussed in chapter 2.

In this chapter an attempt will be made to establish what is already known about engineers' specific information needs as well as the kinds of sources they select or use to satisfy such needs. The information-seeking model developed by Leckie *et al* (1996), is adapted to provide the framework for interpreting and systematising research findings reported in the subject literature on the information needs and information-seeking behaviour of engineers in general.

Most of the studies reported in this chapter investigate engineers' information behaviour. However, some references are made to the studies conducted by Blom (1983), Byström and Järvelin (1995), Choo, Detlor and Turnbull (2000), and Ingwersen and Järvelin (2005) which did not investigate engineers' information behaviour but focused on task performance. Some of the findings reported by the individual researchers are also applicable to other user groups, such as engineers.

3.2 WORK ROLES AND ASSOCIATED TASKS AS CONTEXTS OF ENGINEERS' INFORMATION BEHAVIOUR

As pointed out in chapter 2, Leckie *et al. (*1996) studied the way professionals' personal circumstances and tasks influence their information-seeking and information usage behaviour. As shown in Leckie *et al's* model in figure 2.8, the work roles and related tasks undertaken by professionals in the course of their daily practice prompt particular information needs, which in turn give rise to information-seeking. Professionals' information-seeking is further greatly influenced by a number of interacting factors which can affect the outcome of the information-seeking process. Some of these factors can occur simultaneously.

Blom (1983:19) maintains that the employing organisation is the most important environmental factor influencing task performance. Therefore should an understanding of the nature of engineers' work roles and associated tasks provide some insight into their information needs and information-seeking behaviour. An attempt will be made to indicate the interrelationship between work roles and tasks and how these can influence information-seeking behaviour.

3.2.1 Engineers' work roles as context of information behaviour

According to Leckie *et al.* (1996:179) it is necessary to do an in-depth examination of an individual's work to acquire an understanding of his or her information-seeking behaviour. An understanding of the engineers' work role and work situation can facilitate an understanding of their information-seeking behaviour, and help to predict their information needs and the way in which they retrieve the required information (Leckie *et al.* 1996:179; Wheeler 2004:2).

One of the most prominent work roles of professionals identified by Leckie *et al.* (1996:181) is that of a service provider. In the case of consulting engineers this could refer to their role as an expert sharing expertise, or as the provider of physical products. Embedded within these roles are specific tasks, such as supervising a contract, designing a system or writing a report. These subtle differences between work roles and tasks seem to imply that work roles refer to functions while tasks refer to specific activities that need to be completed. Subject literature reports on engineering tasks will be discussed in more detail in section 3.2.2.

Engineers' work roles and work situations differ from the work roles and work situations of other professional groups, such as scientists, in terms of their professional activity, their attitudes, their orientations, and even as regards their typical family backgrounds (Allen 1988:3). Engineers and scientists communicate with each other about their work in different ways (Allen 1988:3). Krulee and Nadler (in Allen 1988:4) found that science students tended to value education as an end in itself, while engineering and management students value education as a means to an end. Ritti (in Allen 1988:4) found that engineers' goals are largely confined to meeting schedules and developing products that will be successful in the marketplace, and helping companies expand their activities. The empirical work of the engineer therefore does not encourage the continual integration of new ideas and achievements with existing practices (Wolek 1969:473). Publishing research results is therefore not a goal that will have an influence on the availability of published engineering or technical information.

The nature of the project in which engineers are involved is determined by the subject discipline in which the engineer was trained, for example civil, electrical, electronic, or mechanical engineering. Engineers' specific information needs will furthermore be determined by their specific roles in a project, whether as the consultant, the contractor, developer or supplier of a device to be used in the said project (Leckie *et al.* 1996:165). Engineers' work can also be contractual or intended for in-house use (making the information resulting from that project propriety). It is always constrained by time, and is most often conducted in an atmosphere of confidentiality (Gralewska-Vickery 1976:281; Leckie *et al.* 1996:165).

Research by Kwasitsu (2003:5) on the information-seeking behaviour of design, process and manufacturing engineers supports Leckie *et al's* (1996) research results on how the work roles of health-care professionals, lawyers and engineers influence their information needs. Some engineers also seemed to be spending more time seeking information at the start of a new project and less time as the project matures, while others continuously seek information throughout the project (Ellis & Haugan 1997:400; Kwasitsu 2003:5). The specific roles and tasks of engineers thus become the determinants of information needs (Leckie *et al.* 1996:165,167).

3.2.2 Engineers' work tasks as context of information behaviour

A work task can be defined, as indicated in Chapter 1, as 'abstract, objective sequences of actions' (Ingwersen & Järvelin 2005:73). Each work task can be divided into subtasks. In engineering, for example, each engineering task will utilise various technological devices or systems and each of these devices is an entity made up of several interdependent parts or subsystems (Wolek 1969:472). The degree to which each of these tasks has been structured by rules and routine may also have an effect on the use of information (Choo *et al.* 2000b:19). Furthermore, there may be a gap between the engineer's knowledge about the task or the devices that will be utilised and the perceived requirements of the task

(Belkin, Oddy & Brooks 1982:62). This knowledge gap constitutes an information need, which then relates to information-seeking and retrieval (Byström & Järvelin 1995:192; Ingwersen & Järvelin 2005:73).

Byström and Järvelin (1995:192) observed that the complexity or difficulty of the task is one of the most essential factors affecting task performance. An individual's task or the engineer's problematic situation requires some specified hypothetical sets of information, which form the information requirements of the task (Ingwersen & Järvelin 2005:72). As the task complexity increases, so could the complexity of the information required by the engineer, while the number of useful information sources decreases (Byström & Järvelin 1995:211; Ingwersen & Järvelin 2005:83). Within the context of task complexity, information-seeking can be understood as a process in which engineers' understanding of their tasks or problems, their information needs, their relevance criteria (e.g. are the selected information sources the most suitable for the task in hand?) and available information evolve (Järvelin & Ingwersen 2004:1).

Engineers are expected to make informed decisions in a number of situations. The choices they make are largely dependent on their understanding of the context of the task and on their success in obtaining information about this context (Hertzum & Pejtersen 2000:2). An understanding of the relationship between the complexity of a task, information needs and task performance will provide insight into the information-seeking behaviour of engineers (Järvelin & Ingwersen 2004:1).

3.3 FACTORS INFLUENCING ENGINEERS' INFORMATION NEEDS

Various user-related characteristics influence the professionals' information needs. Information needs arise out of situations pertaining to a specific task that is associated with one or more of the work roles played by the professional (in this case, engineers). As indicated in chapter 2, some of the factors that influence or shape engineers' information needs include individual demographics and personal factors the context of the task or project, its frequency, predictability, importance and task complexity (Leckie *et al.* 1996:182; Ellis & Haugan 1997:400-401).

As illustrated in Paisley's (1968) model in chapter 2, perform engineers their tasks within many communication systems that touch every aspect of their work. The unique characteristics of individual engineers will therefore influence all aspects of their life and may affect the role they play within work groups. It may also affect the knowledge they have gained, partly through communication with other people and partly through work experience (Gralewska-Vickery 1976:256-257).

In her study on communication and information needs of earth science engineers, Gralewska-Vickery (1976) found that the range of information required by engineers in their work varied with each career stage. For example, the work of junior engineers will tend to be repetitive and they tend to read as a matter of habit as they were used to doing while at university (Gralewska-Vickery 1976:260). Intermediate engineers become supervisors. Their theoretical knowledge needs to be updated and their fields of specialisation are clearly defined. They are frequently called upon to make decisions, which they have to take even if not all factual data are available (Gralewska-Vickery 1976:261). It is at this stage that engineers communicate with a wide spectrum of other engineers, while they also read more and attend conferences. Senior engineers have less opportunity for direct use of technical skills but do have a greater need for administrative and business skills (Gralewska-Vickery 1976:261).

Leckie *et al.* (1996:183) point out that an unforeseen or unexpected information need could be relatively unimportant and engineers may not need to find a solution to the problem immediately. On the other hand, an unexpected information need could be of great importance and extreme urgency. The level of complexity, combined with the degree of importance and urgency, and the question of whether the information need is anticipated or unexpected, may affect the information-seeking activity undertaken (Ingwersen & Järvelin 2005:68; Vakkari 1998:363; Byström 2005:175).

The characteristics of engineers that influence their information needs will further influence the selection of engineering information sources. The nature of the information sources and the engineers' awareness of information are other factors which also influence information-seeking.

3.4 ENGINEERS' INFORMATION-SEEKING BEHAVIOUR

As pointed out in chapter 2, Leckie *et al.* (1996:180) depicted the information-seeking process as "information is sought" in their model.

3.4.1 Information-seeking patterns ("information is sought")

Research reported in the subject literature has shown that engineers have various reasons for using information sources. For example, King and Griffiths (1991:365-366) found that engineers generally have four motives for using information. These include:

- ways to keep informed about new techniques and methods being employed in their field.
- the application of the information to specific work-related activities (such as new products that could be used for specific projects).
- to prepare various communications, such as written reports, plans or proposals, journal articles or interpersonal communication in the form of information presentations, consultation or advice.
- requiring information necessary for professional development or continuing education.

As pointed out in chapter 1, the major part of information used by engineers is scientific or technical by nature. Engineering information is not necessarily available in a verbal or textual form (Hertzum & Pejterson 2000:7). Engineers obtain much of the information they require by analysing and decoding physically encoded information, such as the devices they use in a project, or by direct personal contact with other engineers. The availability of physically encoded information can greatly influence how engineers seek for information as well as the type of information source they will select to satisfy their information need (Hertzum & Pejterson 2000:7).

As pointed out in chapter 1, engineers gain access to information through various channels' (for example colleagues, clients, contractors or suppliers and phone catalogues) and 'from various sources' (for example colleagues reference books and internal memoranda) (Byström & Järvelin 1995:193). Since information channels guides users to pertinent sources of information and a channel may become a source and vice versa, the rest of the discussion will only refer to the term sources.

A study conducted by Anderson *et al.* (2001:13) investigated the information-seeking behaviour of United States aerospace scientists and engineers. Scientists and engineers selected information sources according to specific patterns.

- The engineers followed a pattern consistent with the principle of least effort. They preferred personal collections and oral communications within the organisation, conferring with others outside the organisation, and referring to the literature, while consulting library intermediaries only as a last option. Holland *et al.* (1991:330) confirm these findings. Gerstberger and Allen (1968:278) remarked that the only way to get an engineer to make use of professional literature would be to bring the literature to the engineer.
- As task uncertainty increased, the search was widened from oral contacts to literature searches and to consulting with library personnel.

3.4.2 Various sources of information used by engineers

According to Gralewska-Vickery (1976:267), the information sources utilised by engineers can be classified in various ways, namely technical or non-technical, oriented to project or to profession, public or private, printed or generated on site, and of continuing or ephemeral value. Engineers' primary source of engineering information is based largely on their personal knowledge or possibly on information contained in books or catalogues in their offices (Shuchman 1981:34).

A distinction can be made between external and internal sources, human and documentary sources, or formal (librarians, libraries and other information services) and informal sources of information (peers as sources of information). Vakkari (1998:368-369) distinguishes between internal or personal information sources (for example personal documents, files and memorandums, or colleagues within the engineering firm), and external or impersonal information sources (information sources that are not available within the engineering firm).

External or impersonal information sources may include information sources that are acquired from personal subscriptions to journals or personally owned textbooks. However, personally owned journals and textbooks could be classified as internal sources although they have been produced outside the engineer's company since they are part of the engineer's personal collection of reference sources. In this sense, the classification of sources as internal refers to the proximity and immediate availability of an information source (Vakkari 1998:369).

3.4.2.1 Internal sources of information used by engineers

The term “internal information sources” refers to information sources that are produced by, or within the engineering company as well as to externally produced information sources that are available within the company, or are personally owned by engineers.

Hertzum’s (2002:2) study reports a general agreement in research findings on internal communication (i.e. personal communications with colleagues working for the same organisation) and costs when it comes to engineers’ selection and retrieval of information sources. Research findings on the use of internal information sources have determined that:

- Internal communication of any kind is more prevalent in engineering work than is communication with information sources that are external to the organisation (i.e. informal information sources such as personal contacts or formal information sources such as text-based sources that contain relevant information) (Case 2002:237; Case 2007:25; Ellis & Haugan 1997:401; Hertzum 2002:2; Hertzum & Pejterson 2000:2; King & Griffiths 1991:10; Shuchman 1981:171).
- Engineers tend to rely on their own information (these could be information sources in their personal collection or their own ‘personal knowledge’ of engineering) and on their colleagues’ knowledge rather than on the library and other internal sources (Case 2002:236-237; Case 2007:255; Hertzum 2002:2; Hertzum & Pejterson 2000:2; Kranich 2005; Weiss 2005). Bates

(2002:8) maintains that active searching for information is a relatively rare act in many people's lives merely because they get so much information in the daily course of events. These findings appear to indicate that favouring 'personal knowledge' and 'personal experimentation' is a general trend among various user groups.

- The use of internal communication could reflect areas of specialised expertise (Anderson *et al.* 2001:13). Perceived expertise may be a better predictor of an engineers' decision to use a particular information source than simply a prediction of how the engineers seek information from a single source (Morrison & Vancouver 2000:4).
- Tasks related to the development of new products depend on internal information (Gerstenfeld & Berger 1980:171).
- 'Word of mouth' is the single most highly rated source of information (Case 2002:237; Case 2007:257; Gerstenfeld & Berger 1980:167; Holland & Powell 1995:10).
- Core resources are often available in the engineer's own personal collection, or come through colleagues, article reviewing and other socially mediated channels (Sandstrom 1999:19).

The subject literature reports on various case studies that convey information about engineers' use of internal information in particular settings. One such study conducted by Hertzum and Pejterson (2000: 4) describes how engineers at Novo Nordisk archive and utilise their documents for future research. A survey by Ward (2001:171) of 27 principal engineers at Ricardo Consulting Engineers revealed that engineers identified their personal memory, personal files, personal books, departmental files, books and databases, other records of previous work, the library and other engineers as important sources of information. Other information sources identified by these engineers include information acquired from clients, manufacturers and suppliers, manuals and brochures, that is trade literature (WFEO/CEI 1979:10), conferences, training courses and leisure contacts. Two engineers, Kranich (2005) and Weiss (2005), described how the engineers working for ABB (a leading company in power and automation technologies), communicated specific product information within the company. Their description corresponds with Hertzum and Pejterson (2000) and Ward's (2001) findings on engineers' use of information within a company.

3.4.2.2 External sources of information used by engineers

Engineers cannot rely only on internal information sources when completing information tasks. They also need to use sources that are not available within their company or organisation. These sources are known as external information sources. External information sources include personal contacts or text-based sources that can be retrieved from conventional information systems or libraries. Studies by Frischmuth and Allen (in Taylor 1991:237), Hertzum and Pejterson's (2000:5), Shuchman (1981:27-28), Taylor (1991:237) and Ward (2001:171-172) indicates engineers' preference for internal sources in comparison to external sources.

Ward (2001:171-172) found that engineers tend to value informal contacts, that is unofficial contacts or contacts that are not work-related, with colleagues. These informal contacts complement the use of formal information sources such as published, text-based information sources, conferences, meetings or formal discussions. A report by Shuchman (1981:27-28) indicated that engineers regard their technical assignments as problems to be worked out at the 'bench' since engineering problems require original solutions which are not reported in the subject literature. This report corresponds with earlier research findings by Garvey and Griffith (1967:1013). Taylor (1991:237) noted that solutions to engineering problems are dictated by specifications that may need to be altered, depending on the properties of material, design and time constraints.

Ward's (2001:172) survey did not uncover any consistent patterns of library use. He found that library use was adventitious, and driven by immediate, practical needs. The most popular reason for using the library was to consult the database. Major complaints related to the unfriendliness of the way books were arranged in the library, and that the engineers, for some reason or other, are unable to loan articles from the library.

It seems as if engineers generally prefer to use internal rather than external sources of information. There also seems to be a tendency to give preference to personal contacts or interpersonal communication rather than utilising text-based information sources. The reasons for engineers' preference for personal contacts or interpersonal communication are varied.

3.4.2.3 Interpersonal communication as sources of information

Personal contacts or networks within the organisation seem to be the most used source of engineering information. This tendency to use personal information sources and network within the organisation can be ascribed to the many new ideas that are obtained by talking to people who do similar work within the organisation (Jain & Triandis 1990:29). Anderson *et al.* (2001:14) and Jain and Triandis (1990:30) propose that a problem could arise from this particular pattern of use since 'oral communication may [be] dysfunctional if the actors who exchange communication do not share a common language …' A common language in this context refers to the evolution of language, concepts and values that are unique to the types of projects undertaken by engineers. However, the use of this local or project specific language could make communications beyond the project boundaries difficult and prone to misunderstanding (Jain & Triandis 1990:30; Tushman 1982:357).

Holland *et al.* (1991:319) refer to studies indicating that aerospace engineers devote more time on average to exchanging and transferring technical information than to any other scientific or technical activity. These authors also report a strong relationship between the communication of technical information and technical performance at both individual and group levels. This implies that the communication of data, information and knowledge is central to the success of the aerospace innovation process.

Zipperer (1993) identified several reasons why exhibit design engineers prefer getting information from their colleagues:

- The engineers often seek feedback on their ideas or designs, either as trusted opinion or as impetus for creative discourse. Katz and Tushman (1979:158) and Anderson *et al.* (2001:14) explain this behaviour when they note that oral communication permits rapid feedback, decoding and synthesis of complex information, which fit well in settings where most research ideas are as yet unformed and difficult to articulate.
- A colleague's memory is often the only access point to filed documents, other than manually searching the documents.
- The engineers' close working relationship with their colleagues enables them to select the person to approach in a given situation based on informal distinctions such as the person being very helpful, too slow, or inefficient.

Since many engineers work on products and/or items of a proprietary nature (Taylor 1991:237), security may be added to this list of reasons for engineers' preference for acquiring information from their colleagues.

A study conducted by Fidel and Green (2004:569) on how engineers working in a particular organisation sought information, found that the chief methods of communication with peers and co-workers were email, phone calls and face-to-face communication. Tenopir and King (2004:53) support these findings. Some engineers also posted documentation on the Web or on a server to communicate with colleagues, contractors or clients while some saw meetings as a vehicle for communication. Hertzum and Pejterson (2000:4) found that interpersonal communication proved to be the primary way engineers become aware of relevant material. Also, one of the biggest advantages of the Web for engineers is the building of common-interest communities (Tenopir & King 2004:53).

Case (2002:236; 2007:256) notes that engineers' most pertinent sources of information are their clients and colleagues concerned with a project or task objectives. This source of information also tends to reinforce usage of the information.

Although engineers seem to prefer personal contacts and interpersonal communications in order to acquire and share information, they invariably need to use text-based information sources. These information sources can also be classified as internal or external sources of information.

3.4.2.4 Text-based information sources used by engineers

Text-based information sources refer to paper-based and electronic information sources. Anderson *et al.* (2001:14) studied how engineers and scientists make a selection among written information sources. They found that the perceived importance or value that engineers attached to the information source was the primary determinant when they selected a specific information source. The primary reason given by the engineers for their choice was prior use of the source, source quality, and the complexity and uncertainty of the task. Task complexity and uncertainty seemed to have been less important reasons compared to the importance of the source to the task at hand.

It does not seem that an information search is negatively affected by the accessibility of text-based information sources. The characteristics of task complexity and uncertainty are also not consistent factors when written information sources are selected. Differing organisational needs and demands could also be a determining factor in engineers' selection of text-based information sources (Anderson *et al.* 2001:14).

Different types of paper-based publications fulfil different information needs (King & Griffiths 1991:365). Trade and news journals for example provide fairly general, but newly created, information while scholarly or professional journals are more likely to provide specific information. The literature used by engineers varies according to the field of specialisation of the engineers (Kremer 1980:124). It tends to be related to their trade, such as reports, catalogues, handbooks and trade journals, rather than research publications (Case 2002:236; 2007:255; WFEO/CEI 1979:10). Kremer's (1980:124) study found that engineers consider books and manuals their best sources of information, followed by standards and specifications. Once again, these rankings of information sources varied according to the field of specialisation of the engineers in question.

Engineering standards are design principles aimed at ensuring an agreed level of quality or attainment and comprise information on features and qualities of products, technology of production, treatment methods, research and measurement methods (WFEO/CEI 1979:9). Standards, such as those developed by the Institute of Electrical and Electronics Engineers (IEEE), the International Standards Organisation (ISO) and the International Telecommunications Union (ITU) prompt the development of new products. These standards are frequently used by research and development engineers working for companies, like ABB (Kranich 2005).

Patents are also a type of trade literature and are a valuable information source because it gives new solutions which can be used for practical needs and aims (WFEO/CEI 1979:9). Kranich (2005) indicated the importance of patents as sources of engineering information.

Mueller, Sorini and Grossman (2006:2) found that books are critical to engineers working for QUALCOMM (an engineering company which develops technologies and solutions for the wireless communication industry). QUALCOMM librarians reported that their engineering clients are comfortable with, and use electronic resources, but prefer to access more traditional library resources, such as books as well as other physical items, such as access control systems or computers. Shuchman (1981:44) discusses the importance of hobby magazines (such as *Popular Science*, *Byte* and *Ham Radio*) as sources of engineering information. Shuchman (1981:144) further suggests that using hobby magazines could reflect a trend towards quick reads and easily understood technical journalism. However, some engineers are of the opinion that the material in peer-reviewed technical journals could be two or three years old, whereas the hobby magazines were apt to be more current (Shuchman 1981:44). Case (2002:236; 2007:256) found that journal literature was invariably neither specific nor timely enough for the practical matters at hand, but more useful for monitoring the environment that is shared with competitors. Other research reporting similar findings are those conducted by Ward (2001) and Garvey and Griffith (1967). The engineers in Ward's study (2001:172) "praise books for reliability, but damn them for a lack of recency."

The WFEO/CEI (1979:9-10) compares the information value of research reports and visits to other institutions. Research reports comprise information on completed research. Visits to other institutions provide engineers with information on the technical level and production organisation in the factory they have visited. This information can then be used in their own organisation for further development of their own products or services.

Mueller *et al.* (2006:3) observed a heavy reliance on web searching for information. They noticed a preponderance of basic searching skills and a certain reliance on only one or perhaps two search engines. QUALCOMM engineers are often not aware of web resources such as IEEE Xplore, ACM Digital Library, patent and standards tools or specialty search engines such as Google Scholar, CiteSeer or Scirus. QUALCOMM engineers who are aware of these resources often use them in a rudimentary manner, overlooking options such as advanced searching, leveraging index terms, and using alerting options. QUALCOMM engineers also tend to stick with only one or two paid access resources and are reluctant to explore others with which they have little experience (Mueller *et al.* 2006:3).

Kraaijenbrink (2007) studied the gaps engineers faced when trying to identify, acquire, and utilise information from the Web. In their respective studies, Hirsh (2000:481) and Kraaijenbrink (2007:9) found that responding engineers either did not have a clear idea of what information they needed, or that they needed information that did not yet exist. Many of Kraaijenbrink's (2007:10) respondents also indicated that they found the identification of appropriate keywords to search for information via a search engine the most difficult part of the whole information-seeking process. The participants in Hirsh's (2000:481) study who regularly used the Internet valued the currency of the information.

It is clear from this discussion that there are various types of information sources available to engineers. These sources can be text-based or personal contacts and can be found both internally or externally in an organisation. Furthermore, engineers seem to prefer internal sources of information as well as personal contacts. Engineers cannot select an information source if they are not aware of the existence of the source and do not know whether the source is available and if they perceive the source to be inaccessible.

3.4.3 Factors influencing information use by engineers

Various factors influence engineers' use of information. Some of these factors that were identified by Anderson *et al* (2001:13) include task related factors, the accessibility and quality of the available information.

- Task complexity was not a factor in sequential choice of an information source.
- Task complexity and task uncertainty were not major factors when written information sources (books, journal articles or Internet sources) were selected.
- Accessibility and quality were not factors in the aerospace engineers' use of different types of information sources.
- The aerospace engineers' perceived importance of the information source to their work was the primary determinant for using a specific information source.

In an extensive study conducted at the University of Manchester, England, Gerstenfeld and Berger (1980:167) found no direct correlation between the frequency with which engineers' use a source and the sources' relative contribution to the task. Gerstenfeld and Berger (1980:167) consequently suggest that researchers do not necessarily use the best sources for information, but rather those with which they are the most familiar or comfortable. Gerstberger and Allen (1968:279) agree with this finding. They also found that engineers compensate for their lack of attention to quality when selecting an information channel by varying the degree of scepticism with which they filter the ideas received. The focus in this process is on technical quality rather than on the reliability of the source.

3.4.3.1 Engineers' awareness of information

Direct or indirect knowledge of various information sources and the perceptions about the information-seeking process, or about the information retrieved, plays a crucial role in the overall information-seeking process (Leckie *et al.* 1996:184-185). The individual engineer's general awareness about information sources and the content thereof can determine the path that information-seeking will take. Some important variables identified by Leckie *et al.* (1996:185) are familiarity and prior success (results obtained from strategy or source), trustworthiness (how reliable or helpful), packaging (convenience, usefulness), timeliness (found when needed), cost (relative cost-effectiveness), quality (level of detail, accuracy) and accessibility (relative ease of access).

Engineers' awareness of the record-related factors influences their information-seeking.

3.4.3.2 Availability of information sources

Contrary to scientists' goals to publish their research findings, engineers' goals are to produce some physical change or devices (Allen 1988:8). This information is not in a verbal or textual form unless it is accompanied by some technical documentation. When technological documentation does exist, it is often most useful only when the author is available to explain and supplement its content (Allen 1988:10; Taylor 1991:235).

Pinelli (1991:20) argues that engineers need information to solve an immediate problem or to make a decision, and their primary output is not information for further research, but rather for a product or a service. The information engineers need should therefore be accurate, up-to-date, reliable and also original (Leckie *et al.* 1996:165). Therefore a strong relationship exists between the communication of technical information and technical performance at both individual and group levels (Holland *et al.* 1991:319).

There are a few barriers in the production of engineering information. One such barrier can be found in engineers' 'legacy to posterity', which is encoded in physical structures (Allen 1988:6). Engineers' primary output is therefore a product or service rather than the publication of technical information or research reports (Pinelli in Wheeler 2001:2). Some intellectual and social effort is required to present technical information in a way that triggers other engineers' attention and get them constructively involved (Hertzum & Pejterson 2000:6).

This notion implies that the only technical information available in a text-based form is information that someone had felt the time and need to write (Hertzum & Pejterson 2000:7). Engineers' employment also provides a barrier to the production of publicly available engineering information. Most engineers are employed by organisations with a well-defined mission (such as, profit, national defence or space exploration) (Allen 1988:6). This necessarily demands a degree of identification with the organisation, which works in two ways to exclude the technologist (or engineer) from information communication channels outside his organisation. First, the engineers are inhibited by their companies' requirements to only work on problems that are of interest to their employers, and second, they must refrain from early disclosure of their research in order to maintain their companies' advantage over competitors (Allen 1998:6).

These barriers in the production of text-based engineering information have not only an influence on the availability of engineering information, but also on the accessibility thereof.

3.4.3.3 Accessibility of information

Accessibility refers to the ease with which engineers can gain access to orapproach information sources, taking both the social, economic and physical costs of use into consideration (Choo *et al.* 2000b:12; Culnan 1985:303).

Culnan (1985:304) proposes three dimensions of accessibility: gaining physical access to the information sources, translating an information need or request into a language that is understood by the source (interface dimension), and being able to retrieve the potentially relevant information physically (informational dimension). Choo *et al.* (2000b:13) add a psychological fourth dimension to this list, for example, the embarrassment of revealing one's ignorance or need for assistance.

Individual engineers have different perceptions of the concept *accessibility* with relation to an information system (Fidel & Green 2004:565-566). Fidel and Green (2004: 570-571) further identified twelve factors that could contribute to engineers' perceptions of the concept ‘accessibility’. They associate accessibility with factors, such as:

- the sources known to the engineers;
- a concentration of several types of information sources in one place;
- information sources providing the correct level of technical detail;
- sources in the required format that could save time;
- sources with which the engineer feels comfortable;
- sources that are physically close (like sources available in the engineers’ office or on his desktop);
- sources that can be searched interactively by using keywords or codes;
- persons who are not busy and who are able to assist with the problem.

The subject literature reports different reasons why engineers would regard information to be accessible. Aguillar (1967) and Taylor (1991:228) indicate a dependence on more personal sources such as personal memory, friends, relatives, colleagues and peers. The ease of use and engineers’ familiarity with an information source determine engineers’ perception of accessibility (Kremer 1980:123; Leckie *et al.* 1996:167; Rosenberg 1967:125). Engineers will also sacrifice quality to minimise the cost of acquiring information (Rosenberg 1967:125; Leckie *et al.* 1996:167). Other reasons given for perceptions of accessibility are the frequency of use and perceptions of technical quality and channel accessibility (Choo *et al.* 2000b:12; Gerstberger & Allen 1968:272; Hertzum & Pejterson 2000:3, Kremer 1980:123).

An information source may be available and accessible to individual engineers, but will not be selected if the engineer does not regard the source to be trustworthy.

3.4.3.4 Trustworthiness of information sources

Hertzum (2002) studied the importance of trust in software engineers' assessment and choice of information sources. Tseng and Fogg (1999:41-42) and Hertzum (2002:2-3) distinguished four types of trust (credibility) on which the trust in information sources is founded:

- first-hand experience or experienced credibility (a tendency to assess people's expertise and trustworthiness based on their personal interaction with people over time);
- reputation or reputed credibility (asking someone for advice based on a colleague's recommendation);
- simple inspection of surface attributes or surface credibility (judging people by the way they dress or the language they use); and
- general assumptions and stereotypes or presumed credibility (trusting friends to tell the truth).

In line with these four types of trust, Van House, Butler and Schiff (1998:41) found that trust is rooted in communities of practice and that the physical distance between people affects their readiness to trust each other. This concept of trust now challenges the least-effort principle by suggesting that engineers' preference for internal sources, such as personal files and colleagues, could just as much be a preference for sources with a known or easily determinable trustworthiness as it is a preference for information that is easily accessible (Hertzum 2002:3).

3.4.3.5 Packaging and form of information sources

Packaging of information refers to the format (such as electronic documents or hard copies of documents) or particular mediums (such as personal contact, a journal article, a catalogue or an object) in which information can be made available. Packaging can therefore also be a prevalent influence since engineers might need their information in an electronic format, or need to discuss the engineering problem with colleagues to find a solution to the problem (Leckie *et al.* 1996:185).

3.4.3.6 Timeliness and cost as factors influencing information-seeking

Time and budget are factors that could influence engineers' task performance (Fidel & Green 2004:568). Time constraints include the time to finish the project and the amount of time engineers have at their disposal to spend on a specific project, taking into consideration other projects in which they are involved or other tasks they need to perform. Budget constraints include the amount of money available to complete a task or to proceed with a particular task, the larger goals of the organisation, and customer satisfaction. This could have a considerable impact on engineers' information needs and information-seeking behaviour and in their particular selection of information sources. Engineers furthermore seem to be quite independent in taking responsibility for their own tasks (Fidel & Green 2004:568).

Mueller *et al.* (2006:2) observed that engineers often move through an information-gathering cycle where the need for information changes drastically during the various phases of the project. Information-seeking by this group is generally in response to very specific problems or projects. Engineers also need to obtain the information quickly or within an acceptable amount of time (Leckie *et al.* 1996:185). This often occurs when they are seeking answers to immediate problems (Mueller *et al.* 2006:2).

King and Griffiths (1991:369), Hertzum (2002:2) and Sandstrom (in Jacoby 2005:259-260) regard the amount of time engineers are willing to spend acquiring and interpreting information found in documents as an indicator of the value of the information. The decision to spend time reading is another indicator of the 'value' of the information similar to the way that the price paid for a journal is an indicator of the perceived value of the journal. Effort costs or cost and time may therefore strongly predict the type of information a person seeks when multiple options are available (Hertzum & Pejterson 2000:6; Morrison & Vancouver 2000:4; Tenopir & King 2004:61). However, the information and knowledge gained may have substantially greater value than that indicated by the amount of time (and money) expended in acquiring and reading the information. Individuals, who regard the costs of information-seeking to be high, seek less information than those who regard the costs as low (Ashford 1986:468).

Cost and time is the most frequently cited barrier to seeking both oral and written information (Hertzum & Pejterson 2000: 6).

3.4.3.7 Quality of information

The users' awareness of the quality of information also influences engineers' information needs. A research project conducted by Auster and Choo (1993:13-14) on how chief executive officers (CEOs) in the Canadian telecommunications industry scanned their business environments for information about trends and developments found that the perceived quality of a source (in terms of its reliability and relevance) was a more important predictor of source use than perceived accessibility of a source. Pinelli (in Leckie *et al.* 1996:186) found that technical quality was one of the strongest determinants of information usage.

Fidel and Green (2004:572) suggest that a new quality factor could be created if the distinction between an information source that "can give data that meets the needs of the project" and an information source that "is most likely to have the information needed" is removed and the two factors are collapsed in to one. The possibility now arises that engineers might rank their perceptions of quality differently by selecting sources of information which contain the required data merely because the information source is accessible and does not necessarily contain quality information. Perceptions of quality ranked according to this new factor makes the distinction between quality and accessibility very vague at times.

3.5 OUTCOMES OF INFORMATION-SEEKING BEHAVIOUR

The outcomes are the results of the information-seeking process and could be the completion of an engineering task.

Information can be used in several ways. Taylor (1991:230) and Choo *et al.* (2000b:15-16) distinguished eight categories to describe the way in which people use information, namely enlightenment, problem understanding, instrumental, factual, conformational, projective, motivational, personal or political. The results of engineers' information-seeking behaviour should culminate in the completion of a tangible project, report or service. Some of the common outcomes or results of information-seeking identified by Leckie *et al.* (1996:187) include providing a service (such as advising a client) or a product (such as constructing a building or a television camera), completing paperwork (writing the final reports or tender documents), realising operational benefits (such as the installation and commissioning of a security surveillance system), and achieving professional development goals.

However, as explained in chapter 2, the possibility exists that the outcome of information-seeking does not satisfy the information need. This unsatisfied need now requires further information-seeking. Leckie *et al.* (1996:187) conceptualised this as a "feedback" loop in their model. This implies that the factors that originally played a role in the information-seeking process could have changed, involving completely different information sources and awareness factors the second time around. Studies have yet to be done on this aspect of the information usage behaviour of engineers.

3.6 CONCLUSION

This chapter focused on research findings reported in the subject literature on the information needs and information-seeking behaviour of engineers. The General Model of the Information-seeking of Professionals, developed by Leckie *et al.* (1996) was adapted to provide the framework for the chapter. For the purposes of this study, the main components of this model have been clarified as follows: work roles and tasks are the contexts of information needs; the characteristics of information needs are the factors influencing information needs, awareness of information relates to information requirements and other factors influencing information-seeking; outcomes are the outcomes or effects of information-seeking (or “information is sourght”); feedback refers to the satisfaction or non-satisfaction of needs.

Leckie *et al’s* (1996) model accommodates a study of professionals’ information needs and information-seeking behaviour according to their different work roles and associated tasks, the characteristics of professionals’ individual information needs, the factors affecting information-seeking, and finally, the outcomes of the information-seeking process. Since this model provided an effective framework for the literature study, it will be used again to analyse the data in the empirical study.

According to various authors, engineers' work tasks are abstract, objective sequences of actions, which can be subdivided into subtasks. Furthermore, engineers are further expected to make informed decisions in a number of situations. The engineers' work roles, work situations and tasks determine their information behaviour. Some of the characteristics that influence or shape engineers' information needs include personal factors, context-specific needs, frequency (recurring needs), predictability (anticipated or unexpected needs), importance and task complexity. These findings concerning the nature of engineers' work tasks and that work roles and work tasks determine their information behaviour will be tested in the empirical study.

The different factors that influence engineers' information-seeking are sources or information and an awareness of information. The sources engineers use to find solutions to information tasks can be internal or external sources, interpersonal sources and text-based or written sources. Research findings indicate that engineers rely on interpersonal contacts and literature from their trade rather than on the information contained in technical journals. These findings will be tested in the empirical study and an attempt will be made at determining why the engineers rely on interpersonal contacts and trade literature.

The outcomes of information-seeking determine the engineers' realisation of their operational benefits, the service they render or the successful completion of the paperwork for the engineering project in which they are involved.

Much has been written on the information needs and information-seeking behaviour of engineers. More recent studies regularly cite earlier studies. The findings of earlier studies seem to be as valid today as they were when the original research was done although changing patterns of information behaviour are reported in more recent studies. The reason for this can probably be found in the nature of engineers' work and the nature of the technical information they need to complete their tasks. Although the studies described in this chapter were conducted on engineers in general, they are largely applicable to consulting engineers as well.

The research findings reported in the subject literature and included in this chapter identified various factors influencing engineers' information needs and the factors affecting their information-seeking behaviour. These findings seem to indicate that conventional information systems found in libraries are unable to provide for engineers' information needs. This assumption will be tested in the empirical investigation of consulting engineers to be dealt with in chapters 5 and 6. Chapter 4 will discuss the research methodology used in this investigation.

The research problem was subdivided into two sub-problems which suggest that the engineers' work roles and associated tasks (sub-problem 1) are important factors influencing engineers' information-seeking behaviour (sub-problem 2). Chapter 4 will focus on the qualitative research methods that will be used in this study. Specific attention will be paid to the data collection method and interview schedules. The interview sample will also be introduced.

CHAPTER 4

RESEARCH METHODOLOGY

4.1 INTRODUCTION

In chapter 2, the various models that have been used to study the information behaviour of engineers were discussed. In chapter 3, the Model of Information-seeking of Professionals developed by Leckie *et al.* (1996) was used as a framework to discuss relevant research findings reported in the subject literature. In this chapter the research method used to investigate the information needs and information-seeking behaviour of consulting engineers is discussed.

The reasons for adopting the qualitative research approach are set out and the different qualitative research methods that were used to study engineers' information behaviour in previous studies are summarised in table 4.1. This enabled the researcher to make a decision about the particular type of qualitative method most suitable for this study. This is followed by a discussion of the sampling technique and data collection method that were used in this study.

4.2 QUALITATIVE RESEARCH

Two different research approaches can be followed when conducting research on the information user, namely a quantitative or qualitative approach. Whereas the aim of quantitative research is to produce generalisable results, qualitative research attempts to describe specific observed phenomena to derive possible explanations for their occurrences (Gorman & Clayton 2005:3; Marshall 1996:522). Since the aim of this study is to acquire an in-depth insight into consulting engineers' information needs and information-seeking behaviour, a qualitative research approach is more suitable for this study.

The qualitative research approach is typically used to answer questions about the complex nature of phenomena and is also referred to as the interpretative, constructivist, or postpositivist approach (Leedy & Ormrod 2005:94). The key assumption made by qualitative researchers is that the meaning of events, occurrences and interactions can be understood only through the eyes of the actual participants in specific situations and "lies within the interpretivist paradigm" (Gorman & Clayton 2005:3).

Subjectivity is a given in qualitative research and it relies on the interpreted, inter-subjective and human nature of reality (Penzhorn 2002:241). A qualitative study is likely to produce tentative answers or hypotheses about what was observed and these hypotheses may form the basis of future studies designed to test the proposed hypotheses (Leedy & Ormrod 2005:94-95). Fidel (1993:222) maintains that a qualitative approach to research offers the best methods for exploring human behaviour and most information retrieval studies that used qualitative methods focused on users and investigated human behaviour in relation to information-seeking and retrieval.

Slater (1990:116) notes qualitative research has a role in mapping or defining the nature of the research problem as well as in investigating its more sensitive aspects. Patton (1990:44) explains that qualitative methods are particularly oriented towards exploration, discovery, and inductive logic to the extent that the researcher attempts to make sense of the situation without imposing pre-existing expectations on the phenomenon or setting under study.

Fidel (1993:222-233) and Wang (1999:58) describe the qualitative approach as having particular characteristics.

- It is nonmanipulative and noncontrolling since it aims at understanding people from their own point of view (Patton 1990:39). Its purpose is to describe how people behave and to understand why they behave the way they do.
- It is humanistic in that the observer and the observed have a good rapport.
- Qualitative research is holistic and case-oriented since it provides for a broad understanding of a particular phenomenon by focusing on unique cases, but at the same time taking into account all the themes that are involved (Patton 1990:40).
- Qualitative research is focused on processes since it examines the dynamics of a process (e.g. interaction during a search), rather than the static attributes of a process (e.g. users' level of education, cognitive styles, or system capabilities).
- It is open and flexible without *a priori* conceptual framework. A qualitative researcher is "open to adapting inquiry as understanding deepens and, or situations change … [and] pursues new paths of discovery as they merge"

(Fidel 1993:226; Patton 1990:41). Quite often data analysis guides data collection (Fidel 1984:274; Fidel 1993:227).

- It uses multiple methods for triangulation. Although interviews, observation, as well as document and log analysis can be used together, the selection of the methods to be used in a particular study is determined by the research question.
- Qualitative research involves fitting qualities into categories by coding the data. Coding can be performed simultaneously with observation or through content analysis where elements of text are the units of analysis. Content analysis is often used to analyse the text of transcribed interviews and verbal protocols.
- It is inductive since it is an approach requiring that abstract constructs, such as hypotheses, models, or theories, be developed during a study, not conceived *a priori.* As a result, both the method of inquiry and the abstract construct are dynamic, evolving as the study progresses. Data analysis involves clustering similar things together and the overall structure of the construct emerges as analysis progresses. Flexible design, the use of multiple methods, and coding of data are needed for inductive analysis to take place (Fidel 1993:231; Patton 1990:40).
- Qualitative research is scientific and valid. It cannot be replicated because it examines a phenomenon at a certain point in time (Fidel 1993:231). Triangulation and peer examination is a common method of ensuring validity (Fidel 1993:232).

In view of the above characteristics it is clear that a qualitative research approach offers the best method of conducting an in-depth study of engineers as a user group.

4.3 VARIOUS QUALITATIVE METHODS USED TO STUDY INFORMATION BEHAVIOUR

To answer the questions, ‘what kinds of investigative methods and strategies should be used to answer the research question(s) for a given purpose?’ and ‘how should the data be obtained and interpreted?’ a review of the various qualitative methods used to study the information needs and information-seeking behaviour of various groups of users in earlier studies was undertaken. The results of this review are summarised in table 4.1. The relevant studies include studies on secondary school students, engineers, scholars and business managers. The following headings are used in the table:

- Study. This column indicates the specific study and the relevant researcher. In some instances it indicates the model that was used in the study.
- Research method. The research method that was adopted for the study is indicated in this column.
- Research design and value for current study. The last column briefly summarises the main aspects of the research design, and where applicable, provides an indication of design aspects that were used in this study of consulting engineers.

The studies were further grouped together according to their research focus.

These are:

- Information needs and uses
- Information-seeking
- Environmental scanning

TABLE 4.1

Qualitative research methods used to study information behaviour

STUDY	RESEARCH METHOD	RESEARCH DESIGN AND VALUE FOR CURRENT STUDY
	Information needs and uses	
Kuhlthau's Information Search Process (ISP) Model	Qualitative study. Longitudinal study.	Started with a qualitative study of secondary school students and the development of the initial model in 1983. The model was verified and refined through quantitative and longitudinal methods of diverse library users in 1989 and further developed in case studies continuing on to 2001. Data was collected at three points during the process of information-seeking using interview techniques to elicit personal accounts (Kuhlthau 2005:230). *Value for the current study* The current study on the information needs and information-seeking behaviour of consulting engineers is not a longitudinal study. The interviewing techniques proved useful in the current study. The study was included here because of the similarities between Kuhlthau's ISP Model and Ellis' Behavioural Model of Information-Seeking.
Dervin and Nilan's Sense-making approach	Set of assumptions. Theoretical perspective. Sense-making approach.	The study tested the Sense-making approach on auditors, engineers and architects. Time-line interviews were used in combination with the critical-incident technique to collect data. Time-line interviews assisted in focusing on a specific task to reconstruct an information need situation and the related activities undertaken to bridge the information gaps. The data analysis focused on individual events rather than individual users (Wang 1999:65). *Value for the current study* The current study will use time-line interviews to focus on a specific task and to reconstruct an information need to bridge the information gaps.
Optimal Foraging Theory	Behavioural approach. Bibliometric and ethnographic methods (Pettigrew, Fidel & Bruce 2001:52).	Sandstrom used co-citation analysis to examine information foraging among scholars studying the evolutionary ecology of hunter-gatherer societies. Sandstrom regarded humanists, scientists and engineers as a single class of information seekers. *Value for the current study* This form of data collection and analysis is not really applicable to a study of engineers' information needs and information-seeking behaviour. However, the Optimal Foraging Theory does provide a method for investigating complex

STUDY	RESEARCH METHOD	RESEARCH DESIGN AND VALUE FOR CURRENT STUDY
		ecologies (situations) which involves a number of factors (Jacoby 2005:259).
Hertzum *et al's* CSA project concerned with the assessment and choice of people sources in a software engineering project	Qualitative Research. Observation and interviews.	Hertzum *et al.* observed and analysed 16 fortnightly project meetings that took place during the formative 8-month period from the initiation of the CSA project. The researcher attended, recorded and transcribed the meetings. Supplementary information was collected by participating in a two-day start-up seminar, conducting interviews with 11 of the core project participants, and inspecting various project documents. Data analysis involved two phases: 11 transcripts were examined and all references to information sources were marked up and annotated. This analysis, combined with findings from the literature provided the input for creating a coding scheme. All 16 transcripts were examined to identify the incidents involving information sources and categorise them according to the coding scheme. Incidents were coded with respect to reasons for discussing, selecting and referring to the information source, employing a primary distinction between quality-related factors and cost-related factors. Incidents were also coded with respect to whether they involved: people or documents; information or commitment (Hertzum, Andersen, Andersen & Hansen 2002:8-10). *Value for the current study* The observation method was not used in the current study. Interviews were used.
Kraaijenbrink's study of the real life gaps in information usage processes of 17 engineers – an information usage processes study.	Qualitative. Sense-making approach.	Kraaijenbrink used the theoretical sampling method to select the engineers for his studies and the critical incident interviewing technique to collect the data. A three step model of information usage gaps were used to analyse the data. These gaps are: Information identification gaps, for example gaps related to information needs, the availability of information, categorisation of information, navigation options, the language used. Information acquisition gaps, for example gaps related to information carriers, intellectual property, roles and matching of actors, time and finance. Information utilisation gaps, for example gaps related to the application domain, the aggregation level of information, abstraction level of information, the quality of information, the missing and incomparable information. *Value for the current study* The study relied on the notion of sense-making gaps as they were discussed in Dervin's Sense-making approach in chapter 2 (section 2.3.5). The identification of sense-making gaps was also the preferred method to analyse the data in the current study.

STUDY	RESEARCH METHOD	RESEARCH DESIGN AND VALUE FOR CURRENT STUDY
	Information-seeking	
Cheuk Wai-Yi & Dervin's Qualitative Sense-making study of the Information-seeking Situations faced by Professionals.	Qualitative. Sense-making approach	Micro-moment time-line interviews. Respondents were asked to recall a typical task he or she had accomplished at work, then focus on all micro-moments when they saw themselves 'running out of sense'. It is these moments that are analysed in the study (Cheuk Wai-Yi & Dervin 1999). *Value for the current study* Apart from being a qualitative study based on the Sense-making approach which is the preferred method to analyse data in the current study, the study also used micro-moment time-line interviews to collect data which was the preferred method for data collection for the current study.
Cheuk Wai-Yi's study into the information-seeking and use process of eight auditors and eight engineers in their workplace contexts.	Qualitative. Sense-making approach	In-depth unstructured interviews were used to collect data. The interview procedure consisted of a warm-up session, in-depth interviews and a brief post-interview sharing session. Participants were asked to think of one or more specific projects that they have completed. They were then encouraged to share the various stages that they have gone through in order to complete their work. This interviewing method is informed by Dervin's (1983) micro-moment time-line interview (Cheuk Wai-Yi 1998b:1-2). The interview dialogues were transcribed and analysed, both manually and with the assistance of qualitative data analysis software titled NUD-IST. *Value for the current study* As in Cheuk Wai-Yi's study, this study is based on the Sense-making approach and used micro-moment time-line interviews to collect data. Data was collected in the current study through time-line interviews and the Sense-making approach guided the data analysis.
Ellis's Behavioural Model of Information-Seeking patterns of engineers and research scientists in the industrial and business environment of an international oil and gas company.	Qualitative. Naturalistic enquiry based on Glaser and Strauss's grounded theory approach.	Informal semi-structured interviews using an interview guide (Ellis & Haugan 1997). *Value for the current study*? Elements of Ellis and Haugan's research were linked to the current study on the information needs and information-seeking behaviour of consulting engineers.
Byström and Järvelin's Task-based Information-seeking Model	Qualitative.	A combination of questionnaires and diaries – the diaries were found suited for collecting data on performance of individual tasks, whereas questionnaires were useful tools for collecting data on the workers studied and their organisation (Byström & Järvelin 1994). The study was conducted in the public administration context. *Value for the current study*

STUDY	RESEARCH METHOD	RESEARCH DESIGN AND VALUE FOR CURRENT STUDY
		Diaries were not used in the current study, but the study is similar to the current one in the sense that it attempted to determine the different aspects to each task, the perceived information needs, and the actual information channels and sources used. These are objectives of the current study. The task-based focus of the study is of value to the current study and this is the reason why it was included in this analysis.
Information-Seeking and Using (ISU) Process Model (Cheuk Wai-Yi 1998b)	Qualitative – qualitative data analysis software entitled NUD-IST was used.	In-depth unstructured interviews, applying Dervin's Sense-making approach for studying people (Cheuk Wai-Yi 1998b). The aim was to encourage the respondents (eight auditors and eight engineers) to share real-life descriptions of how they complete audit assignments and engineering projects. The exact wording of the questions depended on the flow of each interview. All interviews were transcribed. *Value for the current study* This interviewing method is valuable to the current study since this method provided the consulting engineers with the opportunity to explain their information behaviour to the researcher. Although time-line interviews were used in the current study, the responding engineers were encouraged to share real-life descriptions of an engineering project. The exact wording of the questions also depended on the flow of each individual interview, which made the interviews semi-structured.
Hertzum and Pejtersen's investigation into how engineers' information-seeking practices intertwine looking for information documents with looking for informed people.	Two case studies.	*Case study 1* is concerned with how engineers acquired information from previous projects internal to the organisation as well as from external sources: Consisted of ten interviews with people representing all groups involved in handling R&D information. Interviews were based on "a tour of their office" where they explained what information they had, how it was related to their work activities, how it had been acquired, and from whom. Interviews with secretaries, archivists and librarians covered their involvement in filing documents written by the chemists and in seeking information needed by the chemists. *Case study 2* investigates what information was needed and how it was acquired and recorded. The study based on 18 interviews, a questionnaire, and inspection of the project documentation. Researchers focused mainly on what information the engineers needed and used in their work and how they obtained and managed this information. Research approach was inspired by both work analysis and ethnographic

STUDY	RESEARCH METHOD	RESEARCH DESIGN AND VALUE FOR CURRENT STUDY
		approaches to studying engineering work (Hertzum & Pejtersen 2000:4-5). *Value for the current study* Interviews were used in the current study with a focus on the consulting engineers' information needs and uses in their work and how they obtain this information.
	Environmental scanning	
Aguilar's Modes of Environmental Scanning	Field research conducted over a nine month period. The research covered companies in the United States and six Western European countries.	Study population numbered 137 managers from 41 companies. Interviews supplemented by examination of relevant company documents, studies, directives, communication devices (such as company news-abstracting service bulletins). During the interviews respondents were asked to cover at least three of the following topics: To describe their job, where they fit into the company's organisation, and the organisation or persons reporting to him or her on either a solid- or a dotted-line relationship. To list and describe the various sources from which he or she gains external information and to estimate their relative importance. To recall a number of specific recent instances of gaining external information and to specify the source and how he or she came to receive the information. Respondents were asked to provide data for two incidents. If both sets of answers involved internal sources, the respondent was then asked to cite a third case in which an external source was involved. A research program was designed to serve not only a statistical survey of scanning in a number of firms but also a situational analysis of scanning as conducted in a few selected situations (Aguillar 1967:209-215). *Value for the current study* Aguillar's study could contribute to acquiring an understanding of how engineers select people as sources of information. The description of the interviews indicates that micro-moment or time-line interviews were used, although Aguillar did not identify the interviews to be micro-moment interviews.
Auster and Choo's study of Environmental Scanning by CEOS in two Canadian industries.	Quantitative research. Survey combined with other methods.	Data was collected by *mail questionnaire*. The Questionnaire and implementation of the survey followed Dillman's Total Design Method. The questionnaire survey involved three mail follow-ups, sent one, three and seven weeks after the initial mailing. Interviews were used during the following stage, during which interviewees were asked to recall a recent incident requiring information (Auster & Choo 1993:4; Wang 1999:62,64-65). *Value for the current study*?

STUDY	RESEARCH METHOD	RESEARCH DESIGN AND VALUE FOR CURRENT STUDY
		This interview method resembles micro-moment or time-line interviews which is the interview method used in Sense-making and therefore of value to this study.
Correia and Wilson's study of environmental scanning in industrial organisations operating in the chemicals sector.	Qualitative research. Multiple case study coupled with grounded theory method of qualitative analysis.	Documentary evidence collected included formal data (e.g. official designation, address, contact details, name of managing director, etc); publicly available data provided by annual reports of the companies; historical and cultural information provided by the managers. Semi-structured interviews were used to collect core information. Observation played a minor, but non-negligible role – it contributed to the consolidation of impressions or confirmed information based on documentary evidence or in the interviews (Correia & Wilson 2001). *Value for the current study* The semi-structured interviews were of value to the current study, since the interviews in the current study were semi-structured time-line interviews.

The studies summarised in table 4.1 represent various qualitative research designs. These include longitudinal studies, Sense-making, a combination of bibliometric and ethnographic research methods, case studies, the grounded theory approach and field research. The data collection methods were less diverse. Most of the studies collected data through interviews, whether these were unstructured, semi-structured or time-line interviews. The other studies used observation methods as well as a combination of questionnaires and diaries. This summary confirms Wang's (1999:63) findings that interviews are an appropriate data collection method to gather information on user behaviour that is context-dependent.

Two research approaches were adopted to analyse the data in the studies summarised in table 4.1. These are the grounded theory approach and the Sense-making approach. The purpose of the current study is to acquire an understanding of engineers' information needs and information-seeking behaviour rather than to develop new theories. Since the grounded theory approach requires theory development and this was not the purpose of the current study, this approach was therefore not adopted for this study.

Dervin's Sense-making approach, as shown in chapter 2, provides a theoretic perspective on information needs but also embraces a methodological approach, a set of research methods and a set of communication practices (Dervin 1999a:44; Dervin & Nilan 1986:20). As such, it also offers an alternative approach to the study of peoples' use of information and information systems (Savolainen

1993:16). These sense-making characteristics made Sense-making a suitable approach to analyse the data in this study.

4.4 SENSE-MAKING APPROACH

The Sense-making approach is neither purely quantitative nor qualitative, but includes both, and therefore is a third kind of approach, that provides a theory of how to conduct interviews with respondents (Dervin 1992:61; Fidel 1993:223). This study however only applied the qualitative characteristics of Sense-making.

Sense-making is implemented in three ways, that is, in the framing of research questions, in the designing of interviewing and in the analysing and concluding processes of research (Dervin 1999b:737).

Dervin (2005:27-28) highlights two major consequences of sense-making methodological assumptions.

Sense-making assumes that information-seeking is not only habitual but that each individual differs in his behaviour. Thus one cannot only study user behaviour by quantitative methods. Sense-making provides an opportunity to use alternative research designs.

Sense-making assumes that movement through time-space is both facilitated by, and constrained by flows of power. It also assumes that a new moment in time-space makes change always possible even if not always probable. The Sense-making approach therefore requires a method to analyse the data that allow the researcher to determine the conditions or situations where habit or constancy could be found across time-space instances versus those conditions where situational variation can be found (Dervin 1998:36).

4.5 SELECTION OF THE SAMPLE

As indicated in chapter 1, samples for qualitative investigations tend to be small and an appropriate sample size for a qualitative study is one that adequately answers the research question (Marshall 1996:523). A combination of snowball sampling and convenience sampling was used to select the interview sample.

a. Snowball sampling

Snowball sampling is where one respondent is located who fulfils the theoretical criteria, then that person helps to locate others through her or his social networks (Warren 2002:87).

b. Convenience sampling

Convenience sampling is the least rigorous technique. It involves the selection of the most accessible subjects. It is the least costly to the researcher, in terms of time, effort and money (Marshall 1996:523).

Henning, Van Rensburg and Smit (2004:71) and Marshall (1996:524) indicate that these forms of sampling are both related, with one common denominator, namely, that the people who are the most suitable to 'wander with' on the research journey are selected at the time that they are needed. They represent a theoretical 'population' in that they are spokespersons for the topic of inquiry. They are not representative of a population and the findings from the interviews cannot be generalised to a population. The researchers' ability to convincingly argue for the validity of the research findings will determine whether other researchers will be able to transfer elements of the findings to other settings.

Marshall (1996:524) notes that there is no perfect way to sample, but that factors such as the individual's characteristics, spatial and situation influences, and the context of the study could influence the trustworthiness of the research results, should be acknowledged.

The researcher first selected consulting engineers known to her. One of these consulting engineers provided her with the names and contact details of the consulting engineers involved in the construction of a rather large library building in Pretoria. All the consulting engineers on the professional team of this library building were contacted and only those consulting engineers who were willing to participate in the research project were interviewed. Two engineers, who are not involved in the library building project but are also known to the researcher, were also interviewed to expand the representation of engineering disciplines and types of projects. Both of these engineers also fall within the demarcated user group identified in chapter 1, section 1.4.

In all, eleven engineers were selected from amongst the consulting engineers practising in Central and Northern Gauteng. This interview sample represented different engineering disciplines and included electrical, electronics, industrial, mechanical, structural, civil, project and acoustical consulting engineers. All of the engineers are registered as professional engineers with the Engineering Council of South Africa (ECSA).None of the engineers have a properly organised library or information system available within their companies. They represent various age groups and both genders.

Gralewska-Vickery (1976:281; Leckie *et al.* 1996:167) determined that the pattern of information needs and communication sources used vary greatly according to the career stage and job role of an engineer. The selection of responding engineers in this study represents different branches of engineering, varying ages and both genders.

Table 4.2 provides a summary of the age, gender, tasks or projects described of the interview sample. The individual engineers are indicated by the letters A to K together with their engineering disciplines. Engineers B and H are women. Engineer H is the managing director of a rather big civil and structural engineering consultancy. Engineer K is one of her employees. Engineers A and J are business partners and so are engineers C and D. Engineers C and D also preferred to be interviewed as a team and for the purposes of this study, this will be regarded as one interview.

TABLE 4.2

The interview sample

ENGINEER & ENGINEERING DISCIPLINE	**AGE**	**GENDER**	**PROJECT/TASKS DESCRIBED**
Engineer A. *Electrical and Electronic engineering.*	50-60	Male	Library building.
Engineer B. *Structural engineering.*	40-50	Female	Library building.
Engineers C&D. *Mechanical engineering.*	30-40	Male	Library building.
Engineer E. *Electrical engineering.*	70-80	Male	Various building projects.
Engineer F. *Project and Asset Management Engineering*. Engineer F originally qualified as a mechanical engineer but has since become an expert in asset management.	50-60	Male	Asset management project. The engineer described a pre-feasibility study for a larger project. His involvement will only be discussed in Stage 1 – the reporting stage.
Engineer G. *Acoustical engineering.*	50-60	Male	Library building.
Engineer H. *Civil engineering*.	30-40	Female	Pipejacking contract for a city.
Engineer I. *Electrical engineering.*	60-70	Male	Electrification projects for an electricity supply company.
Engineer J. *Electrical engineering*.	60-70	Male	Water transfer scheme for a water board. This project is a retrofit project aimed at expanding an existing water transfer scheme. The engineer was involved in the original project.
Engineer K. *Structural engineering.*	70-80	Male	Library building.

The President of the South African Association of Consulting Engineers (SAACE), (2005c:1) reported that the average age of experienced consulting engineers in South Africa is 56 years. The age distribution of the interview sample is therefore representative of the South African consulting engineering fraternity.

4.6 DATA COLLECTION METHOD

Greeff (2005:287) indicates that interviewing is the predominant research instruments used in questioning as data collection method in qualitative research. The use of interviewing as a data collection method in the qualitative studies summarised in Table 4.1 enabled the researcher to reach the decision to use interviews to collect data for the current study.

4.6.1 Interviews

Greeff (2005:287), Kvale (1996:27) and Sewell (2001:1) define qualitative interviews as “attempts to understand the world from the subjects’ point of view, to unfold the meaning of peoples’ experiences, to uncover their lived world prior to scientific explanations.” This makes qualitative interviewing a kind of guided conversation (Kvale 1984:174; Kvale 1996:27,32; Warren 2002:83,85). Fidel and Green’s (2004:580) study furthermore demonstrated that detailed, unstructured or open-ended interviews with engineers are a promising approach to uncovering their perceptions. Interviews offer two important advantages:

- The interviewees are encouraged to highlight issues or relationships they regard as important through the use of open-ended questions or non-directive listening.
- The interaction between the researcher and the interviewee allows the discussion to move in new and unexpected directions thus providing the opportunity to expand one’s understanding of the issues involved (Gorman

& Clayton 2005:41). For example, in the interaction between the researcher and respondents in the current study the respondents were able to share their views on the usefulness of specific sources of information when the opportunity arose.

4.6.2 Time-line interviews

Sense-making provides a theory of how to conduct interviews with respondents and may be implemented in interviews in several ways, ranging from brief interviews to in-depth interviews (Dervin 1992:70; Dervin 1999a:46-47). The foundational interviewing approach most aligned with Sense-making theory, is called the micro-moment time-line interview (Dervin 1983:10, Dervin 1992:70; Dervin 1999a:47). Wang (1999:67) noted that a combination of the critical-incident technique and the time-line interview technique has become an important methodological development to examine micro-level information-seeking behaviour processes. The interview method allows in-depth discussions with users and provides informative and in-depth data that often reveal thoughts and reasons underlying behaviour (Wang 1999:67). Nilan *et al.* (1988:154) note that since time-line interviews do not presuppose the use of a particular information system, such as a library or an online database, the respondents can freely describe their information behaviour while providing researchers with data on all information systems they use.

Time-line interviews are based on users' perceptions, but it adds the interaction between the interviewer and the interviewee (Wang 1999:63).

Tidline (2005:113) notes Sense-making has frequently been operationalised through time-line and neutral questioning interview techniques. Time-line interviews ask participants to describe their information-seeking sequence and analyses the results using the situation-gaps-uses schema traditionally connected with the methodology. The neutral interview strategy guides users in expressing information needs and experiences in their own words.

In time-line interviews, the interviewer asks the respondent to describe one or more critical situations in detail: first in terms of what happened initially or at the outset, second, in terms of what happened next, third, in terms of the third event, and so on. Then for each time-line event, in terms of the situations (e.g. barriers, constraints, history, memory, experience), gaps (e.g. confusions, worries, questions, muddles), bridges (e.g. ideas, conclusions, feelings opinions, hypotheses, hunches, stories, values, strategies, sources), and outcomes (e.g. 'helps' facilitations, hurts, hindrances, outcomes, effects, impacts) (Dervin 1983:9; Dervin 1992:70; Dervin 1999a:47; Fidel 1984). Schamber (2000:734) regards this as an advantage of time-line interviews. In this way the researcher is rather unobtrusively allowed to access either the respondent's (the interviewee's) past, present or future criteria while focusing on each step of the sense-making process (Nilan *et al.* 1988:154). Situations which are the focus of the interview are selected to fit research purposes (Dervin 1992:72).

The researcher must also be able to interpret the interview responses in a way that does not compromise the original expression of the user, an advantage of inductive content analysis (Schamber 2000:734).

Dervin (1999a:47) indicates that the respondent could also be examined in detail about the basic time-line and then asked to choose the most important event, or question, or contact. She notes some interviews could begin with the situation, others with the gap, the bridge or the outcome. The interviews in this study started with the situation or the task requiring information and then moved on to the gap and the sources of information that were required to bridge the gap.

4.6.2.1 Advantages of time-line interviews

Schamber (2000:741-742) found time-line interviews proved to be a useful tool for orienting respondents to their situations and facilitating recall.

- Time-lines are a naturalistic and relatively unobtrusive means of collecting data about respondents' cognitive perceptions (Nilan *et al.* 1988:154).
- Structured questionnaires are flexible instruments that allow discussion of any number of elements in a respondent's situation, as well as in-depth discussion of specific elements.
- Respondents do not appear to have a problem in describing their own recent experiences. Recall is facilitated by the use of index cards as visual cues for events and questions and by non-threatening probes that encourage respondents to elaborate on their experiences.
- Open-ended and naturally worded items yield in-depth data for content analysis.

4.6.2.2 Disadvantages of time-line interviews

The disadvantages identified by Schamber (2000:742) concern the labour-intensiveness of the methodology.

- The questionnaire is complex and difficult to develop. It has to collect a great deal of data in a limited amount of time. The exact wording of open-ended items is crucial to enhancing recall without introducing bias.
- The questionnaire is complex and difficult to administer. It requires training and experience on the part of the researcher, who needs to work constantly to keep respondents on track and know when and how to probe for more depth and detail.
- The process of transcribing interview audiotape and separating the transcript texts into codable response units for content analysis is time-consuming.

The disadvantages of time-line interviews with regard to contents analysis concern the labour intensiveness of the method, especially with regard to the criterion type scheme which involves the creation of coding data according to certain criteria. These coding schemes are complex, difficult to develop and difficult to apply.

4.6.3 Reliability and validity

The consistence or potential repeatability of results using qualitative research instruments such as time-line interviews can be questioned due to the fact that the interview questionnaire is modified and content analytic coding schemes are created for a specific study (Schamber 2000:742). The goal in qualitative research should be kept in mind when planning interviews and researchers should aim at accurately describing the experience of the phenomenon under study, and not attempt to generalise to theories or models (Krefting 1991:215; Morse & Field 1995:145). The researcher would therefore try to find a pattern in, and a reason for the way in which something happened (Henning *et al.* 2004:6). By using the different stages in an engineering project the researcher was able to identify the information behaviour patterns of the consulting engineers.

Guba (1981:79-82) and Krefting (1991:215) developed a Model of Trustworthiness of Qualitative Research which is based on the identification of four aspects of trustworthiness.

I. Truth value. It is usually obtained from the discovery of human experiences as they are lived and perceived by informants. It is also subject-oriented, and not defined *a priori* by the researcher (Sandelowski 1986 in Krefting 1991:215).

II. Applicability. This refers to the degree to which the findings can be applied to other contexts and settings or with other groups (Krefting 1991:216).

III. Consistency. Since qualitative research emphasises the uniqueness of the human situation, it seeks variation rather than identical repetition (Morse & Field 1995:224; Krefting 1991:216). Consistency in qualitative research is therefore defined in terms of dependability (Krefting 1991:216).

IV. Neutrality. This refers to the degree to which the findings are a function solely of the informants and conditions of the research and not of other biases, motivations, and perspectives (Guba 1981:81-82; Krefting 1991:216).

4.6.4 Interview schedule

The interview instrument or schedule for this study is a questionnaire. It consists of two different sets of questions. The first set of questions was intended for the time-line interviews and was aimed at obtaining information on the responding consulting engineers' work roles and tasks as well as the characteristics of their information needs. This part of the questionnaire is based on the instrument used by Cheuk Wai-Yi (2002:1-2) in her study of information-seeking and use in the workplace. The second set of questions was aimed at obtaining specific information on the information sources used by the consulting engineers. These questions were asked of participants during the interviews as, and when the opportunity presented itself.

a. Time-line interview schedule

The first set of questions pertained to the time-line interview. The interview questions were structured as follows:

(1) Obtain an overview of the respondents' tasks at work.

- Please describe to me your work as a consulting engineer.

- Please describe the job that you have completed in your workplace?
- What is the objective of achieving that task?

(2) Tell me the steps that you need to go through to complete this job?

Task begins - > Step 1- >2 - > 3 -> 4 - > 5 - > 6 - > 7 - > … - > End task

(3) In [Step 1] …

- Do you have any questions in mind? What are they? [gaps: information need]
- What are you trying to find out?
- What situation do you think you are in? [situation]
- What do you feel? [affective]
- How do you or did you find the answer to these questions? Any help? [bridging the gap]
- Why do or did you choose to use this way to get the answer?
- Do you have any difficulties in getting the answer? What are they?
- Are there ways that you can get the answer, but you chose not to use them?
- Did you finally get an answer to your questions? Does it help? How? [help]
- How do you handle or deal with these useful answers?
- If you finally cannot get an answer to your question?

(4) The above questions are repeated for each of the steps that the respondents have shared.

(Cheuk Wai-Yi 2002:1-2).

An example of the adapted questionnaire is included in Appendix A.

The term ‘stage’ was used in the current study rather than ‘step’ which was used by Cheuk Wai-Yi (2002). This is because the Engineering Council of South Africa (ECSA) (2007) uses the term ‘stage’ to describe the different stages in an engineering project. These stages are set out below.

- Report stage. This stage involves the preparation and submission of a report embodying preliminary proposals or feasibility studies and estimates of cost and time where appropriate for consideration by the client (ECSA 2007:4).
- Preliminary design stage. This stage follows the client’s instructions to proceed with the development of preliminary proposals or the basic planning of the project (ECSA 2007:5).
- Design and tender stage. This stage follows the client’s instructions to proceed with the preparation of all documents necessary to enable tenders for the works to be called for, or for the works to be otherwise placed by the client (ECSA 2007:5).
- Working drawing stage. This stage is only relevant for Civil and Structural Engineering disciplines. It follows the client’s instructions to proceed the preparation of any further plans, designs and drawings, excluding shop details, which may be necessary for the execution of the works (ECSA 2007:6).
- Construction stage. This stage involves the overall contract administration and co-ordination, as well as construction monitoring of the execution of the works in accordance with the contract (ECSA 2007:6).

- Targeted procurement stage. This stage entails the completion of the project for which the engineer was contracted. Should the client during any stage of the project, require the consulting engineer to perform work or services pertaining to targeted procurement, such work and or services could entail, but are not limited to, any or all of the following:
    - incorporation of any targeted participation goals
    - the measuring of key participation indicators
    - the selection, appointment and administration of participation
    - auditing compliance to the above by any contractors and/or professional consultants (ECSA 2007:7)

The goal of using these stages in the interview was, as in Dervin's approach, to establish a situation-oriented frame of reference that would encourage the consulting engineers to express themselves as freely and naturally as possible.

b. Questions on use of information sources

The second set of questions was aimed at determining which information sources are generally used by consulting engineers other than the sources they would require to complete the tasks they described. The research findings reported in the subject literature discussed in chapter 3, assisted in the formulation of these questions. The intention was to ask the engineers about their usage of specific information sources should the researcher not be able to derive the answers to these questions from first set of questions in the time-line interview. The additional questions were formulated as follows:

- Do you rely on your personal knowledge, personal files and memory when finding information?
- Do you use codes of practice and standards as sources of engineering information? From where do you get the codes and standards?
- Do you use books such as textbooks in a project and will you buy new books if you need to?
- Do you receive any technical journals and do you use them for personal professional development or your engineering projects?
- Do brochures and, or pamphlets provide for your information needs?
- What role do information technologies and engineering software packages play in providing for your information needs?
- Do you use a digital camera to take photos of a project?
- Do you use the Internet to find project-related information?
- Would you use a library if you had access to one?
- Would you use online databases to find information?
- Do you attend conferences? How important are conferences to you in finding information?
- Do you visit other installations at building sites or factories to find information?
- How important are personal contacts and a social network in finding information?
- What role does email have in your project communications?
- How does cost and time influence your use of information?
- Do you ever publish information on, or about a completed project?

As indicated in chapter 3, section 3.4, Gralewska-Vickery (1976:260) as well as Ellis and Haugan (1997:396) determined that engineers in different career stages utilise different types of information sources and different methods of acquiring information. These career stages could be an indication of different levels of seniority within an engineering company but could also refer to the engineers' age. Unfortunately it was not possible to determine career stages in terms of level of seniority within the company in the current study. This is because most of the responding engineers are directors of their own consulting engineering companies. Despite this problem, the respondents were asked to indicate whether they belonged to the following age groups: 20-30; 30-40; 40-50; 50-60 and 60-70. The reason for this question was to determine whether age is a characteristic affecting information needs and information-seeking behaviour. However age is not necessarily an indicator of career stage or experience. The findings could however assist in acquiring an understanding of how older engineers seek information should there indeed be differences in the information-seeking behaviour of engineers from different age groups.

4.6.5 Administering the interviews

All interviews were audio-taped and freely transcribed by the researcher. The audio-tapes that were used were 90 minutes and 120 minutes in length respectively. Availability of stock at the time of purchase is the reason why different audio tapes were used. Each interview was audio-taped on a separate tape. The 120 minute tapes were the most suitable since it was not necessary to change the tape during the interview and risk loosing important data.

The researcher did not strictly adhere to the interview schedule during the actual interviews.

The researcher followed Cheuk Wai-Yi's (1999:33) example in conducting the interviews in a more natural and less linear manner. For instance, some questions were skipped when the answers were apparent from those given to previous questions. The engineers were not required to share all their information needs during each stage since the interviews were limited to 60 minutes and it was not possible to pursue all the events and questions to the depth required to collect open-ended evaluations of sources and presentations. In some instances, where more detailed information was required, the researcher contacted the relevant engineer at a later stage again and the engineers gladly provided the required information.

Engineers B, H and K were interviewed in English. Verbatim quotes made by these engineers appear in quotation marks. The rest of the interviews were conducted in Afrikaans. The Afrikaans interviews were freely translated for data analysis purposes.

4.7 DATA ANALYSIS

Data analysis follows data collection in a research programme. One of the methods that can be used to analyse the data is the inductive method.

Schamber (2000:742) identified various advantages of the inductive process.

- The inductive process is an unobtrusive adjunct to the interview method in that it is only performed after interviews, on the interview texts and does not force theoretically defined concepts on respondents.
- The inductive process serves the exploratory and descriptive goals of a study. The inductive process of developing content analytic coding schemes refines the operational definitions of variables, and identifies the ranges of variables.
- The inductive process is a necessary method for analysis of unstructured interview texts.

The inductive analysis of data begins with specific observations and builds towards general patterns (Patton 1990:44). The focus is on individuals. The inductive approach begins with the individual engineer's experiences of those instances in which he or she needed to find information, without categorising or delimiting what those experiences were in advance of the fieldwork (Patton 1990:45).

As explained in chapter 2, Dervin's Sense-making approach incorporates situations, or the time-space contexts, gaps or 'information needs' and uses and outcomes or the uses to which the individual puts the information or so-called 'information helps' (Dervin 1983:7). The situations in the current study were translated into tasks needing information. The gaps were translated into information needs and the uses into the selection of information sources and the outcomes of information usage. These three dimensions provided the headings for the different tables that were used to analyse the data collected from the interviews. This use of the Sense-making approach's central idea or concept is similar to the general model used by Kraaijenbrink (2007) in his study of the information usage and processes of engineers. A different set of gaps were used in Kraaijenbrink's study.

4.8 CONCLUSION

This chapter provides an explanation of the research method used in this study. The qualitative research method was discussed and evaluated in terms of the present study. Particular attention was paid to the Sense-making approach, sampling, interviewing and data analysis.

Different qualitative methods adopted in earlier studies to study the information needs and information-seeking behaviour of engineers in general were summarised in table 4.1. Dervin's Sense-making theory was selected as the most appropriate research approach for this study. Sense-making offered the researcher the opportunity for an in-depth and holistic study of consulting engineers as information users. It also seemed to be the more appropriate method for analysing the data in the current study.

The reasons for using a snowball and convenience sample were highlighted and the engineering disciplines and user attributes and characteristics of the sample of consulting engineers for this study were indicated. Attention was paid to time-line interviews as a data collection method most suitable for a qualitative study of this kind.

In chapter 5 the research findings on the information needs of consulting engineers will be analysed and discussed.

CHAPTER 5

RESEARCH FINDINGS ON CONSULTING ENGINEERS' INFORMATION NEEDS AND RELATED CONTEXTS

5.1 INTRODUCTION

Chapter 4 discussed the research method used to conduct the investigation of consulting engineers' information needs and information-seeking behaviour. The different qualitative designs that were used in earlier studies of users' (mostly engineers') information needs and information-seeking behaviour were compared in order to enable the researcher to select the most appropriate research design for this study. Eleven consulting engineers participated in the study.

In this chapter the findings of the empirical study on the work roles and associated tasks of consulting engineers are discussed and how these determine consulting engineers' information needs. Chapter 6 provides further details on these findings by explaining the consulting engineers' use of information sources and information-seeking patterns. The model of the information-seeking of professionals (Leckie *et al.* 1996) is adapted to provide the framework for the discussion in both chapters.

5.2 WORK ROLES AS CONTEXTS OF CONSULTING ENGINEERS' INFORMATION NEEDS

Consulting engineers' work roles are part of the context in which their information needs arise and in which they seek information and therefore they are seen as contextual factors that determine consulting engineers' information needs and information-seeking behaviour.

As pointed out in chapter 3, the numerous work roles assumed by engineers lead to different information needs and they work with a specific objective in mind. Engineers also generally work in small teams and will perform a number of tasks associated with each role or function. The responding consulting engineers were therefore asked to describe their roles as consulting engineers and to contextualise their individual roles. The question was formulated as follows: "Please describe your role as a consulting engineer." The engineers responded as follows:

(NOTE: The Afrikaans-speaking engineers' responses were freely translated while the English-speaking engineers' responses appear in quotation marks).

Engineer A *(Electrical and Electronic engineering):*

Consulting engineers solve their clients' problems. They need to do anything that can make money.

Engineer B *(Structural engineering):*

"Structural design. Concrete or structural steel design. The architect will come up with the concepts. We will look at that concept and say you will need a column and this is the type of slab or column you are looking for, that sort of thickness of slab. He [the architect] will then complete his design and we will finalise the structural design. We will then effectively do the design and the drawings."

Engineers C&D *(Mechanical engineering):*

Mechanical engineers will look at all the mechanical services in a building that include heating, ventilation and air-conditioning (HVAC), and fire protection design. Each building has its own specific requirements and the latter could involve the use of a sprinkler system, emergency detection or special gas fire fighting equipment. In the case of the library building the mechanical consultants also needed to look at a telelift or a book conveyor system which is a service not normally used in buildings or in the retail sector.

Engineer E *(Electrical engineering):*

Consulting engineers advise people. They are paid on an hourly basis.

Engineer F *(Project and Asset Management):*

The asset management consultant's work is slightly different from that of the typical consulting engineer. He doesn't do technical work, but advises his clients on a managerial level. His clients are engineers and he focuses on maintenance management.

Engineer G *(Acoustical engineering):*

The acoustic consultant did not answer this question because he was so eager to describe his information-seeking behaviour that he took the lead in the interview. This consultant also supplied a diagram of the different types of information sources he would use for different projects. A copy of this diagram appears in Appendix B. Engineer G also maintains that acoustic engineers are individualistic in their approach to certain aspects of their work ("*goed*") and regards the acoustic consultant's role in a building project as being a supportive role.

Engineer H *(Civil engineering):*

"A consultant is expected to have expertise to guide a client to make the right decision. So normally with the consultant you start with conceptual design and you're going to [start with] a pre-feasibility, a feasibility, a pre-design phase, a design stage and then you go into implementation. So during that entire project life cycle you would guide your client as to what the right decisions are … So in some instances as civil engineers we also function not only as pure civil engineering[sic]. Normally with a structural project there also is a multidisciplinary team and there is a QS [quantity surveyor] involved. So you don't get too much involved with the costing. Generally in a lot of our projects we function as the QS as well. We do the costing. We do the project management as well in terms of the implementation."

Engineer I *(Electrical engineering):*

Consulting engineers contribute to the creation of facilities. They design electrical- or mechanical services that go into buildings or do electrification projects which are not necessarily building specific. Consulting engineers apply their knowledge to making the world a better place to live in.

Engineer J *(Electrical engineering):*

Consulting engineers need to execute their clients' directives in such a manner that the client is satisfied with the final product. The project must also be completed within the timeframe and budget set by the client. The engineers must ensure that the work they do is in terms of the commission they received from the client.

Engineer K *(Structural engineering):*

" Basically being on a structural side of it, our personal responsibility is to the stability of the structures. This is extremely important because all structures become public areas and industrial areas where any failure can cause disaster. In principle when you have many years of experience, I could most probably say our experiences rely on our memory, are noted is [sic] relying on our filing system [He refers to his personal files which includes his personal sources of engineering information]. And now in the high-tech era, living in a high-tech era, now it is very important that we have engineering websites which can help us out in cases [where] we are falling short in our filing system."

Engineer E's comment "Consulting engineers advise people. They are paid on an hourly basis" in essence summarises the common work role of all the responding consulting engineers: they advise their clients and provide a service. As pointed out in chapter 1, the Engineering Council of South Africa (ECSA) (2007) defined consulting engineers as professionals registered with the Council in terms of the Engineering Professions Act, 2000 (Act no. 46 of 2000).

This comment made by Engineer E reflects Gralewska-Vickery's (1976:266) statement that "consultants have nothing to sell except service, time, knowledge and judgement". This description of consulting engineers also serves as a confirmation of engineers' professionalism since it corresponds with Leckie *et al's* (1996) findings discussed in chapter 3 indicating that professionals' work roles include service provision.

The comment "a consultant is expected to have expertise to guide a client to make the right decision" made by Engineer H as well as Engineer F's statement that his "clients are engineers" indicates that consulting engineers are regarded as experts. This finding also corresponds with Gralewska-Vickery's (1976:266) statement that "consulting engineers are called in when an expert's opinion is needed."

Engineer J further indicated that "consulting engineers need to execute their clients' directives". This mandate would require the engineer to design and manage a project requiring engineering training of some kind, often as a member of a multidisciplinary team which would require him to interact with engineers from various engineering disciplines. The engineers can also be involved in more than one engineering project at a time. This would require them to interact with different clients, work with different multidisciplinary teams, and manage different contractors and projects. This would require the consulting engineers to access various sources of information that are relevant to each of the individual projects in which consulting engineers are involved.

The respondents’ comments above on consulting engineers’ work roles and expertise and the emphasis on engineers’ professionalism in ECSA’s definition of “consulting engineers” in chapter 1 should be taken into account when defining the work role of consulting engineers. Their work role can be defined as follows:

> Consulting engineers are professionals registered in terms of the Engineering Professions Act, 2000 (Act no 46 of 2000) who are experts in their field and who are employed by clients to advise and guide them on the engineering projects they have been commissioned to do.

5.3 ENGINEERING TASKS AS CONTEXTS OF CONSULTING ENGINEERS’ INFORMATION NEEDS

Tasks are embedded in work roles, as indicated in chapter 3, and can be divided into subtasks. In engineering projects certain tasks and subtasks need to be completed for each of the stages identified in chapter 4, section 4.6.4.

The data collected from the interviews that relate to engineering tasks are analysed and discussed according to the three components: situations, gaps and uses or outcomes. As explained in chapter 4, the “situations” in this study were translated into tasks needing information. The “gaps” were translated into information needs and the “uses” into the outcomes and selection of information sources. These components form the headings in tables 5.1 to 5.5 in which respondents’ comments are analysed and presented. The engineers were not asked to identify their own information needs. The “information needed” was derived from the task that was described and the information sources that were used.

The responding engineers were asked to describe a project in which they were involved so that their tasks could be contextualised. They described various projects. These were not necessarily restricted to the building project of which some are team members. Some of the engineers spontaneously described their information use in more than one project and in this way gave an indication of their information needs in different projects. The manner in which different projects influence engineers' information needs and information-seeking behaviour confirms the task-based research findings in studies conducted by Blom (1983), Byström and Järvelin (1995), Ellis and Haugan (1997) and Leckie *et al.* (1996).

Engineers' information use in respect of the additional projects was only described for the preliminary design stage since that is the only stage where some differences in information-seeking occurred. This trend corresponds with Ellis and Haugan's (1997:400) findings that the use of formal information channels decreases as a project progresses. Furthermore, the projects that were described by the responding engineers were not restricted to Central and North Gauteng where the engineers are located. Three engineers even described international projects in which they were involved. The projects described are:

Project 1: The construction of a library building

Project 2: Pre-feasibility study for a mining project which is being developed

Project 3: An electrification project for an electricity supply company

Project 4: Mining building project not involving an architect

Project 5: Concrete repair work

Project 6: Noise control in factories

Project 7: Noise impact studies

Project 8: Sound system design

Project 9: Pipe-jacking contract for a city council

Project 10: A water transfer scheme

5.4 PROJECT STAGES OF CONSULTING ENGINEERS' TASKS

As indicated in chapter 4, the interviews were structured according to the seven (7) project stages identified by ECSA (2007). The design and tender stages are interlinked and were therefore combined for data analysis purposes. The working drawing stage is only pertinent to civil engineers and was therefore combined with the construction stage. The responses collected from the time-line interviews are analysed in different tables. There are four columns in the tables. These are headed "engineer & project", "task", "information needed" and "information sources and outcomes". In each row the engineers' responses in respect of each project, task and related need are indicated. Consulting engineers need to complete various tasks during each stage of an engineering project. The responding consulting engineers described more than one task for each stage. These are indicated as task (a) and task (b). Each task can also generate more than one information need. The different information needs for each task are indicated as need (i) and need (ii) and are expressed in the form of a question framed by the researcher.

The tables provide a verbatim rendition of participants' responses whereas the discussions that follow the tables attempt to interpret, systematise and integrate the responses in respect of the following project stages:

- Project stage 1: Report stage,
- Project stage 2: Preliminary design stage
- Project stages 3 and 4: Design and tender stages
- Project stages 5 and 6: Working drawing and construction stages
- Project stage 7: Target procurement stage.

Particular reference is made to earlier research findings.

Consulting engineers' responses in respect of the various project stages are discussed in terms of different tasks, information needs, the information sources used and the outcomes. The use of these sources will also receive attention in chapter 6.

5.4.1 Project stage 1 – report stage

Projects start as feasibility studies to test the basic concepts (Ellis & Haugan 1997:393). As explained in chapter 4, the report stage embodies such a feasibility study and involves the preparation and submission of a report and estimates of cost and time (ECSA 2007:4).

Not all the professional team members on the library project were involved at the report stage or conceptual design stage. The architect was the first person to be appointed by the client and approached some consulting engineers from varying disciplines to assist him with the conceptual design. The professional team was only appointed after the report was accepted by the client and the go-ahead was given. Engineer A indicated that the appointed professional team need not necessarily include the same consulting engineers that were approached by the architect during the report stage.

In the case of the library building project the architect required the inputs of a structural engineer (Engineer K), the mechanical engineers and the acoustics engineer. Although Engineer B was not involved in the library building at the report stage, she provided information on the typical inputs that would be required from a structural engineer during this stage.

The question put to the responding engineers was formulated as follows: "Please identify a task you had to complete during the report stage and indicate what information was needed and which sources you used." Table 5.1 provides an analysis of the comments of those engineers who were involved in the report stage of the library building.

TABLE 5.1

Project stage 1 - report stage

ENGINEER & PROJECTS	TASK	INFORMATION NEEDED	INFORMATION SOURCES AND OUTCOMES
Engineer B (Structural engineering) Project 1: Library building.	*Project 1, Task (a):* "You will have a very general report …with the architect which stipulates the type of foundation and you would expect to use a concrete frame system, you will be using post tension, you will be using waffle plane. This is a small report [and] is usually one or two pages."	*Project 1, Task (a), need (i):* What type of foundation will be suitable for the building?	*Project 1, Task (a), need (i):* "You would either get a geotechnical engineer, it depends on the client whether he is prepared to do it. The geotechnical engineer will come in, dig a trial hole and from that determine the ground conditions (soil types, water table etc). He will also analyse the ground to ascertain the allowable bearing pressures and the grading of the soil. They would then recommend we use either a pile or a pad … and we would use that report from another engineer to make a decision on the foundation type that should be used."
		Project 1, Task (a), need (ii): What type of structure will the building be? What is the size of the building? What is the scope of the building?	*Project 1, Task (a), need (ii):* "The rest of the information then actually comes from the architect and the client … In some cases if there is something that you have not designed before, you might go into the literature. I would go and speak to somebody else. I would phone around and see if I can find somebody who had done a similar structure and what they sort of looked like and get information from that. Very seldom do I go into technical information from books. At that stage you seldom bring out technical books. Most of the information is by word- of- mouth. It is almost verbal except for the geotechnical report."
Engineers C&D: (Mechanical engineering) Project 1: Library building.	*Project 1, Task (a):* The architect needed information on mechanical requirements in terms of floor space.	*Project 1, Task (a), need (i):* What will the building be used for? *Project 1, Task a, Need (ii):* What are the building's air conditioning and fire protection system needs in terms of the size of the building (floor space,	*Project 1, Task (a), need (i)*: Client (in the case of a government building the client is both the Department of Public Works as well as the department or institution who will be utilising the building). *Project 1, Task (a), Need (ii):* Architect, Internet and other buildings for similar applications.

ENGINEER & PROJECTS	TASK	INFORMATION NEEDED	INFORMATION SOURCES AND OUTCOMES
		surface areas, and volume)?	
Engineer F: (Asset Management) Project 2. Pre-feasibility study for a mining project that was being developed.	*Project 2, Task (a):* Do projections of a coal mine plant's operational costs for the next twenty eight (28) years.	*Project 2, Task (a), need (i):* What historical operational information does the Company have of the old plant? *Project 2, Task (a), need (ii):* Which benchmarks (standards by which something can be measured or judged) will be suitable for the project? *Project 2, Task (a), need (iii):* What are the projected operational costs for the machinery in the new plant for which the projection is being made?	*Project 2, Task (a), need (i):* Industrial information from the old plant for each machine, e.g. maintenance costs, production costs, the hours each machine works, financial information, man hours, company policies for specific items (policies can restrict certain activities and these need to be considered when making projections) – these came from the client's information systems and not from the plant itself. *Project 2, Task (a), need (ii):* Engineer F uses benchmarks to do his study. Some benchmarks come from journal articles, but he also developed a number of benchmarks himself. One of the benchmarks he uses indicates the relationship between preventative measures and the amount of repair work that needs to be done. *Project 2, Task (a), need (iii):* The Company who assisted Engineer F used a software package. Due to the fact that the company could provide very little information, Engineer F had to make some assumptions based on his "engineering judgement". Contractors provided designs for machinery and a break down of costs – including maintenance costs. Most communications for information with the contractor were conducted via email.
Engineer I (Electrical engineering) Project 3: Electrification project for an electricity supply company (ESC). The	*Project 3, Task (a):* During this stage, the consulting engineer needs to appoint a pre-marketer from an accredited list of pre-marketers. The pre-marketer's task is to survey the rural community where families live together in groups or clusters in	*Project 3, Task (a), need (i):* Who are accredited pre-marketers that could be appointed to do the pre-marketing in Area "A"? *Project 3, Task (a), need (ii):* Which of the traditional	*Project 3, Task (a), need (i):* The electricity supply company has a list of accredited pre-marketers whom they have trained. These pre-marketers are in essence land surveyors. The consultant needs to appoint a pre-marketer from the ESC's list. In the end it could be the same pre-marketer the consultant appoints for different electrification projects. *Project 3, Task (a), need (ii):* The information collected by the appointed pre-marketer.

ENGINEER & PROJECTS	TASK	INFORMATION NEEDED	INFORMATION SOURCES AND OUTCOMES
electricity company terms this stage the pre-marketing stage.	traditional homes. He determines which house in each cluster of homes will get electricity and also determines the global positioning system (GPS) coordinates of the selected houses. *Project 3, Task (b)* Report to ECS.	homesteads in the area can be connected to the electricity network? Who lives in the houses? What is the GPS coordinates for the houses? How many houses will be connected? What will the electricity demands for each house be? What is the area to be covered by the electrification project? To which pylon will the new network connect?	The pre-marketer determines the number of homes to be connected to the electricity network and also the area to be covered. The pre-marketer also determines the GPS coordinates for the homes and the connecting pylon. The ESC provides guidelines for the evaluation of an area to determine whether it is a rural village, village, squatter camp or a township. These include the availability of tarred roads, telephone lines, squatter homes, water supplies (taps in the house or next to the house), etc. The nature of the area to be provided with electricity determines the power demands for each house. *Project 3, Task (b)* The information collected in Task (a). The consultant then has to wait for the ESC to complete their network planning.
Engineer K: (Structural engineering) Project 1: Library building.	*Project 1, Task (a):* "…we have to establish what the structure is going to support. And what it is exposed to". *Project 1, Task (b):* Find out *ground conditions.* *Project 1, Task (c):* Determine the type of foundation that would be used.	*Project 1, Task (a), need (i):* What is the purpose of the building? Who is the client? *Project 1, Task (a), need (ii):* What will the building be supporting? *Project 1, Task (b), need (i):* What are the ground conditions? *Project 1, Task (c), need (i):* What type of foundation would best support the building's structure?	*Project 1, Task (a), need (i):* "…looking at the architectural drawings and what the architect required. Also the function and how we can achieve that function." *Project 1,* Task (a), need (i): "And, because it is a library and it is book stacking as well. Book stacking is a very heavy item almost 20 kiloliters per square meter which is 2 ton per square meter. Can you imagine those floors have to support about 2 meters deep of water? It's like every floor is a swimming pool. It is extremely heavy. Obviously it is not everywhere. It is like that because we have office space as well and we've got general space for the public like the reading rooms. That is normally five kilolitres per square meter." *Project 1, Task (b), need (i):* "…normally you get a geotechnical engineer." *Project 1, Task (c), need (i):* The geotechnical engineers "basically recommended that due to the heavy loading that we are going to impose on the foundation that we had to go to piling. Piling is basically pillars. What they do is they drill a hole and fill it with concrete. So we don't impose heavy loading on the soil, but we go down to the rock."

Consulting engineers' responses in respect of the report stage are discussed in terms of different tasks, information needs and the information sources used.

5.4.1.1 Consulting engineers' tasks and information needs

The tasks of the responding structural engineers who are involved in the library building project required them to determine the most suitable foundation and structure for the building. To enable them to do this, they needed to determine the ground conditions of the building site. The mechanical engineers needed to provide the architect with information on the mechanical requirements in terms of floor space.

The tasks of Engineer F (an asset manager) and Engineer I (an electrical engineer) were different. Engineer F needed to do projections of a coal mine plant's operating costs for the next twenty eight years while Engineer I had to appoint a pre-marketer to survey the rural community which was due to receive electricity.

5.4.1.2 Information sources and outcomes

The consulting engineers involved in the report stage of the library building needed information on the application of the building. The structural engineers also required a geotechnical engineer's report on the ground conditions to decide on the type of foundations that would be required. The architect, the client and the geotechnical engineer's report were their only sources of information and "most of the information is by word of mouth" (Engineer B). This is an example of an instance where an engineer wants to understand the priorities of the project and where other people are in fact their only sources of information (Fidel & Green 2004:574; Hertzum & Pejtersen 2000:8).

The information needed by the asset management consultant was different and in essence his whole project forms part of this report stage. He needed industrial information for each machine in an existing plant. These were retrieved from the client's management systems. He also used benchmarks (which he originally got from journal articles or had developed himself) and a software package to calculate the data for the pre-feasibility study.

Engineer I, an electrical engineer involved in an electrification project for an electricity supply company (ESC), needed specific information about the area that would be receiving electricity, that is, site specific information. This information was collected by a pre-marketer on his behalf. As in the case of the structural engineers who need a geotechnical engineers' report, Engineer I depended on the information collected by another person to write his report, making another person his only source of information.

A comparison of the information needed by the engineers involved in the building project with the information needed for the pre-feasibility study (Engineer G) and the electrification project (Engineer I) correspond with earlier research findings indicating that different tasks have different information needs and require the use of different information sources (Anderson *et al.* 2001:148; Byström & Järvelin 1995:193; Cheuk Wai-Yi 1998a:3; Johnson 2003:740; Kraaijenbrink 2007:4; Leckie *et al.* 1996:165-166; Vakkari 1999:825). Different tasks also require the use of different relevance criteria to judge information relevance (Cheuk Wai-Yi 1998:7). Relevance criteria were not tested in the current study due to the nature of time-line interviews where the focus is on tasks and information needs.

As indicated in chapter 3, engineers gain access to information through various channels (e.g.colleagues, phone catalogues and retrieval systems) from various sources (e.g. colleagues, codes of practice, and reports) (Byström & Järvelin 1995:193). The consulting engineers' information-seeking activities during the report stage correspond with these findings. They gain access to information from people, a client's information systems, and benchmarks. Their activities are indicative of different tasks requiring different information. The structural engineers for example needed a geotechnical engineer's report on ground conditions, while the mechanical engineers needed information on the applications of the building. These information-seeking activities are also characteristic of the surveying mode in Ellis' Information-seeking Behaviour Model which involves the selection of starting points for an information search (Ellis & Haugan 1997:395).

5.4.2 Project stage 2 – preliminary design stage

The preliminary design stage follows the client's instructions to proceed with the development of preliminary proposals or basic planning of the project. ECSA (2005:5) prescribed services for this stage involves:

- the establishment of final design criteria;
- design of any process or system where such process design is a prerequisite for the design of the project;
- preparation and submission of preliminary plans, drawings and estimates required for seeking the approval of statutory authorities and the client;
- consultation on all technical matters with the client, authorities and interested parties; and
- submission of estimates of capital and life cycle costs, financial implications and programmes for the implementation of the works.

As in the Project stage 1, the report stage, the responding engineers were asked to respond to the following question: "Please identify a task you had to complete during the preliminary design stage. Indicate what information you needed and which sources did you use."

Table 5.2 analyses the tasks and information needs of the responding consulting engineers during the preliminary design stage.

TABLE 5.2

Project stage 2 - preliminary design stage

ENGINEER & PROJECT	TASK	INFORMATION NEEDED	INFORMATION SOURCES AND OUTCOMES
Engineer A: (Electrical and electronic engineering) Project 1: Library building.	*Project 1, task (a):* Design of electronic services such as access control systems, data communication systems, alarm systems, public address and evacuation systems, and, audiovisual equipment.	*Project 1, task (a), need (i):* What equipment does the client need? *Project 1, task (a), need (ii):* What equipment is available? What are the specifications of the available equipment? What does the equipment cost? Does the equipment's specifications comply with the national building regulations and national standards?	*Project 1, task (a), need (i):* (a)The Clients' inputs through personal contacts. *Project 1, task (a), need (ii):* • Personal experience from previous projects. • Suppliers, these can be suppliers known from previous contracts or it can be new suppliers. Information on suppliers can be found in journals of the engineering trade like *Security World,* and *Buyers Guide.* • Visits to similar installations to see what was done and how it was done. • Architectural drawings. The architect produces them in layers. The engineer requires them in both printed and electronic formats. • Internet. He uses Google search engine and if Google is of no help, Altavista. • Textbooks. The respondent has a good collection of relevant textbooks that are continuously updated with new textbooks that become available. • National standards: e.g. SANS10139 for fire protection and SANS10141 for electrical protection. • Building regulations. These can be found on the Internet and are regulated by Government. • If no specific information can be found, this engineer applies his personal knowledge to formulate an answer. Email is used to correspond with colleagues, clients, contractors, and suppliers. This engineer also asks for quotations or information on equipment via email.
Engineer B: *(Structural engineering)*	*Project 1, task (a):* Write a structural report and do	*Project 1, task (a), needs (i):* What type of folding do I need to suggest? Concrete or clear steel?	*Project 1, task (a), needs (i):* Architect and client. Most information is communicated verbally – this can be written or oral communications.

ENGINEER & PROJECT	TASK	INFORMATION NEEDED	INFORMATION SOURCES AND OUTCOMES
Project 1: Library building.	tender drawings. The quantity surveyor (QS) does the measurements and puts through the bill of quantities for the contractors to price.	Will it be a concrete frame system? Will we be using post tension? Can we use waffle plane? *Project 1, task (a), needs (ii):* Which type of foundation should be stipulated? *Project 1, task (a), needs (iii):* What must the strength of the concrete slabs be? How thick must the concrete slabs be? *Project 1, task (a), needs (iv):* What will the loading conditions for the building be? How much does a stack of books weigh? *Project 1, task (a), needs (v):* (h) Which type of waterproofing and sealants should be used? The client wanted to use a pedestal system. *Project 1, task (a), needs (vi):* What sections are available in steel?	*Project 1, task (a), needs (ii):* Geotechnical engineer. This information will be based on a study of ground conditions. He would suggest the use of a pad or a pile. *Project 1, task (a), needs (iii):* "Once you have fairly designed one slab they all tend to slot into the same formulas we got from our code of practices we use." *Project 1, task (a), needs (iv):* "We might go into literature to look up loading conditions. For example the library had loading conditions. It will be very heavy. So we had to find out what things weighed, what we needed to design for. And for that we had to use literature to see what others had designed for. But a lot of that you can almost get from the architects. The architects know what systems they want to be using. So you phone their suppliers and ask them how heavy the system is. *Project 1, task (a), needs (v):* Internet and email: retrieve suppliers' information from Internet and then correspond with them by email. *Project 1, task (a), needs (vi):* "Sometimes you would get to the steel suppliers to find out what sections they have available so that you could change your design to suit what is available. Most of it you get through phoning people or [using] the Internet."
Project 4: Mining building project where no architect is		*Project 4, task (a), needs (i)* Type of structure, the size, the scope.	*Project 4, task (a), needs (i):* "If there is no architect involved, like for the mining jobs … We will get that information from the *client*. In some cases if there is something that you have not designed before, you might go into

ENGINEER & PROJECT	TASK	INFORMATION NEEDED	INFORMATION SOURCES AND OUTCOMES
involved. Project 5: Concrete repair work.		 *Project 5, task (a), needs (i):* Which additives are most suitable to repair the concrete with?	the literature. I would go and speak to somebody else. I would phone around and see if I can find somebody who had done a similar structure and what they sort of looked like and get information from that …You could also go to ECSA. They can recommend people who they can refer you to." *Project 5, Task (a), needs (i)* "The supplying companies will come to see you and provide you with information. You would phone a representative and ask for specifications on products suitable for a specific application".
Engineers C&D: (Mechanical engineering) Project 1: Library building		*Project 1, task (a), needs (i):* What will the building be used for? *Project 1, task (a), needs (ii):* What are the building's needs? What is the size of the building (floor space, surface areas, and volume)? *Project 1, task (a), needs (iii):* What are the technical specifications of fire protection systems, e.g. smoke protection systems, sprinkler heads? *Project 1, task (a), needs (iv):* What are the technical specifications of air conditioning systems, e.g. pipes (types of pipes and pipe sizes). *Project 1, task (a), needs (v):* What are the requirements set by the building regulations?	*Project 1, task (a), needs (i):* The client. In the case of the library building it will be the library that will occupy and use the building rather than the owners of the building. *Project 1, task (a), needs (ii):* Architect, Internet and other library buildings, e.g.Johannesburg Public Library. *Project 1, task (a), needs (iii):* Fire protection systems – suppliers, SABS specifications – email, faxes or telephone communications, brochures/catalogues. *Project 1, task (a), needs (iv):* Suppliers (email, fax, telephone, brochures/catalogues) and the Internet. (The electrical engineers will need the air conditioning equipment's electrical requirements once they are appointed). *Project 1, task (a), needs (v):* Building regulations are government publications and can be downloaded from the Internet (www.acts.co.za).
Engineer E: (Electrical	*Project 1, task (a), (b) and (c):*	*Project 1, task (a), needs (i):* What does the sketch plan of the	*Project 1, task (a), needs (i):* "Number of offices, auditoriums – you know for an office of X

ENGINEER & PROJECT	TASK	INFORMATION NEEDED	INFORMATION SOURCES AND OUTCOMES
engineering) Project 1: Building project	(a) Design of electric services (b) Preparation of drawings. (c) Preparation of tender documentation. This engineer believes in comprehensive designs and documentation.	building look like? How many offices will there be? How many lecture halls and auditoriums will there be? What are the air conditionings' electricity requirements? *Project 1, task (a), needs (ii):* What are the client's standards? What type of light fittings does the client require? What is the client's budget for the project?	square meters you will need X meter of pipes and X meter of cables, plugs, light fittings and a substation for the building. An auditorium's requirements would be slightly different. You calculate the size of the substation, the thickness of the cables, the number of transformers and distribution boards and allow for pipes for telephone and data network cables. Required information is obtained from the architect and the client. Formulas for cable thickness, transformers and substation capacity are found in *textbooks* used as a student". *Project 1, task (a), needs (i):* Client, for example the type of light fittings the client already has in his stores. Personal contacts; Brochures/catalogues received from suppliers, personal experience. The engineer noted that if something special was needed, he would phone the supplier. He has a relationship with the supplier as well.
Engineer G: (*Acoustical engineering*) Project 1: Library building	*Project 1, task (a):* Noise control in a building such as a library (people talking, operational noise, and the air conditioning systems) as well as isolating external noise that could come from a busy street. *Project 1, task (b), needs (i):* Acoustics for an auditorium.	*Project 1, task (a), needs (i):* Are brick walls, building blocks or glass being used for the building? How much noise will be created by the air conditioning systems? What finishing will be used on the walls? What type of ceilings will be used? The application of the building or room? Is it a reading room, an office or a public meeting place? What are acceptable noise ratio standards? *Project 1, task (b), needs (i):* What is the form/shape of the auditorium? What type of finishing will the client	*Project 1, task (a), needs (i):* The acoustic qualities of the brick walls and building blocks to be used – these are tested once and then the test results are available for all similar projects. These engineers work with a static database of information. Textbooks and suppliers are important sources of information. The architect and architectural drawings are this engineer's primary source of information, especially since he liaises with the client and other team members. The mechanical engineers will provide information on the noise emitted by the air conditioning systems. The client's budget – this will determine the type of finishing used, the type of glass used for large glass panels (glass panels can comply with only thermal heating requirements or thermal and acoustic requirements – the latter is the most expensive). Personal experience from similar projects. *Project 1, task (b), needs (i):* Architect and architectural drawings. For acoustic purposes in an auditorium, the engineer would not use highly absorbent material as some sound echo is needed, especially if it will be used for

ENGINEER & PROJECT	TASK	INFORMATION NEEDED	INFORMATION SOURCES AND OUTCOMES
		require? Wall finishing? Ceilings?	interactive discussions and the audience will be expected to contribute to discussions. For this he would use information sources A (textbooks, journal articles, standards, regulations) and B (Internet, manufacturer information, regulations) indicated in Appendix B.
Project 6: Noise control in factories		*Project 6 task (a), needs (i):* How much noise is emitted by equipment?	*Project 6, task (a), needs (i):* The client is the only person who knows exactly what equipment is being used and will be used in the factory. The supplier should be able to supply this information. Also uses information retrieved from literature.
Project 7: Noise impact studies		*Project 7, task (a), needs (i):* How much noise is emitted by equipment?	*Project 7, task (a), needs (i):* Client: the manufacturer can only provide detailed information on specific components in the project, but not on the combination of components to be used. It always is possible that the company decides to use a different system after the impact study is concluded, and then there will be a discrepancy between the report of the original impact study and the outcomes of the completed project. Also information from existing documentation on the components and previous noise impact studies.
Project 8: Sound system design			*Project 8, task (a), needs (i):* Personal communication with client and suppliers – it always is better to know what new equipment is available at the time of the project and what the equipments' specifications are. Data sheets of old and outdated equipment is often valuable information if newer equipment's information is insufficient or not available. This type of information is not available in textbooks, but kept in personal files.
Engineer H: (*Civil engineering*) Project 9: Pipe-jacking a 1200 diameter pipe through a	*Project 9, task (a):* Determining the pipe size necessary to provide for the ultimate development of the area.	*Project 9, task (a), needs (i):* What are the sewers' capacities in the area?	*Project 1, task (a), needs (i):* Network analysis of sewers' capacity in the area. Worked closely with the city council. Information supplied by the South African Institute for Shift Technology. "Relied heavily on specifications" e.g. the Concrete Institute's specifications and the pipe suppliers'. The suppliers regularly send

ENGINEER & PROJECT	TASK	INFORMATION NEEDED	INFORMATION SOURCES AND OUTCOMES
central business district (CBD) of a large city – this contract was at an early stage in the engineer's career.	*Project 9, task (b):* Design for ultimate densities and the adding of self cleansing velocities. *Project 9, task (c):* Completion of contract documents. *Project 9, task (d):* Costing for pre-tender estimates.	*Project 9, task (b), needs (i):* What is the actual flow in the sewer? *Project 9, task (c), needs (i):* What information needs to be included in contract documents? *Project 9, task (d), needs (i):* What do sewer pipes cost?	representatives to the consultants to update their collection on product specifications with the latest specifications." "A manufacturer gives us guidelines as to how we need to install their pipes and stuff, we might review it and look at it occasionally, but the South African [Bureau of Standards] SABS standard is what we rely on more often in terms of how we bed the pipe and that type of thing. So we get that information from the SABS Codes". *Project 9, task (b), needs (i):* Literature research in a library (the company this engineer worked for at the time had quite an extensive library). She also got a lot of information from the South African Society of Trenchless Technology. Did a lot of mathematical calculations and developed models. Engineer H relied a lot on a mentor working for the city council at the time. The mentor also was very involved in environmental issues. A second mentor supporting this Engineer was very "clued up on contract documents" which helped with contractual issues. The first engineering principles remain the same. *Project 9, task (c), needs (i):* (c) "As consulting civil engineers we are exposed to a number of different contract documents" – there are at least six (6) of them. *Project 9, task (d), needs (i):* "What we tend to do in our organisation is we are trying to build a database of recent tenders that have gone out. So if we do any pre-tender estimates, we rely on that."
Engineer I (*Electrical engineering)* Project 3: Electrification project for an electricity supply company	*Project 3, task (a):* Do the preliminary design.	*Project 3, task (b), needs (i):* ECS report includes design drawings, a transformer diagnosis, statistical information. How many poles are needed? How many homes can be connected to each high voltage pole? What does the site look like? Are there any individual houses that could	*Project 3, task (a), needs (i):* The global positioning system (GPS) information received from the pre-marketer and information on the ESC's network planning. Aerial photos for mapping details. These will also indicate whether there are homes that appear separately from those picked up by the pre-marketer. The ESC is supposed to have a section for aerial photos but not all the photos that they have available are recent enough. Engineer I then acquires the required aerial photos from a cartographic company. The cartographic company can also

ENGINEER & PROJECT	TASK	INFORMATION NEEDED	INFORMATION SOURCES AND OUTCOMES
(ECS).		connect to the ESC that were not picked up by the pre-marketer?	convert the aerial photos that Engineer I got from the ESC to the correct format should that be necessary. The project must also fit into the ESC's *Small World* (a GPS software programme) map. Google Earth is not a good source of information. It is not always comprehensive enough, the information is often old and the data format is not compatible with *Small World*.
	Project 3, task (b): Budget.	*Project 3, task (b), needs (i):* Prices for equipment and labour. How many transformers will there be? Which pylons will be used?	*Project 3, task (b), needs (i):* Budget information comes from the pre-marketing report and the ESC. The ESC provides the equipment and the cost thereof appears in a price list. Engineer I can do the costing once he has completed his preliminary design.
	Project 3, task (c): Submit the preliminary design report to ECS.		*Project 3, task (c), needs (i):* The preliminary design report. Engineer I uses email to communicate with the ESC and other interested parties. He breaks his preliminary report into sections and submits it by email – the preliminary report is too large to send as one file since it includes aerial photos. Information might change as the design progresses – there might be more connections than originally calculated for. Only once the financial committees have approved the project, can the engineer complete the design and tender documents.
	Project 3, task (d): Do a presentation to the Technical Evaluation Forum (TEF). If approved by the TEF, the design proceeds to more financial committees.	*Project 1, task (d), needs (i):* What information must be included in the Powerpoint presentation of the preliminary design report?	*Project 3, task (d), needs (i):* No other information is required for this task.
Engineer J: (Electrical engineering) Project 10: Water transfer	*Project 10, task (a):* This task was the mechanical engineers' responsibility.	No information needed.	[The electrical engineer and the mechanical engineer worked closely together on this project. Engineer J mentioned this stage, but only became involved during the design stage.]

ENGINEER & PROJECT	TASK	INFORMATION NEEDED	INFORMATION SOURCES AND OUTCOMES
scheme.			
Engineer K: (Structural engineering) Project 1: Library building.	*Project 1, task (a):* Determine the structure of the building.	*Project 1, task (a), needs (i):* What does the architect require and how can that function be achieved?	*Project 1, task (a), needs (i):* "We had to [work] in very close contact with the architect himself and the drawings … know the architect's drawings. Knowing what the architect wants to show in the building. The architect is the artist and I just [do] the mechanics."
		Project 1, task (a), needs (ii): What are the internal loading conditions that the building is going to be subjected to?	*Project 1, task (a), needs (ii):* "So the loading in this situation is basically the information from the users of the building which is the library."
		Project 1, task (a), needs (iii): What external loading conditions need to be considered?	*Project 1, task (a), needs (iii):* "The external loading is specified by the standards. The South African Bureau of Standards. OK. Like the … and earthquake tremors and the minimum roof load. That is coming [sic] from the standards."
		Project 1, task (a), needs (iv): What elements need to be considered to which the building could be exposed to? (e.g. cyclones and traffic vibrations)	*Project 1, task (a), needs (iv):* "… it is also a lot of external steelwork. Features in steelwork. There is large steelwork but it is protruding. It is going to be over the building about three meters. Now this type of steelwork is very sensitive for cyclones. Which doesn't happen very often up in Pretoria but because the building life, the life of that building of the library is between 100 and 130 years, the likelihood of a cyclone to appear is there." "Also vibration, traffic vibration. In order to prevent vibration in a low frequency turn-up the glassing could rattle and that could upset the reading room. So we had to get some information out on what sort of support was required for the glassing. And that I got from a website."
		Project 1, task (a), needs (v): What is the geometry of the building?	*Project 1, task (a), needs (v):* "…if you know the geometry of the building and the building elements as well, and the loading basically determined the stability of that building. So you don't have to go further."
		Project 1, task (a), needs (vi): Are there any public water services	*Project 1, task (a), needs (vi):* "And that was obviously the Municipality which normally gives

ENGINEER & PROJECT	TASK	INFORMATION NEEDED	INFORMATION SOURCES AND OUTCOMES
		in the area? *Project 1, task (a), needs (vii):* Can flooding of the basement be avoided? *Project 1, task (a), needs (viii):* If no information can be found in the codes of practice, which other sources are available to provide the information?	that information." *Project 1, task (a), needs (vii):* "So, let me consider water tight concrete. There is no South African code regarding that. So we had to go to the British Code." *Project 1, task (a), needs (viii):* "…and where ever there is no code available you have to go to the building for information which is not coded yet." – [this information comes from the engineers' personal knowledge and experience].

Consulting engineers' responses in respect of the preliminary design stage are discussed according to the tasks and information needed and the information sources and outcomes.

5.4.2.1 Consulting engineers' tasks and information needs

In the library building project, the structural engineers (engineers B and K) needed information on the type of folding they would be using, the framework of the building (concrete or steel), and the type of foundation. The electrical and electronic engineer (Engineer A), the mechanical engineers (Engineers C&D) and the acoustical engineer (Engineer G) needed the technical specifications for equipment they might be using or, as in the case of the acoustical engineer and the electrical engineer (Engineer E), the specifications of the equipment their colleagues would be using. In addition to this, the mechanical engineers needed to know what the building would be used for.

Engineer H (civil engineer) needed details on the sewer capacities and the actual flow in the sewers in the area in which she would be operating. The electrical engineer (Engineer I) working on the electrification project needed site specific information but also equipment specific information while Engineer J was not yet actively involved in the water transfer scheme at this stage.

5.4.2.2 Information sources and outcomes

An important characteristic of engineering practice is the use of a sequence of designs in the course of a project (Wolek 1969:471). This is reflected in Engineer A's (electrical and electronic engineer) comment, in which he indicated that he requires a broad spectrum of information at the start or beginning of a project which becomes narrower and more specific as the project progresses. This was illustrated in his example where he first required information on the technological needs of the proposed conference room in the library building. Thereafter, he needed specific information on each of the components or systems that formed part of his design. This description of Engineer A's information needs at the initial stages of a project provides a very practical illustration of Ellis and Haugan's (1997:395) surveying mode which involves the identification of initial materials to search for and the selection of starting points for the search.

Most of the information needed by the consulting engineers during this stage came from a variety of information sources. This supports Bates' (1989:10) contention that information searchers commonly gather information in bits and pieces, while using a wide variety of sources other than bibliographic databases.

The use of many and varied information sources is also a characteristic of the undirected viewing mode in Aguillar's (1967:19) Modes of Environmental Scanning.

The different types of information sources used by consulting engineers during the Preliminary Design stage include: personal contacts, architectural drawings, suppliers, visits, text-based information sources, the Internet, email, design software, and personal knowledge.

a. Personal contacts

As explained in chapter 3, information on technology is transferred primarily through personal contact. People with experience from exactly the same field, with other contractors and with suppliers of technology are important sources of engineering information for consulting engineers.

Persons contacted by the consulting engineers for information include the client and other members of the professional team (particularly the architect who coordinates the building project); the geotechnical engineers' report and the pre-marketer's report in the electrification project. Engineer B indicated that she would contact a colleague or find someone who had done a similar project for assistance if the project involved a type of design she had not done before. She has less experience than the other responding structural engineer and this could be an indication that she relies on mentors. It could also be a confirmation of Gralewska-Vickery's (1976:281) contention that information needs vary greatly according to the career stage and job role of an engineer. Engineer B's behaviour also reflects the chaining activity in Ellis' Model.

Ellis and Haugan (1997:393) reported that communications within projects is usually transferred orally among project team members through meetings or electronic exchange such as the use of emails. The personal forms of information transfer reported by the responding consulting engineers correspond with Ellis and Haugan's findings.

b. Architectural drawings

Architectural drawings are one of the most important sources of information in a building project since all the work the engineers are required to do are indicated on the drawings. Engineer A noted that he required these drawings in both printed and electronic format. This is in agreement with Leckie *et al's* (1996:185) findings that packaging or format influences the selection of information sources.

c. Suppliers

Suppliers provide engineers with catalogues of their products. Some companies make it their business to update consulting engineers on the latest products that have become available. These are subscription-based services of which some of the engineers receive sponsored editions. Examples of such services are *Specilink* and *Ezee-dex (*a marketing package for sales leads and enquiries).

d. Visits

Visits to similar installations or other building sites to collect information on the latest technologies or trends were important to some of the engineers but not all. Engineers C&D (mechanical engineers) visited other libraries for information on the use of air conditioning systems in libraries to assist them in their designs. Engineer E (an electrical engineer) and Engineer K (a structural engineer) did not regard visits to other sites and installations as impotant. Both engineers E and K are semi-retired and over the age of 70. Engineer H (a civil engineer) also did not visit other sites. Her reason was that the project she described is a ground-breaking project in South Africa and there were no local sites that she could visit that could provide her with information. The motives for site visits correspond with Gralewska-Vickery's (1976:272) findings that visits are an important means of gaining experience since 'seeing means applying'.

e. Text-based sources of information (literature)

Literature consulted by consulting engineers during the design stage of a project include textbooks, codes of practice or national standards, brochures and catalogues, and journals of their trade such as *Security World,* and *Vektor.* They are required to use these sources in order to comply with building regulations as well as for the specifications and prices of the products they use in their designs.

f. Internet

Most of the engineers use the Internet extensively. Some of the reasons given by consulting engineers for their use of the Internet include finding information on products and suppliers, retrieving relevant documents from client websites (such as the Acts that regulate their trade, Department of Public Works and ESKOM) and acquiring information from professional societies. The engineers will access specific websites if they know the URL, such as, the clients' websites (Engineer F) or the directories used by Engineer K. Otherwise they do their searches on Google to find information that could assist them in solving specific engineering problems, such as product related information.

g. Email

Email is also used quite extensively by the engineers to communicate information with project team members or to clarify questions arising from the project in which they are involved. They will also use email to acquire information from possible suppliers. Engineer G is the exception. He prefers personal contact at all times and although he does have an email address, none of his project team members have his email address. Only Fidel and Green's (2004:569) study reports on the role of email as a method of communication.

h. Design software

Most of the engineers interviewed for this study indicated their need for design software, but not necessarily for the particular project they described. Engineer G (an acoustical engineer) explained that the type of projects in which he is involved do not warrant the use of design software. It did not seem as if Engineer E needs design software and Engineer K explicitly stated that he does not use design software. He designs the classical way where "you look at the structure and see how it will work, and put your figures down accordingly." Gralewska-Vickery's (1997:267) study showed that computer software was required particularly by students, junior and intermediate engineers. It would appear as if age plays a role in the need for design software. Two experienced engineers who are over the age of 70, Engineer E and Engineer K, prefer to design according to the classic design method and do not need to use design software packages in their designs.

i. Personal knowledge

Personal knowledge is also required in the preliminary design stage. Engineer J (an electrical engineer) indicated that some projects require considerable technical skills. When no specific information could be found in the literature to solve the problems encountered in such projects, the engineers would return to the "basic principles" (Engineer A, and Engineers C&D) and use their engineering knowledge to solve the problem. Engineer F (an asset management consultant) used the term "engineering judgement". This behaviour is in accordance with Shuchman's (1981:27-28) findings, reported in chapter 3, that engineers regard their technical assignments as problems to be worked out at the "bench".

A comment made by Engineer J, namely, that "it all depends on what you are looking for where you will be finding the final information" indicates that prior knowledge about a task determines the information needs of consulting engineers. According to Vakkari (1999:827) prior knowledge is a major factor in determining what information is needed for its accomplishment. Further comments made by Engineer K on the value of his "personal knowledge, notes and filing system" and Engineer J's claim that engineers rely on their experience in simple projects also appear to support Vakkari's views in this regard. Leckie *et al.* (1996:184) maintain that this tendency to utilise personal knowledge and experience is one of the aspects that makes a "professional" different from other kinds of workers. Personal knowledge and experience also encompass the different ways that work is conducted or practiced within various professions (Leckie et al 1996:184).

5.4.3 Project stages 3 and 4 – design and tender stages

The design and tender stages follow the preliminary design stage and the client's instructions to proceed with the preparation of all documents necessary to enable tenders for the works. The engineers' responsibilities set out by ECSA (2007:5) during this stage involve various activities.

- Advice to the client as to the necessity for further surveys, special visits, use of specialist consultants, setting out or staking out the works, and arranging for such works to be carried out at the client’s expense.
- Preparation of detail designs and tender and/or working drawings.
- Preparation of specifications and schedules of quantities for engineering works.
- Provision of information necessary for the design of other services.
- Submission of updated and revised estimates, capital and life cycle costs, financial implications and programmes for implementation of the works previously submitted.
- Drafting or adapting invitations to tender, tender conditions, forms of tender and conditions of contract.
- Advice to the client on any alternative designs and tenders.

The question in regard to this stage was phrased as follows: “Please identify a task you had to complete during the preliminary design stage. Indicate what information you needed and which sources did you use.”

The engineers’ responses to the question were organised in table 5.3 under the following headings: tasks, information needed, and information sources and outcomes.

TABLE 5.3

Project stages 3 and 4 - design and tender stages

ENGINEER & PROJECT	TASK	INFORMATION NEEDED	INFORMATION SOURCES AND OUTCOMES
Engineer A: (Electrical engineering) Project 1: Library building	*Project 1, task (a):* Evaluation of tender documents to determine whether the services and equipment offered by the tenderer complies with what was requested in the original tender document.	*Project 1, task (a), needs (i):* Needs information on the systems offered by the tenderer.	*Project 1, task (a), needs (i):* Equipment specific or system specific information. The tenderer provides this information in the form of brochures or other technical data he includes in the tender document.
Engineer B: (Structural engineering): Project 1: Library building	*Project 1, task (a):* "We would do tender drawings."	*Project 1, task (a), needs (i):* Needs the architectural design. *Project 1, task (a), needs (ii):* Needs the project budget.	*Project 1, task (a), needs (i):* Architectural design. *Project 1, task (a), needs (ii):* "When you do the budget you will use your experience and will phone the *QS* and ask what a slab this thick would generally cost and they will give it to you. Reinforcement costs this much. The QS will give it to you per square meter. A house will cost RX per square meter. A parking garage will cost RX per square meter, etc."
	Project 1, task (b): "If there is a QS involved, he does the tender evaluation. On smaller jobs we do it ourselves."	*Project 1, task (b), needs (i):* Needs tender documents, design, and budget.	*Project 1, task (b), needs (i):* You will hopefully get everything you need from the *design*. It will not necessarily be the lowest tender. Knowing people and how their work is also influences the tender decision. You do a budget before it goes out on tender. If the tenders come back and one is way out, you know he [the tendered] is wrong."
Engineers C&D (Mechanical engineering)	*Project 1, task (a):* Compilation of tender documents.	*Project 1, task (a), needs (i):* Design; Equipment specifications; General specifications; Costs; Contractual	*Project 1, task (a), needs (i):* The engineers use a basic specification available in their office which they adapt for the specific project. The *QS* has the contractual information.

ENGINEER & PROJECT	TASK	INFORMATION NEEDED	INFORMATION SOURCES AND OUTCOMES
Project 1: Library building		information; Bill of quantities.	Detail design specifications [these are the specification included in the architect's design and could be specifications set by other professional team members]. The client's specifications [specific light fittings, doors, etc.]. Tender documents are compiled by the *QS* and the mechanical engineer's specifications are included in the QS' tender document.
	Project 1, task (b): Tender evaluation.	*Project 1, task (b), needs (i):* Tender documents.	*Project 1, task (b), needs (i):* Tender tariffs. The specifications of the equipment that is being offered.
Engineer E: (Electrical engineering): Project 1: Building project	*Project 1, task (a):* Budget. *Project 1, task (b):* Compiling tender documents.	*Project 1, task (a), needs (i):* Clients' budget and standards. *Project 1, task (b), needs (i):* Detailed design. Bill of quantities. Price schedules.	*Project 1, task (a)&(b), needs (i):* Engineer E needed information from the following sources: Architect, client, SABS standards and regulations, suppliers.
Engineer G: (Acoustical engineering) Project 1: Library building	*Project 1, task (a):* Advises the mechanical engineers on acoustical issues concerning air conditioning systems.	*Project 1, task (a), needs (i):* Which type of air conditioning system is being used?	*Project 1, task (a), needs (i):* The mechanical engineers provide this information. The manufacturers of the equipment also provide specific information on the noise ratios emitted by the equipment. [The acoustic engineer's inputs are reflected in the architect's drawings and tender documents.]
Engineer H: (Civil engineering): Project 9: Pipe-jacking contract.	*Project 9, task (a):* Traffic accommodation.	*Project 9, task (a), needs (i):* Where are the excavations pits going to be?	*Project 9, task (a), needs (i):* "…you had an idea from the equipment utilisers as to what sort of forces they could heavily push and that's from previous experiences the contractor has had. So you did have an indication of what the maximum or minimum length you had could go before you had to have a pit again."
	Project 9, task (b): Weigh leave applications to accommodate other services in the area.	*Project 9, task (b), needs (i):* What other sewers are in the area? Which other services are in the area? Which services will have to be relocated?	*Project 9, task (b), needs (i):* "…remember whilst you have this big diameter pipe fourteen meter maximum below the ground, you still had to divert all the sewers connected to the existing line which was much higher up to divert that into the new one." [The city council provided the information.]
	Project 9, task (c):	*Project 9, task (c), needs (i):*	*Project 9, task (c), needs (i):*

ENGINEER & PROJECT	TASK	INFORMATION NEEDED	INFORMATION SOURCES AND OUTCOMES
	Design drawings. *Project 9, task (d):* The equipment that will be needed to do the pipe-jacking and micro tunnelling. *Project 9, task (e):* Completing tender documents. *Project 9, task (f):* Tender evaluations.	Needs the design drawings. *Project 9, task (d), needs (i):* What equipment is available in South Africa that could be used for pipe-jacking? Would the contractors have to import equipment? *Project 1, task (e), needs (i):* Where are existing sewers that have to connect to the new sewer? *Project 9, task (f), needs (i):* Does the tender comply with the tender specifications? Does the tenderer understand the status quo?	Drawings from the city council indicated where the existing sewers are. "We found instances where we had to relocate services. So that information also had to be detailed and tendered up so that everybody knew what we were dealing with. There were gaslines and all those types of services. We were quite deep down. So that was an advantage." *Project 9, task (d), needs (i):* "That's normally with the contractors. So with few in the country I would normally contact them and enquire about what is available and tell them what is happening". This information then later forms part of the tender adjudication. *Project 1, task (e), needs (i):* "We allowed for the contractor to actually do *detection of services*. He actually did radio detection of services on the line to determine exactly where the positions of the eyes [openings] were. Drilling from the bottom you can't be octave. So there was some innovative work done there … But we actually in our documentation, before it went out to tender, needed to highlight all these issues and problems so that he had enough information on hand to be able to price appropriately." *Project 9, task (f), needs (i):* Tender documents and "…we did conduct interviews with some of the tenderers. The reason being it was a huge project and it was very risky. So we needed to be clear on some of the tenders that were submitted that they understood the status quo …"
Engineer I (Electrical engineering) Project 3: Electrification project for an electricity supply	*Project 3, task (a):* Finalise design, do design drawings.	*Project 3, task (a), needs (i):* Budget, the preliminary design, the Technical Evaluation Forum [TEF] and other financial committees' approval.	*Project 3, task (a), needs (i):* The pre-marketing report, the preliminary design and the budget. All designs for the ESC must adhere to the ESC standards which are based on SABS standards. The ESC has design software which consulting engineers can download and use to do their designs. Consulting engineers working for the ESC need to register with the ESC to get access to these resources.

ENGINEER & PROJECT	TASK	INFORMATION NEEDED	INFORMATION SOURCES AND OUTCOMES
company (ESC).	*Project 3, task (b):* Complete tender documents. *Project 3, task (c):* Go out on tender.	*Project 3, task (b), needs (i):* Bills of quantities, design specifications. *Project 3, task (c), needs (i):* Who does the tender evaluation?	*Project 3, task (b), needs (i):* There are two types of material in an *ESC* tender document that needs to be budgeted for: the material provided by the ESC (pylons, high voltage cables, transformers etc). The ESC also has a maximum fee for labour. All the information on the price lists, labour fees, standards etc are available on the *ESC's website*. Write specifications based on the specifications set by the ESC. *Project 3, task (c), needs (i):* The ESC does the tender evaluation and informs the consulting engineer which contractor to appoint.
Engineer J: (Electrical engineering) Project 10: Water transfer scheme	*Project 10, task (a):* Ensure the pumps' electricity supply to be adequate. *Project 10, task (b):* The pumps are installed underwater. *Project 10, task (c):* Existing control panels need to be adapted and moved to accommodate the new and additional pumps.	*Project 10, task (a) and task (b), needs (i):* Which is the correct manner to install the pumps? How are the pumps started? How must the electricity installations be done? *Project 10, task (c), needs (i):* Are there circuit drawings of the control panels? He needs the civil engineers' and mechanical engineers' drawings. *Project 10, task (c), needs (ii):* Information on the infrastructure:	*Project 1, task (a) and task (b), needs (i):* For background information Engineer J *browses the indexes* [table of contents] of journals in his own collection for articles on a specific topic e.g. the different methods, such as soft-starters, to start a pump. He would follow up on information found in the articles by visiting specific manufacturers' websites for more specific information. Some of the manufacturers have very detailed information on their website. If the information on the website is inadequate, he would phone and ask for a representative who can explain the equipment to him. In some instances he needs to go back to the basic principles described in *textbooks*. This was not necessary for this project since the technology that was used is not new and some of the equipment merely had to be duplicated. If similar equipment no longer existed he would search for equivalents. *Project 10, task (c), needs (i):* In some cases there were original circuit drawings in the control panels which could be used. If these were not available, the panels would be photographed and new drawings would have to be made. *Project 10, task (c), needs (ii):* Drawings prepared by the civil engineers and the mechanical

ENGINEER & PROJECT	TASK	INFORMATION NEEDED	INFORMATION SOURCES AND OUTCOMES
		e.g. drawings of the building indicating the position of the pumps and the switch gear. What instruments does the client want?	engineer – these are emailed to participating team members. Engineer J also uses archived photos of the original project as well as photos he had taken of other changes that happened on the site between the completion of the original project and this current retrofit. The photos are valuable to see what has happened and clarify aspects of the drawings. Most of the information on this project was acquired from the site and the client.
	Project 10, task (d): Try to save on electricity by pumping water in off peak times.	*Project 10, task (d), needs (i):* What is the electricity consumption on the site? When are off-peak times? What are the demands for water?	*Project 10, task (d), needs (i):* The client emailed information on electricity consumption during the previous phase of the project to Engineer J. The client also emailed information on the demands for water. ESKOM provides a lot of information on 'demand site management' on their website.
	Project 10, task (e): Complete tender documents and submit to the client for approval.	*Project 10, task (e), needs (i):* The completed design. Budget information such as the cost of the equipment.	*Project 10, task (e), needs (i):* Where possible Engineer J would phone the original suppliers of equipment and get a quote from them or from the manufacturer of new equipment that would be used. Cable prices, for example, would be found on budget information from other tender documents. In instances where information is not available, the engineer would make an educated guess based on his experience. The electrical industry is well researched and all required information is freely available. No additional information is needed.
	Project 10, task (f): Do tender evaluation.	*Project 10, task (f), needs (i):* Need the tender documents.	*Project 10, task (f), needs (i):* Tender documents submitted by prospective contractors and suppliers.
Engineer K: (Structural engineering) Project 1: Library building.	*Project 1, task (a)&(b):* (a) Complete the final design and (b) provide information to the QS for budgeting and to compile the tender documents.	*Project 1, task (a)&(b), needs (i):* Needs information such as: What waterproofing products will be used? What types of paint should be used?	*Project 1, task (a)&(b), needs (i):* "…You normally contact the suppliers. There is quite a lot on the market. But you are not allowed to basically specify the trade names. That could be biased for the tender. So we set the normal specifications of what we want to [sic]. Typically your painting, your galvanising, also using epoxy paints or what you would normally use in a building. You get these from the suppliers.

ENGINEER & PROJECT	TASK	INFORMATION NEEDED	INFORMATION SOURCES AND OUTCOMES
			Normally the suppliers are very keen to supply the engineers with documentation. Even if all [of it] is for your files.”
		Project 1, task (a)&(b), needs (ii): What are the other engineers’ requirements in the building?	*Project 1, task (a)&(b), needs (ii):* “…they want to put their equipment down and all of them need space and date and pipes for their cables and hangers. It is an interaction thing which needs to be sorted out. But it actually is just as much interaction with joint professions as much as with the architect. But generally how it goes is, the principal agent, who is normally the architect ... Normally all communications should go through the architect. Obviously when a good relationship developed between the engineering sectors, then that can be bypassed not to put further burden on the architect. Because it is a major building. Most of the reports will obviously be done by the architect.”
		Project 1, task (a)&(b), needs (iii): How much concrete will be used?	*Project 1, task (a)&(b), needs (iii):* Basically, we have to make an intelligent guess regarding the volume of concrete and the steel content of concrete and also the tonnage of the external steel work.
		Project 1, task (a)&(b), needs (iv): What structural steel and how much will be used? *Project 1, task (a)&(b), needs (v):* How many piles will there be?	*Project 1, task (a)&(b), needs (iv)&(v):* “…structural steel which is basically steel sections outside of the building which is not part of the main frame of the building. And obviously the piling as well. You need to estimate the number of piles and in order to get a good estimate. We pass this information on to the QS and the *QS* puts it in a format which will be picked up by the contractors and they quote on it.”
		Project 1, task (a)&(b), needs (vi): How much is the steel contact with the concrete?	*Project 1, task (a), needs (vi):* The QS does the budgeting. “We just provide the details. How much is the steel contact with the concrete and so on. 60 kg per square meter. He doesn’t do the pricing. The contractor does it.”

Consulting engineers' comments in respect of the design and tender stage are discussed according to the tasks and information needed and the information sources and outcomes.

5.4.3.1 Consulting engineers' tasks and information needs

The main tasks needed to be completed during the design and tender stage were the completion of designs, the compilation of tender documents and the evaluation of tenders. Only the structural engineers, Engineer B and Engineer K, Engineer I (an electrical engineer), and Engineer J (an electrical engineer) had to finalise their designs before they could continue compiling tender documents.

Engineer H (a civil engineer) also had to consider aspects such as traffic accommodation, weigh leave applications, the accommodation of other services in the area as well as the equipment that was needed for the pipe-jacking and micro tunnelling.

All the engineers participating had to either provide tender information to the quantity surveyor (QS) or they had to complete their own tender documents for the projects they described. Except for Engineer I (an electrical engineer) the engineers then had to evaluate the tender documents. For this purpose, they all needed technical information on the equipment and products that they had specified in their designs as well as prices for this equipment and products. Once they received the completed tenders to evaluate, they needed to consider the client's budget, their own budget for the project and compare the technical specifications for the equipment they specified with the technical specifications of the equipment or products offered by the tenderers.

5.4.3.2 Information sources and outcomes

As in the preliminary design stage, most of the information required by the engineers during the design and tender stages came from a variety of sources, and were in some cases the same sources. The information sources required by the consulting engineers during this stage are architectural designs, suppliers, catalogues or trade literature, standards, building regulations, specifications, design software, personal contacts, and journal articles.

a. Architectural designs

Architectural designs as well as the designs of the other project team members are important sources of information in the design and tender stages. In the case of the water transfer scheme the engineer needed the original project's circuit drawings and photographs taken during the previous project as well as photographs taken after the completion of the project.

b. Suppliers

The suppliers or the equipment utilisers supply the engineers with equipment specific or system specific information. Apart from discussing the equipment with a representative of the company, the engineers also retrieve some of the information from the Internet, brochures or catalogues. For example, Engineer I downloaded design software from the ESC's website and Engineer J retrieved information on 'demand site management' from Eskom's website. As indicated in chapter 2, this pattern of information-seeking behaviour resembles the monitoring mode in Ellis' Model of Information-seeking which involves the exchange of information through contact with the suppliers of technology.

c. Catalogues or other trade literature

Budgeting information can be found in trade catalogues, brochures or suppliers' websites or recent tender documents for similar projects. Engineer H (a civil engineer) finds her information in the *Daily Tender Bulletin* to which she subscribes. Manuals such as *Merkel's builders' pricing & management manual* are invaluable sources of information to compile tender documents (Engineer A).

d. National standards, building regulations and specifications

National standards and building regulations are crucial sources of information during this stage as they regulate specific engineering tasks. The client's specifications are, as indicated by Engineer E (an electrical engineer), important in the case of lighting or air conditioning systems where the client has more than one building he maintains and wants to only use certain products. Another example of client specifications is the retrofit water transfer project described by Engineer J (an electrical engineer) where the new equipment needed to be compliant with the existing equipment. Bear in mind that, especially within the context of Engineer J's project (but also all other engineering projects) every technological device is an entity made up of several interdependent parts or subsystems and that engineers cannot change to new technological concepts or parts that might not be suitable for the existing part or system. The empirical work of the engineer therefore does not encourage the continual integration of new ideas and achievements with existing practice (Wolek 1969:472-473). Solutions to engineering problems are dictated by the specifications that may need to be altered, depending on the properties of material, design and time constraints (Taylor 1991:237).

e. Design software

Only Engineer I (an electrical engineer) mentioned design software at this stage and he mentioned that he can download the required software from the ESC's website.

f. Personal contacts

All the engineers got information from personal contacts. The personal contacts were team members, the architect, the client, suppliers, the quantity surveyor and in the case of Engineer I, the pre-marketer.

g. Journal articles

Engineer G (an acoustical engineer) and Engineer J (an electrical engineer) indicated that they would page through old journals to find articles that could be relevant to a new project if the project involves work they have not done before (which was not the case in the projects they described). In most cases the articles do not appear timeously enough for a new project (Engineer B). This pattern of behaviour indicates an awareness of information in that relevance and timeliness are particular requirements of the engineers in respect of information content. It resembles the informal search mode in Aguillar's Modes of Environmental Scanning and is aimed at obtaining certain specific information (Aguilar 1967:20).

5.4.4 Project stages 5 and 6 — working drawing and construction stages

The working drawing stage is only relevant for civil and structural engineering disciplines. The engineers, following the client's instructions to proceed, prepare any further plans, designs and drawings which may be necessary for the execution of the works (ECSA 2007:5-6). Since the responding structural and civil engineers did not indicate any specific information needs for the working drawing stage, the working drawing stage and the construction stages were combined for this study.

The construction stage involves the overall contract administration and co-ordination, as well as construction monitoring of the execution of the works in accordance with the contract. It also involves placing orders for the works on behalf of the client and advising the client on the preparation of the contract documents (ECSA 2007:6).

The question put to the respondents was formulated as follows: “Please identify a task you had to complete during the working drawing and construction stage. Indicate what information you needed and which sources did you use.”

The collected data for the working drawing and construction stages is analysed in table 5.4 under the following headings: tasks, information needed, information sources and outcomes.

TABLE 5.4

Project stages 5 and 6 - working drawing and construction stages

ENGINEER & PROJECT	**TASK**	**INFORMATION NEEDED**	**INFORMATION SOURCES**
Engineer A: *(Electrical and electronic engineering):* Project 1: Library building	*Project 1, task (a):* This stage involves supervision through visual inspections on site.	*Project 1, task (a), needs (i):* No additional information is needed unless something goes wrong on site e.g. the postal room's door is too wide for the book alarm systems. The door needs to be wider than normal to allow book trolleys to pass through them.	*Project 1, task (a), needs (i):* System test results or an analysis of the system's behaviour. The engineer now has to use his engineering judgement to find a solution to the problem. Digital cameras assist in recording progress, but also details about installations. This information can then be used when reporting on the project. The contractor can also photograph a problem he experiences on site when the engineer is not available on site. He can then either mms [multimedia message service] the photo or email it to the engineer who can then respond immediately with a solution to the problem.
Engineer B: (Structural engineering) Project 1: Library building	*Project 1, task (a):* Ensure the contractor is building what has been designed.	*Project 1, task (a), needs (i):* Construction site information.	*Project 1, task (a), needs (i):* "The information will be coming in from the site. You will have *test* results coming in to show that they are actually doing what they are supposed to be doing. You will be getting concrete cube results, pile results etc. Most of them will be coming from the actual contractor who you have hired to monitor … The information that you need now is not much technical information, it is more reports and test results that you need." Site visits – at least once every 14 days, could be more regular. Communications with architect who is the project leader.
	Project 1, task (b): Design changes eg waterproofing.	*Project 1, task (b), needs (i):* Technical specifications and costs.	*Project 1, task (b), needs (i):* "You might still be looking at your brochures if things change. You for example specified silicon. There often is a contractor who'd come and say they did not use silicon on their last job, but used something else. Can they use that instead? It is cheaper and it works better. Then you'd say let's look at the technical specs. The technical specs you will get from the supplier."
	Project 1, task (c): Problems on site.	*Project 1, task (c), needs (i):* Exact nature of the problem.	*Project 1, task (c), needs (i):* The residential engineer (RE) photographs or makes drawings of the problem – this information can be emailed or faxed to the

ENGINEER & PROJECT	TASK	INFORMATION NEEDED	INFORMATION SOURCES
			engineer.
Engineers C&D: (Mechanical engineering) Project 1: Library building	*Project 1, task (a):* Building programme. *Project 1, task (b):* Project coordination. *Project 1, task (c):* Construction: Adapting the design to suit contractor. The contractor experiences problems with construction.	*Project 1, task (a), needs (i):* Building programme. *Project 1, task (b), needs (i):* Designs for other disciplines. *Project 1, task (c), needs (i):* Needs site information. Needs the detailed design. Needs the guidelines and needs of other team members.	*Project 1, task (a), needs (i):* The main *contractor.* *Project 1, task (b), needs (i):* Professional team members, e.g. electrical and electronic engineers, structural and civil engineers. *Project 1, task (c), needs (i):* The contractor and the construction site, as-built drawings, Minutes from site meetings; Site instructions; Visits to the construction site – at least once in 14 days; Visual inspections; Drawings; photographs of problem; Test results.
Engineer E: (*Electrical engineering):* Project 1: Building project	*Project 1, task (a):* Supervision.	*Project 1, task (a), needs (i):* Site information. Design, drawings and tender documentation. No additional information is required.	*Project 1, task (a), needs (i):* Attend meetings; do sporadic site inspections; communicate with the contractor and with rest of the professional team; personal experience from previous projects.
Engineer G: (Acoustical engineering) Project 1: Library building	*Project 1, task (a):* Supervision. *Project 1, task (b):* Assisting the mechanical engineer in controlling the noise caused by the air conditioning systems. *Project 1, task (c):* Decide on possible	*Project 1, task (a), needs (i):* How to fit the roof; apply the absorbing material to the walls and ceilings. *Project 1, task (b), needs (i):* Determine the required attenuation levels. *Project 1, task (c), needs (i):* Specifications of alternative	*Project 1, task (a), needs (i):* The architect will inform the acoustics consultant when the contractor is busy with work that requires the acoustics consultants' input or supervision. He then visits the construction *site*, inspect the work and issue instructions. Photos could assist when there is a problem on site. Most problems however are about principles that need to be applied. *Project 1, task (b), needs (i):* The air conditioning system used. This information is acquired from the suppliers, personal experience and information kept from similar completed projects. Textbooks provide the basic information but each system behaves differently. The German products behave acoustically the best. *Project 1, task (c), needs (i):* *Supplier or manufacturer* of the alternative material.

ENGINEER & PROJECT	TASK	INFORMATION NEEDED	INFORMATION SOURCES
	use of alternative material.	materials suggested by the contractor.	
Engineer H: (Civil engineering) Project 9: Pipe-jacking contract	*Project 9, task (a):* Contract supervision "You can actually get a difficult contractor with years of experience that can really pull wool over your eyes if you are not familiar with a thing." *Project 9, task (b):* Finding existing sewers that have to be connected to the new line. *Project 9, task (c):* Monitoring services, monitoring progress, processing claimant certificates, checking levels, recording information for preparation of as-built drawings at the end of the contract.	*Project 9, task (a), needs (i):* How to deal with experienced contractors? *Project 9, task (b), needs (i):* What is the position of the eyes in the existing sewers that need to be connected to the new line? *Project 9, task (c), needs (i):* Is the contractor keeping to the design? What is the progress on the contract? Is the contractor sticking to the contract programme? Are the pipe levels according to the designed specifications? What fees are payable to the contractor? What deviations were there in the design?	*Project 9, task (a), needs (i):* Contract documents and mentors. "Then it is up to the contractor to do his bit. We just then monitor to make sure that he actually does [work] according to what is specified in the document. So at that stage there was a fulltime resident engineer (RE) on site. I relied very heavily on him in terms of information. I visited the site quite often. It was at least two or three times a week to make sure that everything was Okay". *Project 9, task (b), needs (i):* "We actually developed a whole new reaming process because we actually drove from the big diameter pipe [so] as to meet the old connection coming up from the property. With that now we did a lot of investigative work for the contractor. We allowed for the contractor to actually do detection of services. He actually did radio detection of services on the line to determine exactly where the positions of the eyes were. Drilling from the bottom you can't be octave. So there was some innovative work done there." *Project 9, task (c), needs (i):* Information received from the site, the residential engineer and the contractor.
Engineer I (Electrical engineering) Project 3:	*Project 3, task (a):* Issue plans to surveyor who pegs the position of each	*Project 3, task (a), needs (i):* Is the design correct? Are the calculations correct as far as the pylons are concerned?	*Project 3, task (a), needs (i):* Needs to check the design and submit the completed design to the ESC.

ENGINEER & PROJECT	TASK	INFORMATION NEEDED	INFORMATION SOURCES
Electrification project for an electricity supply company (ESC).	pylon. *Project 3, task (b):* Appoint contractor. *Project 1, task (c):* Appoint a clerk of works ("klerk van werke") and a project manager.	*Project 3, task (b), needs (i):* Which contractor needs to be appointed? *Project 3, task (c), needs (i):* The clerk of works needs to submit biweekly progress reports.	*Project 3, task (b), needs (i):* Needs instructions from the ESC to appoint a specific contractor based on the tender evaluation. The ESC does the tender evaluation. *Project 3, task (c), needs (i):* Monitor progress, issue instructions and have progress meetings. The meetings are attended by the professional team and all interested parties in the community. Community members come with requests for electricity at this stage when they realise that they have, for some reason, been omitted from the project. This could also require the consulting engineer to adapt his design and re-budget. If there is a problem on site, the project manager would photograph it and send the photo to the consulting engineer who can then advise on how to correct the problem.
Engineer J: (Electrical engineering) Project 10: Water transfer scheme.	*Project 10, task (a):* Supervising the contract. *Project 10, task (b):* Test equipment in the factory before it is shipped to site for installation. *Project 10, task (c):* Acquire technical information on similar equipment should the equipment not operate as specified.	*Project 10, task (a), needs (i):* Needs information from the site and the contractor or even the client. *Project 10, task (b), needs (i):* Factory test results before equipment. Report formats. *Project 10, task (c), needs (i):* Technical information on similar equipment.	*Project 10, task (a), needs (i):* Information from site and the information provided by the contractor. Site conditions could change – the area is subject to flooding – and designs have to be adapted to accommodate these changed conditions. *Project 10, task (b), needs (i):* The factory test results. The format in which these results are reported can be created by the consulting engineer himself or he uses the prescribed format required by the client. *Project 10, task (c), needs (i):* Manufacturers of similar equipment provided the technical information for their equipment. [The engineer explained a situation on a different project where the contractor installed equipment he claimed was according to the specifications, but practice proved differently. This is an instance where additional information is needed at this stage in the contract.]

ENGINEER & PROJECT	TASK	INFORMATION NEEDED	INFORMATION SOURCES
Engineer K: (Structural engineering): Project 1: Library building	*Project 1, task (a):* Overseeing the construction of the building.	*Project 1, task (a), needs (i):* Is the contractor using the correct strength concrete?	*Project 1, task (a), needs (i):* "… We have to specify the strength of the concrete. And the contractor picks the supplier and the contractor [has] to provide us with cube disc tests and we have to make sure that the tests are matching our requirements. And that is a normal procedure. They got 7 day tests and 28 day concrete tests."
		Project 1, task (a), needs (ii): Are the piles strong enough to carry the weight it will have to support once the building is occupied?	*Project 1, task (a), needs (ii):* "We had to find out whether the piles were good enough. We had to do some sonar testing of the piles as well as a load test. We just set up a mechanical bridge – put a weight on it to see whether it can take the weight. That is the information as far as [the] foundation is concerned."
		Project 1, task (a), needs (iii): What information is available on sealants?	*Project 1, task (a), needs (iii):* "It also is very helpful to go onto the Internet. I just type a single term. It is very simple to find that type of information. Basically information related to structures like vibration and that type of thing - you get a lot of irrelevant information. So then I go to the websites I usually use."
		Project 1, task (a), needs (iv): Are meetings important sources of information? Is it important to have contact with the site agent or residential engineer?	*Project 1, task (a), needs (iv):* "Meetings is … what happened is I share the job with [Engineer B] … she looks after the meetings … I still have to go on site to see what is going on … I have close contact with the site engineer so as not to burden … [Engineer B] …The communication normally I put it on the email and I send it to the site agent on the job and to [Engineer B] for filing purposes. And the site agent will pass it on to the contractor."
		Project 1, task (a), needs (v): Could photos and digital cameras assist in recording problems on site?	*Project 1, task (a), needs (v):* Photos are "very handy and were taken of a couple of items where problems may arise … But I didn't have to use a digital camera for that. It was not that critical a situation."
		Project 1, task (a), needs (vi): What information needs to be included in reports?	*Project 1, task (a), needs (vi):* "We don't really write the reports, but we are listing what the requirements are and we follow up that list to achieve the required work. In a big job like that it is a lot of small things."

Consulting engineers' comments in respect of the working drawing and construction stages are discussed in terms of the tasks and information needs, information sources and outcomes.

5.4.4.1 Consulting engineers' tasks and information needs

All the tasks in which the engineers are involved during the working drawing stage and the construction stage are supervision-related and related to checking and testing equipment. For example, Engineer J (an electrical engineer) needed to test equipment in the factory before it was shipped to the site. This saves cost and time since faulty equipment can be repaired or exchanged before shipment and installation.

5.4.4.2 Information sources and outcomes

Information required by the engineers during the working drawing and construction stage of a project mainly comes from the actual construction site or project. This corresponds with Gralewska-Vickery's (1976:267) findings that engineers use information generated by the site and the project. These information sources include system test results, site reports, the use of digital cameras and cellular phones, and trade literature.

a. System test results or an analysis of the system's behaviour

Engineer A indicated that he needs information on the systems test results or an analysis of the system's behaviour to determine whether the system that has been installed behaves according to its specifications. The structural engineers also require concrete cube test results and also the pile test results to ensure the concrete and reinforcement used in the construction of the building is in accordance with the specifications.

b. Site reports

All the engineers indicated that site reports are communicated to team members at site meetings, site visits, in site instructions and during personal communications with the contractor. Kwasitsu (2003:6) and Fidel and Green (2004:569) also found that meetings are a vehicle for communication.

c. Digital cameras and cellular phones

Digital cameras and cellular phones that can send mms (multimedia message service) are useful sources of information at this stage. Consulting engineers take photographs to document or record progress and installation details for their reports. Photographs are also used to resolve a specific problem on site. For instance, the contractor takes a photograph of the problem or makes a drawing of it and sends an email or mms of the photograph to the consultant who can then provide the answer.

d. Trade literature

Engineer A indicated that they might need to refer to their brochure collection in cases where a different product, such as a different sealant, is being used other than those that were originally specified.

e. Factory test results

Factory test results are also important at this stage. According to Engineer J, equipment would be tested in a factory before it is shipped to the site which could be far away. This saves cost and time.

5.4.5 Project stage 7 – target procurement stage

The last stage in an engineering project is the Target procurement stage. According to ECSA (2007:7) should the client during any stage of the project, require the consulting engineer to perform work or services pertaining to targeted procurement, such work and or services could entail, but are not limited to, any or all of the following:

- incorporation of any targeted participation goals
- the measuring of key participation indicators
- the selection, appointment and administration of participation
- auditing compliance to the above by any contractors and, or professional consultant.

The question pertaining to this phase was phrased as follows: “Please identify a task you had to complete during the preliminary design stage. Indicate what information you needed and which sources did you use.”

Table 5.5 summarises consulting engineers’ comments on the target procurement stage under tasks, information needed, and information sources and outcomes.

TABLE 5.5

Project stage 7 - target procurement stage

ENGINEER & PROJECT	TASK	INFORMATION NEEDED	INFORMATION SOURCES AND OUTCOMES
Engineer A: (Electrical and electronic engineering) Project 1: Library building	*Project 1, task (a):* The systems that have been installed need to be commissioned and reported.	*Project 1, task (a), needs (i):* Commissioning results.	*Project 1, task (a), needs (i):* Systems tested.
Engineer B: (Structural engineering): Project 1: Library building	*Project 1, task (a):* "No longer involved. That is when the architect, electrical engineer and other team members have to complete."	*Project 1, task (a), needs (i):* Need as-built drawings.	*Project 1, task (a), needs (i):* As-built information received from site, the contractor and the residential engineer.
Engineers C&D: (Mechanical engineering) Project 1: Library building	*Project 1, task (a):* Writing commissioning reports. *Project 1, task (b):* Change air conditioning settings after the client has occupied building.	*Project 1, task (a), needs (i):* Needs test results, equipment specifications, design. *Project 1, task (b), needs (i):* Building applications.	*Project 1, task (a), needs (i):* All equipment is tested thoroughly – test results are needed As-built drawings. *Project 1, task (b), needs (i):* Number of people in the building once it is occupied can influence the heat burden of the air conditioning system.
Engineer G: (Acoustical engineering) Project 1: Library building	*Project 1, task (a):* Commissioning of systems.	*Project 1, task (a), needs (i):* Were the acoustic designs effective?	*Project 1, task (a), needs (i):* Test results.
Engineer H: (Civil engineering) Project 9: Pipe-jacking	*Project 9, task (a):* Commissioning of the sewer.	*Project 9, task (a), needs (i):* Is the pipeline complete?	*Project 9, task (a), needs (i):* "…in this project we had to do a phase completion because we actually commissioned the line as we moved from the bottom line up. So it was possible to do that. So we actually had a phased completion. At the end of the project we had a final completion.

ENGINEER & PROJECT	TASK	INFORMATION NEEDED	INFORMATION SOURCES AND OUTCOMES
contract.			And obviously then there is a retention for the year."
Engineer I (Electrical engineering). Project 3: Electrification project for an electricity supply company (ESC).	*Project 3, task (a):* Arrange with the ESC to commission the project. *Project 3, task (b):* Prepare single line diagrams in the ESC's format so that the diagrams can be included in *Small World.* *Project 3, task (c):* Arrange for outages so that the new network can be connected to the existing network. *Project 3, task (d):* Complete final report and as-built drawings. *Project 1, task (e):* Submit the final account.	*Project 3, task (a), needs (i):* When can the ESC do the commissioning? *Project 3, task (b), needs (i):* Needs site information. *Project 3, task (c), needs (i):* When can the ESC switch the existing network off so that the new network can be connected?	No additional information is required.
Engineer J: (Electrical engineering): Project 10: Water transfer scheme.	*Project 10, task (a):* Write commissioning reports. *Project 10, task (b):* Completion of as-built drawings and documents.	*Project 10, task (a), needs (i):* Report forms and test results.	*Project 10, task (a), needs (i):* Test result of equipment on site. Either use own report forms or the client's report forms. *Project 10, task (b), needs (i):* Site information, photos taken during site visits while construction was in progress, and information provided by the contractor. *Project 10, task (c), needs (i):*

ENGINEER & PROJECT	**TASK**	**INFORMATION NEEDED**	**INFORMATION SOURCES AND OUTCOMES**
	Project 10, task (c): Complete manuals needed for operational and maintenance purposes. *Project 10, task (d):* Complete financial report.	 *Project 10, task (d), needs (i):* What payments have been made? Was the project completed within the budget?	The contractor must complete the manuals for the equipment and provide them to the client. The engineer only needs to see them. *Project 10, task (d), needs (i):* *Records* of claims and payments made during the project, *budget information*.
Engineer K: (Structural engineering) Project 1: Library building	"No longer involved. That is when the architect, electrical engineer and other team members have to complete [the job]."	Complete final report and update as-built drawings.	As- built information received from site, the contractor and the residential engineer.

As can be seen from the information in table 5.5, the only tasks remaining were the commissioning of systems, completing the final report and updating as-built drawings. As-built drawings are exact representations of completed engineering projects and the consulting engineers are required by legislation to provide their clients with as-built drawings on completion of the project. For example, Engineer I, needs to prepare single line drawings which he has to enter in the ESC's *Small World.* All of the information required during the target procurement stage of a project comes from the project itself and the engineers do not seem to require additional information to complete their projects.

5.5 FACTORS INFLUENCING CONSULTING ENGINEERS' INFORMATION NEEDS

As can be seen from the above discussions, information needs arise from situations that pertain to a specific task that is associated with one or more of the work roles played by the consulting engineer. The factors that influence or shape consulting engineers' information needs include individual demographic factors or user attributes and circumstances, context of the information need, frequency (recurring or new information needs) predictability (an anticipated or unexpected information need) importance (degrees of urgency) and complexity (a problem which is easily resolved or difficult to resolve). Information on these characteristics can be derived from the empirical research findings discussed in sections 5.2 and 5.3.

5.5.1 Consulting engineers' attributes and circumstances

According to Leckie *et al.* (1996:182) the demographic factors that could determine consulting engineers' information needs include their gender, age and geographic location. Career stage could be linked to age. Other user attributes include engineering discipline and personal factors. The interview sample represented consulting engineers from different age groups, engineering disciplines and gender. Geographic location refers to the proximity of a project to an engineer's office and it could exert an influence on information needs in the sense that some projects are managed over a distance.

5.5.1.1 Consulting engineers' age groups

The age groups of the consulting engineers in the interview sample are summarized in table 5.6

TABLE 5.6

Consulting engineers' age groups

Number of Engineers	**Age group**
3 engineers	30-40
1 engineer	40-50
3 engineers	50-60
2 engineers	60-70
2 engineers	70-80

The older engineers in this study are also the more experienced professionals in terms of the number of projects they have completed in their careers as consulting engineers as compared to the younger members of the group.

When considering the different work roles and tasks, there seems to be no difference in the information that was required in the completion of the projects by engineers of different ages. However, there are some differences in the use of specific sources of information by individual engineers. Older engineers tend to rely more on their personal knowledge and personal files and are less inclined to use design software. The two engineers between 70 and 80 years of age indicated that they leave the design software for younger engineers. They themselves use the 'classic' method in their designs. As far as visits to other construction sites and factories are concerned these two engineers do not regard such visits as being important sources of information.

5.5.1.2 Engineering disciplines and information needs

The current study represented a variety of engineering disciplines. These are:

- accoustical engineering (one engineer)
- civil engineering (one engineer)
- electrical and electronic engineering (three electrical engineers and one electronics engineer)
- mechanical engineering (three engineers of which one engineer works as an asset manager)

- structural engineering (two engineers)

When considering the empirical findings on the engineers' work roles and work tasks, there is no difference in the types of information sources required by engineers of different engineering disciplines at the same stages of an engineering project. All the engineers rely on architectural drawings, information regarding the clients' needs, codes of practice, the regulations applicable to their discipline, suppliers, information coming from the building site or construction site, the engineers' personal knowledge of the topic and their personal files. In most cases other people seem to be able to meet consulting engineers' needs for information and were in some cases the engineers' only sources of information as shown in section 5.4.1.2.

5.4.1.3 Gender differences and information needs

The interview sample includes two female engineers. The findings of the current study did not reveal any differences in the information needs of male and female consulting engineers. Although Kreth's (in Tenopir & King 2004:86) study of engineering graduates' writing experiences in industry and in coursework found apparent gender differences in information-seeking behaviour, she came to the conclusion that "these differences are [not] solely accountable for by gender."

5.5.1.4 Geographic location and information needs

As previously indicated all the responding consulting engineers are located in Central and North Gauteng. Some of the engineers described projects in other provinces and countries. The distance between the actual engineering project and the location of the engineers' offices could be a factor influencing their information needs. Engineers who are located far from the project in which they are involved need to rely to a greater extent on photographs, fax, email and telecommunication to communicate project-specific information than those engineers who are located close to the project in which they are involved.

It appears as if the geographic location of the engineering project near to possible dangers for, or threats to, the project influences consulting engineers' information needs. Engineer J, for example, referred to possible flooding on the construction site of the water transfer scheme with which he had to contend during the construction phase of his project. Engineer K referred to aspects, such as, the vibrations caused by traffic in close proximity to the site which had to be considered in the library building.

5.5.1.5 Personal factors and information needs

Although personal factors are not identified by Leckie *et al.* (1996) as a characteristic that influences or shape engineers' information needs, it was identified as an influencing factor in Paisley's (1968) Framework of the "Scientist within Systems" as the "scientist within his own head". Blom (1983:19) also stressed the importance of interpersonal relations and social intercourse as important factors influencing the mutual exchange of information. Personal factors include motivation, interests and preferences and attitudes.

a. Motivation

The consulting engineer's motivation to seek information is based on a need to complete a particular project or task.

Motivation influences the amount of effort consulting engineers will put into finding information which could assist them in solving a problem. All the responding consulting engineers reported on the successful completion of their projects which is an indication of their motivation to deliver a professional service to their clients. Engineer G's graphic illustration discussed in section 5.4.4 and shown in Appendix B is an example of his motivation to find information to solve a particular problem in his field. Other examples are reflected in particular engineers' statements that they would …"go back to the basic principles described in textbooks …" (Engineer J) or rely on their "engineering judgement" (Engineer F) in instances where no other information is available to solve their problems. These findings show how the engineers are prepared to spend time and effort in order to gather information that will enable them to take action and correspond with Choo et al's (1998:6; 2000b:5) views.

b. Interests

Interests are reflected in the consulting engineers' professional interest in their subject disciplines and in extending their knowledge about it through studying new textbooks for personal development (Engineer A) or visiting constructions sites to see how other engineers have dealt with similar problems (Engineer B and Engineers C&D), interpersonal communication with other engineers who are experts in their fields (Engineer G) and providing mentorship to junior engineers (Engineer H and Engineer K).

Consulting engineers' personal interests are also reflected in the engineering disciplines or fields in which they work. Structural engineers and civil engineers, for example, receive the same training. Personal interest however determines whether an engineer will work as a structural engineer or civil engineer. Their personal interests' influences their selection of information sources since civil engineers use a different set of codes of practice or trade literature to structural engineers despite having completed the same engineering degree. However, the structural and civil engineers' responses indicate that they use similar types of information sources at the same stages in their respective projects.

These findings correspond with the assumption of Sandstrom's (1994) Optimal Foraging theory where individuals' selection of information sources are motivated by self-interest (section 2.4.1).

c. Attitudes

A positive or negative attitude towards an information source can influence the engineers' information-seeking patterns. The responding consulting engineers express particular attitudes towards their own work and profession and towards the use of particular information sources such as the internet. The following two statements made by Engineer K and Engineer G reflect their attitudes towards the selection of the Internet as a source of information and is also indicative of the use they make of the Internet:

- Engineer K: "…it also is very helpful to go onto the Internet" is a statement that is indicative of his positive attitude towards the Internet as a source of information.
- Engineer G: "…the minute you require detail information, you are informed that you have to buy it from some organisation or other. So this is not an important source of information for me. I often don't bother to search the Internet." This statement reflects a negative attitude towards the Internet and influences his decision not to select and use the Internet to find information.

d. Personal preferences

Personal preferences also influence engineers' selection or non-selection of information sources. The following statements made by Engineer A and Engineer

G are indicative of their preference for personal contacts as sources of information in instances where they could have used alternative sources of information:

- Engineer A: "…go and speak to somebody else. I would phone around and see if I can find somebody who had done a similar structure and what they sort of looked like and get information from that. Very seldom do I go into technical information from books."
- Engineer G's: "I love one to one communication, face-to-face communication. If the project warrants it, I will easily drive to … to see someone and discuss the aspect in detail with him rather than trying to sort it out over the telephone".

5.5.2 Situation-specific information needs

Leckie *et al.* (1996:182) regard context of information needs as the situation-specific needs which can be prompted both internally and externally. The context in this study is provided by the specific engineering project. The engineering project is closely linked to work roles and tasks.

The particular consulting engineers working on the library building needed information from the same professional team, client, and main contractor. The particular project, such as the library building project, therefore determines which people (the work team or social network) will be approached by the consulting engineers for information. However, a different project which is similar to the project described by the engineers might involve a different professional team, client and contractor. For example, Engineer G described different acoustical engineering projects. For each of these projects he communicated project related information to different project team members, clients and contractors to those with whom he worked when he was involved in seeking information for the library project. This is an example of how work teams influence information needs and the selection of information sources as illustrated in Paisley's (1965) framework of the scientist within systems.

The stage of the engineering project is another contextual factor which influences consulting engineers' information needs. The analyses of their information needs during various stages of a project seem to indicate that most information is gathered in the preliminary design and design stages. The engineers also used both formal and informal sources of information during these stages. Most of the information during the construction stage, as set out in section 5.3.4, originates at the construction site and the consulting engineers no longer use formal sources of information to complete their tasks. This means that the information needs of the engineer become increasingly narrow (Wolek 1969:472). Engineer A's description in table 5.2 and section 5.3.2.2 of the way in which engineers seek information from a variety of sources at the beginning of a project and how their information needs become more specific as the project progresses illustrates this. These findings correspond with research findings reported by Byström and Järvelin (1995), Ellis and Haugan (1997), Vakkari (1998:375), Vakkari (2001a:452), Vakkari (2001b:44) in this regard.

5.5.3 Recurring or new information needs (frequency of use)

Frequency refers to how frequently engineers use the same source of information in repetitive or routine projects. Repetitive projects could influence the consulting engineers' selection of sources of information since they may prefer to use an old source rather than a newer source. A comment made by Engineer J that "… some projects are routine work and hardly require more knowledge than that of an electrician" illustrates how routine projects influence engineers' information needs and subsequently their selection of sources of information and their frequent use of the same sources. It is only when consulting engineers are involved in a project which is not routine from their point of view that they will require information from newer or different sources of information and in this way their selection of information sources will be determined by the nature of the project in which they are involved. The research findings of studies conducted by Gerstberger and Allen (1968:272), Kremer (1980:123), Choo *et al.* (2000b:12), and Hertzum and Pejterson (2000:3) correspond with the comment made by Engineer J.

5.5.4 Importance of information and task complexity

The importance or urgency of the required information and the complexity of the task influence consulting engineers' information needs. As indicated in chapter 3, section 3.4, unexpected information needs can be extremely urgent. This urgency, combined with the level of task complexity may also affect the information-seeking activity which is undertaken. Engineer J provided a good example of an instance where information was urgently needed and he had to innovatively find it. The contractor had installed equipment which he claimed complied with the design specifications. Engineer J then needed a different supplier's information to confirm his calculations that the equipment provided by the contractor did not comply with the required specifications. This was reported in table 5.4.

Most of the engineers indicated that in instances where no information can be found they would rely on their engineering judgement or rely on basic engineering principles. These instances are further examples of where a complex task influences the consulting engineers' decision not to seek for sources of information that could assist them in solving the problem, but to rather rely on their personal knowledge, engineering judgement or basic engineering principles.

5.6 CONCLUSION

The purpose of this chapter was to analyse the comments made by eleven consulting engineers on their work roles and associated tasks during time-line interviews. The six stages in an engineering project identified by the Engineering Council of South Africa provided the different stages for the time-line interviews.

The central concepts of Dervin's Sense-making approach were used for the analysis. The data was organised into tables and the headings that were used to describe the results were tasks, information needed, and information sources and outcomes.

Engineers seem to need various information sources and the particular engineering task determines which sources will be required. Most of the information required during the initial stages of the project (particularly the preliminary design stage) is gathered from a variety of information sources, such as, personal contacts, architectural drawings, suppliers, visits, printed sources (books, codes of practice, journals, brochures), the Internet, email, design software and the engineers' personal knowledge, memory and personal files. During further stages most of the required information is specific to that particular project is collected from the construction site, team members and suppliers. This serves as an indication that engineers' information needs become more specific and the available sources of information decrease as an engineering project progresses.

The factors influencing consulting engineers' information needs that were explored include their attributes and circumstances, such as, age, engineering discipline, geographic location and personal factors (e.g. motivation, interests,attitudes and personal preferences). Information needs are also characterised by the context, frequency, importance and complexity of the engineering task. This discussion showed that work roles and tasks are closely linked to other factors that influence consulting engineers' information needs and information-seeking behaviour. Age seems to influence the use made of electronic sources such as design software the Internet as well as text-based sources such as subject journals.

Other factors that influence consulting engineers' information needs are the context in which the information need (situation-specific needs) arises as well as recurring or new needs. It is only when consulting engineers are involved in a project which is not routine, they will require information from newer or different sources. The importance of the information to complete the tasks as well as the complexity level of the task is further factors that influence consulting engineers' information needs. When information is urgently needed consulting engineers have to creatively find the information or rely on their engineering judgement or basic engineering principles.

chapter 6 reports further research finding on the information behaviour of consulting engineers including their information-seeking patterns. Particular attention is paid to their use of information sources.

CHAPTER 6

RESEARCH FINDINGS ON CONSULTING ENGINEERS' INFORMATION-SEEKING BEHAVIOUR

6.1 INTRODUCTION

From the discussion of the empirical research findings in chapter 5 on participating consulting engineers' individual work roles and work tasks it is clear that these contexts give rise to particular information needs. It would appear as if most of the information needed during the initial stages of an engineering project is accessed from a variety of sources. The information needed during later stages of the project come from the actual project itself. Certain factors, such as the particular engineering discipline and the context of the information need also influence engineers' information-seeking behaviour.

As already indicated in previous chapters, the motivation to seek information arises from an information need. The various factors that determine engineers' information needs also influence their information-seeking. Engineers' information behaviour is influenced by factors associated with the sources of engineering information, the engineers' awareness of information and requirements in respect of information content. The purpose of this chapter is to report on the empirical findings on the use of different sources of information and show how engineers' awareness of information influences their choice of information sources. Findings on the use of information and its outcomes are also addressed in this chapter.

The data analysed in chapter 6 is mainly derived from consulting engineers' responses to the second set of questions on the specific sources of information that they use.

The Afrikaans-speaking engineers' comments will be freely translated while English-speaking engineers' comments will be presented in direct quotes and will appear in quotation marks. Some of the comments appearing in tables 6.1 to 6.17 were also recorded in chapter 5 but are included to illustrate how these factors influence consulting engineers' information-seeking.

6.2 CONSULTING ENGINEERS' USE OF VARIOUS SOURCES OF INFORMATION

The information sources used by consulting engineers are identified in the analysis of information gleaned from the interviews and presented in tables 5.1 to 5.5. These sources are personal contacts, architectural drawings, suppliers and trade literature, visits, text-based sources of information (national standards, building regulations, specifications, codes of practice, books, and journal articles), the Internet, email, design software, personal knowledge, digital cameras, site information, system test results and factory test results of equipment.

An examination of consulting engineers' responses presented in tables 5.2 to 5.5 in respect of the use of the abovementioned information sources shows that engineers obtain much of the information they require by analysing and decoding physically encoded information, such as the devices they use in a project, or by direct personal contact with other engineers, their clients, the suppliers of equipment or products. These patterns of use are in agreement with Hertzum and Pejterson's (2000:7) findings that engineering information is not necessarily available in a verbal or textual form.

Engineering information sources can be divided into various categories. In chapter 3 (section 3.5.2), a distinction was made between internal and external information. The broad categories used to analyse the data for this study are internal information sources (for example personal documents, files), external information sources (information sources not available in the engineering company), interpersonal communication and social networking, and mentorship.

6.2.1 Use of internal sources of information

As indicated in chapter 3, section 3.4.2.1, core information is often available in the engineer's own personal collection or is gathered from colleagues, article reviewing, and other socially mediated channels. Responding consulting engineers' responses in respect of the internal sources of information they utilise pertain to the following sources, namely, personal knowledge, codes of practice, books, technical journals, trade literature, engineering software packages, and digital cameras. These information sources, with the exception of digital cameras, are also used by engineers in general according to earlier research findings reported in the subject literature.

Consulting engineers' comments in respect of their use of internal information sources are recorded in tables 6.1 to 6.7.

6.2.1.1 Personal knowledge and personal memory as sources of information

As pointed out in chapter 3, section 3.4.2.1, the most important source of internal engineering information reported in the subject literature is probably engineers' personal knowledge. Table 6.1 summarises consulting engineers' comments on, and the reasons for their use of personal knowledge, personal memory and personal files. The question was formulated as follows: "Do you rely on your personal knowledge, personal files and memory when finding information?"

TABLE 6.1

Personal knowledge and personal memory as sources of information

Do you rely on your personal knowledge, personal files and memory when finding information? ***Engineer A*** *(Electrical and electronic engineering):* I rely on my experience from previous systems. I use my personal knowledge of systems when the project involves work I regularly do. Technology does not change that much – the principles remain the same, only the models change.
Engineer B *(Structural engineering):* "Make up your own solution." "The structural side is very conservative. There is not much new that happens. Once you have fairly designed one slab they all tend to slot into the same formulas we got from our code of practices we use."
Engineers C&D *(Mechanical engineering):* The basic principles in mechanical engineering remain the same. Basic mechanical engineering principles are mathematical principles and seldom go over in detailed designs.
Engineer E

Do you rely on your personal knowledge, personal files and memory when finding information?
(Electrical engineering): Experience and then of course you have catalogues from companies that supply lights, for example. The basic product remains the same: pipes, wiring, cables and switch-gears. The switch-gears are improved and minimised and refined. The product changes. [The engineer seems to be contradicting himself here, but in essence what he is trying to say is that certain products remain the same, such as pipes and cables, The principles according to which products, such as, switch-gears operate also remains the same, the individual models have, however, been improved and have changed.]
Engineer F *(Asset management):* This engineer used the term “engineering judgement” for occasions when he relies on his personal knowledge to solve an engineering problem. Engineers generally work with very little information. Scientists work with a lot of information. Engineers need to make their decisions with very little information. It is your gut feel and obviously your knowledge that guides your thinking processes. There is very little information that is new to me within my specific subject field. I use literature [reading matter] to confirm my approach by looking at how other engineers approached a similar problem. Sometimes I merely use literature because someone had already formulated and explained the problem which then assists me in conveying my own message.
Engineer G *(Acoustical engineering):* We work with a static database. [The engineer explained that the acoustic qualities of certain products such as bricks and building blocks are only tested once, making the information in his database static.] Basically your experience and measurement results [of acoustic qualities] in other things [such as bricks or building blocks]. A lot of the information I use come from textbooks, subject journals, standards, regulations, things which come from one’s personal library which one has collected over the years.
Engineer H *(Civil engineering):* The first principles are the same.
Engineer I *(Electrical engineering):* [The question was not asked pertinently to this engineer since the opportunity did not arise during the interview. Engineer I also did not make any specific comments that could be used to answer this question.]
Engineer J *(Electrical engineering):* Some projects are routine work and hardly require more knowledge than that of an electrician. Some projects require a lot of technical skills and it is for these projects that electrical engineers would search for information. When no specific information can be found to solve the engineering problem that was encountered, he would return to the “basic principles” to find the solution.

Do you rely on your personal knowledge, personal files and memory when finding information?
Engineer K *(Structural engineering):* "… what this basically boils down to is, your knowledge is your own filing system and that is wonderful."

The comments made by consulting engineers in table 6.1 reveal that they rely to a large extent on their personal knowledge, personal files and personal experience for information for various reasons.

Byström and Järvelin (1994:194-195) categorised tasks according to the ease with which a worker (in this study the engineer) can complete the task. They contend that some tasks are completely determinable and could be automated whereas other tasks are new and cannot be characterised in advance. This task categorisation contextualises Engineer J's comment: "Some projects are routine work and hardly require more knowledge than that of an electrician … Some projects require a lot of technical skills." This comment made by Engineer J is an indication that engineers are sometimes involved in, what has become to them, "routine" tasks. This would also explain why most engineers would favour their own 'personal knowledge' of engineering, and 'personal experimentation' as sources of information as found in studies reported by Aguillar (1967), Gralewska-Vickery (1976:267), Taylor (1991:228), Case (2002:236), Kwasitsu (2003:467), Tenopir and King (2004:87). Tenopir and King (2004:181) point out that the nature of engineering work, as well as engineers' inherent personalities could be a reason for engineers' use of their personal files.

Considering the comments made by Engineers A, B, E, G, H and J, technology does not seem to change that much since the principles remain the same. Although this sounds contradictory to common perceptions, these engineers are merely indicating that the models of the individual products have changed, but the principles according to which they operate have remained the same. The switch-gears to which Engineer E refers is an example of technological advances which have improved the individual models but where the engineering principles according to which switch-gears operate has remained the same. Consulting engineers only consider the switch-gear's operating principles when they design. The contractors or suppliers decide on the model they offer when they tender for a specific project. The fact that the engineers design according to certain principles and not products is therefore a good reason why consulting engineers can use their personal knowledge and personal files for their designs and need not spend the time searching for new sources of information.

Engineer K's comment on his use of books "…look it's very limited now that you have your filing system … My filing system is quite extensive. So you rely less and less on textbooks" stresses the importance of personal documents and files in providing engineering information. This behaviour corresponds with Gralewska-Vickery (1976:276-277, Leckie *et al's* (1996:165), Hertzum and Pejterson's (2000:4), and Ward's (2001:171) findings on engineers' use of their personal documents and files.

6.2.1.2 Consulting engineers' use of codes of practice

Codes of practice are special publications consisting of technical project-oriented information printed in special publications which seem to be an important source of engineering information (Gralewska-Vickery 1976:268). These findings correspond with the empirical research findings reported in chapter 5. Table 6.2 summarises the data collected from the interviews regarding the consulting engineers' use of codes of practice and from where they access it.

The question put to the engineers was phrased as follows: "Do you use codes of practice and standards as sources of engineering information? Where do you get the codes and standards from?"

TABLE 6.2

Consulting engineers' use of codes of practice

Do you use codes of practice and standards as sources of engineering information? Where do you get the codes and standards from?
Engineer A *(Electrical and electronic engineering):* I use the South African codes of practices especially SANS10139 for fire protection and SANS10141 for electrical protection. I will also use the British Standard Code of Practice for smoke detection systems and sometimes the American Code of Practice for Wiring of Premises. The ISO [International Standards Organisation], British and South African standards are available from the SABS. I bought American Standards from a bookstore. I also use regulations. These are government publications and can be downloaded from the Internet.
Engineer B *(Structural engineering):* "The SABS. The majority comes from them. In some cases there is the European Code and British Code for bridges wherever they come from. Sometimes we use the German code, Australian code, etc. We would probably order those through the Internet … I use the British codes because the South African code is based

Do you use codes of practice and standards as sources of engineering information? Where do you get the codes and standards from?
on the British." [International codes will be used for international projects, for example, if the engineers have to design for typhoons in Madagascar, the South African code would not be applicable].
Engineers C&D *(Mechanical engineering):* Any design can be completed as long as the one that the engineer designs is within the parameters set by the regulations he has to use.
Engineer E *(Electrical engineering):* [Engineer E did not comment on his use of codes of practice, standards or regulations. The opportunity also did not arise to ask the question.]
Engineer F *(Asset management):* [Engineer F does not use codes of practices or standards in his field of expertise. He advises clients on maintenance issues in production plants.]
Engineer G *(Acoustical engineering):* SABS. Most of the SABS standards are also International Standards Organisation (ISO) standards which is reprinted and sold at the more reasonable South African rates. The SABS also is the official agent for the British and German standards. In cases where the SABS has to order a standard for a client, they will make a photocopy for the client to use until he/she receives his/her official copy.
Engineer H *(Civil engineering):* "Within the engineering fraternity, in particular, consulting civil engineering now there is an initiative of standardising with the South African National Standards on the CIDB with the format of the document and stuff."
Engineer I *(Electrical engineering):* He uses the electricity supply company's (ESC) specifications which are based on the SABS. These are available on the ESC's website. Uses Google to find information for building projects. Google is like a "yellow pages par excellence." He uses an FTP site for a project in Dar-es-Salaam. The architect would send an email that the drawings have been updated, then you just down load them from the FTP site and update your work on the drawings. Google Earth is too old. If the coordinates are known, Google Earth can provide the engineer with information on where the project is ... Google Earth also is very selective with information. It does not provide detailed information for all areas … A further problem is that the project must be referred geographically. The electricity supplying company (ESC) has something they call *Small World* for their electricity network. The engineer must acquire the coordinates of each high voltage pole and this must be entered into *Small World*. If the engineer now uses Google Earth and does not have the coordinates, the ESC will not accept it. The other problem is the information must be according to scale, and Google Earth's

Do you use codes of practice and standards as sources of engineering information? Where do you get the codes and standards from?
scales are not the same.
Engineer J   **(***Electrical engineering):*   [Engineer E did not comment on his use of codes of practice, standards or regulations. The opportunity also did not arise to ask the question.]
Engineer K   *(Structural engineering):*   Engineer K uses SABS codes of practice and the British codes of practice. "I got [sic] it [the British Codes and SABS codes] in my file. You can obtain all international codes from the South African Bureau of Standards. They got [sic] a collection there. You can go there. They actually print it for you. It is on a disc."

The comments made by engineers recorded in table 6.2 reflect the use of codes of practice, specifications, regulations and standards as sources of information.

All the engineers, except Engineer F, make use of SABS codes of practice have copies of the codes available in their offices. Engineers E and J did not comment. The engineers' subject field will determine the specific code of practice they will consult. The structural engineers also use the British codes of practice. The South African codes as well as the international codes can be obtained from the South African Bureau of Standards. These findings on the use of codes of practice correspond with Gralewska-Vickery (1976:268) and Shuchman's (1981:77-78) findings.

Engineer A indicated that he uses government regulations which can be downloaded from the Internet (www.acts.co.za). Shuchman (1981:48-53) and Leckie *et al's* (1996:166) also found that engineers need varied information on new regulations and technologies.

6.2.1.3 Consulting engineers' use of books

Table 6.3 summarises the responding consulting engineers' use and acquisition of books and textbooks. These books could include codes of practice, standards and regulations which were dealt with in table 6.2. Codes of practice are available in a printed format or on a CD ROM. (Engineer H interpreted the question on books as the use of codes of practice).

The question was phrased as follows: "Do you use books, such as, textbooks in a project and will you buy new books if you need to?"

TABLE 6.3

Consulting engineers' use of books

Do you use books such as textbooks in a project and will you buy new books if you need to?
Engineer A *(Electrical and electronic engineering):* I regularly browse book shops to find new books of interest that relate to my work. I will also buy new books for a specific project.
Engineer B *(Structural engineering):* "A lot of the institutes produce books like PCI publications. They produce technical manuals trying to make things easier. And generally I would use things like that. Lots of these text books come with codes in the front giving you an idea of how much things are going to weigh and how much it costs and things like that. Virtually if I need to find information I will find it from these two books or from course materials that I have done." "If I do buy alternative sources it will be from the Concrete Institute or Construction Institute for their publications."
Engineers C&D *(Mechanical engineering):* [These engineers use technical books. They will buy books on new mechanical engineering fields, for example energy management. Air conditioning technology does not change much. New books in this field are in their third and fourth revision, but in essence remain the same. These engineers buy books when they cannot find the required information in

Do you use books such as textbooks in a project and will you buy new books if you need to?
their office or on the Internet. They believe that if the book is needed for one project, the chances are good that they would need it again in future.]
Engineer E *(Electrical engineering):* You will have to find the information somewhere. I don't think a book would necessarily do the thing. Books are in any case back to the old principles.
Engineer F *(Asset Management):* I buy books. Whenever a new book is advertised and it seems relevant to my topic, I will buy it. Especially books that are published by Conference Communications. This publisher has some connections with the Institute of Asset Management of which I am a member.
Engineer G *(Acoustical engineering):* I have a personal collection of textbooks, standards and regulations. I will buy new books on acoustics when a new book [on acoustics] is published. These books are very expensive because there are so few acoustic engineers worldwide.
Engineer H *(Civil engineering):* [Engineer H did not indicate the use of books during her interview. When asked, it was evident that she interpreted the question as referring to the use of codes of practices, standards and regulations. These she does use, as is evident from her comments in table 6.2.]
Engineer I *(Electrical engineering):* [This engineer has never bought a book on electrical engineering for his own personal collection unless he needed it for a specific project in which case his company would buy the book.]
Engineer J *(Electrical engineering):* [Most of the textbooks Engineers A&J used at university are in the office. They have bought a number of books over the years.] In general we basically use articles and textbooks that are available in the office.
Engineer K *(Structural engineering):* "Look it's very limited now that you have your filing system. I've been into this for more than forty years. My filing system is quite extensive. So you less and less rely on textbooks. And what this basically boils down to is, your knowledge is your own filing system and that is wonderful. I don't buy any books. I haven't in years." [this comment confirms Engineer K's use of his personal knowledge and experience discussed in section 6.2.1.1.]

The comments the engineers made on their use of books and textbooks summarised in table 6.3 reflect the important role that textbooks, in particular, play in providing them with information.

All the consulting engineers use books that provide them with technical project-orientated and profession-orientated information, and in general those books are available in the office (Engineer J). This corresponds with Kremer (1980:53,124) and Mueller *et al's* (2006:2) findings that books, but particularly textbooks, manuals, codes of practice, reference and data books are important to this user group.

With the exception of Engineers E, I and K, the responding consulting engineers will buy books to provide for their information needs. Their rationale is that if they needed the book once for a project, the chances are that they would in future need the book again for a similar project. Engineer A will browse bookshops for new books in his subject field that could be of interest to him.

Research indicating the engineers' use of books as sources of information include the studies conducted by Gralewska-Vickery (1976:267), Kremer (1980:68-69), Mueller *et al.* (2006:2) and Ward (2001:171). The engineers in Mueller *et al's* (2006:2) study indicated their preference for what they considered more traditional library resources such as books.

Despite indications that books are important sources of information, some of the consulting engineers do not seem to use books that much. Engineer K's comment

"… So you less and less rely on textbooks …" and Engineer E's comment "… I don't think a book would necessarily do the thing. Books are in any case back to the old principles …" are indications that books are not regarded as useful sources of information by all consulting engineers when compared to their personal files and documentation. It could be assumed that a subject's age could have an influence on his or her use of books since both Engineer E and Engineer K are semi-retired and above the age of 70. Both of them might therefore rely more on their personal knowledge, experience and personal files compared to Engineers C and D who are between the ages of 30 and 40 and who might buy books if they need the information for a specific project.

All the responding engineers stressed that the basic engineering principles have remained the same over the years and that new textbooks include very little new information although they could provide ideas on new applications for products that have become available.

6.2.1.4 Consulting engineers' use of technical journals

The technical journal is another internal text-based information source used by consulting engineers.

Table 6.4 summarises the responding consulting engineers' use of technical journals. The question was phrased as follows: "Do you receive any technical journals and do you use them for personal professional development or your engineering projects?"

TABLE 6.4

Consulting engineers' use of technical journals

Do you receive any technical journals and do you use them for personal professional development or your engineering projects?
Engineer A   *(Electrical and electronic engineering):*   I do not subscribe to technical journals, but receive *Electron*, *Instrumentation and Control* as part of my membership subscription to professional associations [South African Institute of Electrical Engineering and the South African Institute for Measurement and Control]. My partner receives *Vektor*. We also receive other journals as a result of our South African Association for Consulting Engineers (SAACE) membership. Publishers get a list of SAACE members and post their journals to us. We receive the journals irrespective of whether we want to receive them. Some journals are supplier specific. Most of these journals are never even opened. I only read some of the journals for personal development.
Engineer B   *(Structural engineering):*   "I don't read them. I look at the pictures and if it looks interesting I might read it. If the articles are too long, I will not read it. We just don't have the time."   "We do subscribe to some magazines. You get a list and it is passed around in the office and you get a chance to look at it. That happens between projects … I find that I am more likely to read articles on projects that I have been involved in rather than articles on projects other people have been involved in. You do pick up [information] by glancing at the journals and realise that could be something you need more information on … And if somebody walks into your office and you are reading a journal, they will not regard it as work. Paging through pamphlets is work, but not reading an article."   "You will look more at technical magazines to see more about what new or ideal designs have come in."   "I seldom use technical journals to find information."   "Structural engineering is very conservative, not many changes occur. Engineers involved in bridges might use these sources more."
Engineers C&D   *(Mechanical engineering):*   We receive and subscribe to technical journals e.g. J*ournal of engineering management*; *Cooling; Building Africa.* [The researcher doubts whether these engineers actually pay an additional fee for their journals. They would receive some journals as part of their membership to a professional association and they could regard this subscription as a subscription to the journal.]   We also receive newsletters from ECSA.
Engineer E   *(Electrical engineering):*   I receive and use journals but do not subscribe to any journals. The journals are from companies like Philips. [As indicated by Engineer A, engineers receive journals from companies because of their registration to SAACE and also when the industry learns they are working in a specific field].

Do you receive any technical journals and do you use them for personal professional development or your engineering projects?
Engineer F *(Asset management):* I receive numerous journals but hardly ever read them. I do subscribe to *Maintenance and Asset Management* and read the journal. I will page through the journals to find the article I need. At one stage I copied articles and filed them according to subjects. Now I rather keep the journal and try to remember in which year I saw the article [and then he browses the journals].
Engineer G *(Acoustical engineering):* I have a personal collection of copies of articles from subject journals which I collected while I was a lecturer in the 1970s.
Engineer H *(Civil engineering):* "There is a magazine *No dig international"* [but this engineer does not use it to find contract specific information.] [She does receive technical journals, like those from the South African Institute of Civil Engineers but does not necessarily use them for information she needs for specific projects].
Engineer I *(Electrical engineering):* I receive technical journals but do not subscribe to any. I do not really find the time to read them. When I do read them, it is because I find the information interesting and not because I need it for a specific project.
Engineer J *(Electrical engineering):* I receive technical journals such as *Vektor, Energising, Electricity,* and *Engineering IT* due to my registration with some professional engineering associations. I keep copies of the journals for at least two years and will browse the indexes [table of contents] for articles on topics in which I am interested. I find no need to subscribe to specific journals. The journals we receive free of charge are sufficient. I retrieve what other information I need from the Internet. I would like to get access to in-house journals such as those published by companies like ABB. These are unfortunately not freely available, not even on subscription.
Engineer K *(Structural engineering):* [He receives *Civil engineer* as part of his membership to a professional association.] "It is a very helpful thing to read you know, to see how other people … Obviously you may not find a specific item which you will find helpful." [If he needs an article for a project, but can't remember the details of the article, he can phone the institution and they'll do a search for him].

The engineers' comments on their use of technical journals are summarised in table 6.4 and reveal how these sources are mainly read for personal development purposes rather than for project-related purposes.

All the engineers receive a number of technical journals as part of their membership subscription to their respective professional associations and their affiliation to the South African Association for Consulting Engineers (SAACE). Four of the engineers indicated that they hardly ever read them. When, and if consulting engineers read journal articles (Engineers A, I, J and K), it appears to be mostly for their own personal development or to monitor or scan the environment. This pattern of behaviour corresponds with Case (2002:236; 2007:256) and Tenopir and King's (2004:81) findings in this regard.

Engineers F and J's description of how they scan old journals in their collections and browse through their tables of contents confirms Ellis and Haugan's (1997:398) findings on browsing activities. This type of browsing activity is basically unstructured and *ad hoc.* This pattern of behaviour also resembles the undirected viewing mode in Aguillar's Modes of Environmental Scanning discussed in chapter 2. In this mode viewers rely more on irregular contacts and casual information from external people and sources.

6.2.1.5 *Consulting engineers' use of trade literature*

Trade literature seems to be an important source of engineering information (WFEO/CEI 1979:10), particularly since engineers require market-related information about vendors and customers (Gralewska-Vickery 1976:268; Leckie *et al.* 1996:166). Brochures and pamphlets are examples of such trade literature.

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Table 6.5 summarises the use of trade literature (i.e. brochures and pamphlets) as sources of engineering information. Some of these aspects were also discussed in 5.3.3.2. The relevant question in this regard was phrased as follows: “Do brochures and/or pamphlets provide for your information needs?”

TABLE 6.5

Consulting engineers’ use of trade literature

Do brochures and/or pamphlets (trade literature) provide for your information needs?
Engineer A: *(Electrical engineering):*   I Use pamphlets and brochures a lot and have a rather big collection in my office. I also use old brochures because it often is only the model number that changes, the principle according to which the equipment operates remains the same. I also use *Specilink, Ezee-dex* and *Merkel’s builders’ pricing and management manual.*
Engineer B   *(Structural engineering):*   “Not much for specific information. There are things like *Specifile* [this is a company that collects brochures and makes them available to consultants who subscribe to them]. But we don’t use that much. Generally we have our preferred suppliers. Like our new ‘seeker’ products because I know from experience every time I have used them they have worked.”
Engineers C&D   *(Mechanical engineering):*   Company representatives update these engineers on the latest products that have become available and bring them catalogues which they keep in their ‘library’.
Engineer E   *(Electrical engineering):*   [Uses brochures and pamphlets a lot. He has his own collection in his office and his younger colleagues often consult his collection rather than searching for the information elsewhere.]
Engineer G   *(Acoustical engineering):*   [This engineer often uses old equipment’s data sheets because it includes such detailed technical information.]
Engineer H   *(Civil engineering):*   “Brochures from suppliers” – [this engineer referred to these as specifications and the researcher later realised she was referring to specific product specifications.] “The company, *Specifying Dynamics* collects brochures from companies and will visit the engineering consultancies to update their brochure

Do brochures and/or pamphlets (trade literature) provide for your information needs?
collections."
Engineer I *(Electrical engineering):* I use brochures if I have the latest ones available. The suppliers update my collection from time to time.
Engineer J *(Electrical engineering):* Most companies are now using a group *Specifying Dynamics.* This company regularly comes to see me. They deal with a broad spectrum of products, from tiles to switches. Company representatives also visit me with specific product information supplied by their respective companies.
Engineer K *(Structural engineering):* "Normally the suppliers are very keen to supply the engineers with documentation. Even if all is for your files. Because what they need is to get a business order to get their product sold." "They [the suppliers] bring you brochures."

The comments made by engineers in table 6.5 will shed light on their use of pamphlets and brochures to provide for their information needs.

Consulting engineers' collect brochures and pamphlets during visits or when attending exhibitions or the suppliers provide them with brochures and pamphlets. This is done either directly or through marketing companies that compile files with such brochures as *Specilink, Ezee-dex,* and *Merkels' builders' pricing and management manual'.*

All the responding engineers reported on their use of brochures and manuals. Suppliers seem to regularly update the engineers' brochure collections. There also are companies who collect brochures, repackage the brochures and make them available to the consulting engineers. Examples of such brochure collections include *Specilink, Specifying Dynamics.* Engineer B noted that though her company used to subscribe to *Specifile* they no longer do, because they have their own preferred suppliers whose products they have learned to trust from their experience of using the products. It is clear from the above that trustworthiness influences engineers' selection of information sources as was also found in studies by Hertzum (2002), Tseng and Fogg (1999) and Van House *et al.* (1998).

Engineers seem to use documents (for example books, brochures, pamphlets and journal articles) when they need information about materials to be used in their respective projects (Hertzum & Pejtersen 2000:10; Fidel & Green 2004:574). However, it is clear that brochures are generally viewed as important sources of information in a project whereas books and technical journals are not.

As with Engineer K's comment about his use of books, his other comment "even if all is for your files" once again stresses the importance of personal documents and files in providing engineering information.

6.2.1.6 ***Consulting engineers' use of design software***

Information sources based on computer technology available within the company, such as, software packages are regarded as internal sources of information. Software packages are licensed products which consulting engineers would have to purchase.

Computer programs or engineering software provide engineers with technical project-oriented information which are often generated by engineers (Gralewska-Vickery 1976:267). Table 6.6 summarises the use made of design software programmes by engineers. The researcher did not initially ask the responding engineers about their use of engineering software packages, but some of the engineers spontaneously reported on their use of such packages. Those engineers who did not report on their use of software packages were contacted by email and the collected data from their interviews was updated. The question was phrased as follows: “What role does information technologies and design software play in providing for your information needs?”

TABLE 6.6

Consulting engineers’ use of design software

What role does information technologies and design software play in providing for your information needs?
Engineer A   *(Electrical and electronic engineering):*   I sometimes use design software packages such as a switch gear design package and an illumination design package.
Engineer B   *(Structural engineering):*   “I use the Prokon design software package.”
Engineers C&D   *(Mechanical engineering):*   [These engineers use software packages that simulate the air-conditioning systems. In instances where the software packages do not have the ability to simulate a system, the engineers return to the basic principles and find the solution there.]
Engineer E   *(Electrical engineering)*   I leave that for the younger guys.
Engineer F   *(Asset management):*   The company who assisted me with the pre-feasibility study used a software package.
Engineer G   *(Acoustical engineering):*   I do not use design software packages at all.
Engineer H   *(Civil engineering):*   “I do not compromise on IT. I’ve kept abreast of all the latest software development. No matter how expensive these things are, we actually acquire them as part of our IT budget. I also tried to improve on efficiency in terms of

What role does information technologies and design software play in providing for your information needs?
having each one doing their own stuff."
Engineer I *(Electrical engineering):* I use the software packages provided by the ESC to assist me with estimates, etc.
Engineer J *(Electrical engineering):* I sometimes use design software packages such as a switch gear design package and an illumination design package.
Engineer K *(Structural engineering):* "Now in principle you know it is too vague how [sic] we handle structures at the moment as in basically [sic] when we establish the structures of a building we use the traditional classic methods and we confirm it with the high tech software. We do it the classic way and check it out with the software. I am not using any software … both of them are quite important. But the classic one [design method] is the more important one for the time being."

Consulting engineers' comments on the use of engineering software in table 6.6 also supplement what has already been discussed in 5.3.2.2 and 5.3.3.2 on the role of software programmes in supplying engineering information.

The individual project will determine engineers' use of design software. Engineer A, for example, indicated that he does not use software packages for security systems, but had used them on other projects. Engineer K also indicated that he designs the classic way and someone in the company would confirm his design with the software. Engineer G does not use software packages since his projects do not warrant their use.

Engineer H does not compromise on information technologies (IT) and ensures her company remains abreast with the latest IT developments. She is, however, concerned about young engineers who only want to use design software without having a feel for what they are doing. Engineer H commented on this issue when she discussed the reasons for instituting a mentorship program in her company. Her comments on mentorship appear in table 6.14 and will be discussed in more detail under 6.2.4.

Holland *et al.* (1991:327-328) found that considerable use is made of computers and information technology by engineering students and lecturers although in different proportions with students' use exceeding faculty use. Younger engineers, namely, Engineer B, Engineers C & D (aged 30-40) and Engineer H (aged 30-40) make use of software packages themselves. Although two older engineers, namely, Engineer F (aged 50-60) and Engineer K (aged 70-80) appear to be less inclined to use software packages on their own they do rely on software packages as a means of checking their work indirectly through other persons. On the other hand, Engineer E (aged 70-80) and Engineer G (aged 50-60) do not use software packages at all. Engineer I (aged) is an exception because he does make use of software in spite of his age. These findings correspond with Holland *et al.* (1991) and Tenopir and King's (2004) findings indicating that older engineers are slightly less likely to use computers or networks.

6.2.1.7 *Consulting engineers' use of digital cameras to collect information*

Digital cameras can be used extensively to collect engineering information, depending on the project in which the engineer is involved, but not all types of projects warrant the use of digital cameras.

The collected data was analysed and summarised in table 6.7. The relevant question was phrased as follows: "Do you use a digital camera to take photos of a project? "

TABLE 6.7

Consulting engineers' use of digital cameras to collect information

Do you use a digital camera to take photos of a project?
Engineer A *(Electrical and electronic engineering):* Digital cameras assist me in recording progress, but also provide details about installations. This information can then be used when reporting on the project. The contractor can also photograph a problem he experiences on site when I am not available on site. He can then either send an mms (multi-message service) with the photo or email it to me. I can then respond immediately with a solution to the problem.
Engineer B *(Structural engineering):* "When we don't have a RE [resident engineer], people take photographs of the problem [this is if there is a problem on the construction site and the engineer is not in a position to go to the site to solve the problem], and email it to us, or a drawing which marks out the problem and email or fax it to us (not all sites have access to the internet, but most have access to faxes)."
Engineers C&D *(Mechanical engineering):* [These engineers indicated that, should a problem arise and they are not able to visit the site to solve the problem, someone could photograph the problem and email or mms it to them. They are then able to respond with a solution to the problem.]
Engineer E *(Electrical engineering):* Engineer E does not seem to use digital cameras or photographs in his projects.
Engineer F *(Asset management):* Engineer F requires management information for his projects and digital cameras will not assist him in his work.
Engineer G *(Acoustical engineering):* [Engineer G indicated he does not quite like using photos. But can make use of this source if and when he needs it.]
Engineer H *(Civil engineering):* " … I get photographs from site, from … because it is so far away quite regularly. And then we are busy with some work in … on a dolomite site and the first time

Do you use a digital camera to take photos of a project?
that the manholes were put in for this site, the RE would send me photos of it because I am curious to know just how it is going to work". "We normally as a rule of thumb do photographs. You will notice in our project directory that we have an image directory. Each project has photographs that we keep. And that actually then gets archived. When the project is archived all those images are archived as well. Including things like the site diaries that the RE keeps and things like that."
Engineer I *(Electrical engineering):* The project manager will photograph a problem on site and email it to me. I do not use digital cameras for any other purpose than problem solving.
Engineer J *(Electrical engineering) :* We use cameras a lot on a project – even before digital cameras became available. We take photos of progress on site which is used for reporting purposes, but also of the final commissioning. Photos can also be used to indicate problems on site which need to be addressed.
Engineer K *(Structural engineering):* "A digital camera plays a big role. Even a cell phone that can take a picture is very handy because it always is with you. That is very handy."

The data in table 6.7 illustrate the engineers' use of digital cameras in the design, management and reporting of projects.

With the exception of Engineer F, an asset manager, all of the responding engineers reported how digital cameras or even cellular phones that can take photos, can be used to record progress and solve problems on site. Cellular phones are particularly useful when the consulting engineer is not able to visit the construction site when a problem arises. Someone on site can then take a photograph and either email or mms the photo to the engineer who can then come up with a solution.

Photographs are also used for reporting purposes and Engineer A, Engineer H and Engineer J also archive their photographs with all the other documentation that is relevant to a specific project.

Engineer J found that the photographs that were taken during the water transfer project in 1996 were extremely useful during the retrofit project which he described. These old photos assisted him in determining the changes that had taken place on site during the past ten years, what the original equipment looked like and where it was placed, and also provided specific details of the switch-gear. This enabled him to ensure that the new equipment is compatible with the old equipment.

No reports on the use of digital cameras could be found in the literature, making engineers' comments about their use of digital cameras to collect engineering information an important contribution to our knowledge of this facet of their information-seeking behaviour that has not previously been researched or published.

6.2.2 Use of external sources of information

As previously indicated in 3.5.2.2, external information sources refer to those information sources that are not available within the engineers' company or organisation. External information sources include personal contacts or text-based sources that can be retrieved from conventional information systems or libraries and the Internet. The Internet is also seen as an external information source because information available on the Internet is not created within the engineering company and is hosted outside the company. By the same token, email is regarded as an external source of information despite the fact that emails could also come from personal contacts within the engineering company. The responding engineers were questioned on their use of the Internet, libraries and online databases, conferences and visits and their comments are presented in tables 6.8 to 6.13.

6.2.2.1 Consulting engineers' use of the Internet

The Internet could also have been categorised as an internal information source because the consulting engineer can get access to the Internet in his office. However, the Internet is an information system allowing access to a variety of information which was created outside the engineers' office and is hosted remotely. For this reason it was decided to regard the Internet as an external source of information.

Table 6.8 summarises the responding consulting engineers' use of the Internet. Consulting engineers' comments on their use of the Internet during the preliminary design stage of their projects was also discussed in section 5.3.2.2.

The question was phrased as follows: "Do you use the Internet to find project-related information?"

TABLE 6.8

Consulting engineers' use of the Internet

Do you use the Internet to find project-related information?
Engineer A *(Electrical engineering):* I use the Internet a lot and do information searches on Google and Altavista. I also access some specific websites such as the Department of Public Works' website for contract documentation and specifications, Wikipedia, SAACE (www.saace.co.za), Institution for Electrical and Electronic Engineers (www.ieee.org), Rectron (a computer hardware supplier) (www.rectron.co.za), and Cisco (www.cisco.com).
Engineer B *(Structural engineering):* "When I use the Internet it will mostly be in the final design stage when I will be looking for information on the type of waterproofing products or type of roofing products or more stuff you would buy ... what specs or what … is available. That type of thing." "I just use Google. Because it is easier. I generally find what I need on Google or AskJeeves, but that is not really technical. Sometimes, if you can't find something on Google, I use AskJeeves. Just the wording or so helps me to then find what I need on Google."
Engineers C&D *(Mechanical engineering):* We use Google SA to find information on local products. If there is no information available we will use the international Google.
Engineer E *(Electrical engineering):* I use specific websites, e.g. Dept of Public Works, but prefer using catalogues.
Engineer F *(Asset management):* I use the Internet to find information needed to conduct training on topics stipulated by my clients. I especially use the Internet when I start doing work for a new client. I will visit the client's website to get an understanding of the specific client's needs. I use Google as a search engine to find information. There is a website *The Plant Maintenance Resource Centre* (http://www.plant-maintenance.com/) which is a wonderful source of information [It is a Plant Maintenance Portal]
Engineer G *(Acoustical engineering):* The Internet is a source of supplier information, regulations, legal requirements. I do not really use this source. The minute you require detailed information, you are informed that you have to buy it from some organisation or other. So this is not an important source of information for me. I often don't bother to search the Internet. [If he does need information from the Internet he uses an intermediary (his business partner who is his son-in-law) to find the information. He thinks the intermediary uses Google.]

Do you use the Internet to find project-related information?
Engineer H *(Civil engineering):* "I will visit a specific site if I know of the site, otherwise I will ask my secretary or one of the junior staff to do the searches. I will then check the results. My secretary uses Google SA." "Email plays an important role in project communication." "…now I've got involved in another project. And they have got an FTP (file transfer protocol) site. And that actually is working brilliantly. I think that is a lot more beneficial. Especially when we have a multidisciplinary project team. What we need to keep abreast with there is that we notify people when we are posting things to the site … All our structured drawings went onto the site, the architect can access it without us sending him electronic transmissions or hard copies or whatever. They download it from their site, put the background on, check and interrogate it." "Only the project team has access to the FTP site."
Engineer I *(Electrical engineering):* I use the Internet to retrieve standard forms and information from the Department of Public Works' website as well as … [the ESC's] website. I use Google to find information for building projects. Google is like a "yellow pages par excellence." We used an FTP site for a project in Dar-es-Salaam. The architect would send an email that the drawings have been updated, "then you just download them from the FTP site and update your work on the drawing". Google Earth is too old. If the coordinates are known, Google Earth can provide me with information on where the project is ... Google Earth also is very selective with information. It does not provide detailed information for all areas … A further problem is that the project must be referred geographically. The electricity supplying company (ESC) has something they call *Small World* for their electricity network. I must acquire the coordinates of each high voltage pole and this must be entered into *Small World*. If I now use Google Earth and do not have the coordinates, the ESC will not accept it. The other problem is the information must be according to scale, and Google Earth's scales are not the same. [Similar statements made by Engineer I on Google Earth is reported in Table 5.2.]
Engineer J *(Electrical engineering):* [Engineer J visits specific manufacturers' or suppliers' websites to find information on products or specific technologies if he knows the URL. When Engineer J needs information such as information on equipment or a company he is not familiar with, he uses Google.] A lot of information is freely available on the Internet. I am often frustrated by the fact that international institutes publish quality articles on the Internet, but that these articles are not free. The information in the article is often not worth the money I have to pay since I do not require all the detail provided in the article. I often only need a sketch. Most universities include interesting information on their websites, including South African universities. Like a case study that was published for a doctoral degree which is easily accessible. I have used an FTP site on a project. The site worked well provided everybody uploaded their documents timeously and all documents are in a standardised

Do you use the Internet to find project-related information?
format. The site also required some computer skills, something not all the engineers, especially the older engineers, had. It worked very well as a repository. The QS did not benefit much from the system.
Engineer K *(Structural engineering):* "It is also very helpful to go onto the Internet. I just type a single term. It is very simple to find that type of information. Basically information related to structures like vibration and that type of thing you get a lot of irrelevant information. So then I go to the websites I usually use." These are: RoyMech (www.roymech.co.uk), American Institute of Steel Construction, Inc (www.aisc.org), Efunda (www.efunda.com), www.scotland.gov.uk and www.snopes.com.science. The search engines Engineer K uses are Google and Dogpile.

The responses in table 6.8 on the use that consulting engineers make of the Internet illustrates the important role it plays in meeting their information needs.

With the exception of Engineer G and Engineer H who use an intermediary to do their Internet searches, all the engineers use the Internet to find information and conduct their own searches. They all tend to use Google or specific websites such as the Department of Public Works' website and the engineering institutes' websites. Engineer B also uses AskJeeves to come up with terms she could use to improve her search on Google. Engineer A also uses Altavista. His experience is that Google is not always that good in providing technical information. Engineer F reported the use of a subject portal and Engineer K the use of web directories. Engineer K also uses Dogpile, the only one of the responding consulting engineers to use a meta-search engine.

This reliance on Google corresponds with Mueller *et al's* (2006:3) findings that engineers rely on only one or two search engines. Mueller *et al.* (2006:3) contend that engineers are often not aware of speciality search engines such as Google Scholar and the availability of alerting services. Bearing in mind that none of the responding engineers reported on the use of speciality search engines or the use of alerting services, Mueller *et al's* contentions could be applicable to consulting engineers as well.

Mueller *et al.* (2006:3) report a heavy reliance on web searching for information from QUALCOMM's engineering population. Kraaijenbrink's (2007:14) findings support these reports. This could be due to the fact that engineers perceive the Internet as easily accessible because it is available on their desktops (Hirsh 2000:481) and physically close (Fidel & Green 2004:569).

Engineer G, who uses an intermediary to do his searches, claims that the Internet does not provide him with the required detailed information he needs and he therefore does not use the Internet extensively to retrieve relevant information.

Engineer J's frustration with being unable to find the quality information he needs on the Internet corresponds with Kraaijenbrink's (2007:13) findings indicating that the information engineers find on the Internet often is at a different aggregation level than what they need. This could also be an indication of the gap between the information needed by Engineer J and the information he perceived that he had received. A gap also exists between the information as claimed by the source and the factual information that proved to be useful (Kraaijenbrink 2007:14). Another possible explanation for his frustration could be a language gap in the use of commercial brand names and technical names describing a product (Kraaijenbrink 2007:10). This could explain findings indicating that much of the technical information engineers needed was not available or too difficult to find resulting in heightened awareness of the quality of the information in an information source (Fidel & Green 2004:573; Hirsh 2000:481).

In their study of one large manufacturing company Fidel and Green (2004:569) report that some engineers posted documentation on the Web or on a server to communicate with colleagues, contractors or clients. It can be assumed that this behaviour is similar to the use of FTP sites reported on by Engineer H, Engineer I and Engineer J, the main difference being that Engineers H, I and J work for different companies and so do the other members of the professional teams of which they form a part.

6.2.2.2 Consulting engineers' use of email in project communication

Email is an Internet service that is used for personal communication. Use of email for interpersonal communication and social networking is one of the chief methods of communication amongst engineers (Fidel & Green 2004:569; Tenopir & King 2004:52). The engineers were asked about their use of email in a specific project. The question was phrased as follows: "What role does email have in your project communications?" Their responses are summarised in table 6.9. Engineers' use of email was also discussed in the preliminary design stage in section 5.3.2.2(g).

TABLE 6.9

Consulting engineers' use of email in project communication

What role does email have in your project communications?
Engineer A *(Electrical and electronic engineering):* I use email to correspond with colleagues, clients, contractors, and suppliers. I

also ask for quotations or information on equipment via email.
Engineer B *(Structural engineering):* "I like to have things in writing. I use email a lot. I don't use faxes and that type of stuff at all … I am not great at filing. If it is on my computer, I know where to find it and I don't have to print it out. If I do need it printed, then I just print it out." [The engineer also receives product updates via email].
Engineers C&D *(Mechanical engineering):* We receive articles by email; communicate with colleagues and construction team by email and telephone.
Engineer E *(Electrical engineering):* Project correspondence and payment certificates are done via email.
Engineer F *(Asset management):* [Engineer F uses either email or personal contacts to communicate with his client. He seldom uses telephone communications.]
Engineer G *(Acoustical engineering):* [This engineer only uses email when he has to – very few clients or contractors even have his email address.]
Engineer H *(Civil engineering):* "What we do is we issue instructions via email to him [the RE on the contract] and he will then formalise it into a site instruction and send it through. We make a point of ensuring that everything is written and communicated, even if it is sent by email. It still has to be put on the site instruction. In site form [that is the format required for site instructions] and that is then sent back to us." If there is a problem on site? "We get it almost immediately if there is a problem. Even if it means PDFing a drawing, marking it up and PDFing the drawing and sending it to us. We can respond quite quickly."
Engineer I *(Electrical engineering):* I use email a lot to communicate with my clients, contractors and project managers. [This engineer does a lot of international projects, particularly building projects.]
Engineer J *(Electrical engineering):* I use email for correspondence and also to get information from clients and suppliers.
Engineer K *(Structural engineering):* "The communication - normally I put it on the email and I send it to the site agent on the job. I send it to the site agent and to [Engineer B] for filing purposes. And the site agent will pass it on to the contractor. That is closing the circle. So we have got a record of it. And the email is the best way to do it because it is easy to send copies to all the relevant disciplines".

The comments in table 6.9 reflect the responding consulting engineers' preference for email as a means of communication.

All the engineers use email, confirming Fidel and Green's (2004:569) and Hirsh's (2000:484) findings. Engineer G is however rather reluctant to use email and he prefers face-face communication or a discussion via telephone. He would rather get into his car and drive to the client or contractor and sort things out, than communicate through email. Engineer G's reluctance to use email seems to be a personal preference rather than an indication of a specific trend among older engineers since the other older engineers have no problem in using email.

6.2.2.3 Use of libraries by consulting engineers

Libraries can be regarded as an internal source of information in instances where the engineering company has a library available within the company. Since none of the responding consulting engineers have a well organised library available in their companies, libraries are regarded as external sources of information.

The responding consulting engineers were asked about their perceptions and use of libraries although the subject literature reports that engineers do not tend to use libraries (Gralewska-Vickery 1976:281; Ellis & Haugan1997:401; Leckie *et al.* 1996:165-166; Fidel & Green 2004:12; Taylor 1991:227). The question was phrased as follows: "Would you use a library if you had access to one?"

The consulting engineers' responses are presented in table 6.10.

TABLE 6.10

Use of libraries by consulting engineers

Would you use a library if you had access to one?
Engineer A   *(Electrical and electronic engineering)*:   "The library is an unfriendly environment." [Engineer A does not make use of a library or library system to retrieve information].
Engineer B   *(Structural engineering)*:   "We had a proper library ... We have now literally only design codes and product brochures. That type of thing. There is very little other technical information. The library is just a central place where everybody can look and find something."   "There is SAICE, the South African Institute for Civil Engineering, or the Concrete Technology Institute. They have their own library. When I was at … [a construction company] we would use them a lot. That particular library. 'Cause we regularly did things that were different, even at … Then we would use the library. But generally you don't have the time and you want quick information."
Engineers C&D   *(Mechanical engineering)*:   "No." [The engineers maintain that if they need information from a book for one project, the chances are that they will need it again; they will therefore buy the book to provide for their future needs.]
Engineer G   *(Acoustical engineering)*:   I once used library services, but the subscription fees then became too expensive and the use I made of these services did not warrant the cost involved.
Engineer H   *(Civil engineering)*:   "The company has its own little library and I am looking into acquiring the most appropriate software package to organise it." [The library was shown to the researcher and consists mostly of a collection of Codes of Practices and trade literature. It did not appear to contain textbooks or journals].
Engineer I   *(Electrical engineering):*   [The consulting engineering company, of which this engineer was a director before his semi-retirement, has a small library with some books – a shelf for each engineering discipline. There are not that many books that would warrant a librarian to organise them.]
Engineer J   *(Electrical engineering):*

Would you use a library if you had access to one?
I last used a library in 1975. I have never needed a library for books. I have however found a need to get access to technical articles. I have found technical articles through my membership of the University of Pretoria's Academic Information Centre. [This company used to subscribe to the Academic Information Centre and still subscribes to interlibrary loan services. They have not used the service for a number of years and doubt whether they will use it again].
Engineer K   *(Structural engineering):*   "And these two institutions, the Civil Engineers and there is another one the South African Institute of Steel Construction are very well geared up for information. They got [sic] a beautiful library with basically the technical information you need. Not all of it, but I must say most of it is available in their library. And then you can go up there and read it up and some of the items which don't have any restrictions on them, you can actually make copies of."   Asked if he does his own searches on databases or in the library's catalogue he responded with: "Actually I go down there in person and tell them what I want and the librarian does the search for me."

The data in table 6.10 reveals that consulting engineers are fairly reluctant to use libraries.

The responding consulting engineers do not seem to make use of a library nor do they have a properly organised library available in their companies. Engineers B, H and I did refer to the availability of a library within their organisations, but these libraries are merely a central place where specific information sources can be kept and made available to all the engineers in the company. The libraries are also not formally organised. This corresponds with Napp's (2004:250) findings indicating that most consulting engineering firms do not have librarians.

Engineer K (a structural engineer) is the only consulting engineer who reported that he does use a library. He uses the library of the South African Institute of Steel Construction. He normally gets the librarian to do the information searches for him. He did not report when he last used the library. Except for Engineers B, H and I (reported on in the previous paragraph), none of the other responding consulting engineers even mentioned that their individual engineering associations had libraries available for the use of their members.

Ward's (2001:172) survey also did not uncover any consistent patterns of library use. He found that library use was adventitious, and driven by immediate, practical needs. Major complaints related to the unfriendliness of the way the book stock was arranged, and to the absence of articles for loan. These complaints correspond with Engineer A's statement that libraries are "unfriendly places."

Holland *et al.* (1991:333) also indicated that there seems to be little to substantiate the belief that instruction in library or engineering information use has a significant impact either on broadening the frequency of use of information products and sources used by engineering students.

The findings of this study together with the findings made by earlier studies once again support Gerstberger and Allen's (1968:277) statement that engineers will not be attracted to the library by improvements in the quality and quantity of the material contained there. The library must, in a sense come to them.

6.2.2.4 Consulting engineers' use of online databases

Online databases usually provide paid for access to information. It is important to keep in mind that none of the engineers that were interviewed have access to a well organised library in their own organisations. In South Africa however, the

Index to South African Periodicals (ISAP) is available free-of-charge on the National Library of South Africa's (NLSA) website (http://www.nlsa.ac.za). However, journal articles need to be ordered from the NLSA, since the free version of ISAP withholds certain information such as the volume and issue numbers of the journal.

The researcher asked some of the responding engineers whether they would use an online database if they had access to it. These engineers' responses to the question: "Would you use online databases to find information?" is presented in table 6.11.

TABLE 6.11

Consulting engineers' use of online databases

Would you use online databases to find information?
Engineer A *(Electrical and electronic engineering):* Does not use online databases to find information.
Engineer B *(Structural engineering)*: "These guys [the managing directors of the engineering company] won't pay for access; they will pay to download documents that were found for free." "There also is Specifile, you can subscribe to this service and they collect all the technical details of products. But, we have our preferred suppliers and products because they work. I will rather be safe than sorry."
Engineers C&D *(Mechanical engineering):* The opportunity to ask the question did not present itself.
Engineer E *(Electrical engineering):* The opportunity to ask the question did not present itself.
Engineer F *(Asset management):* I am probably supposed to know of it. Is it similar to Sabinet's stuff? No I have not used ISAP. When I start searching for information, then I find what I am looking for. I have never needed to use ISAP ... I didn't know about it. I seriously doubt whether I will ever find information on ISAP unless they organise international stuff. There are not really any other South Africans who can teach

Would you use online databases to find information?
me anything about my subject field.
Engineer G: *(Acoustical engineering):* The opportunity to ask the question did not present itself.
Engineer H *(Civil engineering):* “The one thing that we find very useful is subscribing to the *Daily Tender Bulletin*. There is a company that set it up ... Subscription costs is around R1300 per month.”
Engineer I *(Electrical engineering):* The opportunity to ask the question did not present itself.
Engineer J *(Electrical engineering):* Understands the value of online databases and reckons online databases could be useful but has never used them.
Engineer K *(Structural engineering):* He get access to online databases through the Institute of Steel Construction’s Library. The Librarian does the searches for him – even the searches in the library catalogue, so he does not really know about online databases.

The data in table 6.11 illustrates the fact that engineers do not generally make use of online databases.

Only Engineer H subscribes and uses an online database, the *Daily Tender Bulletin.* Her use of an online database corresponds with Mueller *et al’s* (2006:3) findings that engineers adhere to only one or two paid access resources and are reluctant to explore others. Engineer K probably does get access to an online database at the Institute of Steel Construction’s Library although he does not realise it since the librarian does the information searches for him and provides him with copies of the relevant journal articles. The mere fact that only two out of the eleven consulting engineers that were interviewed make use of online databases, confirms Hurd *et al.* (1992:138) and Leckie *et al.’s* (1996:166) findings that engineers fail to take advantage of electronic information access and retrieval systems. Admittedly none of the responding engineers have access to online databases within their own companies. An exception is the ISAP database which is freely available on the Internet but none of the engineers seemed to know about its existence.

6.2.2.5 Conference attendance for personal development

Since 1 January 2006 all South African professional engineers are required to formally undertake continuing professional development (CPD) activities and are required to prove that they have acquired at least 5 CPD credits per annum to renew their registration as professional engineers (ECSA 2005:15). In view of comments made by Engineers A, B, C and D, J and K, conference attendance is one way of acquiring the required CPD credits. The responding engineers were asked about their perceptions of conference attendance and their responses are presented in table 6.12.

The question was phrased as follows: “Do you attend conferences? How important is conference attendance to you in finding information?”

TABLE 6.12

Conference attendance for personal development

Do you attend conferences? How important is conference attendance to you in finding information?
Engineer A   *(Electrical and electronic engineering):*   I attend conferences since we need to comply with Continuing Professional Development (CPD) regulations.

Do you attend conferences? How important is conference attendance to you in finding information?
Engineer B   *(Electrical engineering):*   “We are now [saddled] with these CPD points. We now have to go to lectures to keep us up to date. You will go to a lecture or a conference or whatever. You need to go to so many per year to keep your professional registration. You get a lot of what is new there, but things don’t change that much.”
Engineers C&D   *(Mechanical engineering):*   We are often invited to attend workshops for continuing professional development purposes. These often have an international speaker from a specific company and they usually address a specific topic.
Engineer E   *(Electrical engineering):*   Not really. Interesting to attend and network, but a catalogue or personal contact with the suppliers is more valuable to find information.
Engineer F   *(Asset management):*   I present many papers at conferences and also do asset management training for companies.   I make contact with prospective clients at conferences and training sessions.
Engineer G   *(Acoustical engineering):*   The opportunity to ask the question did not present itself.
Engineer H   *(Civil engineering)*   The opportunity to ask the question did not present itself.
Engineer I   *(Electrical engineering):*   I do not attend conferences anymore. I do not find the time to do so. I am semi-retired, so it is no longer a part of my job description.
Engineer J   *(Electrical engineering):*   I should attend conferences; especially those aimed at my specific field of expertise, but do not really have the time to do so. Engineers are now required by law to attend conferences and workshops for continuing professional development purposes.
Engineer K   *(Structural engineering):*   “The workshops are quite handy obviously and normally all the guys are quite reluctant to go. Typical[ly] the time thing. But it is handy because technology changed quite drastically. The rate of change is incredible in technology and many aspects of it, the older guys would not understand it. So if it is a high-tech presentation of some structural aspects, I would attend it. Well I have learnt that I am supposed to attend conferences. I will look into that. I think next year in 2008 I need to do something about it.”

The responses in table 6.12 reflect consulting engineers' fairly negative attitudes towards the South African government's ruling that all professionals have to attend conferences.

Engineer E, Engineer J and Engineer K noted that they should attend conferences, but do not really do so. Engineer E finds catalogues are more valuable sources of information than conferences. Engineer F presents papers at conferences and uses the opportunity to liaise with prospective clients as it is a marketing opportunity. Although Ellis and Haugan (1997:397) maintain that participation in conferences is another means for monitoring, Tenopir and King (2004:81) found that engineers considered conference proceedings to be of poor quality and out-of-date when compared to scientific journals.

Only 41,7% of the engineers in Kwasitsu's (2003:467) study regarded conferences as important sources of information. Gralewska-Vickery (1976:273) determined that young engineers want more opportunity at conferences to mix with their experienced colleagues or peers. Studies by Ellis and Haugan (1997:397) as well as Hertzum and Pejtersen (2000:5) determined that engineers use conference proceedings to keep up-to-date. The comments in table 6.12 seem to agree with these findings.

6.2.2.6 Consulting engineers' use of visits to gather information

As indicated in chapter 3, engineering information is not always available in a verbal or textual form. Engineers obtain much of the information they require by analysing and decoding physically encoded information, such as the devices they use in a project, or by direct personal contact with other engineers. Table 6.13 presents responding consulting engineers' views and behaviour regarding visits. Visits could also occur during the preliminary design stage of an engineering project as shown in chapter 5, section 5.3.2.2(d).

The question was phrased as follows: "Do you visit other installations at building sites or factories to find information?"

TABLE 6.13

Consulting engineers' use of visits to gather information

Do you visit other installations of building sites or factories to find information?
Engineer A *(Electrical and electronic engineering):* I visit factories to inspect and test equipment before it is shipped to the site. I view other installations to get ideas. I will collect pamphlets at exhibitions that provide technical information on products which I might need in future. Technology does not change that quickly – the principles remain the same, only the models change. This implies equipment can improve, but the principles according to which they operate remain the same. The information I collected, for example, for television cameras for the … building in 1984 is as relevant today as they were then because the principle according to which the cameras work is still the same.
Engineer B *(Structural engineering):* "I like sites. I started [out] in contracting. Any excuse I get to go to a site, I do. When you design something, someone has to build it. So I like to see the new construction methods, new systems. Because there is quite a lot of change. New ways of supporting, scaffolding etc. And I like to see that before I design. Because if I know they are going to use a certain system to support it I can design it accordingly."
Engineer C&D *(Mechanical engineering):* We visit exhibitions. Most exhibitions include presentations by suppliers or manufacturers. We do visit other installations to see what other engineers do. We acquire a lot of information from viewing other people's work. You see a different way of doing something. When we have a specific need, we will go walking about to see what

Do you visit other installations of building sites or factories to find information?
has been done – especially if it is something new or something rare. You also see what you should not do.
Engineer E *(Electrical engineering):* Only to learn what not to do. Or how to do it when it is a special project – not an important source of information.
Engineer G *(Acoustical engineering):* He visits factories and loves to attend presentations by manufacturers to get new ideas and debate issues: "... Some of the guys working in the sound system industry and in building material use basically imported products. These guys often bring an expert from their international suppliers to come and do a presentation. They would then invite the consultants to such a presentation or organise a special presentation for consultants. I make a point of attending those sessions."
Engineer H *(Civil engineering):* "I will visit sites." [The pipejacking project described by this engineer was a first in South Africa and a groundbreaking project – so there were no sites she could visit.]
Engineer I *(Electrical engineering):* I will still try to attend security exhibitions.
Engineer J *(Electrical engineering):* Visits to similar installations are valuable when I do a project for the first time, for example when I designed a security system for a jail. But if you have seen one, you have seen them all. Visits to factories to see how a product is manufactured can be valuable, especially when I was a young engineer. Now I will only visit factories to test equipment to ensure that they are ready for installation.
Engineer K *(Structural engineering):* "It is normally advisable. In engineering you do ... But we didn't go into that at the library[project]."

The data in table 6.13 illustrates the importance attached to site visits and visits to factories as a source of information to satisfy consulting engineers information needs.

The responding engineers visit various types of installations, building sites and factories for different reasons.

- Factories are visited to inspect equipment to ensure that the equipment complies with the specifications and is ready for installation before it is shipped to the construction site. This supports Gralewska-Vickery's (1976:272) findings in this regard.
- Factories are also visited to see how a product is manufactured. This agrees with the WFEO/CEI's (1979:9-10) findings that visits provide engineers with information on the technical level and production organisation in the factory they have visited. Engineer J indicated that this was particularly valuable to him as a young engineer but that he no longer pays such visits.
- They visit similar installations when doing a project for the first time to assess methods and equipment. This is in accordance with Gralewska-Vickery's (1976:272) findings that visits are conducted to assess equipment.
- They attend the presentations given at exhibitions to get new ideas and debate certain aspects. This agrees with Gralewska-Vickery's (1976:272) findings that visits are a way of finding out what is going on.

As in the case of the use of engineering software, the two older engineers no longer regard visits to factories and exhibitions as an important source of information.

6.2.3 Consulting engineers' use of interpersonal communication and social networking

As pointed out in chapter 3, interpersonal communication and social networking could be viewed as examples of the invisible colleges, reference or work teams that form part of the various systems that influence the users' information needs as illustrated in Paisley's (1968) Framework of the Scientist within Systems. It was shown that engineers have a need to acquire information and convey their knowledge through interpersonal communication. It is therefore seen as a characteristic of their information needs. Engineers also use personal communications and networking as part of their patterns of information-seeking since various studies have reported engineers' preference for personal contacts as sources of information. These studies include research by Aguillar (1969), Anderson *et al.* (2001:13-14), Case (2002:237), Case (2007:255), Hertzum (2002:2), Hertzum and Pejterson (2000:2), Holland *et al.* (1991:319), Holland and Powell (1995:255), Katz and Tushman (1979); Kremer (1980:124), and Taylor (1991:228). Personal contacts could be made within the engineering company or outside it, that is, they could be viewed as internal or external sources. The responding engineers were asked about the role interpersonal communication and social networking plays in providing them with information. Their responses are presented in table 6.14.

The question was phrased as follows: "How important are personal contacts and a social network in finding information to you?"

TABLE 6.14

Consulting engineers' use of interpersonal communication and social networking

How important are personal contacts and a social network in finding information to you?
Engineer A *(Electrical and electronic engineering):* I email or phone personal contacts for information.
Engineer B *(Structural engineering):* "It is literally networking. I often speak to the people in the office. They will say no they don't but please phone this guy, he will know. And so it goes on. Or you can, if it is very different, you can also look at the Internet just to find similar information … from a design point of view I would personally go to speak to people that I know through networking."
Engineer C&D *(Mechanical engineering):* Very important: client, suppliers, contractors, architects and other consultants – these contacts often result in more work (contracts). We will approach other engineers if they experience problems, simply because the engineer we approach is more experienced or has a different reference framework.
Engineer E *(Electrical engineering):* The one knows of the other. I received a call, for example, from a company in ... who wanted extra power at their workstations. When I asked them where they got my name from, they replied that they had contacted the supplier of the generator they had bought and the supplier advised them to contact me. Sometimes it is a client that remembers you after a number of years. I receive calls from old clients asking whether I still remember them.
Engineer F *(Asset management):* I have a lot of personal communication with clients.
Engineer G *(Acoustical engineering):* You need to hear from the client and the other team members what their needs are and in which direction they are moving. A different type of communication through mediation of the client is especially important when we are busy with a noise impact study. I may be different from my colleagues. I love one-to-one communication, face-to-face communication. If the project warrants it, I will easily drive to Johannesburg to see someone and discuss the aspect in detail with him rather than trying to sort it out over the telephone.
Engineer H *(Civil engineering):* "I became aware of it through acquaintances that I knew from the industry and an elderly gentleman as well. I tend to know who to contact."

How important are personal contacts and a social network in finding information to you?
"I have been exposed to quite a few people who have been around for a long time and they are very eager. I don't know whether it has something to do with being a female in the industry that they have taken how serious I am about this with an interest in making sure, that one tends to excel and want to know about this and stuff. But whenever you do tend to contact them, they never ever [answer in the negative]. If they can't give you the information they always refer you to someone else." "I tend to know who to contact."
Engineer I *(Electrical engineering):* Engineer I did not indicate any specific networking practices.
Engineer J *(Electrical engineering):* We will phone different suppliers for product prices.
Engineer K *(Structural engineering):* "Well, it is very important. Look, I have worked for quite a long time with other engineers as well. And sometimes to get other engineers' opinion gives you a better insight into the problem. So it is quite important to keep contact with your old mates. Because we help each other out."

The data in table 6.14 shows how important personal contacts and social networking are for consulting engineers.

Engineer E indicated he has a relationship with his suppliers as well and Engineer K stressed the importance of keeping contact with "your old mates." These comments are in agreement with a comment made by one of Fidel and Green's (2004:570) interviewees: "We have developed a pretty nice little network, and actually a lot of us are friends …." These business relationships are examples of intensional networks. The term "intensional" denotes the effort and purposefulness with which people construct and manage personal networks. Nardi, Whittaker and Schwarz (2000:3-4) describe them as "egocentric" networks that arise from individuals and their communication and workplace activity.

Engineer G prefers personal (face-to-face) contacts with suppliers of equipment and technology to any other method of exchanging technical information. This preference for personal contacts is in agreement with Ellis and Haugan (1997:397), Hirsh (2000:484) and Wheeler's (2004:3) findings which emphasise the importance of contact with suppliers of equipment in the exchange of technical information. As indicated by Ellis and Haugan (1997:399) the reason for this could be the time-saving aspect. Personality as a factor could also be linked to Engineer G's preference for personal contacts. Tidwell and Sias's (2005:22) study provides added theoretical grounding concerning the specific links between personality traits and information-seeking behaviour. This is a facet of usage behaviour which requires further investigation by a qualified researcher.

Two other very important reasons for personal communications is that a colleague's memory often is the only access point to filed documents, and that context information (i.e. information which pertains only to the specific task) must be obtained from people (Ellis & Haugan 1997:399; Fidel & Green 2004:574; Hertzum & Pejtersen 2000:10).

The study by Johnson (2004:15) which investigated the relational factors associated with the choice of people as information sources determined that the characteristics that are most strongly associated with personal information sources are predictive of who is chosen as an information source. Johnson's (2004) study also suggested that there are factors other than least effort that explain the preference for people as sources of information.

6.2.4 Consulting engineers' use of mentors to gather information

Mentorship could influence consulting engineers' selection of information sources. Mentorship has been found to be an important element in engineers' information communication networks (Tenopir & King 2004:86). Senior engineers seem to take responsibility for younger engineers' training. Engineer H stressed the importance of mentorship in her career as a consulting engineer. Mentorship is also a form of personal contact and social networking. No formal question was asked on mentorship, but three of the responding consulting engineers spontaneously reported their views on mentorship. These views are summarised in table 6.15.

TABLE 6.15

Consulting engineers' use of mentors to gather information

Three spontaneous reports on personal views of mentorship
Engineer E *(Electrical engineering)*: Young engineers will often come to ask you for information. I am now the specialist [the mentor] in the company. It is much easier [for the young engineers] to ask you for some information and then I give it to them.
Engineer H *(Civil engineering)*: "Someone that can guide you and give you the information with all those years of experience and stuff." "Fortunately in my career I actually have learnt from the best. I had as a mentor …" "I also learnt of a gentleman called … who was part of the arbitration committee and stuff. And he was very clued up on contract documents. So I basically had very good grounding in so far as I had learnt from the best in the country at the time. And they sort of took it upon themselves to make sure that I excelled in certain things. And that was great. The point I also want to make is, no matter what you learn in textbooks, no matter what you get on the Internet and stuff, in the engineering environment, the best teacher remains a good mentor." "The junior people place too much emphasis on packages of design software and stuff like that and they forget the first principles and they forget the ground and the basic stuff you know that they would have acquired during their formal training. And they do not ask the relevant questions as a result of that because

Three spontaneous reports on personal views of mentorship
they are sort of sitting there and everything is behind that black box and they automatically take as God for which is so wrong. So that's [the] thing I am currently faced with. In fact we are going through a major training initiative." [Engineer H employs semi-retired engineers to mentor the young engineers in her company. Engineer K is one such engineer in her employment].
Engineer K *(Structural engineering):* "Basically my intention now because I am on my way out, I am trying to pass on my info as much as possible to other guys in the next generation. Because you help them to get their personal and professional files in order. It is very helpful for them. So basically it is one of my jobs here. So pass it on. You can't load it down in one shot. It takes time to be digested. As the problems come up you pass it on to the person [it] is more important for him to understand it."

The views on mentorship shared by the three engineers summarised in table 6.15 shows that senior engineers have a wealth of experience and knowledge to pass on to younger engineers.

Engineer H indicated her reliance on mentors and the important role mentors played in her career as a young and inexperienced engineer – this was at the time she was involved in the pipejacking contract. She so strongly believes in mentorship that she employs semi-retired engineers (of which Engineer K is one) to mentor the young engineers in her company. Both Engineers E and K referred to their roles as mentors. This is in agreement with Gralewska-Vickery's (1976:262) findings that senior engineers are often responsible for the training of personnel.

6.3 FACTORS INFLUENCING CONSULTING ENGINEERS' INFORMATION-SEEKING

Consulting engineers' awareness of information influences their information-seeking behaviour. Other factors include the trustworthiness of the source, its cost and time, the time required to access it, its availability and accessibility versus the quality of information.

6.3.1 Consulting engineers' general awareness of information

As explained in chapter 2, section 2.5.4.3 and chapter 3, section 3.5.3, awareness of information could influence engineers' information-seeking. Leckie *et al.* (1996:184-185) point out that knowledge of information sources and the perceptions formed about the process, or about the information retrieved, play a crucial role in the information-seeking process. The individual engineers' awareness of information sources can determine how the engineer will go about seeking information. Trustworthiness, familiarity, packaging, timelines, cost, quality and accessibility are factors that could potentially influence engineers' awareness of information (Leckie *et al.* 1996:185). Engineers' general awareness of potential sources of information and their requirements in respect of the information content can be added to these factors.

Engineering information is everywhere. Engineer J stated that information sometimes appears from nowhere and from an unexpected source, such as a magazine which is not work-related. He provided an example of finding a Voiceover-IP exchange diagram in an in-flight magazine which is the same model he was using in a different project. This is similar to Kremer's (1980:125) findings where respondents found an item of information by chance. If possible, Engineer J tears the relevant page out and places it in a 'go file' which he can consult at a later stage when he needs the particular information. Engineer F indicated a similar behaviour pattern.

Engineer B also reported a similar pattern of behaviour to that of Engineer J (reported in section 6.2.1.4, table 6.4) claiming to "… pick up [information] by glancing at the journals…" This awareness of information not only resembles Ellis's monitoring mode but also Aguillar's undirected viewing mode referred to in chapter 2.

As pointed out in chapter 2, an individual engineer's general awareness about information sources and, or requirements in respect of the content thereof can determine the path that information-seeking will take. It could take the form of browsing journals of a specific year to find an article as in the case of Engineer F, as shown in table 6.4 or contacting a specific person as in the case of Engineer H, as illustrated in table 6.14. Some of the factors identified by Leckie *et al.* (1996:185) as influencing engineers' awareness of information are trust, cost, time, accessibility, availability and the quality of the information.

6.3.2 Trustworthiness as a factor in the selection of information sources

Consulting engineers were not asked to share their views on the trustworthiness of a source but a few engineers did comment on how trust would affect their selection of information sources. Comments made by the engineers such as "…then you would rather use old trusted sources" (Engineer B in table 6.16) and "... we have our preferred suppliers …because I know from my experience every time I have used them they have worked" (Engineer B in table 6.5). Engineer G's tendency to use his "…personal collection of copies of articles from subject journals which I collected …" could be an indication that the source is a trusted one, but could also be that these sources were easily accessible or that Engineer G was unaware of newer and perhaps more relevant sources of information. These comments correspond with Hertzum's (2002:12) findings indicating engineers' preference for internal information sources could be a preference for sources that are easily accessible. It could also be a preference for sources of information that are trusted by the engineers to be reliable and relevant.

6.3.3 Influence of cost and time on information source selection

As pointed out in chapter 3, the most frequently cited barrier for seeking both oral and written information is cost or time. These also are factors that could influence engineers' task performance (Fidel & Green 2004:568) since information-seeking among engineers is generally in response to very specific problems or projects to which they seek immediate answers (Mueller *et al.* 2006:2). The responding consulting engineers were asked about how cost and time influences their selection of information sources. The question was phrased as follows: How does cost and time influence your use of information? Their responses to the question are summarised in table 6.16.

TABLE 6.16

Influence of cost and time on the selection of information sources

How does cost and time influence your use of information?
Engineer A   *(Electrical and electronic engineering):*   Engineer A: Cost = Time and Time = Income. This engineer will not buy expensive information sources for a small project. But, he will buy information if he is doing research for a big project or if the information source contains information which could be valuable for his continuing professional development.
Engineer B   *(Structural engineering):*   "These guys [referring to the directors of the consulting engineering company she is employed by] will not allow you to use paid for library systems. If you can get the information freely available, then we can use it and the company will pay for the download of the document. I, myself would not pay a yearly fee for information. If I know the information is there, I will pay for it. But I first want to find the information before I pay for it."   "Time is limited and you are not paid to gather information, you are supposed to know everything. You have a cost limitation and these impact on the amount of time available to gather information."   "But generally you don't have the time and you want quick information. Usually because of time. Time does not allow you 6 months for research. Usually you have a day at the most to find information. It is quicker to pick up the phone and phone somebody or do a quick search on the Internet or physically go somewhere to find the information."   "If you have two days to analyse, then I would look at newer sources. If you have a few hours, then you would rather use old trusted sources. Sometimes the older sources are simpler and more general which is generally enough. Newer sources often tend to be more complicated and tend to go into more depth."   [Even if Engineer B can access a database like ISAP which is available free of charge, it is unlikely that she would use it because of the time delay between requesting an article from the National Library and receiving the article.]
Engineers C&D   *(Mechanical engineering):*   The opportunity to ask the question did not present itself.
Engineer E   *(Electrical engineering):*   He will not buy books or information for a project. Books are in any case based

How does cost and time influence your use of information?
on old principles. The basic technology remains the same, the product changes and for that you need brochures and catalogues. You must spend the time to find the right information at the design stage. If you leave any grey areas, you will be caught at some stage.
Engineer F *(Asset management):* The opportunity did not present itself to ask the question.
Engineer G *(Acoustical engineering):* The opportunity did not present itself to ask the question.
Engineer H *(Civil engineering):* The opportunity did not present itself to ask the question.
Engineer I *(Electrical engineering):* The opportunity did not present itself to ask the question.
Engineer J *(Electrical engineering):* This engineer finds it very frustrating when he finds valuable information on the Internet for which he is required to pay. Often he only needs very little information from that document, and not the whole mathematical calculations as to how the author arrived at the solution.
Engineer K *(Structural engineering):* The opportunity did not present itself to ask the question.

The data summarised in table 6.16 shows how critical cost and time are in consulting engineers' working day and the effect it has on their selection of information sources.

The responding engineers in this study were not specifically asked on how time influences their information-seeking behaviour, but Engineer B's comment "if you have two days to analyse, then I would look at newer sources. If you have a few hours, then you would rather use old trusted sources" (table 6.16) is an indication of how time influences engineers' ability and willingness to seek new information. Research findings by Hertzum (2002:2), Hertzum and Pejtersen (2000:6), King and Griffiths (1991:369), Morrison and Vancouver (2000:4), Sandstrom (in Jacoby

2005:259-260), and Ward (2001:171) show that the time engineers are willing to spend acquiring and reading information found in documents is an indicator of the value of that information.

The research findings by Rosenberg (1967:125) and Leckie *et al.* (1996:167) indicate that engineers will sacrifice quality to minimise the cost of acquiring information. These findings do not seem to apply to the responding consulting engineers. Some of the engineers indicated a willingness to buy new books and search the Internet for information when new information is needed. Engineer B's comment "Virtually if I need to find information I will find it from these two books or from course materials …" (table 6.3) and "things don't change that much (Engineer B in table 6.11) best summarises engineers' reasons for not acquiring new sources of information when starting a new project – they don't need newer information to successfully complete their projects. Newer information sources such as books and journal articles do not necessarily mean better quality, since they "… often tend to be more complicated and tend to go into more depth" (Engineer B in table 6.16) than what is required for the completion of the project The engineers simply don't have the time to study the newer sources for information which is already available in their older and trusted sources. This perception in regard to newer sources is reflected in Anderson *et al's* (2001:148) findings indicating that the primary determinant for selecting an information source was the perceived importance of the source to the user's work.

6.3.4 Availability and accessibility versus quality of information

The responding consulting engineers were not asked to indicate whether the accessibility and quality of an information source influenced their decision to select a specific source. However, it appears that these factors did not play a role since the engineers indicated that the availability or accessibility of information did not prohibit them to successfully complete their tasks. The claims made by the responding consulting engineers that basic engineering principles have remained the same implies that the engineers can rely on their “engineering judgement” and need not seek alternative sources of information. This is supported by the explanation offered by Wolek (1969:473) indicating that engineers’ empirical work does not encourage the continual integration of new ideas. It seems as if the specific factors (such as tasks, cost, time, trustworthiness and availability) that motivate an engineer to prefer one source over another can also be associated with the reason for engineers’ perception of the quality of the information source (Fidel & Green 2004:572, 580).

Research has repeatedly reported on engineers’ reliance on oral communication and information sources internal to their organisation (Hertzum 2002:9). The generally agreed-upon explanation of this finding is that engineers follow a principle of least effort by choosing their information sources on the basis of ease of access rather than the quality of contents. However, Hertzum (2002:9) argues that engineers’ preference for information conveyed by their colleagues within their own companies or employing organisation is just as much a preference for internal sources with a known or easily determinable trustworthiness as it is a preference for information that is easily accessible.

6.4 OUTCOMES OF INFORMATION USAGE BY CONSULTING ENGINEERS

As indicated in chapter 3, engineers' information-seeking culminates in the completion of a tangible project or report or in providing a service or product. The outcome represents the ending activities involved in the information-seeking process.

The target procurement stage analysed and discussed in chapter 5, section 5.3.5 is one of the outcomes of engineers' use of information. Another result could be the publication of documents or articles reflecting on the history of the project or discussing design aspects of the project in which the consulting engineers were involved. As pointed out in chapter 1, section 1.1, research findings reported in the literature indicate, however, that engineers tend not to publish information on engineering projects and that a vacuum exists in the production and effective dissemination of technical information. The publication of information on engineering projects is an example of consulting engineers being able to find the time and the need to communicate engineering information with other engineers.

Some of the responding engineers spontaneously stated that they would occasionally publish information on a project they had completed. Table 6.17 summarises their comments in response to the question, "Do you publish information on or about a completed projects?"

TABLE 6.17

Publications on completed projects

Do you publish information on or about a completed project?
Engineer A *(Electrical and electronic engineering):* We [i.e. Engineers A and J] will publish brochures on the history of a big project, including photographs of the projects' development. We have also published articles on a project, but last did this in 1996 after the completion of a water transfer project.
Engineers C&D *(Mechanical engineering):* We write articles on projects in which we provide detailed information on the project. We think it is selfish to mankind if you think you have an innovative way to do something and refuse to share it. No design is a secret and most consultants will be able to design the same or similar systems. We are not in the market to patent a product.
Engineer F *(Asset management):* I do a lot of training. I just do it. I am the entertainer for a group of people and must teach them a number of things. And that is the biggest percentage of my work. But then, in most cases, I get consultation work from these presentations.
Engineer J *(Electrical engineering):* Sometimes, at the end of the project, we [i.e. Engineers A and J] would publish a small document relating the history of the document. The information contained in that document often is priceless. The Water Board recently needed information on the 1996 project and the document published at that time provided the required information. I needed to go to ... in Randburg. There was a reporter from a technical journal who took a few photos and needed some information for a small article they were going to publish on the project.

The data summarised in table 6.17 illustrates the consulting engineers' positive attitude to publishing their work either internally or externally.

As indicated in chapter 1, information is not available in written form unless someone has felt a need to write it down and spent time doing it (Hertzum & Pejterson, 2000:7). A spontaneous comment made by four of the responding consulting engineers confirms this statement. Engineers A and J publish a brochure after the completion of some projects. These publications are then handed out to all the persons that were involved in the project, but these publications are never made available to a wider audience. Engineers C&D will write and publish an article on the design of a completed project. Engineer F does a lot of training on asset management. This is not really publishing, but is a form of information dissemination which is used by Engineer F to market his consulting services.

6.5 CONCLUSION

This chapter analysed and discussed the comments made during interviews with responding consulting engineers to explain how information sources are used by the consulting engineers. It also showed how the consulting engineers' awareness of information influences their information-seeking behaviour. Trustworthiness, cost and time, availability and accessibility and quality also exert an influence on the selection of information sources. The focus of the empirical investigation was the types of information sources used by consulting engineers. A distinction was made between internal sources of information (i.e. personal knowledge, codes of practice, books, technical journals, trade literature, engineering software packages, and digital cameras) and external sources of information (i.e. the Internet, libraries and online databases, conferences and visits).

As far as internal sources of information are concerned, consulting engineers' appear to rely on their personal knowledge and personal memory for information. The analysis of the text-based sources of information used by consulting engineers indicates that codes of practice and trade literature are very important sources of information. Books, though important, are not used as much by the consulting engineers as codes of practice and trade literature. Technical journals seem to be perceived as the least important source of information.

Digital sources of information used by the consulting engineers are software packages and digital cameras. The use of software packages is determined by the project in which the engineers' are involved. The two older engineers, Engineer E and Engineer K indicated that they do not use software packages and prefer to leave the use of software packages to their younger colleagues. Digital cameras are often used by consulting engineers to collect engineering information from their project sites, and these could be used at a later stage again if the engineer is involved in retrofit projects, such as the water transfer scheme described by Engineer J.

The current study indicated that the Internet and email are important external sources of engineering information. Only Engineer G indicated his reluctance to use the Internet and email. The rest of the consulting engineers seem to use email often to communicate information with their professional team members on a project and to acquire information for a project. Consulting engineers' use of FTP sites to communicate project-related information is an interesting development which warrants further research.

Other external sources of engineering information include libraries, online databases, conferences and visits. However, the empirical study indicates that responding consulting engineers do not seem to regard libraries and online databases as important sources of engineering information. The engineers attend conferences, but this seems to be because they are required to do so to comply with the stipulated continuing professional development (CPD) regulations set by the Engineering Council of South Africa (ECSA). Visits to exhibitions and factories are regarded as important sources of information.

As far as the use of interpersonal communication and social networking are concerned the empirical findings correspond with findings reported in the literature indicating that these are very important sources of engineering information. Mentorship is also a form of interpersonal communication and the study indicates the value of mentorship in communicating engineering information to fellow engineers.

Factors that could affect consulting engineers' information-seeking reported in the study are an awareness of information, trustworthiness, timeliness and cost, and the availability or accessibility and quality of information. The findings indicate that packaging or format could be an important factor influencing engineers' use of information sources. Cost and time seem to be a barrier to accessing information sources. These findings correspond with the findings reported in the subject literature. These factors were not studied in the same detail as the sources of engineering information and the findings of a future study might differ.

An interesting aspect that was commented on by consulting engineers, and about which no evidence in the literature could be found, is that the basic engineering principles have not changed despite technological changes that are noticeable in society.

The findings show that the target procurement stage as the final stage in an engineering project, is one of the outcomes of consulting engineers' information-seeking. Some consulting engineers also published articles or little brochures on their projects while one consulting engineer does a lot of training.

Chapter 7 will conclude this study by providing a summary of the research methodology and the empirical research findings. Recommendations for an Internet-based information system for consulting engineers as well as recommendations for future research will also be made.

CHAPTER 7

CONCLUSION

7.1 INTRODUCTION

The purpose of this study was to determine the specific information needs and information-seeking behaviour of consulting engineers in South Africa within the context of their work roles, tasks and individual characteristics. Knowledge about the specific information sources they use to complete their various projects could be applied in the development of a unique information system to meet the information needs of consulting engineers.

Certain statements were made in chapter 1 regarding the unique information needs and information-seeking behaviour of engineers. These suggested that there is a lack of freely available documented engineering information. Consulting engineers are also more dependent on their own information sources and alternative information resources such as colleagues, bookstores and the Internet to meet their information needs than on formal sources of information.

The study was based on the following research problem formulated in chapter 1:

> What are the information needs and information-seeking behaviour of consulting engineers, and what are the factors that influence or shape their information needs and information-seeking behaviour? This problem was then divided into two sub-problems. These were:

1. How does the individual consulting engineer's work role and engineering task influence his or her information needs and information-seeking?

1.1 What are consulting engineers' work roles?

1.2 How do engineering tasks influence consulting engineers' information needs and information-seeking?

1.3. What are the characteristics of consulting engineers' information needs and how does it influence or shape their information-seeking?

2 What are the factors that influence consulting engineers' information-seeking behaviour and how do these factors affect the outcomes of information-seeking?

2.1 How do the factors related to various types of information sources affect consulting engineers' information-seeking?

2.2 How does an awareness of information sources, perceptions of the value of the information sources and the types of information required influence the consulting engineers' information-seeking?

2.3 What are the outcomes of engineers' information-seeking?

These research questions were addressed theoretically and empirically in order to make recommendations for the design of an Internet-based information service. A further purpose was to develop a model of the information-seeking behaviour of consulting engineers.

7.2 THEORETICAL APPROACHES TO A STUDY OF THE INFORMATION NEEDS AND INFORMATION-SEEKING BEHAVIOUR OF ENGINEERS

The first theoretical question which needed to be addressed was the selection of an appropriate research model to provide the context for the study. Various research models were used to study the information needs and information-seeking behaviour of different types of users mainly in work-related contexts in chapter 2. The General model of professionals' information-seeking developed by Leckie, Pettigrew and Sylvain (1996) provided the basic framework for a discussion of research findings reported in the subject literature on the information needs and information-seeking behaviour of engineers in general in chapter 3. The model was slightly adapted and used to systematise the collected data in chapters 5 and 6. It also enabled the researcher to study the consulting engineer as an information user or information seeker within the context of their work roles and tasks and various other factors that influence their information needs and information-seeking behaviour.

Certain information behaviour models highlighted various aspects that were important for this study. These models are Aguillar's (1967) Modes of environmental scanning, Paisley's (1968) "Scientists within systems", Sandstrom's (1994) Optimal foraging theory, and Ellis' (1989) Model of information-seeking behaviour. Aspects that are important in the models used, include the different ways people scan their environments for relevant information, browsing techniques that are generally used, how people seek information from a variety of sources as well as social networking theories.

One common element in all the information behaviour models is that a knowledge gap leads to an information need and has information-seeking behaviour as a result to enable the engineer to complete his or her task and move on. The uses the information is put to, can then be interpreted as the outcomes of the information-seeking.

Dervin's (1983) Sense-making approach rests upon the abovementioned premise, namely, that tasks requiring information lead to an information need (a gap in the engineers' knowledge base) which has information-seeking as a result. Since specific information is required to complete the task, the task is a determinant of the information that is needed and of the information source that would provide the answer to the problem.

The theoretical study provided the point of departure for the empirical investigation of the information needs and information-seeking behaviour of consulting engineers as determined by their work roles and tasks, the factors that affect their information needs and the factors associated with the sources of information, their awareness of information, and information requirements and the outcomes of their information-seeking.

7.3 RESEARCH FINDINGS

A qualitative research approach was adopted for the empirical investigation since the purpose of the study was to acquire an in-depth understanding of consulting engineers' information needs and information-seeking behaviour.

Dervin's (1983) Sense-making approach was selected to analyse the information gathered during the empirical investigation in chapters 5 and 6. In addition, the Sense-making approach provides a theory of how to conduct in-depth interviews with respondents.

Interviews and more specifically micro-moment time-line interviews were selected as the most suitable qualitative method for data collection. The time-line interviews were based on the different stages in an engineering project according to the stages set by the Engineering Council of South Africa (ECSA). These stages not only guided the interviews, but also provided the structure for the analysis of the different engineering tasks.

A combination of snowball sampling and convenience sampling was used to select the interview sample. Eleven engineers located in Central and North Gauteng who do not have a formal library or information service available within their individual companies participated in the study. The engineers represented different engineering disciplines, genders and age groups. More men than women and more older than young consulting engineers took part in the interviews. This seeming imbalance between the sexes and age groupings is in fact representative of the consulting engineering fraternity in South Africa.

The empirical study involved an in-depth investigation into the characteristics or nature of consulting engineers' information needs and the factors that influence their information needs and preferences for specific information sources and systems, their use of information, the outcomes of their information-seeking and their information-seeking patterns.

The findings from the empirical study shed light on the two sub-problems and their related questions.

7.3.1 Consulting engineers' work roles and tasks

The first sub-problem pertains to the individual consulting engineer's work role and engineering tasks and how it influences his or her information needs and information-seeking behaviour.

7.3.1.1 Consulting engineers' work roles and information needs

An analysis of the participating consulting engineers' comments on their work roles indicated that they are professionals who are regarded as experts in their subject field and who advise their clients on engineering projects. They have nothing to sell but their time and knowledge. These findings are consistent with the definitions provided by Gralewska-Vickery (1976) and the Engineering Council of

South Africa (2007) indicating that consulting engineers advise their clients and communicate with fellow engineers, contractors and clients.

The findings show that the advisory role of consulting engineers requires them to design and manage an engineering project to the satisfaction of the client. The findings also show that consulting engineers can further be involved in more than one project simultaneously. This implies that a consulting engineer could be working with different professional teams, contractors and clients at any point in time in his career. The consulting engineer therefore continuously requires and uses information from a variety of sources. The consulting engineer might even seek similar information from different sources of information since the context of the information need is different.

7.3.1.2 Engineering tasks and information needs

The question on how engineering tasks influence consulting engineers' information needs and information-seeking required an analysis of engineering tasks which needs to be completed at various stages of an engineering project. These tasks are embedded in the consulting engineers' work roles. The research findings show how the stage in an engineering project determines the tasks. For example, tasks related to the preparation and evaluation of tender documents are completed during the tender stage while tasks related to overseeing the construction of the project forms part of the construction stage. Tasks and their related information needs were analysed in tables 5.1 to 5.5.

A selection of twenty tasks and related information needs are summarised in table 7.1 to illustrate how the stages in an engineering project determine the tasks which need to be completed. It also illustrates how engineering tasks lead to information needs and give rise to information-seeking to bridge the cognitive gaps in consulting engineers' knowledge and, in so doing, enable them to continue to the next task.

TABLE 7.1

Summary of consulting engineers' tasks and information needs

Project stage	Tasks	Information needs
Stage 1 – Reporting stage.	1. Determine the type of foundation. 2. What is the structure going to support? 3. What are the mechanical requirements in terms of floor space?	1. Geotechnical report on soil conditions. 2. Architect's drawings, clients' information on the planned use of the building. 3. The buildings' air conditioning requirements.
Stage 2 – Preliminary design stage.	4. Determine the structure of the building. 5. Noise control in a building. 6. Design electrical services. 7. Completion of contract documents. 8. Do costing for pretender estimates. 9. Submit preliminary design to client for approval.	4. The architect's requirements and design. 5. What building material is used to construct the building? 6. What does the sketch plan of the building look like? How many offices are there? 7. What information needs to be included in contract documents? 8. How much does a specific product cost? 9. Preliminary design report.
Stages 3 and 4 – Design and tender stages.	10. Complete final design. 11. Provide budgeting information to QS.	10. What structural steel will be used? How many piles will there

	12. Compile tender documents. 13. Do tender evaluation. 14. Coordinate design with the designs of other engineering disciplines.	be? 11. What are the different products' specifications? 12. What information needs to be included in tender document? 13. Tender documents 14. What are the other disciplines' requirements?
Stages 5 and 6 – Working drawing and construction stages.	15. Monitoring construction. 16. Evaluate specifications of alternative products offered by contractor.	15. Construction site information. Building programme. Engineering judgement. Digital cameras to record progress. Concrete cube test results. 16. Factory test results
Stage 7 – Target procurement stage.	17. Complete as-built drawings. 18. Commission systems 19. Report on system's compliance. 20. Is task complete? 21. Were designs effective?	17. As-built information. 18. System test results; 19. Equipment test results 20. Design and equipment test results.

The findings of the empirical research reflect Dervin's Sense-making assumptions already mentioned in section 7.2 above. The findings also reflect the statements made in the definition for information needs in chapter 1. The definition stated that information needs arise when an individual senses a problematic situation or an information gap and that information needs then lead to information-seeking and the use of specific sources of information. The findings on the required sources of information to satisfy these needs are discussed in 7.3.3.1.

Consulting engineers' information needs and therefore their information-seeking are most intense in the initial phases of an engineering project when both formal and informal information channels are utilised. Consulting engineers also need more information on a project from a greater variety of sources during the preliminary design stage than they require during the target procurement stage. Engineer A (an electronics engineer) also explained how engineers' information needs become more specific as the project progresses. These findings and Engineer A's explanation correspond with relevant research findings reported by Byström and Järvelin (1995), Ellis and Haugan (1997), Vakkari (1998:375), Vakkari (2001a:452), Vakkari (2001b:44).

The findings on how tasks give rise to information needs also corresponds with the definition for tasks in chapter 1, section 1.7.5 where tasks are regarded as instructions to perform certain activities to achieve a specific goal.

7.3.2 Factors influencing consulting engineers' information needs

There are various user-related factors that influence information needs. The characteristics of consulting engineers that influence their information needs are their individual attributes and circumstances (including particular demographic factors) on the one hand, and various project- or task-related factors, namely, context, frequency predictability, complexity and importance, on the other.

7.3.2.1 ***Attributes and circumstances of consulting engineers***

An attempt was made to determine whether consulting engineers' age, engineering discipline, gender and geographical location can influence their information needs.

a. Age

There are no differences in the information required by consulting engineers of different ages to complete their various tasks in an engineering project. However, there does seem to be a difference in the sources that are used by consulting engineers of different ages. The older and more experienced engineers, in terms of the number of projects they have completed during their careers, tend to rely more on their personal knowledge and are less inclined to use design software than younger engineers. These findings correspond with the findings of Ellis and Haugan (1997) and Gralewska-Vickery (1976).

b. Engineering discipline

The engineering discipline does not seem to have an effect on the types of information sources that are selected by consulting engineers. All the engineers preferred personal contacts, codes of practice, and trade literature at similar stages in their projects. However, the actual source of information could be different for each engineering discipline. For example, each engineering discipline has its own codes of practice and regulations. These are also different for different countries.

c. Gender

The present study did not uncover any gender differences in the types of information required by male and female consulting engineers. However, it should be noted that only two women participated in the study. A different study involving more women could result in different findings. The study by Kreth (in Tenopir & King 2004:86) found gender differences in the writing skills of engineers, but more studies are required to confirm the research findings.

d. Geographic location

As previously indicated, all the participating consulting engineers were from the same geographic location. The assumption was that consulting engineers from other geographical regions would have similar information needs than those who participated in the study. Some of the engineers described their involvement in the same project while others described their involvement in projects which were geographically located far from their companies' offices. The findings indicated that the information needs and information-seeking behaviour of both groups of consulting engineers were similar for the different stages of their projects. This seems to indicate that the assumption regarding geographical location was valid.

However, consulting engineers' preferences for specific sources of information can be influenced by geographic location. For example, the structural engineers use different codes of practice when they design a building in an area where hazardous weather conditions, such as cyclones, could threaten the safety of the building compared to the codes they normally use in areas not threatened by cyclones. This influence that geographical location has on the selection of information sources is similar to the influence that context and tasks have on the selection of sources.

The different geographic locations of particular projects seem to influence the ways in which the information is communicated. Those consulting engineers who are managing projects in distant locations rely more on faxes and digital photographs to communicate and receive site-related information than those engineers reporting on the local project.

The information needs and information-seeking behaviour of consulting engineers working within the South African context do not seem to differ from those of the engineers investigated in the international studies reported on in chapter 3. Engineers working in different geographic locations therefore seem to have similar information needs and seem to use similar sources of information to meet their needs.

e. Personal factors

The personal factors that were revealed as exerting an influence on consulting engineers' selection of information sources are their personal interests, motivation to successfully complete their projects, their professional attitudes and attitudes towards specific information sources, and personal preferences.

7.3.2.2 *Work roles and tasks as contexts of the information needs of consulting engineers*

Consulting engineers' work roles and tasks provide the context for their information needs and refer to their roles as consultants or researchers, the companies they work for, and the requirements of the tasks they need to complete. The research findings show that engineering projects and the different project stages provide the context for consulting engineers' information needs. They are involved in different projects simultaneously. Each project can have a different professional team, contractor, suppliers and client. This suggests that the engineers will approach different people for (sometimes similar) information which is related to the individual project. The consulting engineers will therefore have different "social networks" for each project. Engineer G provided examples of how projects determine his 'social networks'. Work roles and tasks as contexts of consulting engineers' information needs also embrace their social networks. It is similar to the different systems illustrated by Paisley's (1968) Conceptual framework of the scientist within systems' and Blom's (1983) scientific communication system as discussed in chapter 2.

The project stage, as shown in table 7.1, determines the information needs and information-seeking of consulting engineers. Consulting engineers also require information from a variety of sources in the initial stages. Their information needs however becomes more specific as the project progresses and the number of sources that could provide the answer to a problem becomes less. In the end, they will only need project specific information, such as, system test results and commissioning reports. These findings correspond with the findings reported by Ellis and Haugan (1997) and Wolek (1969).

The consulting engineers working within the South African context do not seem to have different information needs to the engineers investigated in international studies.

7.3.2.3 Frequency and predictability of engineering tasks and projects

Tasks can become routine when consulting engineers are involved in a number of similar projects. The findings show that they are inclined to rely to a greater extent on their personal knowledge and experience in repetitive tasks than on a search for new information. Some of the consulting engineers also reported that engineering principles have remained constant despite the technological advances that have been made. These comments also explain why consulting engineers do not seek new information for similar projects because similar projects require similar types of information.

7.3.2.4 Importance of information and task complexity

The importance of information in complex tasks can be linked to factors such as the availability and accessibility of information. Information is often not available for complex tasks and the engineers then need to rely on their engineering judgement or return to basic engineering principles to find the solution to the problem.

7.3.3 Information-seeking patterns of consulting engineers during various project stages

In table 7.1, consulting engineers' information needs during various project stages were identified. The project stage also determines which sources consulting engineers will select during information-seeking and could therefore also be regarded as a factor influencing the consulting engineers' information needs. Various influencing factors will be discussed in more detail under 7.3.5.

The methods used by consulting engineers to gather information during these stages of their projects are summarised below.

(1) *Stage 1 – Reporting stage*

During the reporting stage information is obtained from personal contacts such as the client, the architect and geotechnical engineers.

(2) Stage 2 – Preliminary design stage

During the preliminary design stage consulting engineers continue to gather information through personal contacts. Information is also gleaned from architectural designs and drawings, suppliers of products, visits to sites and factories. Text-based sources of information preferred are textbooks, codes of practice or national standards, brochures and catalogues, and only one or two specific engineering trade journals such as *Security World* and *Vektor.* Information is also obtained from the Internet, email and design software. Consulting engineers also draw on their own personal knowledge and personal files at this stage.

(3) Stage 3 and 4 – Design and tender stages

Architectural designs and drawings, suppliers, catalogues or other trade literature, national standards, building regulations and specifications, design software, personal contacts, and journal articles still serve as important sources of information at this stage.

(4) Stage 5 and 6 – Working drawing stage and construction stage

During this stage the consulting engineer relies on system test results or an analysis of the system's behaviour, construction site reports, digital cameras and cellular phones, brochures and pamphlets as well as factory test results.

(5) Stage 7 – Target procurement stage

All the required information during this stage comes from the project itself.

The above summary seems to indicate that consulting engineers create their own information sources as they progress with a project. These information sources include drawings, photographs of the project which are used both for reporting and record keeping, the construction site itself or the different installations of products, site meetings, site instructions, test results, and commissioning reports. These sources of information will therefore be kept in the consulting engineers' personal files and are often project-specific sources of information and do not apply to a different but similar project.

7.3.4 Consulting engineers' use of various sources of information

The information-seeking patterns of consulting engineers during the various stages of their projects (i.e. the "Information is sought" aspect in model (figure 2.10)) and their use of different sources of information is influenced by their awareness of information as well as the requirements in respect of information content.

As previously indicated, sources of information were classified in this study as internal, external, interpersonal communication and social networking and mentorship.

7.3.4.1 Use of internal sources of information

Internal sources of information used by consulting engineers are personal knowledge, codes of practice, books, technical journals, trade literature, engineering software, and digital cameras.

(a) Personal knowledge and personal files as sources of information

The findings indicate that consulting engineers' rely primarily on their own knowledge and personal files for information. The basic engineering principles used in the consulting engineers' designs have remained the same over the years. This explains why consulting engineers do not always need new information when they design a project since they apply these basic principles. International studies reporting similar findings include the studies by Gralewska-Vickery (1976), Kwasitsu (2003), Taylor (1991), and Tenopir and King (2004).

(b) Consulting engineers' use of books, codes of practice, acts and *regulations*

Textbooks and codes of practice are mainly used during the preliminary design and design stages of an engineering project. Consulting engineers buy these sources since they anticipate that they would need them for more than one project and prefer to have their own copies available. South African codes of practice and some international codes of practice are acquired from the South

African Bureau of Standards (SABS). Regulations and Acts are retrieved from the Internet. These empirical findings correspond with the findings reported by Gralewska-Vickery (1976), Leckie *et al.* (1996) and Shuchman (1981) and namely, that engineers use textbooks and codes of practice as sources of information.

(c) Consulting engineers' use of technical journals

Technical journals seem to be the least frequently used printed source of information for engineering projects and are mainly used for personal development. The reasons given for this trend is a lack of time. The engineers might browse through old issues in their personal collections to find information. The empirical findings on the use of technical journals are consistent with the findings of studies reported by Case (2002; 2007) and Tenopir and King (2004).

(d) Consulting engineers' use of trade literature

Trade literature such as brochures and pamphlets are indispensable sources of information for consulting engineers. All the consulting engineers use publications, such as, *Specifile, Specilink* and *Ezee-dex* which consist of brochures and pamphlets of the products they use in their designs which can be acquired from companies that collect the trade literature and repackage it. The empirical findings correspond with the findings reported by Fidel and

Green (2004), Hertzum (2002), Hertzum and Pejtersen (2000), Tseng and Fogg (1999), and Van House *et al.* (1998).

(e) Consulting engineers' use of design software

There appears to be differences in the use that consulting engineers make of engineering software packages. Younger engineers seem to rely more on software packages than older engineers who prefer to use the "classical" method of design. Holland *et al.* (1991), and Tenopir and King (2004) reported similar findings.

(f) Consulting engineers' use of digital cameras

The consulting engineers described how they use digital cameras (and cellular phones with an mms facility that can take a photograph) to record progress in their projects. Digital cameras are also used to communicate problems which the contractor experiences on site to the consulting engineer when he or she is not available on site. The current study appears to be the first to report on the use of digital cameras to photograph project progress and to assist in reporting.

7.3.4.2 Use of external sources of information

The external sources of information used by consulting engineers are the Internet, email, libraries, online databases, conferences and visits to sites and factories.

(a) Consulting engineers' use of the Internet

Most of the responding consulting engineers reported that they find the Internet an important source of information. All of the participating consulting engineers indicated their preference for Google as a search engine. Other search engines used by consulting engineers are AltaVista, AskJeeves, Dogpile and web resources such as Wikipedia, Some of the engineers also reported their use of subject portals and some specific websites. These findings correspond with the findings by Fidel and Green (2004), Hirsh (2000), Kraaijenbrink (2007), and Mueller *et al.* (2006).

Three of the consulting engineers commented on how they use FTP sites to communicate project-related information. FTP sites are secure sites available on the Internet to which the engineers post large files such as drawings which they need to communicate with the rest of the professional team on the project. Access to the FTP sites is restricted and a password is needed to gain access to the site. Similar use of the Internet to communicate project-related information was reported by Fidel and Green (2004:569).

(b) Use of email to communicate project information

Email seems to be the most frequently used method of personal communication between consulting engineers and their clients, contractors and suppliers. The empirical findings on the use of email correspond with the findings reported by and Fidel and Green (2004) and Hirsh (2000), *(c) Consulting engineers' use of libraries and online databases*

The responding South African consulting engineers only have limited access to libraries and online databases within their own companies. However, this limited access does not seem to prohibit them from accessing the information they require since the findings show that they rarely use library and information services and online databases. Comments made by the responding consulting engineers that they use their own textbooks or buy books to find information could explain this trend.

The consulting engineers do not seem to be aware of online databases such as the ISAP database. This is unfortunate as ISAP is freely available on the Internet and some of the journals that these engineers receive on subscription are indexed on ISAP.

Studies reported in the literature on engineers' use of libraries and online databases that correspond with these empirical findings are those by Ellis and Haugan (1997), Fidel and Green (2004), Gerstberger and Allen (1968), Gralewska-Vickery 1976), Holland *et al.* (1991), Leckie *et al.* (1996), Mueller *et al.* (2006), Taylor (1991), and Ward (2001).

(d) Conference attendance for personal development

Conferences seem to be used only for personal development and the older group of engineers in particular seem very reluctant to attend conferences. The cost of attending conferences could be the main reason for this reluctance. Costs refer to the conference fees that need to be paid as well as costs in terms of time and income that the consulting engineers lose when working on their projects. One consulting engineer mentioned marketing opportunities as his reason for attending conferences. Studies reporting on conference attendance as a source of information that correspond with these empirical findings include the studies by Ellis and Haugan (1997), Gralewska-Vickery (1976), Hertzum and Pejtersen (2000), Kwasitsu (2003), and Tenopir and King (2004).

(e) Visits to construction sites, factories and installations to gather information

The participating consulting engineers also indicated that visits to construction sites, factories and other installations are important sources of information. Some of the consulting engineers also reported that they would visit factories to test equipment before the equipment is shipped to the construction site for installation. Studies reporting similar findings include the studies by Gralewska-Vickery (1976) and the WFEO/CEI (1979).

7.3.4.3 Interpersonal communication and social networking as sources of information

In the reporting stage, in particular, consulting engineers are solely reliant on other people as sources of information. These personal sources of information include clients' needs, geotechnical engineers' reports, and the architects' drawings in the reporting stage of the library building project. On such a multidisciplinary project, the engineers also have to communicate with team members to communicate and accommodate the different needs in their designs. Some of the engineers also indicated their preference for personal contacts as sources of information. International studies reporting on interpersonal communication and social networking include studies by Ellis and Haugan (1997), Fidel and Green (2004), Hertzum and Pejtersen (2000), Hirsh (2000), and Wheeler (2004).

7.3.4.4. Using mentors to gather information

Mentorship refers to a situation in which more experienced engineers guide their younger colleagues by sharing their personal knowledge and expertise with them. It can be regarded as a form of in-service training, although the mentors are not necessarily working for the same companies as the engineer being mentored. The findings show that mentors are an important source of information in projects that are challenging to young and inexperienced engineers. Gralewska-Vickery (1976) reported on mentors as a source of information.

7.3.5 Factors influencing consulting engineers information-seeking behaviour

Factors associated with the different types of information sources and consulting engineers of information and the requirements in respect of information influence their selection. These factors include consulting engineers' general awareness of information, the trust that they put in sources of information and specific products, cost of the information source and the time restrictions to access the information, and the accessibility and availability of information sources.

7.3.5.1 General awareness of information

The findings indicates that engineering information is everywhere and that information sometimes appears from nowhere and from an unexpected source, such as a magazine which is not work-related. Engineers will therefore often browse journals to find relevant information. These findings correspond with Kremer's (1980) findings where respondents found items of information by chance.

7.3.5.2. Trustworthiness as a factor in information-seeking

Trust seems to be a factor when selecting information sources and products. Engineer B (a structural engineer) gave trustworthiness as a reason for her preference for certain products, the British codes of practice and old textbooks compared to the South African codes of practice and newer textbooks. The empirical findings correspond with Hertzum's (2002) findings regarding engineers' preference for sources they can trust or that are known for their trustworthiness.

7.3.5.3 Cost and time as a factor in information-seeking

Cost and time seem to be important factors impacting on the selection of information sources. Most engineers indicated that they do not have much time available to seek information. Since the time that is required to find information (whether it is the time seeking the information or the time spent waiting for the information to be delivered) is time lost to complete a task which in turn has a loss of income as a result. Cost and time could therefore also be a reason why mentors are such important sources of engineering information and why consulting engineers are reluctant to attend conferences. The empirical findings on cost and time as factors influencing the selection of information sources are in agreement with the findings of Hertzum (2002), Hertzum and Pejtersen (2000), King (1991), Morrison and Vancouver (2000), Sandstrom (in Jacoby 2005), and Ward (2001).

7.3.5.4 Availability and accessibility of information

The research findings show that consulting engineers sometimes need to innovatively seek for information since the information required may not be readily available. The unavailability or inaccessibility of specific sources of information does not hinder consulting engineers from completing their tasks. When specific information is not available, consulting engineers rely on basic engineering principles or their engineering judgement to complete a task or solve a problem. This could also be an indication of how the importance of information and task complexity affect the selection of information sources.

7.3.5.5 Quality of information as a factor in information-seeking

The quality of information does not seem to affect the consulting engineer's selection of an information source. The level of the information and the amount of information available in the source is more important. Some engineers were adamant that they do not want to buy a source that consists of a number of pages if only one page of calculations or drawings appearing in the source is relevant to their project. This underlines the importance of relevancy and immediacy as information requirements of engineers.

7.3.6 Outcomes of the information usage of consulting engineers

The general outcome of consulting engineers' information use is the completion of the engineering project in which the engineers are involved. This is the Target Procurement stage in an engineering project. Another outcome could be the publication of an article on the completed project. However, this is not the objective of the engineers' information use and only a few consulting engineers reported that they would at times publish articles or a brochure on an engineering project.

The findings on the factors that influence consulting engineers' information-seeking behaviour and the outcomes thereof correspond with the definition given for information-seeking in chapter 1, section 1.7.6.

The empirical findings of the study illustrates how consulting engineers generate, communicate and use information. These findings also correspond with the definition for information given for information behaviour in chapter 1, section 1.7.1.

Based on the findings of the study certain recommendations are made in respect of a proposed information service which is freely available on the Internet.

7.4 RECOMMENDATIONS

The recommendations are based on the use the consulting engineers make of the Internet and some specific sources of information. However, since only a small group of consulting engineers participated in the study, further research will be required to determine whether such a service will be viable.

The responding consulting engineers all use, with the exception of Engineer G (an acoustics engineer), the Internet. Some engineers make use of subject portals and web directories. All the engineers make use of the services offered by companies which make trade literature freely available in a printed format.

Bearing in mind that consulting engineers make use of the Internet, a web-based service or subject portal could be developed on which various types of information which is relevant to consulting engineers is published. The types of information sources that should be made available on the web-based service include trade literature, technical journals, an online catalogue, hypertext links to engineering websites, and a database of engineering expertise.

a. Trade literature

Companies disseminating trade literature such as *Specifile, Specilink, Ezee-dex* and *Merkels builders' pricing and management manual* could make these information sources available through the web-service. Some of these services are free and the companies could use the savings on the printing costs of their publications to sponsor the hosting of the web-service. The consulting engineers need to subscribe to *Merkels* but the subscription could be for online access rather than for a printed copy. The advantage to both the companies and the consulting engineers is that information can be updated more regularly making the existing services they offer more current.

b. Technical journals

Although consulting engineers are reluctant to use technical journals, some of them use these journals for their own personal development. However, they could be missing a lot of important information if they have to browse through old journals for articles that were previously published. The suggested web-service could provide online access to the full-texts of journals such as *Mining Week* which are freely available to all consulting engineers. The web-service can also provide hypertext links to journals such as *Vektor* and *Civil Engineer* which are available on engineering institutes' websites. The responding consulting engineers do not use the ISAP database which is available free-of-charge on the Internet because it does not give them immediate access to the complete article. However, should they be able to search the electronic text of the journal hosted on a web-service, the possibility exists that these consulting engineers would make more use of these journals than is currently the case. They would also have to be made aware of the existence of the database.

c. Online catalogue

Most of the consulting engineers indicated that they buy books but also that they do not have a formally organised library available in their companies. The proposed web service could therefore also provide a link to a kind of social catalogue which the engineers could use to organise their books. Library Thing (http://www.librarything.com) is an example of such a social catalogue which is available on the Internet. Furthermore, engineers would not need specialised skills to add new books to the catalogue themselves or to access it. However, the consulting engineers could be reluctant to use a social catalogue because of the time involved to add sources to it. They would have to be convinced of the advantages of a catalogue to organise their personal collections.

d. Hypertext links to engineering websites

The web-service could also include hypertext links to Internet sites, such as, www.cisco.com, www.saace.com, and www.acts.co.za. These sites are regularly used by consulting engineers.

e. Database of engineering expertise

An online database of engineering expertise could be included on a web-based information service. Consulting engineers could provide their business details and fields of expertise on this database. The database could then become a valuable source for tracing people to find information while it simultaneously serves as a marketing tool for consulting engineers on which they could ‘advertise’ the services they offer.

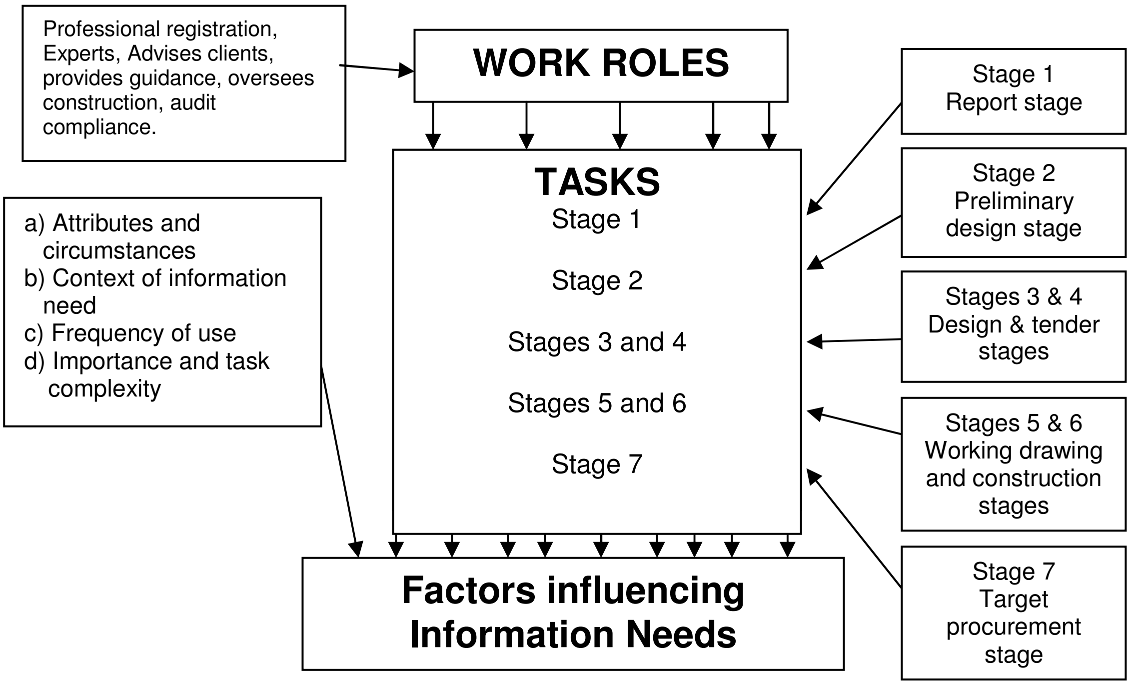
Based on the theoretical study and empirical findings discussed in sections 7.2 and 7.3, a model has been developed to explain the information needs and the information-seeking behaviour of consulting engineers.

7.5 MODEL OF THE INFORMATION-SEEKING OF CONSULTING ENGINEERS

As indicated in section 7.2, Leckie *et al’s* (1996) Model of Professional’s Information-Seeking was used as a systematic framework for a discussion of the empirical findings. In addition the existing model was adapted to accommodate the different tasks in the various stages of a consulting engineering project. Figure 7.1 graphically illustrates the different stages in an engineering project that require different sets of tasks and different types of information sources. The addition of stages to the Model accommodates not only a study of how work roles and tasks influence information-seeking, but also a study of the influence of different stages in an engineering project on the selection of information sources.

FIGURE 7.1

Work roles, tasks and factors influencing the information needs of consulting engineers



Source: Adapted from Leckie *et al's* (1996:180) General Model of the Information-Seeking of Professionals

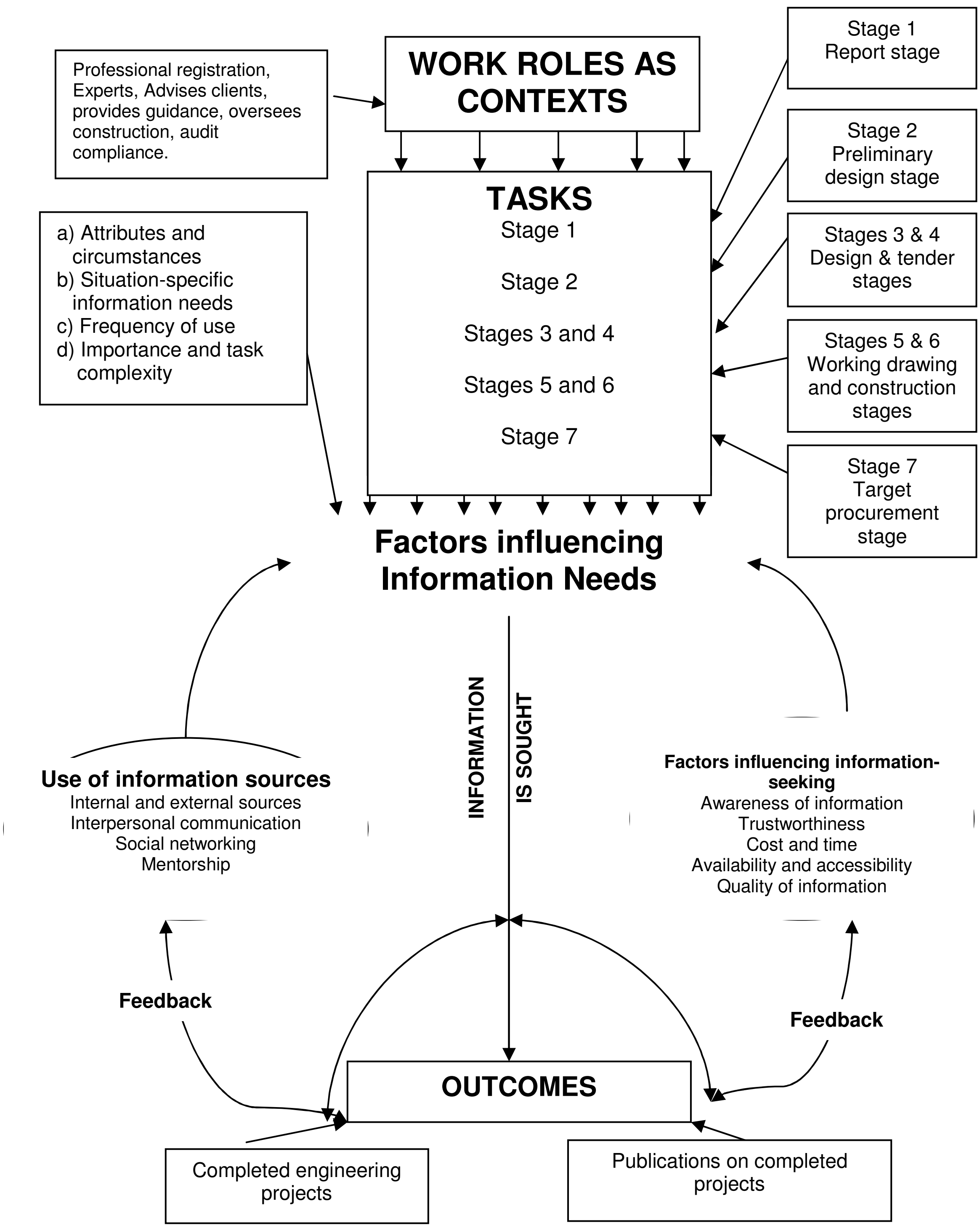
These adaptations made to Leckie *et al's* (1996) model illustrates the different stages in an engineering project. They were incorporated into the model in order to provide a framework for studying the information needs and information-seeking behaviour of consulting engineers by means of time-line interviews.

The characteristics of consulting engineers' information needs and the factors relating to the sources of information, an awareness of information and the requirements in respect of information content influence information-seeking.

Figure 7.2 illustrates the completed model. The adapted model now illustrates how information needs that arise in work role and task-related contexts lead to information-seeking. The figure also illustrates how different factors determine consulting engineers' information needs. It also illustrates how the factors related to the sources of information, an awareness of information, trustworthiness, cost and time, availability and accessibility, and quality of information (information requirements in respect of information content) influence information-seeking. The outcomes of information-seeking can either be the completion of the task or the publication of information on the completed project. As explained in chapter 3 (section 3.6), the possibility exists that information-seeking may not satisfy the information need and the unsatisfied need requires further information-seeking. This is conceptualised as a "feedback" loop in the model.

FIGURE 7.2

Model of the information-seeking behaviour of consulting engineers



Source: Adapted from Leckie et al's Model of the information-seeking of professionals)

The adapted model in figure 7.2 could be used as a conceptual framework for future research on the information behaviour of consulting engineers.

7.6 FUTURE RESEARCH

Some other aspects identified in the study that could warrant further research are geographic location, environmental scanning, gender differences and engineering disciplines, the Internet, the use of digital cameras and social networking.

7.6.1 Geographic location's influence on information needs

Only a small group of consulting engineers participated in the study. Future studies need to address the information behaviour of consulting engineers working for companies with formally organised libraries and which provides access to online sources. Although geographic location does not seem to influence consulting engineers' information behaviour, similar studies on consulting engineers in other geographic locations are needed to confirm these findings.

7.6.2 Environmental scanning as a means to collect information

Helping engineers become familiar with the particular people from whom they might obtain information at particular stages in a project is of prime importance. This has been generally neglected by both research and practice in Information Science. Furthermore, social networking and environmental scanning could open up new areas of research, particularly in view of the fact that consulting engineers' varied use of information sources is a characteristic of the undirected viewing mode in Aguillar's Modes of Environmental Scanning.

7.6.3 Influence of gender differences and engineering disciplines on information needs and information-seeking behaviour

With the increase in women entering the engineering profession, more studies could be conducted on gender differences in information use amongst engineers to enhance existing knowledge of the information use of women engineers. More comparative studies on the information needs and information-seeking behaviour of engineers from different engineering disciplines could contribute to our knowledge in this regard.

7.6.4 Consulting engineers' use of the Internet and information communication technologies

Further studies are required on engineers' use of the Internet and the role the Internet plays in disseminating technical and trade literature. Such research could pose some challenges to website designers and organisations offering information services on the Internet. Future research should also address the use of FTP sites to communicate project-specific information to project team members to stimulate the development of similar sites that might be more effective than FTP sites.

Studies focused on the services that collect and disseminate trade literature to consulting engineers will assist researchers in acquiring a better understanding of how these services meet consulting engineers' information needs. Research into the impact of the Internet on the production, collection, dissemination and use of trade literature could be very valuable for the rendering of similar services in future.

New interactive information communication tools such as weblogs, discussion boards and wikis have become available. Future research on the use consulting engineers make of these interactive information communication tools could assist in the development of information systems supporting the use of such information technologies.

7.6.5 Consulting engineers' use of digital cameras

This study is the first to report on the use consulting engineers make of digital cameras and cell phones to record information that could be used during their engineering projects. Further studies are therefore needed to determine whether engineers working in a different context also make use of digital cameras and cellular phones in their projects.

7.6.6 Social networking as a means to find information

The findings have shown that consulting engineers rely primarily on personal contacts for information and the project-related social network determines who is contacted for information. More studies on how consulting engineers network and use peoples' expertise to supplement their own knowledge could enrich existing knowledge on the topic.

7.7 CONCLUSION

In this chapter the theoretical and empirical research findings are summarised. Recommendations for the development of a web-based information service were made, and a model for studying the information-seeking behaviour of engineers was proposed. The identification of aspects for future research concluded the chapter.

Two theoretical frameworks were used to systematise and explain research findings on task-based and project-related information needs and information-seeking behaviour of consulting engineers in South Africa. These are the General model of the information-seeking of professionals developed by Leckie *et al* (1996) and Dervin's Sense-making approach (1983).

A model for studying the information-seeking behaviour of engineers was proposed. The proposed Model of the Information-Seeking of Consulting Engineers is adapted from Leckie *et al's* (1996) General model of the information-seeking of professionals and based on the theoretical and empirical research conducted for this study. The new model provides pertinent information on the consulting engineers' work roles, tasks and factors influencing information needs as well as pertinent information on how factors associated with different sources of information and an awareness of information influence consulting engineers' information-seeking behaviour. Two possible outcomes of information are also indicated.

Findings on consulting engineers' information needs showed how work roles and tasks lead to information needs and determines consulting engineers' preferences for certain information sources. The sources of information most used by consulting engineers are other people, personal files and knowledge, trade literature, codes of practice, textbooks and the Internet.

Recommendations for the provision of an Internet-based information service involve the creation of a subject portal or web directory which either includes the full texts to trade literature as well as to the full texts of technical journals which consulting engineers receive free of charge.

Future studies should focus on geographic location as a factor influencing engineers' information-seeking. Studies focusing on environmental scanning as a form of information-seeking behaviour, the influence of gender and engineering disciplines on information needs and information-seeking behaviour as well as the use of information communication technologies could also be valuable.

APPENDIX A

Interview schedule for the qualitative study on the information needs and information–seeking behaviour of consulting engineers

For the purposes of this study, I understand an information source to be any source of information that could assist the engineer in completing his/her task. This information source could be a person, an object, a telephone conversation, a written document (including emails or faxes), pamphlets, internet sites or any other source the engineer could utilise to solve his/her problem.

1. Obtain an overview of the respondents' tasks at work
   - It is known that engineers in different stages of their careers, utilise different types of information sources and different methods of acquiring information, could you please give me an indication of your age group: 20-30; 30-40; 40-50; 50-60; and 60-70
   - Please describe your work as a consulting engineer.
   - Please describe a project that you have recently completed?
   - What is the objective of achieving that task?
2. Please describe the project stages that you needed to go through to complete this project? The Stages identified by ECSA are:
   - Stage 1: Report Stage -
   - Stage 2: Preliminary Design Stage -
   - Stage 3: Design and Tender Stage -
   - Stage 4: Working drawing stage -
   - Stage 5: Construction stage -

- Stage 6: Targeted Procurement stage -

3. In Stage …
   - Did you have any questions in mind? What were they? What information do you need?
   - What did you try to find out?
   - How did you find the answer to these questions? Any help?
   - Why did you choose to use this way to get the answer?
   - Did you have any difficulties to get the answer? What were they?
   - Were there ways that you can get the answer, but you chose not to use them?
   - Did you finally get an answer to your questions? Does it help? How?
   - How do you handle/deal with these useful answers?
   - If you finally could not get an answer to your question? What couldn't it help?
   - What role does email have in collecting data or other information for a project?
   - Do you ever use the telephone to collect data or information?
4. Above questions are repeated for each of the steps that the respondents have shared.

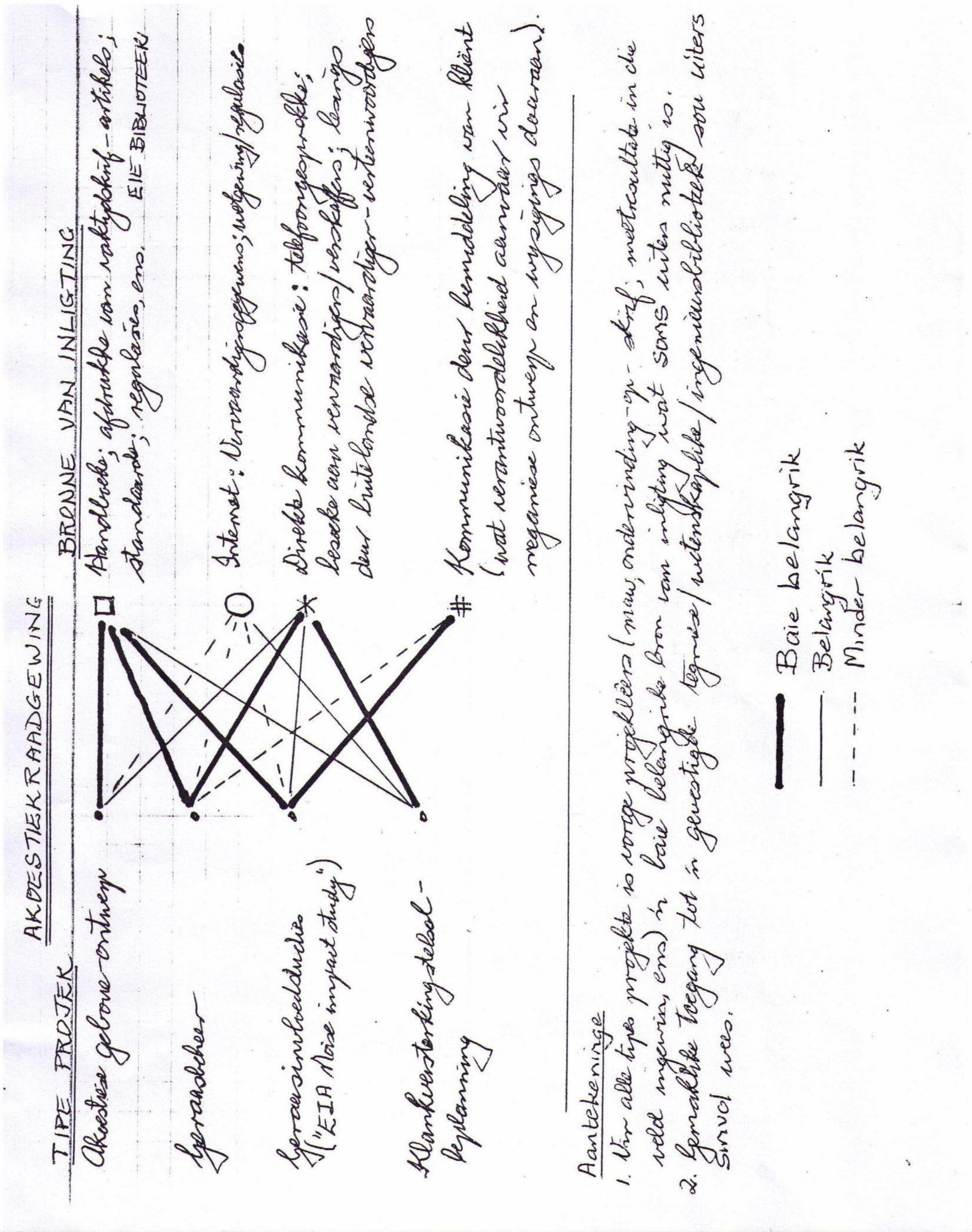
B: INFORMATION SOURCES QUESTIONNAIRE

1. Do you subscribe to / or receive any technical journals?
2. What is the value of these journals to your work related information needs?

3. How important are textbooks or technical books in answering your information needs?
4. How important are personal contacts in finding information?
5. Do you attend conferences? If yes, what contribution do conferences make to solve your work related information needs? Or do conferences merely contribute to your knowledge base on your specific field of interest?
6. What role does a library have in solving your information needs?
7. What role does the Internet have in solving your information needs?
8. If you use the Internet to find information, which search engines do you prefer and why?
9. What type of information do you retrieve from the Internet? Government regulations? Standards and specifications? Specific product information? Technical information?
10. How does a project's budget influence the amount of time you can spend on finding information?
11. Would you prefer using an old trusted information source or would you attempt to find a newer more up to date source but not knowing the reliability of that source?
12. What role does cost play in acquiring the information you need? Would you select an expensive but comprehensive source which includes high quality information? Or would you select a cheaper source, which includes reliable information but which might not be as comprehensive as the more expensive information source?

APPENDIX B

Engineer G's diagrammatic representation of types of information sources used by acoustic engineers. The diagram is in Afrikaans.



APPENDIX C

Form for research subject's permission

Title of research project: Information needs and –seeking behaviour 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.

The nature, objective, and implications have been explained to me and I understand them.

I understand that the project is aimed at acquiring an insight into the information needs of consulting engineers as well as into consulting engineers' information-seeking behaviour and use of the Internet. The intention at this stage is not to provide consulting engineers with the actual information required, Internet training, etc.

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 purposes of publication or conference presentations.

Upon signature of this form, you will be provided with a copy.

Signed: ………………………………………………..

Date:……………………………………………………

Witness:……………………………………………….

Date:…………………………………………………..

Researcher:……………………………………………

Date:………………...

APPENDIX C (CONTINUED)

Vorm vir toestemming deur deelnemers aan die navorsingprojek

Titel van die navorsingsprojek: Inligtingbehoeftes en soekgedrag van raadgewende ingenieurs.

Ek…………………………………………… ……………………………………….
Gee hiermee vrywilliglik toestemming tot my deelname aan die projek soos deur mev Madely du Preez (Department Inligtingkunde, Universiteit van Pretoria) aan my verduidelik. Deelname sal 'n indiepte persoonlike onderhoud beteken. Ek gee toestemming dat die onderhoud opgeneem mag word.

Die aard, doel, en implikasies van die projek is aan my verduidelik en ek verstaan dit.

Ek verstaan die doel van die projek is om insig te verkry in die inligtingbehoeftes van raadgewende ingenieurs asook raadgewende ingeneurs se inligtingsoekgedrag en Internet gebruik. Die doel op hierdie stadium is nie om raadgewende ingenieurs met inligting as sodanig of Internetopleiding, ens. te voorsien nie.

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.

Met die ondertekening van hierdie vorm sal ek van 'n kopie voorsien word.

Geteken: ……………………………………………

Datum………………...

Getuie:……………………………………………..

Datum………………...

Navorser:.…………………………………………..

Datum………………..

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