The Information Behaviour Of Consulting Engineers In South Africa

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ABSTRACT

Consulting engineers are professionals who are either self-employed or work for a consulting engineering company. They do not all necessarily have formally organised information services, such as libraries, available in their companies to provide in their information needs. The objective is to report on a qualitative study investigating the information behaviour of a small group of self-employed consulting engineers working in Gauteng. A combination of convenience and snowball sampling was used to select the eleven responding consulting engineers for this study. Semi-structured time-line interviews were conducted to collect the data. The gap-metaphor in Dervin's sense-making approach was used to analyse the data. Leckie, Pettigrew and Sylvain's general model of the information-seeking of professionals provided the framework for the study. The results showed that consulting engineers rely heavily on people, personal files and personal knowledge for information. Other frequently used information sources include the Internet, File Transfer Protocol (FTP) sites and digital cameras. Consulting engineers need information from varied sources in the initial stages of a project. Information in the final stages of a project comes from the project itself. In conclusion comments are made on the use of Leckie et al's model and the gap-metaphor in Dervin's sense-making methodology.

KEYWORDS

Information-seeking, information needs, consulting engineers, information behaviour, qualitative studies.

1 INTRODUCTION

Engineers do not seem to make use of libraries to provide in their work-related information needs. Most studies investigating engineers' information behaviour have been conducted on engineers working within a research and development environment as well as on engineers working for the same organisation. These include the studies by Cheuk Wai-Yi (1998), Ellis and Haugan (1997), Fidel and Green (2004), Hertzum and Pejtersen (2000), and Holland, Pinelli, Barclay and Kennedy (1991). Dervin and Nilan (1986) wrote a review article on engineers' information behaviour. Ward (2001) appears to be the only researcher to have conducted a study on the information behaviour of consulting engineers. Du Preez's (2007) literature review summarised the most important findings of these studies and supported her research on the information behaviour of consulting engineers in South Africa. This article reports on Du Preez's (2008) study.

Du Preez (2008:172) defined consulting engineers as experts in their field of engineering. They advise their clients on engineering projects and offer a service. The South African *Engineering Profession Act, 2000, (Act no. 46 of 2000)* (ECSA 2007:3) requires all practicing engineers to be registered as professional engineers with the Engineering Council of South Africa (ECSA). Consulting engineering companies can be, but are not necessarily required to be, affiliated with the South African Association of Consulting Engineers (SAACE). Some consulting engineers also subscribe to engineering associations or institutes that are relevant to their specific engineering discipline.

Some of the larger consulting engineering companies have formally organised information services, such as libraries, available within the respective companies. However, the smaller companies seldom have enough resources available to employ information workers or have a formally organised library or information service. Engineers that work for such companies therefore need to rely on information services that are made available by the National Library of South Africa (NLSA), the Council for Scientific and Industrial Research (CSIR), the engineering associations or institutes to which the individual engineers subscribe (Du Preez 2008:3), or their own initiatives.

The purpose of this article is to report on a study to determine the influence work roles and tasks have on consulting engineers' information needs and resulting information behaviour. The article will show how specific engineering tasks influence the consulting engineers' use of information sources. The characteristics of engineers' information needs and the factors that influence their information behaviour will also be explored. This was a qualitative study into the information behaviour of a small convenience sample of consulting engineers employed by small engineering companies in South Africa – the first study of its kind to be conducted in Southern Africa. Information

behaviour, in the context of this article, includes aspects of human behaviour (such as work roles and tasks) that require the consulting engineers to generate, communicate and seek information that is relevant to their information needs. This discussion will include a brief description of the research design, the method of data collection and data analysis.

2 RESEARCH DESIGN

To deepen an understanding of engineers' information behaviour, a systematic review of the literature was completed. The studies reviewed include those conducted by Belkin, Oddy and Brooks (1982), Cheuk Wai-Yi (1998), Ellis and Haugan (1997), Gralewska-Vickery (1976), Hertzum and Pejtersen (2000), King and Griffiths (1991), Kraaijenbrink (2007), Kwasitsu (2003), Leckie, Pettigrew and Sylvain (1996), Mueller, Sorini and Grossman (2006), Shuchman (1981), Ward (2001) and Wolek (1969). These studies report on research aimed at acquiring an understanding of engineers' information needs as well as on how engineers' and other professionals' information behaviour was studied. From the literature review, a suitable research method and theoretical model could be selected to serve as a framework for the study.

An examination of models discussed in the subject literature indicated that although they may focus on different aspects of information behaviour, there is also some overlap (Du Preez 2008). The models that have been reported in studies on information needs and information-seeking behaviour of engineers include Ellis' (1989) behavioural model of information-seeking, Dervin's (1983) sense-making approach, Leckie, Pettigrew and Sylvain's (1996) general model of the information-seeking of professionals, and Cheuk Wai-Yi's (1998) information-seeking and using (ISU) process model. Leckie *et al*'s (1996) general model of the information-seeking of professionals was selected from these to provide the framework for the literature review and for systematising the data collected in the empirical research component of the study. Du Preez (2008) found that Leckie *et al*'s (1996) model supports studies aimed at exploring the influence of work roles and tasks on the selection of information sources. The gap-metaphor in Dervin's (1983) sense-making approach was selected as basis for the qualitative analysis of the data collected from the semi-structured time-line interviews pertaining to consulting engineers' tasks.

2.1 GENERAL MODEL OF THE INFORMATION-SEEKING OF PROFESSIONALS

Leckie *et al*'s (1996) general model of the information-seeking of professionals reflects the information behaviour of professionals from the individual's information needs and information-seeking point of view. Their model facilitates an understanding of how

engineers' work roles, work related tasks and user-related characteristics of information needs influence their information seeking. Other factors that influence information-seeking addressed by Leckie *et al.* (1996) are the sources of information, an awareness of the existence of information and the outcomes of the information-seeking process. According to Leckie *et al.* (1996) the outcomes of information-seeking either result in the completion of a task or, in instances where the retrieved information did not satisfy the information need, the outcomes could prompt a renewed search. The model therefore seemed suitable as a framework to study the information behaviour (including information needs and information seeking) of consulting engineers in South Africa.

2.2 THE GAP-METAPHOR IN DERVIN'S SENSE-MAKING APPROACH

Apart from a framework a research method was also required to analyse the data. This was provided by the gap-metaphor in Dervin's (1983) sense-making approach.

The sense-making approach is an important process model which provides a theoretical approach to information behaviour studies. It is also a set of research methods (Dervin & Nilan 1986; Dervin 1999). The central metaphor, also known as the gap-metaphor, of Sense-making 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 & Nilan 1986:21; Nilan, Peek & Snyder 1988; Dervin 1999; Pettigrew, Fidel & Bruce 2001; Dervin 2005:27).

Sense-making gaps are cognitive gaps as perceived by individuals which can be explained as "a situation in which people are unable to make sense of their experiences" (Choo, Detlor & Turnbull 2000; Kraaijenbrink 2007). The cognitive gaps or situations prompt consulting engineers to seek information to bridge their knowledge gaps and make sense of their experiences (Cheuk Wai-Yi 1998).

Time-line interviews, the data collection method most used in sense-making studies provided the means to determine specific cognitive gaps arising from the engineers' tasks. This method can assist in revealing the nature of a problematic situation, the extent to which information can bridge cognitive gaps and the nature of the outcomes from the use of information (Wilson 1999).

2.3 DATA COLLECTION

Semi-structured time-line interviews were used to collect the data for the study from the interview sample. Structured time-line interviews would have, due to the repetitive questioning, frustrated the responding consulting engineers since they spontaneously discussed their information needs and information-seeking behaviour. They also explained the use they make of different information sources in some detail.

2.4 THE INTERVIEW SAMPLE

Eleven consulting engineers were selected from amongst the consulting engineers located in Gauteng (a province in South Africa). A combination of snowball sampling and convenience sampling was used to select the interview sample for this study. Three of the eleven responding engineers are known to the author. One of these engineers provided the contact details of the professional team involved with a large building in Pretoria. All of the engineers on this list were approached and only those engineers who were willing to participate in the study were interviewed. These engineers represented different age groups, different engineering disciplines and gender (the sample included two women).

The responding engineers were asked to describe a recent project that they were involved in. Although most of the responding consulting engineers were involved with the construction of a large building in Pretoria, not all the engineers chose to describe their involvement in the building. Some of the engineers described projects located away from their offices which therefore had to be managed over a distance.

Most of the responding consulting engineers did not work for the same companies. Although some of the responding consulting engineers were business partners, no more than two engineers were, however, interviewed from the same company. None of the responding consulting engineers have a formally organised library or information service available within their companies. References made to a 'library' by some of the engineers were references to a central place in the engineers' offices where they kept specific sources of information such as their trade literature collections, codes of conduct, regulations and textbooks.

2.5 TIME-LINE INTERVIEWS

As mentioned, micro-moment or time-line interviews are the interviewing approach most aligned with sense-making theory (Dervin 1999; Tidline 2005). This interview method allows for in-depth discussions with users and can provide informative and in-depth data that often reveal thoughts and reasons underlying behaviour (Wang 1999). Using time-line interviews can also assist in detecting hidden information not possible through other methods of data collection.

Furthermore, the use of time-line interviews made it possible to determine the different tasks requiring information, the resulting information needs as well as the information sources used by the engineers to satisfy their information needs.

The different stages that were identified by the Engineering Council of South Africa (ECSA) (2007) to describe engineering projects and measure progress in projects were used to establish a situation-oriented frame of reference that would encourage the

engineers to express themselves as freely and naturally as possible. These stages are the report stage, preliminary design stage, design stage, tender stage, working drawing stage, construction stage, and targeted procurement stage. Four stages, the design, tender, working drawing, and construction stages were combined into two stages, the design and tender stages and the working drawing and construction stages in Du Preez's (2008) study. This was done because the tender stage is embedded in the design stage and the working drawing stage is only used by structural engineers.

The consulting engineers were asked to describe their individual projects and the tasks that they had to complete during each stage. They then had to indicate which information was required to complete each task. The reasons why specific sources of information were used to complete the task were also embedded in the engineers' responses.

Time-line interviews unfortunately only allowed for the description of information needs encountered in the specific project described by the consulting engineers and did not allow them to respond on information needs related to other projects they may be involved with at the same time.

Since the method of questioning could not offer an holistic view of all the potential sources of information that may be used for task completion for all projects in which an engineer is involved, a second set of questions was prepared to determine the potential use of specific sources of information not referred to during the time-line interviews. In this way it was possible to get a fairly comprehensive view of all the sources of information used by the consulting engineers and acquire an understanding for the reasons for their use. The study therefore offers insight into

- project specific information needs and information behaviour
- individual engineers' use of information resources (including preferences as well as reasons).

3 RESEARCH FINDINGS

The following paragraphs will report on selected findings pertaining to the work roles of consulting engineers, engineering tasks requiring information, characteristics of consulting engineers' information needs, factors influencing information-seeking and the outcomes of information-seeking.

The interview sample is summarised in table 1.

Table 1: The interview sample

ENGINEER & ENGINEERING DISCIPLINE	AGE	GENDER	PROJECT/TASKS DESCRIBED
Engineer A *Electrical and electronic engineering*	50-60	Male	Large building
Engineer B *Structural engineering*	40-50	Female	Library building
Engineers C&D *Mechanical engineering*	30-40 (*both*)	Male (*both*)	Library building (*both*)
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 was only 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

3.1 WORK ROLES OF CONSULTING ENGINEERS

The first aim of the interviews was to determine the consulting engineers' work roles since work roles and work situations can facilitate an understanding of their information-seeking behaviour, and can help to predict their information needs (Leckie *et al* 1996; Vakkari 1998; Wheeler 2004). In order to determine the work roles of consult-

ing engineers, the respondents were asked to briefly describe their roles as consulting engineers. An analysis of their responses enabled Du Preez (2008:174) to formulate the following definition for South African consulting engineers, which also reflects their work role:

> "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."

The concept 'consulting engineer' and the requirements to practice as a consulting engineer can be different in other countries. The above definition is therefore only applicable to consulting engineers practicing in South Africa.

3.2 ENGINEERING TASKS REQUIRING INFORMATION

Work tasks are embedded in work roles (Leckie *et al* 1996). Work tasks can be defined as 'abstract, objective sequences of actions' (Ingwersen & Järvelin 2005). Each task can further be divided into subtasks. The degree to which these tasks have been structured by rules and routines may have an effect on the use of information (Choo *et al* 2000). As pointed out consulting engineers in South Africa have their work tasks embedded in the following phases: report stage, preliminary design stage, design and tender stage (combined for purposes of the study), working drawing and construction stage (combined for purposes of the study), and targeted procurement stage.

Engineers often utilise various technological devices or systems to complete tasks or subtasks in these stages. Such devices (eg turnstall and card reader in a building's access control system) can be entities made up of several interdependent parts or subsystems (Wolek 1969). From the work of Belkin, Oddy and Brooks (1982) we know there may be a gap between the engineer's knowledge about the tasks or the devices that will be utilised and the perceived requirements of a task. This knowledge gap constitutes an information need, which then may relate to information-seeking and information retrieval (Byström & Järvelin 1995; Ingwersen & Järvelin 2005).

As previously indicated, the data pertaining to the consulting engineers' tasks that was collected from the semi-structured time-line interviews was analysed according to the gap-metaphor in Dervin's (1983) sense-making approach. The sense-making situations were translated into tasks needing information, knowledge gaps were translated into information needs and the uses of information into information sources and the outcomes. This way of analysing the data is similar to the way in which Kraaijenbrink (2007) analysed the data in his study of the information usage and processes of engineers. To illustrate how this was done, table 2 offers an excerpt from the analysis of data collected for the design and tender stage of an engineering project. Engineer E

and Engineer G's comments were randomly selected for this purpose. (The stage to portray was also randomly selected.) Engineer E's comments show that an engineering task can have more than one need and might require the engineers to access more than one source of information[1].

Table 2: Design and tender stages

Engineer & project	Task	Information needed	Information sources and outcomes
Engineer E: (Electrical engineering)	*Task(a):* Budgeting *Task (a):* Compiling tender documents	*Task (a), needs (i):* Clients' budget and standards *Task (a), needs (ii):* Detailed design Bill of quantities Price schedules	*Task (a), needs (i)&(ii):* I needed information from the architect, the client [in this project the client was the occupant of the building and the Department of Public Works who commissioned the project and who will own the completed building], SABS standards, regulations, and suppliers.
Engineer G: (Acoustical engineering)	*Task (a):* Advising the mechanical engineers on acoustical issues concerning air conditioning systems	*Task (a), needs (i):* Which type of air conditioning system is being used?	*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.

In addition to the sources mentioned in table 2, the choice of information sources used during each stage is discussed in section (3.3.5).

Table 3 briefly summarises the findings pertaining to the consulting engineers' task related information needs during the various stages of their projects. This is an exhaustive list of the tasks and information needs described by the consulting engineers during the individual interviews.

1. The interviews were freely translated into English since they were conducted in Afrikaans.

Table 3: Summary of consulting engineers' tasks and information needs (Du Preez 2008:313-314)

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. Complete 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 quantity surveyor QS 12. Compile tender documents 13. Do tender evaluation 14. Coordinate design with the designs of other engineering disciplines	10. What structural steel will be used? How many piles will there 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. Monitor 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 and the designs effective?	17. As-built information 18. System test results 19. Equipment test results 20. Design and equipment test results

The empirical research findings showed how specific engineering tasks influence the consulting engineers' information needs and the selection of sources of information to complete their tasks. It appeared that they often used the same sources of information to complete different tasks in various stages of the project, for example the architect's design and the client's requirements. The consulting engineers use these two information sources during all the different stages of a project. Specific patterns of information needs and use throughout a specific engineering project could therefore be identified. These will be discussed when exploring the factors influencing the consulting engineers' information-seeking.

3.3 CHARACTERISTICS OF CONSULTING ENGINEERS' INFORMATION NEEDS

Apart from the information needs that arise from work roles and engineering tasks, there are also certain characteristics of consulting engineers' information needs that can influence or shape their information behaviour (Leckie *et al* 1996:182). Their information needs are influenced by the consulting engineers' individual attributes and circumstances (including particular demographic factors) and various project- or task-related factors such as context, frequency predictability, complexity and importance.

3.3.1 CONSULTING ENGINEERS' ATTRIBUTES AS A CHARACTERISTIC OF THEIR INFORMATION NEEDS

The attributes of consulting engineers that seem to influence the consulting engineers' information needs are:

- *Age.* The responding consulting engineers' ages were indicative of their experience as consultants. The older engineers tended to act as mentors and relied more on their personal knowledge and personal files than the younger engineers. The two oldest responding engineers do not use design software but are confident in using the Internet to find information.
- *Engineering discipline.* All the engineers often needed similar information sources at similar stages of a project. It seemed that the engineering discipline influenced the selection of specific sources, for example the selection of codes of practice was determined by the engineering discipline.
- *Geographic location of the project.* The geographic location of the project influenced the engineers' preference for specific sources of information and the way information was communicated. Consulting engineers managing projects over a distance relied more on photographs, faxes and emails to solve site specific problems than the engineers managing projects located geographically closer to their offices.

- *Personal factors.* Personal preferences seemed an important personal factor that influenced the consulting engineers' selection of sources. For example, one engineer prefers face-to-face communication and will rather drive to the construction site or the client, discuss the problem and find a solution to the problem rather than making use of email or telephone communications.

3.3.2 THE INFLUENCE OF SITUATIONAL CONTEXT ON CONSULTING ENGINEERS' INFORMATION NEEDS

Consulting engineers finding themselves in a specific situational context may have information needs that arise in a specific context. The situational context will determine the specific information source that will be selected by the consulting engineer. For example, will the project determine which person will be approached for information or which code of practice will be selected? According to Leckie *et al* (1996) this can be regarded as a situation specific need. A specific engineering project (e.g. building a library or hospital), the geographical location thereof (e.g. Pretoria in South Africa) and the stage of the project in which the engineer is involved in at a particular point in time, provided the context for information needs in this study.

Each engineering project (eg a library or hospital building) has a professional team (an architect, a quantity surveyor, civil and structural engineers, electrical and mechanical engineers and contractors) that are cooperatively responsible for the completion of the project. These professional teams resemble different social networks and different projects can potentially have different social networks. The situational context of information needs arising from a specific engineering project can therefore lead to the formatting and utilisation of the specific social network that the consulting engineers will seek information from.

The social networks the consulting engineers are involved in are examples of the intensional networks described by Nardi, Whittaker and Schwarz (2000) but also resemble the information patches in Sandstrom's (1994) Optimal foraging theory. Only, the consulting engineers simultaneously collect (forage) information from different information patches – the project determines the specific information patch – rather than exhausting a specific information patch before moving on to the next patch as Sandstrom describes information foraging.

3.3.3 HOW RECURRING INFORMATION NEEDS (FREQUENCY) INFLUENCE CONSULTING ENGINEERS' INFORMATION-SEEKING

In cases where tasks become routine, as in repetitive projects, the consulting engineers relied more on their personal knowledge and experience to complete the task. This behaviour corresponds with the findings reported by Gerstberger and Allen (1968), and

Hertzum and Pejtersen (2000). The explanation given by the responding consulting engineers for their reliance on their personal knowledge is that engineering principles have remained constant and they therefore do not require new information for repetitive projects.

3.3.4 THE INFLUENCE OF THE COMPLEXITY OF A TASK ON AN INFORMATION NEED

In some instances complex tasks needed to be completed for which no or very little information was available. In these instances the consulting engineers relied on their engineering judgement or returned to basic engineering principles to find a solution for their problem. The unavailability of information therefore did not prevent the engineers to complete their tasks.

Leckie *et al* (1996) identified two more factors that can influence the consulting engineers' information-seeking behaviour. These are sources of information and an awareness of information. (To be discussed in sections 3.5 and 3.6.) The data collected from the time-line interviews as well as the data from a second set of questions aimed at determining the role of potential sources of information not used by the consulting engineers in the projects they described, wereas used to examine these.

3.3.5 THE INFLUENCE OF SOURCES OF INFORMATION ON CONSULTING ENGINEERS' INFORMATION-SEEKING

The following is a summary of the sources of information that were used by the consulting engineers during the different stages of the engineering projects they had described.

- Stage 1 – Reporting stage: personal contacts such as the client, the architect, geotechnical engineers.
- Stage 2 – Preliminary design stage: personal contacts, architectural design and drawings, suppliers, visits, task-based sources of information (literature) (eg textbooks, codes of practice, standards, brochures or catalogues, and engineering trade journals such as *Security World* and *Vektor*), Internet, e-mail, design software, personal knowledge and personal files.
- Stage 3 and 4 – Design and tender stages: architectural designs and drawings, suppliers, catalogues, brochures, pamphlets, standards, regulations design software, personal contacts, and journal articles.
- Stage 5 and 6 – Working drawing and construction stages: system test results or an analysis of the system's behaviour, construction site reports, digital cameras and cellular phones, brochures and pamphlets, factory test results.

- Stage 7 – Target procurement stage: The only tasks remaining during this stage are the commissioning of systems, completion of the final report and updating as-built drawings. All the required information during this stage comes from the project itself.

Consulting engineers, as can be seen from the above summary, utilised a variety of formal and informal sources of information during the different stages of their projects. The consulting engineers' information-seeking was most extensive during the preliminary design stage of the project when they sought information from a variety of information sources. Most of the information during the construction phase came from the construction site and very little additional information was required. These findings correspond with Ellis and Haugan's (1997) findings indicating engineers seek more information from other sources than the project at the onset of that project.

Studying the consulting engineers' information-seeking activities during the different stages of their projects made it possible to recognise components from other information-seeking models. These include the different situations in Cheuk Wai-Yi's (1998) information-seeking and using model which often requires information from similar sources (Cheuk Wai-Yi 1998); the surveying mode in Ellis's information-seeking behaviour model (Ellis & Haugan 1997); information patches in Sandstrom's (1994) optimal foraging theory; initiation stage in Kuhlthau's (1993) information process model; and information search in Aguillar's (1967) modes of environmental scanning.

Vakkari (1998:368–369) distinguishes between internal or personal information sources, and external or impersonal information sources. The same divisions were used for this study reporting on consulting engineers' information behaviour except that interpersonal communication and social networking were added as separate divisions since they can be regarded as both internal and external sources of information. These are explained in the next two sections.

3.3.5.1 INTERNAL SOURCES OF INFORMATION

The following are examples of internal sources of engineering information used most by the consulting engineers.

- *Personal knowledge and personal files* are important sources of consulting engineering information.
- *Books, codes of practice, acts* and *regulations* are used frequently by consulting engineers, especially the codes of practice, building regulations and acts. Most of the consulting engineers also indicated that they buy these sources for their own collections since the chances are that they would need them for more than one project. All South African codes of practice and some international codes of practice

are available from the South African Bureau of Standards (SABS). Regulations and Acts are retrieved from the Internet.

- *Trade literature* provides important engineering information and the consulting engineers frequently use trade literature during the design and tender stages of their projects. They use publications, such as, *Specifile, Specilink* and *Ezee-dex* which consist of brochures and pamphlets of the products they use in their designs. These publications can be acquired from companies that collect the trade literature and repackage it.
- *Digital cameras.* This study seems to be the first to report on the use of digital cameras to record project progress and assist in reporting. Photographs are also very useful sources of information in retrofit projects – this is when an old project is upgraded or extended. It seems as if the use of digital cameras has become a standard practice amongst most of the consulting engineers. From this practice it seems to be evident that practical solutions become a determinant of consulting engineers' information behaviour.
- *Engineering software.* The younger engineers seem to rely more on software packages than the older engineers who prefer to use the "classical" method of design. However, some projects do not warrant the use of software packages. The project or task will therefore determine whether a software package is used or not. Holland, Pinelli, Barclay and Kennedy (1991), and Tenopir and King (2004) reported similar findings.
- *Technical journals* seem to be the least frequently used source of project related information. The engineers mainly use technical journals for personal development. The engineers will browse old numbers of their journals for relevant articles when they need specific information.

3.3.5.2 EXTERNAL SOURCES OF INFORMATION

The consulting engineers also discussed the role played by external sources.

- *Internet.* Most of the consulting engineers reported that they frequently accessed the Internet for information. All the engineers preferred Google as a search engine and, with the exception of two engineers, do their own information searches on the Internet. Other frequently used search engines and meta search engines are Dogpile and AltaVista. AltaVista proved to be useful in retrieving technical information for specific products. Some of the engineers also use Wikipedia and AskJeeves (currently known as Ask.com) to clarify terminology or to assist them in finding relevant keywords to conduct their information searches, subject portals and specific websites like www.acts.co.za.

- *FTP sites* are secure sites to which only the engineers involved in the project for which the site was created have access. FTP sites have proved to be useful in bridging the communication gap between project team members who are employed by different companies. The engineers will upload their drawings on an FTP site and inform their team members via email that new information is available on the site. Fidel and Green (2004) have reported that engineers posted information on the Internet, but one can assume it was on an intranet since the engineers seemed to be employed by the same company. The behaviour described by Fidel and Green (2004) might therefore be different from the use of FTP sites described by the consulting engineers.
- *Email* is used frequently to exchange information with fellow team members but also to issue instructions to contractors, place orders and manage a project.
- *Visits* to factories and other installations are important sources of information. The younger engineers found visits useful to learn how specific products are manufactured. One structural engineer uses visits to other building sites to keep up to date with the latest construction techniques. Some engineers also reported that they would visit factories to test equipment before the equipment is shipped to the construction site for installation. Visits in these instances save the consulting engineers and the contractors time and minimises costs since faulty equipment can be fixed before it is shipped to the construction site.
- *Libraries* and *online databases* could provide engineers with information. These resources are, however used the least by consulting engineers, if ever.
- *Conferences* are mainly attended for personal development purposes and to comply with the Engineering Council of South Africa's (2005:15) continuing professional development requirements. The cost of attending conferences – this is the cost related to conference fees as well as the costs related to the time and income lost while attending the conference – could be the main reason for the consulting engineers' reluctance to attend conferences.

3.3.5.3 INTERPERSONAL CONTACTS

The empirical findings showed a preference for personal contacts as sources of engineering information. The main reason for this trend seems to be that people often are the engineers' only sources of information (considering the client's needs and the information needed from the architect and the mechanical engineers reported in table 2). The studies reported on by Ellis and Haugan (1997), Hirsh (2000), Hertzum and Pejtersen (2000), Fidel and Green (2004), and Wheeler (2004) reported similar preferences for interpersonal contacts.

As explained in the context of information needs, the consulting engineers will approach a different person for information in similar but different projects. The specific project will therefore determine the social network or intentional network that will provide the consulting engineers with information that is relevant to the project.

3.3.6 AWARENESS OF INFORMATION

Awareness of information includes consulting engineers' perceptions of trust, cost or time, accessibility or availability of information sources.

Cost and time do seem to be important factors impacting on the selection of information sources. Most consulting engineers indicated that they don't 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 or the time spent studying a new information source) is time lost to complete a task. Time and cost considerations can also be the reason why mentorship is such an important source of engineering information and why consulting engineers are reluctant to attend conferences.

The trust consulting engineers put to information sources can be related to the time they have available in studying new sources of information. One consulting engineer commented that she simply did not have the time to study a new source that would only provide her with information similar to what she would find in one of her trusted sources. She also commented on her preference to use specific products that she trusted and knew would work – this comment is not the same as using a trusted source for information, but could be an indicator of how trust could influence the selection of an information source.

None of the responding consulting engineers reported that they had problems in accessing the required information or that they experienced problems in finding the relevant information to solve a problem. They would innovatively find the required information or rely on their personal knowledge or engineering judgement in instances when the required information is neither available nor accessible. Availability or accessibility of information therefore does not seem to be a factor influencing consulting engineers' selection of information sources.

Whether the required information appears in a pamphlet or a technical journal does not seem to be a factor when engineers select information. What seems to be more important is the level of sophistication of the information and the amount of information available in the source. Engineers do not want to buy a source that consists of a number of pages if they only need one page of calculations or drawings from the source. Information summarised in graphics and statistics is easy for them to interpret and saves time.

3.4 OUTCOMES OF INFORMATION-SEEKING

The outcomes of information-seeking make up the final component in Leckie *et al*'s (1996) general model of professionals' information-seeking. The findings for this component could be derived from the time-line interviews since the outcomes involve the completion of tasks during each stage of the engineering project and eventually the completion of the project – the target procurement stage when the consulting engineers need to submit a final report on the project to the client.

Writing an article on a completed project is another possible outcome of consulting engineers' information-seeking. This is however not the main objective of the engineers' mandate and seem to feature low in their information behaviour. Only a few engineers reported that they would at times publish articles or a brochure on a completed project.

4 CONCLUSION

This article aimed at reporting on the author's study into the information behaviour of consulting engineers in South Africa. Leckie, Pettigrew and Sylvain's (1996) general model of professionals' information-seeking provided the framework for this report in the same way it was used to structure the data collected for the literature review (Du Preez 2007; Du Preez 2008:99–133) and empirical study (Du Preez 2008:168–305). The article also briefly showed how the gap-bridging metaphor in Dervin's (1983) sense-making approach was used to analyse the data collected from time-line interviews. This method assisted in determining the consulting engineers' information needs during the various stages of individual projects.

The objectives of the study were to determine how consulting engineers' tasks impact on their information needs and the information sources they require to complete their tasks. Other aspects that influence these decisions were also considered. The empirical findings met these objectives and indicated that the engineers collect most of the information they need for their projects during the preliminary design stage and the design and tender stages from a variety of information sources. Thereafter most of the information comes from the construction site or the project itself. People, personal knowledge and personal files seem to be the most used sources of information. Future studies on consulting engineers' social networks could therefore prove very useful in acquiring an understanding of the potential role social networks has in providing engineering information.

This study seems to be the first to report on how engineers use FTP sites to communicate project related information with professional team members. The study also

seems to be the first to report on how consulting engineers use digital cameras to record progress in projects. More studies are required to determine whether engineers working in different work environments also utilise digital cameras to record progress and collect information for their projects. A comparative study focusing on the use of digital cameras by consulting engineers and other professionals such as architects and quantity surveyors could also be useful.

Leckie *et al*'s (1996) model proved to be a useful model to study the information behaviour of consulting engineers. Using the model made it possible to study the task related information behaviour of consulting engineers as well as the other factors that influence the engineers' selection of information sources. This is despite the models' focus being on the individual and not on a community of practice. However, great care needed to be taken not to duplicate data. This was a particular challenge when discussing task-related information needs and when discussing information sources as factors influencing consulting engineers, information-seeking.

The gap-metaphor in Dervin's (1983) sense-making approach also proved valuable in analysing the data collected from the time-line interviews that pertain to the engineering tasks requiring information at various stages of an engineering project. Using the gap-metaphor and time-line interviews enabled the researcher to determine the task-related information needs and the sources that were required to satisfy those needs. However, the use of time-line interviews did not assist in acquiring a general overview of all the potential sources of information used by consulting engineers (this was captured by an additional set of questions). Furthermore, when analysing the data, it was quite difficult not to confuse an information need with the seeking of information from specific sources of information.

Future research projects can also focus on consulting engineers' use of FTP sites to communicate project related engineering information and the role of social networks in providing engineering information.

The reported empirical findings could guide the development of a unique Internet based information service that could provide in the information needs of consulting engineers who do not have an information service available within their own companies and for the development of a model of the information behaviour of engineers.

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