

**FRAMEWORK FOR AN ADVANCED RESEARCH INFORMATION LITERACY  
(ARIL) PROGRAMME FOR POSTGRADUATE RESEARCHERS IN  
ENGINEERING**

**By**

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## DECLARATION

I, Karien du Bruyn, declare that *Framework for an advanced research information literacy (ARIL) programme for postgraduate researchers in engineering* is my own work, and that all the sources used and quoted herein have been acknowledged by complete references.

I further acknowledge that this thesis, which I hereby submit for the degree DPhil (Information Science) at the University of Pretoria, is my own work and has not previously been submitted by me for a degree at this or any other tertiary institution.



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Signature

(Mrs K du Bruyn)

30 Augustus 2016

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## ABSTRACT

The need for an advanced research information literacy (ARIL) framework was motivated by challenges faced by several stakeholders at academic institutions to support postgraduate researchers in an academic context (e.g. supervisors, academic departments, academic libraries). This applies to the full postgraduate research trajectory stretching from master's level to well-established researchers. Research must meet with institutional requirements, international standards and the expectations of industry and praxis. Information literacy skills are essential for successful conduct and reporting of research, as well as the dissemination of research results.

What constitutes basic information literacy skills is well captured (although frequently revised) in standards of information literacy applied to various contexts, including the academic and workplace context. However, what constitutes ARIL remains a subject of research. This study therefore explored the concept from the subject literature before suggesting an ARIL framework that guided a case study with researchers on several levels of postgraduate research at a South African academic institution. Based on empirical findings, the conceptually inspired (based on a definition) ARIL framework was then reconsidered to recommend an ARIL framework for practical implementation that can also guide further research. Engineering researchers were selected for the empirical component as a group of researchers who need to meet the requirements of academic scholarship as well as industry.

The study was guided by the following research question:

**How can an advanced research information literacy (ARIL) framework inform the development of programmes supporting the scholarly research process of engineers in a South African higher education environment?**

Six sub-research questions addressed various components of the research question:

1. What are the characteristics of introductory and advanced research information literacy programmes as reported in subject literature?
2. What are the documented information needs, information behaviour and information-related experiences of engineering researchers in academic institutions, as well as from industry?
3. What are the current self-reported ARIL skills of South African postgraduate engineering researchers?

4. How do information literacy skills, knowledge, and practices of engineers differ between master's, doctoral, post-doctoral, established and expert researcher levels?
5. How can an ARIL framework assist to determine which skills need to be developed at various levels of the engineering research process?
6. Which guidelines and interventions are required to support the implementation of a comprehensive research information literacy framework for engineers?

A mixed methods approach to a single case study was applied. Seven engineering departments from a South African institution with a leading faculty in engineering participated in the study. Data collection occurred between September and December 2015. A semi-structured, self-administered web-based questionnaire collected mostly quantitative data from 68 participants. Individual and focus group interviews collected mostly qualitative data. Twelve individual interviews were conducted, as well as three focus group interviews with 19 participants. A short, structured questionnaire collected demographic data from the interview and focus group participants. All participants gave written/electronically recorded informed consent for participation, as well as for the recording of interviews. Invitations were distributed to all master's and doctoral students as well as staff in the department, through the department's offices. Descriptive statistical analysis was applied to the quantitative data and thematic analysis to the qualitative data.

Data collection was guided by typical phases in the full research lifecycle, including conceptualising a research topic, obtaining research funding, discovery of information, management and organisation of information, data collection/generation and analysis, data curation, creation of information formats, management of intellectual property rights, dissemination of findings and measurement of impact in a field of study. The thesis reports on findings for each. Three key themes are conspicuous:

- Commitment to a culture of quality in postgraduate engineering research
- Progression from dependent to independent and expert researchers
- Preparation and positioning for impact in a specific field of study.

The findings and recommendations from this study describe practices that could inform both theoretical and practical issues relevant to ARIL support for engineering researchers on all levels from master's study to expert research.

**Keywords:**

Advanced research information literacy; Case study; Engineers; Engineering research; Information literacy skills; Postgraduate research; Research capacity building.

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## ACRONYMS AND ABBREVIATIONS

ACRL	Association of College and Research Libraries
ALA	American Library Association
ASCII	American Standard Code for Information Interchange
ASEO	Academic Search Engine Optimization
ATLAS.ti	Archiv fur Technik, Lebenswelt und Alltagsprache
CAS	Chemical Abstracts Service
CC	Creative Commons
CHET	Centre for Higher Education Transformation
COS	Community of Science
DCI	Data Citation Index
DIPP	Digital Interactive Poster Presentation
DOI	Digital Object Identifier
EBIT	Engineering, Built Environment and Information Technology
ERA	Excellence in Research for Australia
ESI	Essential Science Indicators
FTE	Full-time Equivalent
FTP	File Transfer Protocol
GIM	Group Information Management
HEFCE	Higher Education Funding Council for England
HPC	High Performance Computing
HTML	Hyper Text Markup Language
IB	Information Behaviour
ICT	Information and Communication Technology
IEEE	Institute of Electrical and Electronics Engineers
IF	Impact Factor
IP	Intellectual Property
Irs	Institutional Repositories
IRB	Institutional Review Board
ISO	International Standards Organization
ISI	Institute for Scientific Information
ISP	Information Seeking Process
IT	Information Technology

JCR	Journal Citation Reports
JISC	Joint Information Systems Committee
LIS	Library and Information Sciences
MATLAB	MATrix LABORatory
MEMO	Minnesota Educational Media Organization
MINITAB	Statistical Analysis Software Package
NRF	National Research Foundation
NQF	National Qualifications Framework
NUD.IST	Non-numerical Unstructured Data Indexing Searching and Theorizing
OA	Open Access
OCLC	Online Computer Library Catalog
PDF	Portable Document Format
RAE	Research Assessment Exercise
RIN	Research Information Network
RPM	Research Performance Management
RSS	Real Simple Syndication
RU	Rhodes University
SABS	South African Bureau of Standards
SAQA	South African Qualifications Authority
SAS	Statistical Analysis Software
SCONUL	Society of College, National and University Libraries
SEO	Search Engine Optimization
SET	Science, Engineering and Technology
SHERPA	Securing a Hybrid Environment for Research Preservation and Access
SJR	SCImago Journal Ranking
SPSS	Statistical Package for Social Sciences
SU	Stellenbosch University
SYSTAT	Statistics and Statistical Graphical Software Package
TMs	Trademarks
TOC	Table of Contents
UCT	University of Cape Town
UK	United Kingdom

UP	University of Pretoria
URI	Universal Resource Identifier
UUID	Universally Unique Identifier
VLE	Virtual Learning Environment
VRE	Virtual Research Environment
VUT	Vaal University of Technology
WITS	Witwatersrand University
WOS	Web of Science
WWW	World Wide Web
XML	Extensible Markup Language

## CHAPTER 1: INTRODUCTION AND BACKGROUND TO STUDY

### 1.1 INTRODUCTION

Librarians and faculty have long assumed that researchers on postgraduate level have adequate standards of information literacy (Conway, 2011<sup>1</sup>:121; Streatfield, Allen & Wilson, 2010:231; Booth, 2007; Kong, Hunter & Lin, 2007:154; Machet, 2005:193). Previous efforts to train and support postgraduate students in information literacy were therefore mostly based on undergraduate programmes, which often concentrate on a narrow set of generic information literacy skills, rather than focusing on discipline-specific postgraduate needs (Streatfield, Allen & Wilson, 2010:238; Green & Macauley, 2007:317). Support in the past also focused mainly on information searching and retrieval skills regarding specific information retrieval tools (Adams, Buetow, Edlin *et al.*, 2016:2; Hall & Jaquet, 2016:1020; Brewerton, 2012:104; Tautkeviciene, 2011:2; Green, 2010:316; Kohl-Frey, 2008:136; Jankowska, Hertel & Young, 2006:61). In addition, many previous studies were guided by a needs analysis approach only, without supplying more specific guidelines for improving specific skills (Randall *et al.*, 2008; Rempel, 2008; Marcus, Covert-Vail & Mandel, 2007; Rowlands & Fieldhouse, 2007; Stein *et al.*, 2006; Wright *et al.*, 2006).

Along with universities being required to demonstrate their effectiveness regarding student outcomes, there is a growing trend among academic libraries to increase their value to various communities on campus (Soria, Fransen & Nackerud, 2013:147). One such community is postgraduate researchers; the literature confirms gradually developing awareness of the pressing, scattered, unique and complex needs of this group in higher education institutions (Hall & Jaquet, 2016:1016; Brewerton, 2012:97, Blanton-Kent *et al.*, 2010:1; Hoffmann *et al.*, 2008; Green & Macauley, 2007:317; Wainwright, 2005:452). Radical transformations taking place in scholarly communication and practice in recent years (Bourgh, Coleman & Erway, 2009:1) have resulted in growing recognition that various research skills need to be developed on postgraduate level, and that more intentional guidance may be required (Dash, 2015:146; Mamtora, 2013:355; O'Grady & Beam, 2011:76; Streatfield, Allen & Wilson, 2010:237; Rempel, 2008:157; Booth, 2007; Genoni, Merrick & Wilson, 2006:743). Many academic libraries are creating new positions to assist specifically

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<sup>1</sup> In-text references are according to date; most recent references first. If multiple references have the same date of publication, they are presented in alphabetical order according to author.

postgraduate researchers, e.g. “Research support librarian”, “Research support specialist”, and “Research liaison manager” (Brewerton, 2012:98). Librarians’ efforts to engage more deeply in the workflow of scientific research and postgraduate students’ research needs, have, however, still been marginal (O’Grady & Beam, 2011:76; Housewright & Schonfield, 2008:31; Rempel, 2008:163; Jankowska, Hertel & Young, 2006:60; Wright *et al.*, 2006:141). According to Exner (2014:461), information literacy training for researchers seldom takes original research processes into consideration, and no guidance on information literacy support is given to researchers in different faculties. Literature confirms challenges in meeting the needs of postgraduate students and their supervisors (Hall & Jaquet, 2016:1021), and many academic libraries may therefore currently be failing to deliver the right kind of training and guidance to postgraduate researchers (Bracke, 2011:72; Streatfield, Allen & Wilson, 2010:230; Gomersall, 2007:301). This sets the rationale for a study on the research information literacy needs of postgraduate researchers.

## **1.2 BACKGROUND**

Most research problems arise from a concrete problem observed in reality (Fouche & de Vos, 2005:92). The rationale for this proposed study initially arose from the researcher’s contact and informal conversations with academics, supervisors and postgraduate students at the Vaal University of Technology (VUT) since 2010. Supervisors across all disciplines often mentioned postgraduate students’ lack of basic research skills and a need for research support on campus. At the time, the researcher also became involved with postgraduate induction programmes offered on campus and observed that most students needed support regarding information literacy in a research context. This observation was confirmed in recent literature, where popular variables used in studies focusing on research productivity include institutional size, age, gender, self-efficacy and information utilisation, although the influence of information literacy has not been revealed sufficiently (Okiki & Mabawonku, 2013:10). The researcher also realised that different approaches need to be taken to supporting different disciplines, because of different needs, interests and behaviour, and that a “one size fits all” approach cannot be effective (Blanton-Kent *et al.*, 2010:1; Housewright & Schonfeld, 2008:30; Rempel, 2008:162; Sadler & Given, 2007:125; Grafstein, 2002:197).

### **1.2.1 Postgraduate research support**

Information literacy skills are essential for postgraduate students to function effectively in an information environment characterised by constant change (Green & Macauley, 2007:319), which will continue to change in coming years (Mamtora, 2013:368). Rempel (2010:543) and

Hoffmann *et al.* (2008:4) suggest that research support services must be tailored for postgraduate students, and targeted workshops should consider the particular stage of research in which graduate students are engaged. Some of these research support services include assistance with the literature review process (Green, 2010:314; Rempel, 2010:535; Rempel, 2008:157; Gomersall, 2007:302), searching and scanning of information (O’Grady & Beam, 2011:76; Booth & Tattersall, 2009; Booth, 2007; Gomersall, 2007:303, Antwi-Nsiah *et al.*, 2006), current awareness strategies (Boden, 2007:172; Booth, 2007), support in the use of bibliographic management software (Booth, 2007; Harrison & Jones, 2007; Antwi-Nsiah *et al.*, 2006), advice on publishing research results (Hall & Jaquet, 2016:1015; O’Grady & Beam, 2011:76; Rasul & Singh, 2010:83; Kohl-Frey, 2008:136; Boden, 2007:172; Booth, 2007; Harrison & Jones, 2007), copyright and intellectual property (IP) assistance (Thomas, 2011:43; Streatfield, Allen & Wilson, 2010:237; Booth, 2007), advice on collaboration with other researchers (Thomas, 2011:43; Genoni, Merrick & Willson, 2006:735), assistance with data management practices (Hall & Jaquet, 2016:1015; Thomas, 2011:43; Rempel, 2010:539; Pilerot, 2004:94), services giving advice on journal ranking systems (Herther, 2008:367; Booth, 2007), assistance with the evaluation of resources (Jamali & Nicholas, 2006:7), funding and grant application support (Hensley, 2009:207; Genoni, Merrick & Willson, 2006:744; Harrison & Hughes, 2002:11), and assistance with research ethics (Harrison & Hughes, 2002:19). Even assistance with research methodology (Rasul & Singh, 2010:83; Harrison & Hughes, 2002:19) is suggested in the literature. Services of this nature indicate a shift in focus from developing basic information literacy skills, which focus mostly on seeking, accessing and using information resources, to more advanced information literacy skills needed during the research process.

### **1.3 PURPOSE, OBJECTIVES, CONTRIBUTION AND VALUE OF STUDY**

Research studies directed at information literacy of engineers in academic institutions are sparse (Douglas, Van Epps, Mihalec-Adkins, Fosmire & Purzer, 2015:129). Based on available relevant literature, as well as the researcher’s observations during postgraduate induction programmes, the purpose of this study was to develop an advanced research information literacy (ARIL) framework for postgraduate engineering researchers during the various stages of their research careers. The intention with the framework was that it should serve as a guide in developing programmes for engineering researchers in higher education environments.

The following objectives thus guided the study:

- Determining what an ARIL framework should entail.
- Determining how an ARIL framework can assist in determining which skills need to be developed on various levels of the engineering research process.
- Developing an ARIL framework for engineering researchers that can also be adapted for other disciplines.
- Determining which guidelines and interventions are required to support the implementation of an ARIL framework for engineers.

The higher education environment in South Africa can be divided between public and private institutions, of which public institutions can be subdivided into universities, comprehensive universities and universities of technology. The VUT (where the researcher is currently employed), can benefit from such a framework, which could assist to address low research output in the Faculty of Engineering and Technology. Focused support of engineering researchers, through covering a broad array of information literacy skills, may also result in more effective and confident postgraduate researchers at other local institutions, since earlier studies confirm that these researchers across disciplines often feel overwhelmed, anxious and frustrated (Marcus, Covert-Vail & Mandel, 2007:17; Pilerot, 2004:93). International academic institutions may also benefit from this research, since a limited amount of literature is available regarding support for postgraduate engineers in the higher education environment according to the various stages of their research careers. The value and contribution of the study thus extend beyond the researcher's institution of employment to the national (South African) arena of higher education, as well as internationally. Detail on the contribution of the study will be clearer from the recommendations on practice and theory (sections 8.6.1 and 8.6.2 in Chapter 8).

#### **1.4 STATEMENT OF THE PROBLEM, RESEARCH QUESTION AND SUB-QUESTIONS**

The widespread assumption that postgraduate researchers are information-literate has resulted in neglecting their information literacy needs and requirements altogether (Streatfield, Allen & Wilson, 2010:230). It also resulted in uncoordinated approaches globally, in variations in the breadth and depth of information literacy training sessions on offer, over-concentration on information seeking activities (Streatfield, Allen & Wilson, 2010:230) and often in ignoring the unique characteristics of different disciplines (Inskip, 2013:3). The entire research lifecycle should rather be taken into consideration to avoid the narrow scope of information

literacy training on offer to postgraduate researchers (Mamtora, 2013:355), and to enhance deeper understanding of the various stages of research and a research career. Consideration of the research lifecycle might reveal different needs (Aucland, 2012:2).

Against this background, this study set out to address the problem of deepening understanding of the impact of research stages in postgraduate research on information literacy skills applying to discipline-specific postgraduate research. For the purpose of this study the focus was on postgraduate research in a South African academic context. The discipline was engineering.

The study was guided by the following research question:

How can an ARIL framework inform the development of programmes supporting the scholarly research process of engineers in a South African higher education environment?

In order to explore the research question fully, the following sub-questions were asked:

- What are the characteristics of introductory and ARIL programmes reported in the subject literature?
- What are the documented information needs, information behaviour and information-related experiences of engineering researchers in academic institutions, as well as in industry?
- What are the current self-reported ARIL skills of South African postgraduate engineering researchers?
- How do information literacy skills, knowledge and practices of engineering researchers differ between master's, doctoral, post-doctoral, established and expert researcher levels?
- How can an ARIL framework assist to determine which skills need to be developed during various levels of engineering research to support all processes in the research lifecycle?
- Which guidelines and interventions are required to support the implementation of an ARIL framework for engineers?

## **1.5 ASSUMPTIONS**

It is assumed that librarians may have a broader role to play in the scholarly research process of engineers than what was previously believed. The researcher (a librarian) also assumes that

skills, knowledge and practices regarding information literacy will differ between researchers on master's, doctoral, post-doctoral, established and expert levels. Finally, the researcher assumes that information literacy plays an important role in the scholarly research process of engineers, and that an ARIL framework can guide future interventions to improve research efficiency.

## **1.6 METHODOLOGY**

### **1.6.1 Research design**

Ivankova, Creswell and Plano Clark (2007:255) identify three recognised approaches to conducting research, namely quantitative, qualitative and mixed methods. They state that the choice of a specific approach depends on the researcher's philosophical orientation, the type of knowledge sought, and preference for data collection methods. In this empirical study, the researcher implemented both objective and subjective methods to collect data. Collecting both numerical and text data provided more comprehensive evidence regarding the research problem than either quantitative or qualitative research could do alone (Creswell & Plano Clark, 2007:9; Ivankova, Creswell & Plano Clark, 2007:259). The study thus used a mixed methods research design.

### **1.6.2 Single-case study design**

A case study survey was selected as research method. It was decided to focus on only a single institution. Although they have limitations, single-case studies are often used (Babbie, 2010:309; Nieuwenhuis, 2007:75), also in studies regarding information literacy. If conducted as an in-depth study, a researcher may discover the reasons for the successes and failures of a specific institution (Lues & Lategan, 2006:19), as opposed to studying multiple institutions superficially (Rule & John, 2011:7). For the purpose of this study, such findings can support the improvement of practice at other institutions.

### **1.6.3 Selection of participants (i.e. sampling)**

The selection of participants comprised two phases. The researcher first identified a research-intensive university in South Africa, with a proven strong track record of global impact in the field of engineering (the chosen discipline of focus). Thereafter, she had to decide who to include as engineering postgraduate researchers, by including those (both staff and students) enrolled for master's and doctoral qualifications, as well as those who already held a doctoral degree. In a South African academic context these include researchers appointed in a post-doctoral position in an academic department, academics without a National Research

Foundation (NRF) rating and the various levels of NRF-rated researchers. The ratings are awarded by the South African NRF to researchers, based on a peer-review system reflecting their status as researchers. For the purposes of the study the term ‘established researchers’ refers to researchers with C (nationally established) and B (internationally established) ratings. Expert researchers are those who have an A rating. There are also special ratings for young researchers (explained in more detail in Section 4.2.1.2.) Bent, Gannon-Leary and Webb (2007:85) divide researchers according to seven “ages”, namely master’s, doctoral, contract, early career, established, senior and expert researchers. This study categorised participants as master’s, doctoral, post-doctoral (post-doctoral appointees and participants with a doctoral degree, with or without an NRF rating), established researchers (nationally and internationally according to NRF C and B ratings) and expert researchers (according to an NRF A rating).

The complete coverage of a total population is seldom possible and often impractical and uneconomical (Welman & Kruger, 2001:46). Case studies are not associated with sampling techniques, since the focus is on gaining in-depth information from information-rich sources. Participants were therefore invited through engineering departments of the institution chosen for the case study to participate in the quantitative phase of the study.

Once the first part of the study (quantitative) had been completed, the process of conducting focus group and individual interviews (qualitative component) commenced. The researcher included a section at the end of the questionnaire (see Addendum D) where respondents had to indicate whether they would be willing to participate in follow-up focus group interviews. Respondents who agreed were contacted to make arrangements for focus group interviews; the researcher attempted to ensure representation of engineering researchers on master’s, doctoral and post-doctoral levels as far as possible. Focus group and individual interviews were conducted on the premises of the university, and the size of groups ranged from seven to ten participants, in order to keep the sessions manageable. Researchers could also opt for an individual interview if this was more convenient.

#### **1.6.4 Data collection strategies**

Data collection was based on the use of an electronic self-administered semi-structured questionnaire as part of the first (quantitative) phase of the empirical study. This was followed by focus group interviews, and as alternative, individual interviews in the second (qualitative) phase.

Focus group interviews were selected for the qualitative component of this study, as these should provide better insight to enable understanding of specific issues that surfaced from the questionnaire survey. Individual interviews were employed to accommodate those engineering researchers who were unable to attend focus group interview sessions. According to Jankowska, Hertel and Young (2006:67) qualitative data provides a “richness and context that add life to the numbers, and meat to the bones of quantitative data”.

#### *1.6.4.1 Questionnaire (quantitative technique)*

The researcher conducted a web-based self-administered, semi-structured questionnaire. It was assumed that more respondents would be reached this way, since researchers are often not physically on campus. According to Denscombe (2003:42), the advantages of electronic questionnaires include that they are simple to construct and easy to answer; respondents only need to complete the answers and use the reply button to return the questionnaire. Data collected can allow the researcher to describe trends and explain relationships between variables (Leedy & Ormrod, 2010:95; Ivankova, Creswell & Plano Clark, 2007:255). Questionnaires are also associated with relatively low costs to design and the opportunity to collect information from a large number of respondents in a short time (Delpont, 2005:167). Participants can complete the questionnaire in their own time and can check personal records if necessary, with no interviewer present who may influence the respondent (Maree, 2007:157; Delpont, 2005:167).

Limitations regarding questionnaires, however, include high non-response rates, as well as unanswered or wrongly interpreted answers (Delpont, 2005:167). The researcher has no control over the conditions under which the questionnaire is completed and no assistance is available to participants while they are completing the questionnaire (Leedy & Ormrod, 2010:189; Maree, 2007:157; Denscombe, 2003:42).

Guidelines provided by Leedy and Ormrod (2010:194), Denscombe (2003:152), and Mouton (2001:103) on the construction of questionnaires were followed. These include keeping questionnaires short, keeping the respondent’s task simple, providing clear instructions, using unambiguous language, avoiding vague questions, avoiding double-barrelled questions, avoiding technical jargon, ensuring that the style of questions is suitable to the target group, providing a rationale for items where the purpose might not be obvious to participants, avoiding leading questions, determining coding of questions in advance and benefiting from pilot testing.

Guidelines provided in the literature regarding maximising return rates of mailed questionnaires were also considered: the timing, good first impressions, motivation of participants, offering to distribute the results of the study and being gently persistent (Leedy & Ormrod, 2010:202). Questions were mainly in closed format (providing a list of possibilities to choose from and using a Likert scale). Many of the questions included an option of 'other', and allowed respondents to add additional comments.

Questionnaires were only sent to participants after a pilot study had been done (Strydom, 2005:210; Welman & Kruger, 2001:141). Feedback provided valuable information to improve the questionnaire and thus contributed to the overall success and effectiveness of the research project.

#### *1.6.4.2 Individual and focus group interviews (qualitative techniques)*

The purpose of focus group interviews was to explore issues presented in the questionnaire survey extensively, and to follow up on the analysis of the data collected. Librarians often use focus groups to collect data from postgraduate students (Sadler & Given, 2007:125).

According to Morgan (1998:9), focus group interviews are based on listening to people and learning from them. Focus groups are aimed at collecting qualitative data – the words and images of participants regarding the phenomenon that is studied. Sample sizes can be small (Ivankova, Creswell & Plano Clark, 2007:257; Greeff, 2005:301; Morgan, 1998:13).

Advantages of focus groups include that they provide an opportunity to observe and stimulate interaction on a topic from various people in a limited period of time. They can provide rich information and direct evidence of similarities and differences in participants' opinions and experiences (Greeff, 2005:312; Babbie & Mouton, 2001:292; Morgan, 1998:9). Data on multiple viewpoints can be generated and information can be gathered in a shorter period than individual interviews would have taken. Furthermore, focus groups can support exploration and discovery, provide for context and depth, and allow for interpretation from the researcher's side through broad open-ended research questions.

Disadvantages of focus group interviews include increased costs and time, interviewer effect, respondent inhibitions, invasion of privacy, the need for skilled researchers and problems relating to researcher bias (Greeff, 2005:312; Denscombe, 2003:190).

Continuous monitoring of all interpretations through member checks after every interview session was used to ensure a true reflection of information provided by participants, and to

limit bias. Although there were disadvantages associated with conducting focus group interviews, the rich data hoped for (and actually obtained) far exceeded the disadvantages noted in the literature.

An interview schedule was used, based on predetermined open-ended questions (see Appendix E). The questions guided the issues to be discussed and ensured that discussions kept to the focus of the topic (Leedy & Ormrod, 2010:148). Facilities, equipment and logistical issues were addressed beforehand, which included the identification of a quiet location without interruptions and technical issues regarding the recording of the interviews. A moderator led the discussions during each focus group interview session; all were audiotaped with signed permission of each participant. Handwritten notes taken during the interviews were added afterwards, along with notes on participants' behaviour and non-verbal reactions during the focus group interview sessions. Individual interviews were conducted with established and expert level researchers to accommodate their schedules, and were also tape-recorded where signed permission was given by the participant. The interview schedule for the focus group also guided individual interviews.

Interview questions were piloted in a focus group session with a group of engineering researchers from the VUT who did not form part of the case study.

#### *1.6.4.3 Profile questionnaire for focus group and individual interviews*

A brief questionnaire was used to collect profile (i.e. demographic) data from researchers who participated in the individual and focus group interviews (see Addendum H).

### **1.6.5 Data analysis and interpretation**

According to Creswell (2009:183), the process of data analysis includes making sense of data. It involves preparing data for analysis and moving deeper into understanding the data.

#### *1.6.5.1 Descriptive statistics for questionnaire (quantitative phase)*

Validation of questions was done before sending out the final questionnaire, in order to address issues regarding the coding and capturing of data onto the computer system.

#### *1.6.5.2 Thematic analysis for individual and focus group interviews (qualitative phase)*

Leedy and Ormrod (2010:153) identified four phases during the qualitative data analysis process, namely breaking large units into smaller ones (organisation), getting an overall sense of the topic (perusal), grouping data into categories or themes to find meaning (classification) and using tables, diagrams and graphs to explain findings (synthesis). The researcher

therefore first started to organise all transcripts and data, then perused them, to form a clear and holistic understanding of the information at hand. Thereafter, the coding process commenced, where data was broken down, named, categorised and conceptualised according to themes. Open and axial coding techniques were used, through identifying specific recurrent words from which themes could be identified, whereafter it was reconstructed to present new insight. An independent coder was approached to confirm the main findings, as part of quality control regarding the data.

For quantitative analysis appropriate graphs, diagrams and tables are included. Data collected through the literature review, quantitative and qualitative instruments was triangulated. Themes and triangulated data are used to address the research question and sub-question.

### **1.6.6 Reliability and validity**

The aim of the study was to gather data of a high quality to answer the pre-determined research question and sub-question. Methods to ensure that data obtained was valid and reliable were therefore used.

Validity can be ensured through designing an instrument that measures what it should measure and that measures it accurately (Leedy & Ormrod, 2010: 28; Delport, 2005:160). Validity and reliability reflect the degree to which error may be prevalent in a measurement. A qualified experienced statistician gave input on the validity and reliability of the questionnaire.

Validity in qualitative research refers to checking the accuracy of findings by employing certain procedures (Leedy & Ormrod, 2010:100). Multiple strategies were implemented; member checks were used to determine the accuracy of qualitative findings, thick descriptions were used to convey findings, negative information was addressed, and prolonged time was spent in the field until data saturation was reached (Leedy & Ormrod, 2010:100; Babbie & Mouton, 2001:275).

Track was kept of data by recording the main discussions and events throughout the interview sessions. Credibility of the data was ensured through the accurate identification and description of events, according to guidelines given by Babbie and Mouton (2001:277). Transferability was achieved through providing thick, detailed and precise descriptions of data, again according to guidelines provided by Babbie and Mouton (2001:277).

### **1.6.7 Ethical considerations**

Ethical considerations come into play during three stages of a research project, namely during the recruiting of participants, during the measurement process, and when results obtained are released (Welman & Kruger, 2001:171; Denscombe, 2003:134). Ethics is an integral part of responsible research and needs to be considered when research is conducted with human participants (Leedy & Ormrod, 2010:101). During qualitative research, a researcher is personally involved with participants and needs to adhere to guidelines; for example, as pointed out by Strydom (2005:58), by ensuring that no person's rights will be violated, only collecting data on the principle of informed consent, not deceiving participants, taking proper action and showing research competence, ensuring good co-operation between the researcher and participants, adhering to ethical requirements to ensure participant confidentiality in reporting findings and debriefing participants in projects where it is necessary.

Ethical clearance was obtained from the ethics committee from the selected university in this case study, since human subjects were involved in the empirical research, as well as from the research ethics committee of the Faculty of Engineering, Built Environment and Information Technology, University of Pretoria, as the degree-granting institution.

#### *1.6.7.1 Informed consent*

A separate section was added to the questionnaire to give participants the opportunity to give informed consent. Leedy and Ormrod (2010:102) point to issues that need to be covered in such a consent form, namely a brief description of the nature of the study, what participation will involve, a voluntary participation statement, guarantees regarding confidentiality, the researcher's name and contact details, and a place for the participant to sign and date the letter, indicating his/her agreement to participate. The same process was repeated during focus group and individual interviews, where a letter of consent was handed out to every respondent. Participants had to read the document and were allowed to ask questions, whereafter they were requested to sign the document. All respondents were again reminded that they could withdraw at any stage. They were also asked (on the form) to agree to interviews being tape-recorded.

#### *1.6.7.2 Privacy and confidentiality*

Any research involving human beings should respect participant's right to privacy, and researchers should keep the nature and quality of participants' performance strictly confidential (Leedy & Ormrod, 2010:202). The researcher kept all participants' information

and responses private and all results were presented anonymously, to protect the identities of individuals.

## **1.7 STUDY DEMARCATION**

This study concentrated on public higher education institutions in South Africa and did not include colleges or other private institutions offering higher education courses. The population represented engineering postgraduate researchers enrolled for or holding master's, doctoral or post-doctoral qualifications, as well as rated researchers according to the NRF rating categories.

## **1.8 LITERATURE REVIEW**

Fink (1998:3) defines a literature review as a “systematic, explicit, and reproducible method for identifying, evaluating and interpreting the existing body of recorded work produced by researchers, scholars, and practitioners.” This important part of the research process (non-empirical) assists researchers in providing information on research already conducted, as well as inconsistencies and gaps in existing literature, and allows researchers to indicate where their proposed research fits in (Leedy & Ormrod, 2010:66; Welman & Kruger, 2001:33). The following electronic databases were used to gather relevant information: Academic Search Premier, LISTA, LISA, ERIC, Compendex, Ingenta, Thompons Reuter's Web of Science, Informaworld (Taylor & Francis), ScienceDirect, SABINET, and Emerald. Different search engines were also used to gather quality scholarly information on the World Wide Web. The Nexus database from the NRF was searched to ensure that there was no duplication of previous research on this topic in the South African context. Keywords that were used to search for information included researchers, master's, doctoral, PhD, “information literacy”, information needs” “scholarly communication” “higher education”, “academic research”, “research needs”, “research skills”, engineering researchers”, engineers AND research, “research support”, “library support”. All searches were conducted by making use of Boolean operators where possible, as well as available filtering and refining methods, such as limiting according to field.

The literature review section is organised according to themes, which is a prevalent practice in exploratory studies (Mouton, 2001:93). Two key themes are discussed here: information literacy and ARIL.

### 1.8.1 Information literacy

The concept “information literacy” was introduced in 1974 by Paul Zurkowski, in his motivation for the establishment of a national programme to achieve universal information literacy (Eisenberg, Lowe & Spitzer, 2004:3). A great amount of literature has since been published by professional organisations and individual scholars, in response to the rapid increase in information and technological developments. In 1989 the American Library Association (ALA) Presidential Committee on Information Literacy provided a definition of an information-literate person, which was widely accepted in the library field (Eisenberg, Lowe & Spitzer, 2004:4). According to this definition, an information-literate person is somebody who is able to “recognise when information is needed, and [has] the ability to locate, evaluate, and use effectively the needed information” (ALA, 1989). Several widely known international information literacy models followed, which have been developed through research and evaluation, with many similarities among them. Some of the well-known American models include Kuhlthau’s model of the information seeking process (ISP) (Kuhlthau, 1999:12), Eisenberg/Berkowitz’s Information Problem-Solving (Big6 Skills), Irving’s Information Skills, and the Stripling/Pitts Research Process (Eisenberg, Lowe & Spitzer, 2004:40). Models developed in the United Kingdom include the seven pillars model of information literacy developed in 1999 by the Society of College, National and University Libraries (SCONUL), and the PLUS (Purpose, Location, Use and Self-evaluation) and PGCE (Plan, Gather, Communicate, Evaluate) models (Ordidge, 2001:2). The “seven faces of information literacy” model was developed in Australia by Christine Bruce in 1997 (Bruce, 1997). Specific characteristics and competencies were formulated, based on different standards, to describe information-literate persons. These include recognising a need for information, gaining efficient and effective access to information, evaluating information and its sources critically, incorporating selected information into one’s knowledge base, using information effectively to accomplish a specific purpose, understanding the economic, legal and social issues concerning the use of information, and accessing and using information ethically and legally (De Jager & Nassimbeni, 2002:168).

Most of the information literacy models that were developed focus on undergraduate students, who are mostly involved with early research stages (Streatfield, Allen & Wilson, 2010:230). Undergraduate students were for many years perceived as those most in need of information literacy assistance in higher education institutions (Jankowska, Hertel & Young, 2006:61). Literature in recent years, however, has indicated growing awareness of the fact

that undergraduates' information needs and information behaviour differ from those of postgraduate researchers (Jamali & Nicholas, 2006:2).

### **1.8.2 Advanced research information literacy**

Literature suggests that librarians should concentrate not only on access to equipment and information resources, but should support the full range of research support services, namely the discovery of information, information organisation, providing facilities for a repository, selecting publishing channels, guidelines on intellectual property issues and guidelines on the promotion and dissemination of research findings (Rempel, 2010:545; Streatfield, Allen & Wilson, 2010:234; Hooks & Corbett, 2005:246; Wainwright, 2005:452). This indicates the need for a broader landscape in which research support services should be designed. Research information literacy activities and related services that have been reported in the past include information seeking, writing, current awareness, bibliographic management, copyright and intellectual property, data management, collaboration, publishing, grant writing and research ethics. Many studies, however, focus on activities that cover only a specific part of the scholarly research process, without investigating the scholarly research process in more detail as it applies to a specific discipline. According to Hoffmann *et al.* (2008:1), research on support to postgraduate researchers has been growing in recent decades, indicating varying levels of success in meeting information-literacy needs of graduate students, without the emergence of a single effective approach as the best for doing so.

## **1.9 KEY TERM CLARIFICATION**

Certain key concepts will be clarified in the next sections to provide context and clarity on how the terms were interpreted for the purposes of the study.

### **1.9.1 Research**

Leedy and Ormrod (2010:2) define research as “a systematic process of collecting, analyzing and interpreting information (data) in order to increase our understanding of the phenomenon about which we are interested or concerned”. The NRF provides a more detailed definition, by stating that research is an “original investigation undertaken to gain knowledge and/or enhance understanding”, and that it includes the creation and development of the intellectual infrastructure of subjects and disciplines, the invention of ideas, images, performances and artifacts embodying new or substantially developed insights, and building on existing knowledge to produce new or improved materials, devices, products, policies or processes. When referring to research in the context of this study, a scholarly research process is

implied, where original knowledge is created, followed by peer-review processes, before findings are published according to certain standards in recognised accredited outlets.

### **1.9.2 Researcher**

For the purpose of this study, the term *researcher* is interpreted as referring to somebody who is involved in the creation of original knowledge, by designing or improving materials, devices, products, policies or processes, to develop the intellectual infrastructure of a specific subject or discipline, through adding new or substantially developed insights while building on existing knowledge. In this study *researcher* refers to a scholarly researcher at an academic institution.

### **1.9.3 Postgraduate**

Postgraduate studies refer to studies done “after completing a first degree” (Oxford Dictionary and Thesaurus, 2009:711).

Postgraduate students in the context of this study refer to engineering students and staff members, who are in the process of acquiring a master’s or a doctoral qualification, those holding these qualifications, those appointed in post-doctoral positions, as well as those with NRF ratings. Engineering students on honours level of studies were excluded.

### **1.9.4 Higher education institutions**

Higher education institutions in South Africa can be divided into public and private institutions, of which there are currently 23 public and 87 private institutions. Public institutions can further be divided into universities, comprehensive universities and universities of technology. Only one higher education institution was included in this case study.

### **1.9.5 Information literacy**

The term “information”, can be defined as: “knowledge acquired in any manner” (Collins English dictionary, 2009:399). The same dictionary identifies “literacy” as “the ability to read and write” (Collins English dictionary, 2009:454). Literature confirms the existence of many different kinds of literacies, namely visual literacy, technological/computer literacy, tool literacy, resource literacy, research literacy, publishing literacy and many others (Repanovici & Landoy, 2007:3).

There are certain common elements to the many existing definitions, frameworks and models regarding information literacy, namely the identification of a need for information, access to

the information, acquisition, evaluation, manipulation and the ethical use of information (Boon, *et al.*, 2007:206). The most commonly cited definition, however, is that an information-literate person “must be able to recognise when information is needed, and have the ability to locate, evaluate, and use effectively the needed information” (ALA, 1989). According to Langford (1998:69), information literacy is a means to an end, and the end depends on what the individual/community wants at that time. For the purpose of this study information literacy was accepted as a dynamic and constantly changing concept regarding the use and management of information, which may reflect changes in society and may even continue to change over time.

### **1.9.6 Advanced research information literacy**

ARIL refers to skills beyond those required on undergraduate levels in higher education, and therefore includes not only skills in using information sources, but also skills involved in creating new knowledge. ARIL in this study refers to various phases and associated processes during the scholarly research process.

### **1.9.7 Engineers**

The field of engineering involves extroverted activities, which include searching for workable solutions to problems through generating a product, a process or a service, whereas science is an introverted activity concerned with the natural world (Lindberg, *et al.*, 2008; Pinelli, 1991:6). Engineers in this study are therefore seen as professional practitioners concerned with applying scientific knowledge to develop solutions for technical and practical problems.

### **1.9.8 Information literacy training**

Worldwide, libraries have been involved with information literacy training over many years. Training sessions are mostly offered in groups, through web-based tutorials, portals, or individual sessions. Many of these sessions are offered as stand-alone courses, others are course-integrated, and some are even curriculum-integrated in certain academic institutions.

## **1.10 DIVISION OF CHAPTERS**

Chapter 1 provides an introduction, rationale, and general overview regarding the study. The importance of the study is highlighted, and the study is contextualised in a higher education environment. The overall aims and goals of the study are explained by specifying the research problem and sub-problems. The research design and structure of the study, as well as the methodology followed to address the problem, are presented. An outline indicating the main topics to be discussed in each remaining chapter is provided.

Chapter 2 establishes a conceptual framework by discussing the differences between basic and ARIL concepts, using structured literature analysis. The link between ARIL and the scholarly research process is discussed. The primary phases during the academic research process are identified, before documented information literacy processes relating to each category are identified and discussed. Chapter two concludes with an overview and summary of the main conclusions.

Chapter 3 focuses on the information behaviour of engineers. It provides a holistic overview regarding documented information skills, practices and needs of engineering researchers in higher education institutions globally. The chapter concludes with an overview and summary of main conclusions, which will influence the empirical part of the study.

Chapter 4 describes the design and methodology followed in the study, as well as measurement instruments used. Questions that were asked in the questionnaire, as well as in focus group and individual interviews, are explained and motivated. Data collection processes, techniques, and data analysis processes are also explained.

Chapter 5 focuses on the presentation and discussion of quantitative results obtained, based on empirical research.

Chapter 6 focuses on qualitative data obtained during focus group and individual interviews. Main trends and patterns in the data are discussed with reference to the research question and sub-questions.

Chapter 7 presents the triangulation of findings from the literature, quantitative and qualitative data. The chapter concludes with an interpretation of findings and highlights key results. A framework for ARIL is proposed. Guidelines are provided on the implementation of the model at institutions of higher education.

Chapter 8 concludes the thesis by summarising and highlighting findings obtained in the study. The larger relevance and value of this study are indicated. Recommendations for theory and practice, as well as suggestions for future research, are included.

## 1.11 CONCLUSION

This chapter covered the introduction and background to the research problem, the research problem, research question and sub-questions. It also covered the research purpose and objectives, the clarification of key concepts, a brief literature review, the research design and the division of chapters to follow.

## CHAPTER 2: LITERATURE ANALYSIS TO CONCEPTUALISE ARIL

### 2.1 INTRODUCTION

The purpose of this chapter is to provide a conceptual framework that will serve to clarify the term “advanced research information literacy” (ARIL). This framework is necessary, since it will assist the researcher in answering the central research question, namely:

“How can an advanced research information literacy framework inform the development of programmes supporting the scholarly research process of engineers in a South African higher education environment?”

This chapter will be divided into two parts. The first will focus on the background and clarification of “literacy” and “information literacy”, followed by brief discussions on information literacy in different contexts. The second part will focus on connecting information literacy to the academic research process – thus conceptualising ARIL. The chapter will conclude with a brief summary.

### 2.2 EXTENDED CLARIFICATION OF CONCEPTS FUNDAMENTAL TO STUDY

Concepts often need to be clarified in research studies, since people may associate different meanings with concepts. This section will give context and background on two concepts that form the basis of ARIL: “literacy”, and “information literacy”. The section will expand on the operational definitions provided in Chapter 1 (section 1.9) and the importance of these skills.

Apart from face-to-face communication, writing has been the only medium for preserving and transferring information for many years (Marcum, 2002:13). The term “literacy” referred primarily to the ability to read and write; reading and writing were seen as the two most important competencies in a predominantly print environment over many centuries. Even today, literacy is still widely defined as: “the ability to read and write, and to use language effectively” (Collins English Dictionary, 2009:454). The concept of literacy has evolved over the years (Matusiak, 2012:3), and although traditional information sources such as word of mouth, print, radio, television and telephone are still used today, electronic and computerised communication systems rapidly gained field (Gunter, 2007:2). According to Eisenberg *et al.* (2004:173) basic literacy is “no longer sufficient for survival in the Information Age”.

Information and communication technology (ICT) developments in the twenty-first century resulted in more interactive ways of communication and demanded new competencies and skills in the construction of web pages, navigating the web, and participating in online chat

groups (Marcum, 2002:14). Many other literacies also evolved (Brophy, 2007:517), among others computer literacy, digital literacy, electronic information literacy, ethical literacy, hyper-literacy, information literacy, information fluency, internet literacy, library literacy, media literacy, network literacy, research literacy, resource literacy, technological literacy, tool literacy, visual literacy and Web literacy (Matusiak, 2012:3; Brophy, 2007; Repanovici & Landoy, 2007:3; Eisenberg, *et al.*, 2004; Overholtzer & Tombarge, 2003:55; Owusu-Ansah, 2003; Correia, 2002; Langford, 1998; Shapiro & Hughes, 1996). It is evident that “literacy” is not restricted to a limited set of skills anymore, but can be seen as an overarching concept for multiple literacies (Elmborg, 2006:195; Langford, 1998). Survival in the modern information society therefore requires an extensive set of skills going beyond reading and writing.

Johnson (2003:6) describes literacy as a “contextual ability” accompanied by a “range of competencies”. Most types of literacy develop throughout a person’s lifetime (Langford, 1998). The need to acquire various types of literacy is accepted as a lifelong dynamic process. This study will focus on research information literacy.

### **2.2.1 Information literacy**

“Information literacy” is often regarded as an overarching literacy, including text-based literacy, library skills, computer skills and problem-solving skills that can enhance information literacy (Lloyd & Williamson, 2008:9; King, 2007:19; Owusu-Ansah, 2003:222; Langford, 1998; Sayed & de Jager, 1997:6-7). The importance of information literacy is clear from numerous references to the information age and the explosion of information output (Bothma *et al.*, 2008:12; Correia, 2002:5).

According to Julien and Barker (2009:12) information literacy skills are essential in the information age, since the critical evaluation of information is central to economic and personal well-being. Because of continuous technological change and the rapidly developing, complex information environment, information literacy has become critical for the twenty-first century (Bruce, 2004:1; Correia, 2002:5). There is stronger focus on skills to access, evaluate, manage, and use information effectively, which require information literacy (Green, 2010:313; Jiyane & Onyancha, 2010:12; Boon *et al.*, 2007:204; Pawley, 2003:423).

Librarians have attempted to define and clarify information literacy over many years. Most of the frameworks and models developed are based on librarians’ conceptions and experiences of information literacy, often resulting in “tick boxes” (Boon *et al.*, 2007:205; Pawley,

2003:422). Johnston and Webber (2003:338) warn against a definition, framework or model based on a “tick the box” approach. This reduces a complex set of skills to small discrete units. Bawden and Robinson (2009:187) also note the highly library-centric interpretation of information literacy based on linear stages: recognition of a need for information, choice of the best source(s), accessing of information, evaluation, organisation, storage, communication and usage of information. Elmborg (2006:194) argues that information literacy models attempt to standardise the complexities of research into linear stages in order to provide universal structures. De Jager and Nassimbeni (2002:168) and Eisenberg *et al.*, (2004:55) recognise information literacy as a process, characterised by a logical progression of phases, rather than a discrete set of skills.

Information literacy frameworks and models of information seeking show many similarities, as illustrated in Table 0.1. They differ mostly in referring to processes, phases, steps, skills, components or elements of information literacy. Table 0.1 will streamline discussion by referring to only processes, components and skills as inclusive of these. The ISP model of Kuhlthau (2004) is included, since it is strongly associated with information literacy (Kuhlthau, Maniotes & Caspari, 2015; Maniotes & Kuhlthau, 2014).

**Table 0.1 Information literacy and information seeking models**

Model	Processes, Phases and Skills
Kuhlthau’s (2004) ISP model	Initiation, selection, exploration, collection, search closure and presentation
Big Blue model of information skills (2002)	Knowing how to find different types of information and deciding on relevant information, identifying and searching appropriate sources, interpreting information effectively, exploring and developing information, planning a search strategy, making judgements, exploring, developing and exchanging information, identifying outcomes, critically monitoring progress, and evaluating the overall strategy and outcomes
Association of College and Research Libraries (ACRL) (2000) information literacy competency standards	Determining the nature and extent of information needed, evaluating sources, accessing information, using information ethically and legally, evaluating information, understanding economic, legal and social issues, incorporating selected information, and using information effectively to accomplish a specific purpose

Model	Processes, Phases and Skills
Seven pillars of information literacy model (Sconul,1999)	Recognising a need for information, distinguishing ways to address gaps, constructing strategies to locate information, locating and accessing information, comparing and evaluating information, organising information, applying and communicating information, and synthesising and building upon existing information
Seven faces of information literacy in higher education model (Bruce, 1997)	Information technology, information sources, information processes, information control, knowledge construction, knowledge extension, and wisdom
PLUS model (Herring, 1996)	Purpose, location, use, and self-evaluation
Information problem solving (Big Six skills model) (Eisenberg & Berkowitz, 1990)	Task definition, formulation of information seeking strategies, location and access of information, use of information, synthesis and evaluation of information
Research process model (Stripling & Pitts, 1988)	Choosing a broad topic, getting an overview, narrowing the topic, developing a statement of purpose, formulating a question, planning for research, finding/analysing/evaluating sources, evaluating evidence, establishing conclusions and creating and presenting the final product

Most publications are from the United States of America. The definition cited most often, formulated in 1989, is from the American Library Association: “To be information literate, a person must be able to recognise when information is needed, and have the ability to locate, evaluate, and use effectively the needed information” (ALA, 1989). This definition is “easily understood by practitioners and by non-experts” (Julien & Hoffman, 2008:22).

Information literacy is thus a combination of skills, processes and phases (as noted in Table 0.1) which can be applied in specific contexts. For the purpose of this study the operational definition in Chapter 1 is accepted, namely information literacy is a person’s ability to apply relevant contemporary IT, as well as cognitive competencies during interaction with, and responsible use of information in different formats, throughout his/her lifetime, in order to develop personally and professionally.

Although there is abundant literature on information literacy, we are, according to Eisenberg *et al.* (2004:177), only at the beginning of the information literacy movement, and “an explosion in this topic is imminent”. The following section explores changes in the focus, support and services related to information literacy to expect in different contexts.

### **2.3 INFORMATION LITERACY IN DIFFERENT CONTEXTS**

Information and technology affect every person, in every possible setting (Eisenberg, *et al.*, 2008:39). Information literacy has been studied in different contexts since the term was first coined. Bruce (2000:92) divides research into three phases: (1) in the 1980s it focused on user studies; (2) in the 1990s information literacy was applied to education; (3) followed by an exploratory phase marked by the use of a broadening range of paradigms, and a variety of contexts, e.g. specific communities, workplace and use of IT.

The following sub-sections will address information literacy in school, undergraduate, postgraduate, workplace and community contexts.

#### **2.3.1 Information literacy in a school context**

School librarians undertake many information literacy initiatives. These include access to library material, assistance to teachers to select appropriate learning materials, and collaborating with teachers to integrate library skills into classroom instruction (Neuman, 2004:499). Internet and ICT developments during the 1990s provided momentum to address information literacy in the educational sector (Probert, 2009:24; Krige, 2008:3). The internet became a popular information source for school research, because of its convenience, ease of use and time efficiency (Julien & Barker, 2009:14; Krige, 2008:26; Demner, 2001:1). School children often use the internet for educational and recreational purposes and as communication medium (Johnson, 2011:64; van Aalst, *et al.*, 2007:537; Williams & Rowlands, 2007:8). The internet and mobile access further contributed to the implementation of virtual learning environments (VLEs) (Shenton & Hay-Gibson, 2010:70).

Despite increased internet and information technology (IT) use, the information literacy levels of school children are not increasing (Feurguson, 2011:7). They have difficulties with information searching and finding relevant information from large amounts of available information (Julien & Barker, 2009:14; Krige, 2008:1; van Aalst *et al.*, 2007:548; Williams & Rowlands, 2007:10). A study performed in 2007 found that young children have difficulty with the formulation of appropriate search terms, since they prefer natural language questions (Williams & Rowlands, 2007:9). Young children also do not evaluate information; they

struggle to judge the quality of information on web pages (Julien & Barker, 2009:15; Krige, 2008:1; Williams & Rowlands, 2007:11). Smith, Given, Julien, Ouellette and DeLong (2013) also report on school-based information literacy.

Because of IT developments and the growth in both print and electronic information formats, school librarians became more important. They need to guide school children in the use of reliable digital information sources with authenticated peer-reviewed information (Krige, 2008:11). According to Scheirer (2000:8), information literacy will play a central role in the curriculum programmes in schools of the future. The increased emphasis on accountability of schools is also contributing to a focus on information literacy (Eisenberg *et al.*, 2004:68). Demands on school librarians are increasing. They are expected to teach IT skills and troubleshoot. They need to learn about new technologies and to learn which internet resources are suitable for students as well as teachers (Scheirer, 2000:2).

One of the exit level competencies identified for South African schools is that learners should be able to “collect, analyse, organise and critically evaluate information” (SAQA, 2001:24). This relates directly to information literacy. Many school children in South Africa, however, are ill-prepared in many areas of information literacy when they leave school (South Africa, 2010; King, 2007:1; Machet, 2005:180) and many have never used a computer before they enter higher education (King, 2007:1; Jagarnath, 2004:4; De Jager & Nassimbeni, 2002:170). In South Africa many school children have never had access to school libraries either, which has a negative impact on their awareness of how to use a range of available information sources (Machet, 2005:181; Selematsela, 2005:19; De Jager & Nassimbeni, 2002:170). This might eventually affect their skills at university level. The information literacy levels of school children from developed countries are not necessarily higher (Julien & Barker, 2009:15). Often school children still perceive libraries as providing predominantly print-based information resources (Hyams & Tarter, 2010:29; Williams & Rowlands, 2007:12). In addition there is little evidence of systematic and coordinated approaches to improve information literacy levels in schools (Herring, 2011:6; Probert, 2009:26; Lonsdale & Armstrong, 2006:13).

Collaboration between school librarians and teachers is very important in order to offer successful information literacy programmes and to incorporate information literacy skills into learning programmes (Scheirer, 2000:1). Librarians therefore need to get involved with information literacy training programmes in schools and to become advocates for information

literacy (Herring, 2011:8; Shenton, 2011:66; Shenton & Hay-Gibson, 2010:70; Miller, 2003:27). The role of school librarians has therefore evolved from being providers of supplementary resources and services to essential participation in instructional teams, with the focus on enhancing student learning (Neuman, 2004:513). According to Krige (2008:11), effective library and information services to high school children could result in improved information literacy, which will ultimately contribute to enhanced academic performance. The assumption is that adequate information literacy competencies relevant to a specific task or process may lead to more successful and effective completion of tasks and processes.

Apart from the need for sufficient and qualified school librarians providing library instruction (Chu, 2013:398), effective collaboration between them and higher education institutions is also necessary in order to ease the burden on these institutions of preparing students for information literacy. Information literacy in an undergraduate context will be discussed in the next few paragraphs, which will confirm the importance of information literacy skills in a higher education context.

### **2.3.2 Information literacy in an undergraduate context**

In the South African context the terms undergraduate and postgraduate students, as used in this thesis, refer to students studying at an institution of higher education such as a university, university of technology or comprehensive university. If applicable, reports on information literacy at colleges, research institutions and polytechnics will also be considered.

ICT developments resulted in a major shift in academic library services, from mostly reference services to library instruction (Elmborg, 2006:192). Automated libraries and digital resources became difficult to use without guidance and basic skills. This often resulted in mandatory user instruction sessions offered by academic librarians to help students deal with problems in seeking information, as well as information overload (Singh & Klingenberg, 2009:3). Such instruction sessions are mostly aimed at undergraduate students (Exner, 2014:460). They are considered the user group most in need of assistance (Jiyane & Onyancha, 2010:21; Pawley, 2003:424; De Jager & Nassimbeni, 2002:177). Instruction sessions offered to undergraduate students are often referred to as “one-shot instruction sessions” because of the limited time allocated to these interventions (Badke, 2012:67), and they focus strongly on how to use libraries (Badke, 2012:51). Detlor, Booker, Serenko and Julien (2012), Detlor, Julien, Willson, Serenko and Lavalley (2011), Julien and Boon (2002),

Julien (2000, 2005), Lawal, Underwood, Lwehabura and Stilwell (2010) and Serenko, Detlor, Julien and Booker (2012) also report on academic information literacy.

Research regarding information literacy in undergraduate contexts seems to focus mostly on basic, general skills, which are fundamental to the seeking, evaluation and use of information (Smith, 2003:9). Topics include library services, library information systems, the library catalogue as a discovery tool, the variety of information resources available, the layout of the physical library, identification of different electronic databases and online searching (Palmer & Tucker, 2003:5; Abbott, 2001:4; Nerz & Weiner, 2001). Bibliographies, special collection services, serials publication, the nature of a website, copyright, plagiarism, online catalogues, using Boolean operators effectively, and the use of search engines have also been mentioned (Jiyane & Onyancha, 2010:23; King, 2007:167; De Jager & Nassimbeni, 2005:36; Owusu-Ansah, 2004:5; Salisbury & Ellis, 2003:212; De Jager & Nassimbeni, 2002:178). According to Driscoll (2010:3), topics should also include the development of search strategies, critical evaluation of information sources and the fair use of information.

The pedagogic role of librarians became prominent in academic libraries because of the significant time and resources invested in the instruction of information literacy (Julien & Genius, 2011:103; McCallum & Collins, 2011:10; Bewick & Corall, 2010:1; Jiyane & Onyancha, 2010:12; Singh & Klingenberg, 2009:8; van Aalst *et al.*, 2007:537; Elmborg, 2006:192). Literature on information literacy in an undergraduate context often centres on instruction processes and principles (Julien & Genius, 2011:103; McCallum & Collins, 2011:11; Driscoll, 2010; Elmborg, 2006:192), as well as the assessment of student competencies (Adams, Buetow, Edlin *et al.*, 2016:2; Dennis, Murphey & Rogers, 2011:1; Fain, 2011:109; Fitzpatrick & Meulemans, 2011:142; Nutefall, 2005:94; Eisenberg, *et al.*, 2004:104; Dunn, 2002:27; D'Angelo, 2001:282). As the teaching role of librarians became more prominent, more literature was also published on collaboration initiatives between librarians and academics, as well as implementing and sustaining information literacy programmes (Adams, Buetow, Edlin *et al.*, 2016:2; Kenedy & Monty, 2011:116; Rhodes & Ralph, 2010:228; Singh & Klingenberg, 2009:8; Housewright & Schonfeld, 2008:31; Duskatsch, 2007:467; King, 2007:31; Smith, 2006:7). Some librarians might thus be bound by an instructional focus on information literacy in an undergraduate context, basing services, training and assessment on established standards, frameworks and models (Badke, 2012:71).

The discussion in the next section will signal a different context, and the need for a different approach to information literacy support at postgraduate level (Aucland, 2012:2).

### **2.3.3 Information literacy in a postgraduate context**

Rapid growth and developments in ICT not only affected undergraduate students in academic institutions, as hinted at in the previous section, but also revolutionised the research environment on postgraduate level (Kroll & Forsman, 2010:5; Luce, 2008:42; Brown & Swan, 2007:2; Gunter, 2007:8; Vincent-Lancrin, 2006:20). The widespread adoption of technological innovations provided postgraduate researchers with access to digital resources through a wider variety of channels, such as websites, archives, e-journals, e-books, discipline-specific websites, digital libraries and gateways (Gardiner *et al.*, 2006:342). Attitudes, behaviours and expectations of postgraduate researchers changed (Schonfeld & Housewright, 2010:15) and many became highly dependent on electronic resources (Connaway & Dickey, 2010:4; Haines *et al.*, 2010:75; Schonfeld & Housewright, 2010:2). Postgraduate researchers also started to indicate strong preferences for speed, ease and convenience when searching for information (Blanton-Kent, 2010:1; Connaway & Dickey, 2010:4; Haines *et al.*, 2010:75; Kroll & Forsman, 2010:17). Studies confirm their strong preference for using the internet, especially the Google search engine (Tautkeviciene *et al.*, 2011:4; Connaway & Dickey, 2010:4; Kroll & Forsman, 2010:16; Schonfeld & Housewright, 2010:7). Although there is evidence of anxiety among postgraduate researchers regarding the use of information in electronic format (Tautkeviciene, *et al.*, 2011:8; Vezzosi, 2009:74; Marcus, *et al.*, 2007:16) technological developments have resulted in a preference to access information resources without using the library as a gateway to information (Haines, *et al.*, 2010:77; Law, 2009:2; Gunter, 2007:8). Library staff consequently became somewhat removed from the world of researchers, with fewer opportunities to communicate effectively (Creaser & Spezi, 2013:14; Kroll & Forsman, 2010:5; Rempel, 2010:534; Schonfeld & Housewright, 2010:2; Haglund & Olsson, 2008:56; Hoffmann, *et al.*, 2008:2; Rowlands & Fieldhouse, 2007:33). Many postgraduate researchers rarely seek assistance from librarians, and seldom attend training classes specifically offered to them (Blanton-Kent, 2010:1; Haines, *et al.*, 2010:76; RIN, 2010:9; Schulze, 2008:657; Haglund & Olsson, 2008:55; Randall, *et al.*, 2008:2).

Research into the information literacy of postgraduate user groups was limited until recently (Han, 2012:3; Chen & Van Ullen, 2011:210; Hagen, 2011:1; O'Grady & Beam, 2011:77; Healy, 2010; Rempel, 2010:534; Streatfield, *et al.*, 2010:230; Harrington, 2009:180; Singh,

2007:468). Some studies indicate that librarians and academics often assume that researchers have already acquired adequate levels of information literacy competencies on postgraduate level (Chen & Van Ullen, 2011:223; Harkins, Rodrigues & Orlov, 2011:28; Rhodes & Ralph, 2010:227; Rempel, 2008:157; Booth, 2007:1; Green & Macauley, 2007:320; Sadler & Given, 2007:125). There is, however, growing recognition that information literacy support should be linked more closely with the research process (Hall & Jacuet, 2016:1015; Streatfield *et al.*, 2010:237; Patterson, 2009:17). It has also become evident to many academic librarians that it may be inappropriate to attempt to meet the information literacy needs of postgraduate researchers by implementing instruction methods based on undergraduate student information needs, or as extensions of these. Since postgraduate studies require researchers to make original contributions to knowledge, unlike undergraduate studies (Miller, 2014:75), the focus should rather be on the specialised and unique needs of researchers (Booth & Tattersall, 2009; Housewright & Schonfeld, 2008:30; Booth, 2007:9; Green & Macauley, 2007:317; Ackerson, 1996:249).

The South African National Qualifications Framework (NQF), stipulates that postgraduate researchers on master's level is required, among others, to access, process and manage information, and to “design and implement a strategy for the processing and management of information, in order to conduct a comprehensive review of leading and current research in an area of specialisation to produce significant insights” (SAQA, 2010:8). On doctorate level, researchers are required to “demonstrate an ability to make independent judgements about managing incomplete or inconsistent information or data in an iterative process of analysis and synthesis, for the development of significant original insights into new complex and abstract ideas, information or issues” (SAQA, 2010:10). Postgraduate researchers therefore need a range of skills, and training and development are required to keep up with the latest developments in the research environment (Hagen, 2011:1; Harris, 2011:601; Lategan *et al.*, 2011:2). Postgraduate researchers unfortunately often lack faculty guidance (Adams, Buetow, Edlin, *et al.*, 2016:1; Harris, 2011:603), and some postgraduate supervisors are even providing guidance according to a “pre-internet era”, similar to the environment in which they obtained their own doctoral qualifications (Badke, 2012:48; Lippincott & Lynch, 2010:6). This era refers to a time when IT did not play such a significant role in research (Streatfield, Allen & Wilson, 2010:237). According to Hagen (2011:1), research and publication technologies are becoming more complex, and postgraduate researchers increasingly need special assistance, which may fall beyond the expertise of supervisors or

mentors in their departments. As a result, postgraduate researchers often rely on themselves, or peers, to learn new skills (Rempel, 2010:541).

There is thus a role for academic librarians to support postgraduate researchers. They, however, need to be educated regarding the research process, since increased understanding of the way postgraduate researchers carry out research can assist in providing relevant support to this group. Although many academic librarians are still supporting the needs of researchers through traditional services focused on information discovery (Hall & Jaquet, 2016:1020), certain aspects of information and data management (Hall & Jaquet, 2016:1015; Aucland, 2012:2) have been employed to provide support services aimed specifically at postgraduate researchers. Literature confirms the importance of additional services. These include support in defining and developing a research topic (Meerah, 2010:185; Harrison & Jones, 2007; Repanovici & Landoy, 2007:11; Singh, 2007:469); training regarding the installation and downloading of software, as well as using application software (Hagen, 2011:1; Daniels, *et al.*, 2010:118; Smith, 2006:119; Robertson, 2003:5); explaining scholarly communication processes (Hall & Jaquet, 2016: 1015; Tautkevičienė, *et al.*, 2011:3; Thomas, 2011:44; Hensley, 2009:205; Hoffmann, *et al.*, 2008:9; Boden, 2007:172; Booth, 2007; Antwi-Nsiah *et al.*, 2006:2; Macauley, 2004:5); provision of resources on research methods (Thomas, 2011:43; Rasul & Singh, 2010:83; Mutulu, 2009:5; Doskatch, 2007:470; Fallon & Antonesa, 2007:31; Macauley, 2004:5; Harrison & Hughes, 2002:19); and provision of resources with overviews of the research process (Chen & Van Ullen, 2011:210; Daniels, *et al.*, 2010:120; Meerah, 2010:187; Mutula, 2009:5; Singh & Klingenberg, 2009:13; Musoke, 2008:535; Doskatch, 2007:470; Macauley, 2004:5). Other typical services offered to postgraduate researchers include in-depth consultations, presentations at postgraduate seminars, assistance with literature reviews, determining impact factors, training regarding the use of citation management software, as well as provision of postgraduate spaces in academic libraries (Covert-Vail & Collard, 2012:8; Hagen, 2011:2, Doskatsch, 2007:471; Garner, 2006:3; East, 2005:138; Poirier, 2005:8; Robertson, 2003:5; Macauley, 2001:248). The extent of research support varies among academic institutions (Creaser & Spezi, 2013:5). It almost seems as if the prioritisation of library services is not necessarily based on a full assessment of the specific research phases and processes that need to be supported (Palmer *et al.*, 2009:42).

Categories of popular support services offered to postgraduate researchers are portrayed in Table 0.2. This categorisation is by no means an exhaustive list of studies, but serves as an indication of more recent studies on support offered to postgraduate researchers.

**Table 0.2 Postgraduate research support**

<b>Research Support Service</b>	<b>Recent Relevant Literature</b>
Discovery of information sources	Chen & Van Ullen (2011:210); OCLC (2011); Newby (2011:228); O'Grady & Beam (2011:76); Tautkevičienė <i>et al.</i> (2011:3); Thomas (2011:44); Daniels <i>et al.</i> (2010:126); Green (2010:314); Haines <i>et al.</i> (2010:76); Healy (2010); Kroll & Forsman (2010:12); Meerah (2010:188); Rempel (2010:535); RIN (2010:9); Rasul & Singh (2010:80); Schonfeld & Housewright (2010:5); Streatfield <i>et al.</i> (2010:234); Booth & Tattersall (2009); Harrington (2009:186); Hensley (2009:205); MacColl & Erway (2009:16); Palmer <i>et al.</i> (2009); RIN & British Library (2009); Vezzosi (2009:71); Chu & Law (2008:175); Haglund & Olsson (2008:55); Hoffmann <i>et al.</i> (2008:9); Herther (2008:369); Kohl-Frey (2008:136); Musoke (2008:535); Schulze, (2008:658).
Gathering and organisation of information	Covert-Vail & Collard (2012:6), Hagen (2011:1); OCLC (2011); Tautkevičienė <i>et al.</i> (2011:3); Thomas (2011:43); Green (2010:314); Kroll & Forsman (2010:5); Rempel (2010:539); Rasul & Singh (2010:80); RIN (2010:9); Streatfield <i>et al.</i> (2010:234); Hensley (2009:205); Harrington (2009:186); MacColl & Erway (2009:7); Palmer (2009); RIN & British Library (2009); Vezzosi (2009:72); Haglund & Olsson (2008:55); Musoke (2008:535); Randall <i>et al.</i> (2008:2).
Creation of research documents	Chen & Van Ullen (2011:225); Hagen (2011:2); OCLC (2011); Tautkevičienė <i>et al.</i> (2011:3); Thomas (2011:44); Daniels <i>et al.</i> (2010:126); Healy (2010); Kroll & Forsman (2010:18); Lippincott & Lynch (2010:14); Rempel (2010:533); Rasul & Singh (2010:82); RIN (2010:12); Meerah (2010:187); Streatfield <i>et al.</i> (2010:237); Harrington (2009:185); Mutulu (2009:5); MacColl & Erway (2009:7); Palmer <i>et al.</i> (2009); RIN & British Library (2009); Singh & Klingenberg (2009:14); Vezzosi (2009:73); Brophy (2008:10); Haglund & Olsson (2008:55); Hoffmann <i>et al.</i> (2008:9); Kohl-Frey (2008:136); Musoke (2008:535); Schulze (2008:658).
Publishing of research findings	Hall & Jaquet (2016:1015); Mulligan & Mabe (2011:309); O'Grady & Beam (2011:76); OCLC (2011); Thomas (2011:44); Haines <i>et al.</i> (2010:77); Healy (2010); Kroll & Forsman (2010:13); Meerah (2010:187); Rempel (2010:543); RIN (2010:6); Rasul & Singh (2010:82); Streatfield <i>et al.</i> (2010:234); MacColl & Erway (2009:17); Vezzosi (2009:73); Kohl-Frey (2008:136); Musoke (2008:535).

Many of the support services and training sessions aimed at postgraduate researchers, however, are marked by limited success (MacColl & Jubb, 2011:3; Blanton-Kent, *et al.*, 2010:1; Daniels, *et al.*, 2010:120; Haines, *et al.*, 2010:77; RIN & British Library, 2009; Hoffmann, *et al.*, 2008:3; Gomersall, 2007:307). There are also indications that information literacy levels of researchers have not necessarily improved (Connaway & Dickey, 2010:4; Stoffberg & Blignaut, 2008:4; Gunter, 2007:63). One reason for the limited impact may be that support for postgraduate students is often largely confined to basic information literacy skills specifically focussing on the retrieval of information (Brewerton, 2012:104; Tautkeviciene, *et al.*, 2011:2; Streatfield, *et al.*, 2010:232; Singh, 2007:468; Macauley, 2004:1; White, *et al.*, 2004:1; Smith, 2003:2; Bruce, 2001:107). Another reason may be the library-centric approach taken by librarians, which is often based on a deficit model, where the deficiencies of postgraduate researchers are the main focus in many studies (Booth, 2007; Green & Macauley, 2007:319; East, 2005:134; Macauley, 2001:235). Other possible reasons include the typical linear process followed by librarians, beginning with defining a topic, followed by the searching of databases, and finishing with the evaluation of results, without acknowledging the complex and dynamic research process (Haines *et al.*, 2010:77; Foster, 2005:11). Some authors also refer to the lack of librarians holding a qualification at least equivalent to master's level, combined with limited research experience or knowledge of the scholarly research process (Daniels *et al.*, 2010:120; Rempel, 2010:534; Smith, 2006:125; Herman, 2004:119). Rempel (2010:534) refers to librarians' "superficial method of instructing" postgraduate researchers, which results from lack of understanding what the research process involves. Another reason for not meeting postgraduate researchers' information needs may be the absence of an overall strategy and coordination regarding information literacy training in academic institutions (Streatfield, *et al.*, 2010:236; Hoffmann, *et al.*, 2008:3; Doskatch, 2007:469). It can therefore be argued that a possible gap could have emerged between postgraduate researchers' and librarians' perceptions of information literacy training needs (Bracke, 2011:72; Green, 2010:313; Haines, *et al.*, 2010:77; MacColl & Erway, 2009:5; Sadler & Given, 2007:121).

#### 2.3.4 Information literacy in a workplace context

Some studies on information literacy started to move beyond the educational sector, towards the workplace environment (Lawal, Stilwell, Kuhn & Underwood, 2014). The following paragraphs will explore information literacy further, by focusing on information literacy in a workplace context, which implies a different set of information literacy competencies needed by employees to function effectively.

Information literacy is relevant to people of all ages and goes beyond the formal classroom setting; everybody relies on information in different formats every day (Repanovici & Landoy, 2007:2; Pilerot, 2004:96, Given, 2002:17). Bruce (2004:1) regards information literacy as “pivotal to the pursuit of lifelong learning, and central to achieving both personal empowerment and economic development.”

The body of literature on information literacy experiences in a workplace environment has grown over the years, and this has become an established research area. Bruce (1999:35) identified several characteristics of workplace information literacy, namely varying emphasis on technology, a capacity to engage in broad professional responsibilities, social collaboration, a need to partner with information intermediaries and emphasis on intellectual manipulation of information, instead of on technical skill. Information literacy support in the workplace should therefore also take social relationships into account in view of regular collaborative projects between employees, in addition to the use of traditional electronic and printed sources (Hoyer, 2011:12; Crawford & Irving, 2009:36; Lloyd & Williamson, 2008:5). Current information literacy definitions, however, often emphasise the importance of connecting with textual information only, while the importance of informal learning and other sources of information accessed through communication are omitted (Lloyd, 2005:87). Lloyd (2006:574) also emphasises that the workplace requires broader engagement with information, which includes not only textual sources, but physical and social modalities as well. The workplace is often described as a unique, complex and sophisticated environment (Crawford & Irving, 2009:29; Johnston & Webber, 2004:12), which is characterised by competition, creativity, accountability and productivity (Crawford & Irving, 2009:29; George, *et al.*, 2000:2). A need for continuous improvement, a commitment to lifelong learning, as well as the ability to seek out and identify innovations are therefore needed in the workplace (Eisenberg, 2004:60). The huge amounts of information available today relevant to the workplace, however, “can be paralyzing”, and the establishment of data relevancy, resolution of information priority levels and determination of source reliability can be time-

consuming and overwhelming (Somerville, Howard & Mirijamdotter, 2009:119). According to Oman (2001:35), it cannot be assumed that future workers will bring everything they need to know in a work environment from the classroom, because of constant developments in IT, which demand flexible and lifelong learning skills from employees.

Some important workplace skills that could be part of information literacy training and support initiatives are project management skills, ethical use of information, research methodologies, mentoring, computer skills, teamwork, communication skills, presentation and writing skills (Meerah, 2010:185; Mutulu, 2009:5; Schulze, 2008:658; Macauley, 2004:5; Hunter, 2002:20), as well as the ability to employ social media tools (Sokoloff, 2013:10). Skills may also be required regarding innovation and creativity, initiative and flexibility, job applications and compiling curricula vitae, networking, career planning, and interviewing techniques (Gilbert *et al.*, 2004:381). The management of intellectual property and the commercialisation of research are further essential skills in the workplace (Harman, 2010:5), as well as skills to identify funding sources for research projects (Solmon, 2009:79).

University curricula have been challenged in recent years to form partnerships, and to strengthen links with business and industry (Lategan *et al.*, 2011:1; Macauley, 2004:5). Such partnerships are attempts to improve the employability of graduates for industry (Barrie, 2006:215); these are based on findings that the training students receive during formal education does not prepare them sufficiently for the workplace environment (Harman, 2010:2; Hoyer, 2010:11; Wendlandt & Rochlen, 2008:151; Levine, 2005:1; Golde & Dore, 2001:3).

To accommodate a closer link between universities and industry, all South African educational institutions are required to include and assess the following abilities in all outcomes for each qualification: identification and solving of problems; working effectively as part of a team; being responsible and effectively organising and managing oneself; collecting, analysing, organising and critically evaluating information; communicating effectively; using science and technology effectively; understanding the world as a set of related systems and contributing to social and economic development of society at large (SAQA, 2001:24).

According to Gravett and Geyser (2004:141), higher education institutions should identify the needs of the private sector, after which curricula need to be reorganised, to match those desired needs. Numerous lists of attributes have since been published by individual

universities regarding the skills, knowledge and abilities university graduates should have beyond disciplinary content knowledge (Barrie, 2004:262). According to Barrie (2004:270), these skills and abilities can be divided into five clusters: research and enquiry, information literacy, personal and intellectual autonomy, ethical, social and professional understanding, and communication. A study by Sokoloff (2012), however, found little evidence of a direct link between library information literacy initiatives and the business community, stating that current information literacy competency standards may be failing to “translate into workplace information skills” (Sokoloff, 2012:12). This statement was confirmed by Emanuel and Roh (2013:533), who found that engineering researchers in the workplace were not as information literate as expected, with many displaying only basic information searching skills and low competencies in effectively conducting literature searches. Engineering researchers in an academic context may therefore need to be prepared for the workplace (Nair, Patil & Mertova, 2009:132; Manathunga & Lant, 2006:72), since the twenty-first century requires them to demonstrate various skills in different environments (Keleher, Keleher & Simon, 2011:1). Some significant differences between the information behaviour of engineers in academic and workplace contexts are illustrated in Table 0.3.

**Table 0.3 Differences between academic and workplace engineering contexts**

Aspect	Academic Context	Workplace Context
Information sources preferred	External sources (scholarly journal articles, books, conference proceedings) (Engel, <i>et al.</i> , 2011:551; Okafor & Ukwoma, 2011:58; Tucci, 2011:5; Chu & Law, 2007:31)	Internal sources (technical reports, standards, catalogues, patents) (Jeffryes & Lafferty, 2012:3; Waters, Kasuto & McNaughton, 2012:127; Engel, <i>et al.</i> , 2011:550; Du Preez, 2008:324; Fidel & Green, 2004:564)
Utilisation of information services	Extensive use of electronic databases and some other library services (Waters, <i>et al.</i> , 2012:126; Engel, <i>et al.</i> , 2011; Tucci, 2011:4)	Limited access to libraries and electronic databases (Emanuel & Roh, 2013:533; Jeffryes & Lafferty, 2012:6; Du Preez & Fourie, 2009:138; Tenopir & King, 2004:39; Kwasitsu, 2003:472)
Main focus of institution	Research and teaching (Gider, Likar, Kern & Miklavcic, 2011:332; Du Preez & Fourie, 2009:154; Tenopir & King, 2004:79)	Innovation, production and development of products (Pinelli & Haynie, 2010:56; Tenopir & King, 2004:79; De Smet, 1992:105)
Publishing of research results	Regular open disclosure of information, due to publishing obligations and academic culture (Okafor & Ukwoma, 2011:58; Speight & Foote, 2011:241; Tucci, 2011:7; Pinelli, 2001:137).	Restrictions on occasion due to commercial obligations (Harney, Monks, Alexopoulos, Buckley & Hogan, 2011:11; Speight & Foote, 2011:47; Pinelli & Haynie, 2010:54)

Aspect	Academic Context	Workplace Context
	There may, however, sometimes be confidentiality restrictions	
Popular publishing channels	Scholarly journals, books and conferences (Speight & Foote, 2011:236; Du Preez, 2008:4; Tenopir & King, 2004:80; Ellis & Haughan, 1997:401)	Internal/company documents and professional sources (Steiner, 2011:33; Knievel, Heaney & Van Baalen-Wood, 2010:58; Leckie, Pettigrew & Sylvain, 1996:182)

Table 0.3 highlights the importance of including some aspects relevant to the workplace context in ARIL support programmes for engineers in an academic environment, since it is increasingly important to prepare postgraduate students to work effectively “across and between universities and industry” (Morris, Pitt & Manathunga, 2012:633). ARIL support programmes for academic researchers should ensure that competencies extend beyond the educational sector into industry (Sokoloff, 2012:2; Hoyer, 2010:11). Skill should be extended to include networking skills, locating experts, non-academic writing, public communication skills (Hoyer, 2010:19), as well as working with grey literature. Grey literature can be defined as “manifold document types produced on all levels of government, academics, business and industry in print and electronic formats that are protected by intellectual property rights, of sufficient quality to be collected and preserved by library holdings or institutional repositories, but not controlled by commercial publishers i.e., where publishing is not the primary activity of the producing body” (Schopf, 2010:1). Grey literature includes conference papers, technical papers, company reports, theses and dissertations, patents, prototypes, courses, press releases and procedural instructions (Jeffery, 2000:65). Existing information literacy competency standards mostly do not explicitly address a direct link between academic and workplace contexts in the manner reflected in Table 0.3 and in this section (Sokoloff, 2012:12; Hoyer, 2010:19; Hepworth & Smith, 2008:220; Kong, Hunter & Lin, 2007:149). Inskip (2013: 14) confirms the problem of many information literacy training courses for postgraduate researchers only taking existing needs and practices into account, without addressing future employability skills (Inskip, 2013:14).

It is therefore evident that academic librarians should keep information literacy needs relevant to specific workplace contexts in mind when planning support services and information literacy training programmes (Emanuel & Roh, 2013:536). Such programmes furthermore need to be aligned with the main goal of universities, namely to prepare students for future careers (Austin, 2012:61; Oxnam, 2003:1). Informed employees should be

cultivated to be “engaged, enabled, and enriched by the social, procedural, and physical information that constitutes their information universe” (Somerville, Howard & Mirijamdotter, 2009:121). Librarians may therefore be required to make a conceptual shift, from a library-centered view of information literacy, focusing on specific tools, to a more holistic view of information literacy, where training is based on transferrable concepts and skills (Doskatch, 2007:467). Such skills are dealt with in more detail in Chapter 3.

### **2.3.5 Information literacy in a community context**

Information literacy is also important in the everyday life of citizens and communities, where it is seen as a “lifelong learning process that starts at the younger age and proceeds until post work stage where each citizen requires different kinds of information in different phases of life” (Singh & Klingenberg, 2009:1). Individuals need to be information-literate, in order to manage their everyday lives, environmental surroundings, as well as a constantly changing society (Nara, 2007:1). According to Hoyer (2011:10) and McKenzie (2003:19), research regarding information literacy in a community context is often ignored, owing to the focus on information literacy in an academic environment. Often information behaviour models are generated from research in academic or workplace environments focusing on a single current need, not addressing the information behaviour of individuals in their everyday lives (McKenzie, 2003:20). Although literature is growing in the field of everyday life information seeking, the studying and reporting of information literacy in community settings is “still very much in its infancy” (Lloyd & Williamson, 2008:7).

The traditional role of public libraries is to ensure public access to information, which implies deep involvement with the information needs of communities (Crawford & Irving, 2009:36). The emergence of the internet resulted in a plethora of information being made available to wider communities through outlets other than libraries and bookstores; it removed barriers of distance, availability and access to information (Krige, 2008:27). Developments in ICT and the empowering of communities regarding information literacy skills therefore became an important part of the missions of public libraries (Webber & Johnston, 2003:269). The internet became a popular source of information. It provides access to communication, entertainment, business, search engines, news, foreign languages, as well as the searching of online library catalogues (Sinn, Syn & Kim, 2011:320; Julien & Hoffman, 2008:27). These are topics to be addressed in information literacy training.

Citizens in the twenty-first century have to function in an ever-changing environment while taking many decisions, such as where to locate a business, how to vote, or even regarding family matters (Hancock, 1993). Knowledge of medical conditions has also become an important personal research topic, with increased emphasis on health literacy evident in the literature (Marshall, Sahn & McCarthy, 2012; Berkman, Sheridan, Donahue, Halpern & Crotty, 2011; Schnitzer, Rosenzweig & Harris, 2011). Citizens must be able to locate, access, retrieve, evaluate and interpret information for personal use, and should also be able to participate in community affairs, where they are expected to make informed decisions on local, national and international problems (Correia, 2002:2). Information seeking methods that citizens employ in everyday life include active seeking, active scanning, serendipitous encounters and acting on referral to a source through another's initiative (McKenzie, 2003:26).

Knowledge and literacies relevant to everyday life are important to all, and may include prose, document and quantitative literacies (Kutner & White, 2007:12). Other important skills relevant to information literacy in a community context include the management of vast amounts of grey literature, effective social networking regarding identifying key information sources, non-academic writing skills and public communication skills (Hoyer, 2011:16). Effective citizens in the digital age, however, may require training in information literacy skills to access, evaluate and use information efficiently to inform decision-making on all aspects of their lives (Julien & Hoffman, 2008:39; Savolainen, 2002:211). The role of public libraries is therefore changing.

According to Julien and Hoffman (2008:39), citizens often gain information literacy skills through personal experience and from personal sources such as friends and family, instead of attending formal library training. The role of public libraries is then to bring IT to diverse populations, and to promote information literacy among those communities (Julien & Hoffman, 2008:20). According to Julien and Genius (2011:109), stronger focus on instruction of the community is becoming important, and librarians working in public libraries need to embrace this new role.

The preceding sections outlined the scope and different contexts in which information literacy has been studied over the years. Different needs among different groups of people were discussed, as well as relevant information literacy support services required in everyday context. During the discussion of information literacy in a postgraduate context, it became

evident that limited literature is available regarding structured approaches to information literacy support for academic postgraduate researchers. There thus seems to be a need for a new information literacy concept. Such a concept, ARIL, will be argued for in the next section of this chapter.

## **2.4 MOTIVATION FOR A NEW CONCEPT - ARIL**

The literature analysis in the first part of the chapter confirmed that school children, citizens and undergraduate students often need basic information literacy competencies, with specific reference to accessing information electronically. In contrast to this, postgraduate researchers often exhibit more specific and unique information needs. As already mentioned earlier, the general conception of information literacy as it currently stands is not adequate to guide initiatives on postgraduate level; it does not address all the phases and processes performed by researchers. The focus of information literacy training is too much on basic information retrieval and basic use of information. This is confirmed by Grafstein (2002:197), who states that current information literacy definitions and frameworks often emphasise generic skills related to general processes of retrieving and evaluating information, rather than focusing on skills required for acquiring knowledge or doing research in a specific area.

There is thus a gap in the literature, requiring an approach to supporting the information literacy needs of more advanced user groups such as postgraduate researchers. A conceptual framework is needed to guide the development of appropriate information literacy programmes for this group. The concept of “advanced research information literacy (ARIL)” is proposed to guide such a framework. This indicates a shift from basic information literacy support towards support specifically aimed at researchers. A broad differentiation between information literacy and ARIL concepts (taken from the preceding discussion) is illustrated in Table 0.34. The table highlights some major differences between these two concepts.

**Table 0.4 Relationship between information literacy and advanced research information literacy concepts**

Focus	Information Literacy	Advanced Research Information Literacy
Target audience	Undergraduates	Postgraduate students/researchers
Focus of information literacy instruction	Discovery tools (Information as a <i>goal</i> )	Discovery tools, as well as tools relevant to various other research activities. (Information as a <i>tool</i> )
Information source requirements	Mostly textual and prescribed information	Various/different types and formats of information relevant to research lifecycles
Origin of information need	Lecturer/syllabi	Research topic
Nature of engagement with information	Primarily individualised	Towards collaborative approaches for non-academic postgraduate research
Volume of information required to manage	Defined reading lists	Significant amounts of resources in various formats
Interaction with information	Using and reproducing existing information (synthesising)	Using existing information, generating and disseminating new knowledge
Context in which audience will benefit	Higher education environment	Higher education and workplace environment

### 2.4.1 Advanced research information literacy

Literature in recent years has increasingly been arguing for the development of new and more integrated services to support researchers at all stages of the research lifecycle (Brewerton, 2012:104; Haines, *et al.*, 2010:78; RIN, 2010:8; Housewright & Schonfeld, 2008:30; Brophy, 2007:57). This may be due to an increased realisation that researchers may require more ARIL skills to deal effectively with information (Green & Macauley, 2007:319). It can therefore be argued that information needs evolve as intellectual interests become more sophisticated. Studies often recognise the different stages during the research process and suggest targeted support services to postgraduate researchers, based on different information needs during different stages (Chen & Van Ullen, 2011:222; Rempel, 2010:543; Streatfield, *et al.*, 2010:238; RIN & British Library, 2009; Repanovici & Landoy, 2007:7; Barrett, 2005:330). Researchers in their first year of postgraduate research will therefore have different needs from those in their third year of research. Many of the current support services offered to postgraduate researchers by libraries may not necessarily address the required information literacy support for the entire research process. Postgraduate researchers may need a whole suite of support services to reach their goals. Booth and Tattersall (2009:2)

warn against supporting a “traditional library paradigm”, which may comprise a context different from research activities. (This point has also been argued in earlier sections.)

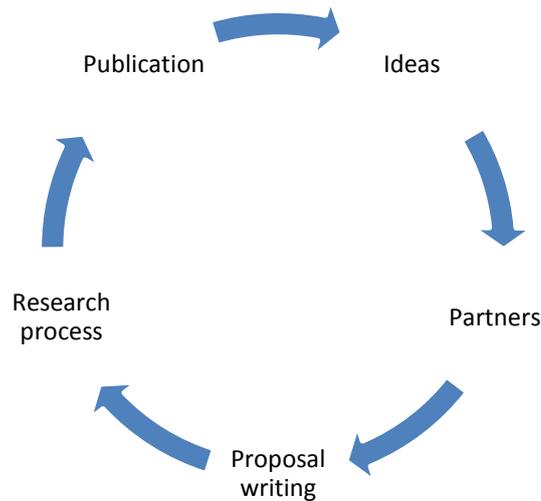
A next step towards the conceptualisation of ARIL is a closer look at research processes and lifecycles manifesting themselves during postgraduate research.

#### **2.4.2 Research lifecycles**

Research lifecycles are often used as a “convenient abstraction when talking about research processes in general” (Voss & Procter, 2009:178). A wealth of literature is available across disciplines, regarding attempts to outline and interpret the basic research process and relevant lifecycles. According to Leedy and Ormrod (2010:7), the following six elements relevant to the research process are important: a problem in the mind of the researcher, the clear statement of the problem, subdivision of the problem into appropriate sub-problems, tentative solutions to the problem, looking for, collecting and organising data, and the interpretation of the meaning of the data, which leads to a resolution of the problem.

Lues and Lategan (2006:3) identify seven phases during the research process, which include turning a theme or idea into a researchable problem statement; literature and data collection; data processing; information and data analysis; results, findings and conclusions; evaluation, recommendation, implementation and presentation; and finally research outputs. According to Mamtora (2013:356), the four main elements of a research cycle are idea discovery, funding, experimentation and results dissemination. Research processes thus include the identification of a research topic, searching for information/literature and doing a review, proposal writing, collection and analysis of data and publication of results. According to the Joint Information Systems Committee (JISC) the research cycle starts with the generation of a researchable problem, followed by the identification and discovery of information as well as experts and subsequently the proposal writing process, the actual gathering and analysis of data and the publication of research results. This research lifecycle is illustrated in Figure 0.1

**Figure 0.1 Illustration of a typical research lifecycle**



Apart from studies suggesting the broad elements of the research process and relevant activities, there are those that look at the research process from an information seeking point of view and that are therefore relevant to information literacy. Ellis (1993) identified six information seeking processes in 1993, as part of a study performed among academic researchers in the United Kingdom. This study, based on a grounded research approach, suggests the following processes: starting, chaining, browsing, differentiating, monitoring and extracting (Ellis, 1993:480). Revisions of this model were made by Meho and Tibbo in 2003, in response to ICT developments. They added accessing, networking, verifying, and information managing activities (Meho & Tibbo, 2003:583). These studies were some of the first performed in the Library and Information Sciences (LIS) field that focused on research lifecycles, and only concentrated on the initial stage of the research process, namely information seeking. In this study ARIL, however, is regarded as a literacy applicable to postgraduate researchers, who are involved in all, or some, of the research phases mentioned in Table 0.4. These phases provide an indication of a typical research lifecycle in an academic context, with the focus on information literacy. Most of the studies noted in Table 0.5 were performed by librarians. Although Table 0.5 is not intended as a comprehensive list of studies performed in this area, it serves as a point of departure for the conceptualisation of ARIL. Detail on the information seeking behaviour of engineers in particular is provided in chapter 3.

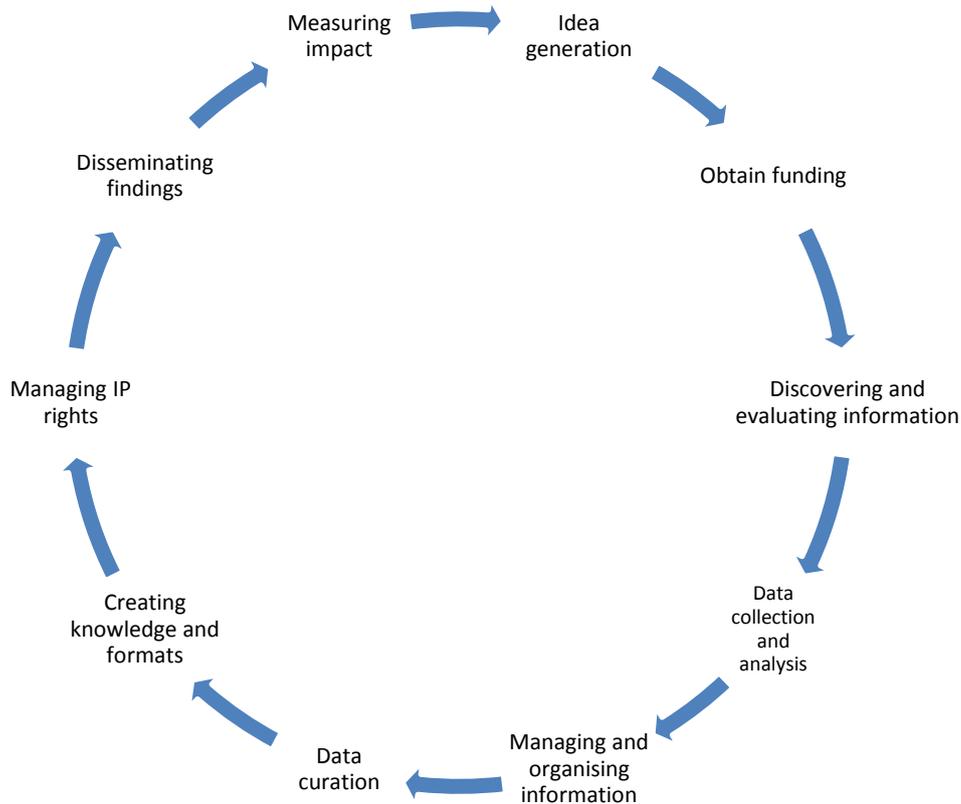
**Table 0.5 Research lifecycle from an information literacy perspective**

<b>Study Performed</b>	<b>Suggested Research Lifecycle</b>
Unsworth (2000)	Discovering, annotating, comparing, referring, sampling, illustrating, and representing
Minnesota Educational Media Organisation (MEMO) (2004)	Question, gather and evaluate, organise and draw conclusions, communicate, evaluate the product and process
University of Minnesota Libraries (2006)	Discover, gather, create, and share
Ngatai (2006)	Plan, identify, search, interpret, locate, manage, and communicate
MacCall & Erway (2009)	Funding, discovery, gathering, creation, retaining, sharing, and assessing
Research Information Network (RIN) (2010)	Generating and developing new ideas/projects/proposals, seeking, securing and managing funding, experimental process, and dissemination and publication of findings
SCONUL seven pillars of information literacy: A research lens (2011)	Identify, scope, plan, gather, evaluate, manage and present

Although researchers' understanding of information activities during an increasingly fluid research process remains incomplete (Palmer *et al.*, 2009:8), the various interpretations of scholarly research lifecycles can serve as guidelines for decisions on information literacy skills and thus also support services required by postgraduate researchers.

Based on a combination of the interpretations in preceding paragraphs, ten research processes were identified. These are illustrated in Fig 2.2 as a broad research lifecycle although it does not imply a linear process, or that these are the only processes associated with postgraduate research. Researchers in other fields might also follow other processes. The lifecycle goes beyond traditional support services offered to postgraduate researchers; traditional support often covers primarily the discovery and sharing of information, as well as activities such as the generation of a researchable topic, obtaining funding, the discovery and evaluation of information, the processes of data collection and analysis, the management and organisation of information, curation of data, creation of research documents, the management of intellectual property rights where appropriate, the publication of results and the measurement of impact in a specific field of study.

**Figure 0.2 Adapted research lifecycle**



Each process as part of the research lifecycle identified in Figure 0.2 will be briefly explained in the next paragraphs. The lifecycle will be further expanded and developed after completion of the empirical component.

- *Identification of a researchable topic* involves the identification of a suitable topic that is worth studying, and that will “advance the frontiers of knowledge” (Leedy & Ormrod, 2010:45). A systematic approach followed by researchers during this process, where high volumes of literature in a variety of formats are scanned, requires that researchers should be directed to appropriate and relevant information resources during this phase of the research process.
- *Funding* involves the seeking, allocation and management of funding opportunities. This very important activity, often performed during postgraduate research, may include the writing of grant proposals, receiving alerts regarding funding opportunities, and setting up budget requirements. Postgraduate researchers therefore need to be aware of the various funding sources and foundations, as well as of effective ways to access relevant databases.

- *Discovery and evaluation* involve various techniques to search for information, which may include serendipitous (Case, 2007:32; Barrett, 2005:326; Foster & Ford, 2003:321), collaborative (Shah & Marchionini, 2010:1970; Hertzum, 2008:1), or structured discovery (Ramirez, 2006:1; Leckie, Pettigrew & Sylvain, 1996:165). The discovery of information may include the ability to perform extensive searches on the internet and electronic databases (Newby, 2011:227), as well as the effective identification of information sources in various formats, which may include text, as well as people (Connaway & Dickey, 2010:4). Discovery may involve searching for new information, as well as effective search techniques and strategies to keep up to date with new publications. Another important element associated with the discovery process includes the critical evaluation of information, in order to determine its credibility.
- *Data collection and analysis* entail the empirical phase of research studies, where specialised methods are employed to obtain, process and visualise data, which may lead to new knowledge.
- *Managing and organising information* are important activities in order to enhance future retrieval. Researchers need to be systematic and also need to have an organisation system in place, where physical information formats are stored. According to Blignaut and Els (2010:102) researchers should implement systematic and meticulous file management strategies to avoid incoherent version control, misfiling feedback from supervisors, waste of time and effort and loss of documents. This process also involves the effective use of automated citation and referencing techniques. Many authors acknowledge the importance of knowledge and competencies regarding reference management software among postgraduate researchers (Saw, Lui & Yu, 2008:64; Hoffmann, Antwi-Nsiah, Feng & Stanley, 2008:12; Doskatsch, 2007:470; Pikas, 2007:9; East, 2005:138; Poirier, 2005:8; Macauley, 2001:245).
- *Data curation* is increasingly becoming an important activity, and researchers therefore need to be aware of various techniques to ensure that data is preserved and that datasets are accessed and used by others where possible.
- *Creation* involves activities during the actual writing up of the research. Reading, annotation, and subsequent “marshalling evidence from both paper and electronic documents” require certain competencies in a range of technologies (Randall, Smith, Clark & Foster, 2008:2). Researchers should therefore be fluent in word processing and other relevant software to compile dissertations and articles (Blignaut & Els, 2010:102).

- *Management of intellectual rights* involves the protection of an author's original work, and postgraduate researchers need to be informed regarding the use of others' work, as well as licensing their own work (Hagen, 2011:3; Rempel, 2010:544). According to Connaway and Dickey (2009:2), researchers are often concerned about privacy and safety issues regarding their work, and they should therefore be familiar with the use of various techniques to protect their intellectual property.
- *Dissemination* refers to activities during the sharing of research results, which may be oral or in writing. The selection of appropriate outlets in which to publish research results is therefore important (Knight & Steinbach, 2008:1); refereed academic journals and conferences are two popular publication channels for academic researchers. Other publication outlets may include repositories, patents, standards, informal information exchange, conferences, public meetings and joint cooperative ventures (Mischo & Schlembach, 2011:432; Cohen, Nelson & Walsh, 2002:14). Postgraduate researchers may also need assistance with designing posters as a method to present and communicate research results (Gider, Likar, Kern & Miklavcic, 2011:3; Jennings & Ferguson, 1995:307). Knowledge and understanding of scholarly publishing models may be important as well, and researchers need to understand certain practices and processes regarding scholarly communication (Thomas, 2011:44; Rempel, 2010:542; Hoffmann, Antwi-Nsiah, Feng & Stanley, 2008:12), which can assist them in deciding upon the most efficient dissemination outlet by taking institutional, budgetary, and wider economic implications into account (Houghton, Rasmussen, Sheehan, Oppenheim, Morris, Creaser, Greenwood, Summers & Gurlay, 2009:1).
- *Measurement* involves assessment of the impact of a study or journal in a specific field, through measuring the number of citations of publications (Dumont, *et al.*, 2005:8). Researchers may therefore need to know how citation impact is determined, as well as which tools and formulas are used to calculate and determine the impact of their own research as well as those of others.

The ten research phases can be regarded as an integral part of the conceptualisation of ARIL, although these phases are not static or linear, cannot be compartmentalised, and may overlap during the research lifecycle.

ARIL therefore builds on the skills, processes and phases normally associated with information literacy (also referred to as traditional information literacy) for school level, university entrance level and lifelong learning. These skills are well captured in information literacy standards and include identifying the nature and extent of information needed, as well as discovering, accessing, evaluating and using relevant information ethically. Although ARIL overlaps with workplace information literacy, it is especially aimed at enabling researchers from postgraduate level to internationally established researchers to complete responsible, high-quality research in a competitive international environment. This statement is the baseline of a definition for ARIL, which will continue to evolve throughout the study.

## 2.5 CONCLUSION

The first part of this chapter provided background information on information literacy, by discussing the different contexts in which information literacy has been studied over the years. It became evident that information literacy support should differentiate between undergraduate and postgraduate user groups, but that literature does not offer a strategic approach to supporting postgraduate researchers, with specific reference to direction, specific recommendations and successful strategies to develop information literacy skills. Most current information literacy models may therefore be inadequate in addressing the specific and unique information needs of postgraduate researchers, as well as in addressing the information literacy of employees performing research in a workplace context.

The focus of information services to postgraduate researchers should be on supporting activities throughout the entire academic research process. A conceptual framework for ARIL started to evolve in this chapter.

The literature often emphasises the importance of the link between research information literacy and a specific discipline (Rhodes & Ralph, 2010:232; Solmon, 2009:79), and confirms the diversity of research populations, their unique and various needs, as well as specific infrastructure requirements (Aucland, 2012:2; Blanton-Kent, 2010:1; Hoffmann *et al.*, 2008:2; Green & Macauley, 2007:317; Sadler & Given, 2007:115; Friedlander, 2002:18). Focus on the information literacy needs of a specific discipline may therefore be necessary, to provide relevant information services to that user group.

The next chapter will focus on the documented skills and needs of engineering researchers in an academic context, where the conceptualisation of ARIL will be further developed.

## **CHAPTER 3: EXPLORING ARIL WITH REFERENCE TO TYPICAL ACADEMIC ENGINEERING RESEARCH PROCESSES**

### **3.1 INTRODUCTION**

The chapter builds on the emerging conceptualisation of ARIL that started in the previous chapter. The main argument is that ARIL builds on the skills, processes and phases normally associated with traditional information literacy skills for school level, university entrance level and workplace level lifelong learning. It is especially aimed at enabling researchers from postgraduate level to internationally established researchers to complete responsible, high-quality research in a competitive international environment.

This chapter will focus on academic researchers, with specific reference to studies on information literacy and engineers. Studies on information behaviour and information practice are also considered. These are umbrella terms covering how people “do things” when they “deal with information” (Savolainen, 2007:126). It is assumed that understanding of information behaviour would shed light on information literacy skills and support for information literacy (Li, 2011:2; Boon, Johnston & Webber, 2007:206). This also applies to information practice. Many information literacy definitions refer to a series of information behaviours a person may exhibit (Loertscher & Wools, 1997:3). This confirms the link between information literacy, information behaviour and information practice studies. The need to align research on information literacy and information behaviour is also argued by Shenton and Hay-Gibson (2012:30; 2011:167) Williamson and Asla (2009:77) and Pinto and Sales (2007:532).

This chapter will start with a brief reflection on what it means to be an engineer, before exploring how the ARIL processes noted in Chapter 2 are reflected in reports on the information behaviour and information practice of engineers (especially those in an academic context).

### **3.2 REFLECTION ON WHAT IT MEANS TO BE AN *ENGINEER***

Many information literacy studies have indicated that information services need to be tailored according to the requirements of specific disciplines (Chen & Van Ullen, 2011:219; Blanton-Kent, 2010:1; Connaway & Dickey, 2010:4; Kroll & Forsman, 2010:20; Rempel, 2010:543; Rowlands & Fieldhouse, 2007:33; Sadler & Given, 2007:125). Some studies also suggest that disciplinary differences will not only persist, but will continue to evolve (Harley, Acord, Earl-Novell, Lawrence & King, 2010:28; Schonfeld & Housewright, 2010:34; Jamali &

Nicholas, 2006:10). According to Smith (2003:2), discipline-specific approaches are important for three reasons: they establish context, focus on structures and processes within a discipline and acknowledge the use of specific types of data, tools and search processes. Some researchers group engineers and scientists together in the same study, since it is assumed that these two disciplines are similar (Engel, Robbins & Kulp, 2011:548; Pinelli & Haynie, 2010:56; Boon, 2008:128; Pinelli, 2001:144). This practice often leads to overgeneralisation, conflicting results and overlooking more specific and underlying differences, making it difficult to get a clear picture of the specific information needs of engineers (Jamali & Nicholas, 2006:10; Leckie, Pettigrew & Sylvain, 1996:164; Pinelli, 1991:5). Both science and technology are critical in economic and social development (Okafor, 2010:181) and engineering can rather be seen as the *application* of science (Kousar & Mahmood, 2015: 52; Speight & Foote, 2011:39; O’Sullivan & Cochrane, 2009:1; Chanson, 2007:261; Royal Academy of Engineering, 2000:9).

Differences between engineers and scientists are indicated in many studies – also in educational contexts (Kwasitsu, 2003:467; Leckie Pettigrew & Sylvain, 1996:162), types of work activities and roles (Pinelli & Haynie, 2010:54; Du Preez, 2008:202; Kwasitsu, 2003:465; Anderson, Glassman McAfee & Pinelli, 2001:133; Leckie, Pettigrew & Sylvain, 1996:162), individual attributes (Du Preez & Fourie, 2009:147; Du Preez, 2008:315; Tenopir & King, 2004:85), and differences in their information seeking behaviour (Du Preez & Fourie, 2009:139; Fidel & Green, 2004:564; Tenopir & King, 2004:25; Anderson *et al.*, 2001:132; Ellis & Haugan, 1997:401). According to Pinelli and Haynie (2010:56), however, the key difference between engineers and scientists lies in the output of their work.

Differences between engineers’ and scientists’ research information are portrayed in Table 3.1. This also hints at differences in behaviour between the two user groups, and can be further motivation for why researchers from the two fields should be treated separately.

**Table 0.1 Differences in the information output from science and engineering**

Output	Science	Engineering	Citations
Format of information	Documents/reports	Products, processes and services	Speight & Foote (2011:39); Pinelli & Haynie (2010:54); O'Sullivan & Cochrane, (2009:1); Du Preez, (2008:333); Lindberg, Pinelli & Batterson (2008:2); Tenopir & King (2004:37); Pinelli (2001:133); Leckie, Pettigrew & Sylvain (1996:164)
Availability of information	Universally available	Occasional restrictions	Lindberg <i>et al.</i> , (2008:2); Tenopir & King (2004:37); Pinelli (2001:133)
Output channels	Journal articles, conference presentations, professional meetings	Reports, standards and patents	Pinelli & Haynie (2010:54); Lindberg, <i>et al.</i> (2008:2); Pinelli (2001:144)

This chapter will focus only on studies on engineers and will exclude studies covering only scientists or combining scientists and engineers in the same study without a clear distinction between the two.

The research processes identified for ARIL in section 2.4.1 are explored in more detail in section 3.

### **3.3 INFORMATION LITERACY IN THE CONTEXT OF ACADEMIC RESEARCH – PERSPECTIVES FROM THE LITERATURE**

The following sub-sections present findings for the research phases identified in section 2.4.1: generating a researchable topic, obtaining research funding, discovering and evaluating information, collecting and analysing data, managing and organising information, curating data, creating research documents, managing IP rights, disseminating findings and measuring impact. Each phase is briefly discussed with reference to processes and issues applicable to engineering researchers in an academic context are highlighted.

#### **3.3.1 Identification of a researchable topic**

The selection of a research-worthy topic to investigate is regarded as the first concrete step in research (Struwig & Stead, 2001:31; Welman & Kruger, 2001:33). It is normally based on a perceived problem that needs to be researched (Leedy & Ormrod, 2010:45; Struwig & Stead,

2001:22). The “definition, construction and articulation of the research problem itself” is therefore critical to the progress of a beginning researcher (Zuber-Skerritt, 1987:84). The narrowing down of a topic in order to derive a problem statement may be challenging for many university students (Badke, 2012:18; Fouche & De Vos, 2005:98), and workshops focusing on conceptual frameworks are not uncommon (Leshem & Trafford, 2007:95). There is, however, limited evidence of academic librarians actively engaging in this (Aucland, 2012:17), or in identifying and applying theory to research (i.e. identifying and applying a theoretical framework) (Exner, 2014:463).

Apart from the importance of formulating research problem statements, goals and research questions or hypotheses during this phase of the research lifecycle, the identification of a gap in the existing literature is an important first step for researchers, in order to ensure that new knowledge is created (Ellis & Levy, 2008:23). Although significant research has already been conducted in engineering and its many disciplines (Welman & Kruger, 2001:17), new research projects are expected to fill a gap in existing knowledge (Okiki & Mabawonku, 2013:9; Leedy & Ormrod, 2010:45; Welman & Kruger, 2001:17). The scanning of literature therefore plays an important part during this phase of the research lifecycle, since “the presence of the research problem is almost always established through the literature review”. The literature review assists researchers with the formulation of the research goals, the type of research planned and the formulation of research questions (Ellis & Levy, 2008:22).

Various processes are important in post-graduate research after identifying a researchable topic. The most important are discussed in the following sub-sections (3.3.2 – 3.3.11)

### **3.3.2 Identification of a specific research topic**

#### *3.3.2.1 Identification of a gap in existing literature*

Researchers are often free to choose a researchable topic drawn from own experiences and ideas (Fouche & De Vos, 2005:89; Mouton, 2001:27) or from direct observation (Fouche & De Vos, 2005:92). Research topics may also be determined by employers or funders (Blaxter Hughes & Tight, 2006:22), research organisations (Struwig & Stead, 2001:22) or by supervisors (Blaxter Hughes & Tight, 2006:29). Topics can be identified through attending professional conferences (Leedy & Ormrod, 2010:47) or by performing small-scale investigations (Struwig & Stead, 2001:22). In addition, research topics can be identified through the scanning of literature (Struwig & Stead, 2001:33) and important information sources, including recently completed doctoral theses (Ellis & Levy, 2008:26), dissertations

and research reports (Leedy & Ormrod, 2010:44; Mouton, 2001:28). South African researchers must be able to perform searches on the NEXUS database (<http://www.hsrc.ac.za/nexus.html>) established to avoid research duplication on a national level (Mouton, 2001:31). Books, journal articles, conference papers, unpublished research reports (Welman & Kruger, 2001:17), online scholarly databases (Leedy & Ormrod, 2010:69; Welman & Kruger, 2001:34), and the internet (Leedy & Ormrod, 2010:18) are other important resources to scan during this phase of the research process. Research performance management (RPM) tools such as SciVal Spotlight ([www.elsevier.com/government/scival-spotlight](http://www.elsevier.com/government/scival-spotlight)) can also assist researchers to obtain an overview of research topics and to identify research topics in line with institutional research strengths (Raju & Schoombee, 2013:27). These resources can assist researchers to determine what other researchers have done in their specific field of study, to focus ideas further, to shape research questions and hypotheses, and to explore the context of a project (Blaxter, Hughes & Tight, 2006:101).

When reviewing the literature during the initial phase of a research study, knowledge of information sources and what they cover, as well as the identification of the latest and earlier publications, is important. Review articles can give a general overview of a topic and reveal key authors on the topic and in the specific discipline (Mouton, 2001:29). Researchers may, however, need guidance on how to do systematic investigations to find suitable resources, to know which type of sources to include and which authors to quote, and to know how to locate resources effectively (Blaxter, Hughes & Tight, 2006:105). Sufficient time should be allocated for the process of identifying and locating appropriate information sources, and then for reflection on and synthesis of the existing information on a topic. Some resources may not be available immediately, and may need to be requested on interlibrary lending or even purchased (Welman & Kruger, 2001:34).

Researchers may find research literature overwhelming during this stage because of high volumes of literature available, the variety of literature, lack of boundaries and clear demarcation, as well as conflicting arguments, opinions and interpretations in the literature (Blaxter, Hughes & Tight, 2006:101). To address the problem concept, mind and argument mapping techniques can be employed during this phase.

#### 3.3.2.2 *Concept, mind and argument mapping*

Researchers can employ concept and mind mapping tools for visual representations of the relationships between huge amounts of literature (Hegazy, Ali & Abdel-Monem, 2011:239).

According to Leedy and Ormrod (2010:55), researchers can benefit from employing a “paper-and-pencil” approach or by using specific software aimed at researchers, for example MindManager (<http://www.mindjet.com>), FreeMind (<http://www.freemind.sourceforge.net>) and SciPlore (<http://www.sciplore.org>) (Hegazy, Ali & Abdel-Monem, 2011:240), as well as Inspiration ([www.inspiration.com](http://www.inspiration.com)), BrainStorm ([www.brainstormsw.com](http://www.brainstormsw.com)) or MindJet ([www.mindjet.com](http://www.mindjet.com)) (Leedy & Ormrod, 2010:55).

Engineering research projects are often referred to as “applied research”, since they mostly focus on practical issues such as products, processes and services (Speight & Foote, 2011:39; Pinelli & Haynie, 2010:54; O’Sullivan & Cochrane, 2009:1; Du Preez, 2008:333; Lindberg, Pinelli & Batterson, 2008:2), which have “immediate relevance to current practices, procedures, and policies” (Leedy & Ormrod, 2010:44). The effective and critical scanning of scholarly literature to identify a gap in existing knowledge is an important skill for postgraduate engineering researchers. The following criteria are important when refining a research topic: contribution to new knowledge (Yearworth, Edwards, Davis, Burger & Terry, 2013:1077; Panas & Pantouvakis, 2010:77), meeting the needs of industrial sponsors and whether the proposed study will fulfil the requirements for a postgraduate qualification in a specific field (Yearworth, Edwards, Davis, Burger & Terry, 2013:1077). Brainstorming sessions and diagrams are also often employed by engineers during the initial phase of a study to identify important factors (Vardeman & Jobe, 2001:60).

During this phase it may become evident that funding needs to be obtained to do the research.

### **3.3.3 Obtaining research funding**

Not all research projects require researchers to apply and manage research funding. The ability to secure research funding is, however, often a key element in performing successful scientific research (Koppelman & Holloway, 2012:63; Jowkar, Didegah & Gazni, 2011:599; Szelenyi & Goldberg, 2011:775; Arnett, 2009:2607; Berg, Gill, Brown, Zerzan, Elmore & Wilson, 2007:1588). Academic researchers may require funding to develop their careers, to develop certain research skills, and to carry out specific research projects (Koppelman & Holloway, 2012:64; Rattihalli & Field, 2011:57; Berg *et al.*, 2007:1589). Obtaining research funding, however, became more competitive over the years (Koppelman & Holloway, 2012:63; Rattihalli & Field, 2011:57), in response to increased needs to justify spending taxpayers’ money (Jacob & Lefgren, 2011:1168; Vincent-Lancrin, 2006:18; Royal Academy of Engineering, 2000:5). Most engineering funding applications are associated with resource-

intensive research projects and according to statistics the success rate of engineering applications in the UK during 2008/2009 was only 26% (Geard & Noble, 2010:2).

Information literacy skills important to obtaining research funding include discovering funding opportunities, identifying collaborators, writing and compiling funding proposals, and budgeting for anticipated expenses.

### *3.3.3.1 Discovering funding opportunities*

Large numbers of potential funding sources are available, for example government initiatives, advocacy groups, charity organisations and industries (Koppelman & Holloway, 2012:64), as well as university-wide and discipline-specific scholarships. Most funding sources provide a wealth of information freely available on the internet (Berg *et al.*, 2007:1590). Some funding databases even provide weekly e-mail updates, funding-related notices, notifications on requests for applications and new funding programme announcements (Berg *et al.*, 2007:1588). The NRF database ([www.nrf.ac.za](http://www.nrf.ac.za)) is an important electronic database for academic researchers in South Africa; it provides information on local and international funding opportunities, fellowship programmes, selection criteria and centres of excellence, to name a few. Academic researchers may also find funding opportunities through their home institutions' and departmental webpages. They must thus be able to identify suitable databases and websites containing information on funding opportunities (Harrison, Herbohn, Mangaoang & Vanclay, 2002:214). Although the first step for many researchers is to apply for funding from recognised organisations, crowdfunding is gaining momentum in certain disciplines, where researchers get the public interested in their work through online campaigns, which can enable them to supplement existing studies, purchase software or fund experiments (Larkin, 2013:1).

### *3.3.3.2 Finding collaborators*

Apart from discovering funding opportunities, academic researchers also often need to identify suitable collaborators to be considered for funding opportunities. Collaboration with other experts, teams and institutions is becoming crucial to the success of academic research projects and funding applications (Rattihalli & Field, 2011:58; Harley *et al.*, 2010:16; Niu, Hemminger, Lown, Adams, Brown, Level, McLure, Powers, Tennant & Cataldo, 2010:874; Atkinson, Britton, Coveney, De Roure, Garnett, Geddes, Gurney, Haines, Hughes, Ingram, Jeffreys, Lyon, Osborne, Perrott, Procter, Rusbridge, Trefethen, & Watson, 2009:41; Schleyer, Spallek, Butler, Subramanian, Weiss, Poythress, Rattanathikun & Mueller, 2008:1;

Berg *et al.*, 2007:1589; Harrison *et al.*, 2002:211); grant funding agencies need assurance that the relevant skills and expertise are available “to ensure the success of the project among the applicants” (Johnson, 2011:65). Engineering researchers are also increasingly required to collaborate with other engineers as well as with researchers across disciplines (Sampson & Comer, 2011:12; Riemer, 2007:93).

The effective identification of potential collaborators is therefore important during the process of obtaining funding for research. Academic researchers can employ communication and collaborative technologies such as LinkedIn ([www.linkedin.com](http://www.linkedin.com)), Research Crossroads ([www.researchcrossroads.org](http://www.researchcrossroads.org)), and Community of Science (COS) ([www.cos.com](http://www.cos.com)) (Schleyer *et al.*, 2008:3). Google Scholar ([www.scholar.google.com](http://www.scholar.google.com)) is also often used as a first step in acquiring information on colleagues and experts (Schleyer *et al.*, 2008:11). Many other systems are available globally, which implies that increased effort and awareness may be required of researchers to identify collaborators, to search effectively in different domains, to use social networks effectively and to keep updated online personal profiles (Schleyer *et al.*, 2008:2).

### 3.3.3.3 *Writing funding proposals*

In addition to the discovery of funding sources and collaborators, the actual writing of the funding proposal is very important. Researchers need to be aware of and adhere to funding proposal guidelines and requirements, since a specific structured layout often needs to be followed (Hammond & Wellington, 2013:156). Layouts may include an abstract, introduction, research plan, aims and objectives, background information, research methods and design, literature review, ethical clearance statement, track record of researcher and a data sharing plan (McAreevey & Muir, 2011:395; Arnett, 2009:2609; Berg *et al.*, 2007:1591; Harrison *et al.*, 2002:215). Apart from the specifications for the application layout, researchers must also keep the assessment criteria of the funding body in mind (Johnson, 2011:66). Quality proposals require proper planning. Since a lot of time is required for preparing funding proposals, researchers must avoid wasting time and energy on unsuccessful proposals (Koppelman & Holloway, 2012:66; Rattihalli & Field, 2011:59; Steiner, 2011:36; Dunlop, 2010:57; Geard & Noble, 2010:2; Arnett, 2009:2610). They thus require assistance on writing funding proposals. Unfortunately there are often limited initiatives in this regard (Koppelman & Holloway, 2012:63; Arnett, 2009:2607).

#### 3.3.3.4 *Budgeting*

The setting up of a budget is another important aspect regarding successful funding applications. According to Arnett (2009:2609), the budget is one of the most important parts of a funding proposal. Doing research can be costly when considering man hours, staffing and equipment, travelling, attending conferences, postage, printing, purchasing of research books and acquisition of specific equipment (Rattihalli & Field, 2011:57; Berg *et al.*, 2007:1591; Andretta, 2005:5, Harrison *et al.*, 2002:213). Researchers are also required to manage the funds properly and report to funding bodies on how they spend the money (Harrison *et al.*, 2002:216). They thus need to be aware of ethical issues during the budgeting process, such as fraudulent activities regarding acceptance and using funds from different organisations to fund the same project (Reich, 2012:146), as well as potential conflicts of interest between researchers and funding agencies, which may affect the “objectivity of independent scientists and the integrity of science” (Miller, Babor, Mcgovern, Obot & Buhringer, 2008:190).

Although budgeting skills are recognised as critical to the formal education of engineers, most engineering programmes do not specifically cover these skill sets (O’Sullivan & Cochrane, 2009:1).

#### **3.3.4 Discovery and evaluation of information**

The discovery of relevant research information is a third fundamental research phase. Apart from the process where resources are scanned during the initial process where a researchable topic is identified, there are also other times when the discovery of relevant information is very important. Rich understanding regarding the discovery of information developed over the years and moved from early studies in a paper-based environment to an environment where computers, online catalogues, online database searching, the internet, the World Wide Web (WWW) and digital libraries are commonly used (Bates, 2010:7). Along with the various information formats available today, different methods of discovering information developed, ranging from active information seeking to browsing and monitoring. Academic disciplines differ in the formats and types of information they value (Badke, 2012:129). Typical support offered by academic librarians during the discovery of information are advice on information sources in various subject areas, help in finding required resources and providing training regarding the finding of relevant resources (i.e. training in information searching and information retrieval) (Aucland, 2012:19).

The transformation of methods for discovering information can largely be attributed to developments in ICT (Harley *et al.*, 2010:18; Hemminger, Lu, Vaughan & Adams, 2007:2205; Chanson, 2006:1). Such methods are serendipitous information discovery (Case, 2007:32; Barrett, 2005:326; Foster & Ford, 2003:321), collaborative information discovery (Shah & Marchionini, 2010:1970; Hertzum, 2008:1), structured information discovery (Ramirez, 2006:1; Leckie *et al.*, 1996:165), and many others such as information monitoring and browsing. A few of the methods considered most important will be briefly discussed.

#### 3.3.4.1 *Serendipitous information discovery*

Serendipitous information discovery is the seemingly accidental discovery of relevant information (Case, 2007:32; Foster & Ford, 2003:329) and can therefore be regarded as an informal, semi-structured strategy of information discovery (Marchionini, 1995:100). This is considered as an integral part of information discovery and the generation of new knowledge across disciplines (Foster & Ford, 2003:337). According to Case (2007:89), browsing is closely related to serendipitous information discovery.

Browsing is a popular and effective approach to information discovery, since researchers can gain an overview of a topic, monitor a process, increase awareness about new developments or clarify a problem (Marchionini, 1995:103; Ellis, 1989:187). Browsing in a traditional print environment is often associated with browsing through library card catalogues, bookshelves, printed publisher's catalogues, content pages of journals on library shelves, book displays at conferences and title lists, abstracts and summaries of documents (Choo, Detlor & Turnbull, 1999:6; Marchionini, 1995:100; Ellis, 1989:187). Traditional browsing methods, however, have been gradually replaced with electronic browsing methods, which became widely used as a result of ICT developments. Postgraduate researchers may therefore need to develop effective searching skills with regard to the browsing features of multidisciplinary databases and search engines, as well as journal tables of contents (TOC) services. Browsing activities are especially important in fields where information is scattered across disciplines (Newby, 2011:227).

Electronic browsing methods employed by academic engineering researchers involve accessing electronic publisher websites, browsing through electronic mail messages, online TOCs of journals, browsing through conference programmes, professional associations' websites, as well as known experts' homepages (Bennett & Buhler, 2010:7,8; Wang, Dervos, Zhang & Wu, 2007:14,15). The browsing of physical bookshelves is, however, still important to them (Chanson, 2008:10).

The chaining of references can also be regarded as a serendipitous information discovery method. Backward chaining entails following up references referred to in a document (also referred to as citation pearl searching). Forward chaining entails following more recent publications citing a specific document (George, Bright, Hurlbert, Linke, St. Clair & Stein, 2006:13; Choo *et al.*, 1999:9; Ellis, 1989:183). Postgraduate researchers should thus be able to perform searches for cited references. Useful electronic information resources for this are CiteSeer (<http://citeseerx.ist.psu.edu/index>) (George *et al.*, 2006:14), PubMed (<http://www.ncbi.nlm.nih.gov/pubmed>), EbscoHost ([www.ebscohost.com](http://www.ebscohost.com)), Scopus ([www.scopus.com](http://www.scopus.com)), and the WOS citation indexes (<http://thomsonreuters.com>) (Newby, 2011:227; Ellis, 1989:183). According to Wang *et al.* (2007:17), academic engineering researchers perform less forward chaining to find new information, although they frequently follow citations backwards. They show a preference for CiteSeer, rather than the WOS citation indexes.

#### 3.3.4.2 Collaborative information discovery

Academic researchers also use collaborative information discovery methods. The research environment, once characterised by individual researchers working on a topic in isolation, is moving towards a collaborative environment, where scholars are networking in a global community (Brewerton, 2012:97; Simons, 2012:3). Collaborative discovery of information requires both social and technical skills to connect with information sources, as well as the ability to build personal learning networks and communities of interest (Farkas, 2012:89; Marchionini, 2006:43). According to Bozeman and Corley (2004:602), academic researchers collaborate for the following reasons: to obtain access to expertise, equipment and resources; to encourage cross-fertilisation across disciplines; to obtain prestige or visibility; to gain tacit knowledge about a technique; to pool knowledge together in tackling complex problems; to enhance productivity and to increase specialisation. D'Este and Perkmann (2011:327) confirm these reasons and add commercialisation, which entails additional personal income

and the seeking of IP rights. Academic researchers must therefore be able to identify people as sources of information in order to collaborate successfully (Connaway & Dickey, 2010:4).

Academic engineering researchers are active collaborators (Johnson, 2011:16; Soorymoorthy, 2011:223; Lee & Bozeman, 2005:683). This is partially due to the fact that engineering research is becoming more multi-, inter- and transdisciplinary; this requires more integrated responses to research problems (Martin, 2011:473; Sampson & Comer, 2011:12; Tucci, 2011:6). Since there are limited knowledge and resources, and information overload to cope with, it is useful to collaborate (Foster, 2005:7). The effective solving of problems in teams is therefore becoming crucial and in some cases new modules are developed at academic institutions to support engineering researchers with this (Gider, *et al.*, 2011:334).

Collaboration is mostly based on the use of electronic media and personal contact.

(a) Electronic collaboration

ICT developments enhanced the ways in which academic researchers collaborate with each other (Mutula, 2011:262); the web offers social networks, social bookmarking, Skype, wikis, blogs, e-mail messages, video and teleconferencing, file transfer protocol (FTP), discussion lists, ranking and reviewing, websites, and other multimedia applications (Harley *et al.*, 2010:16; Niu *et al.*, 2010:880; Thomas, 2011:38; Thomas, Satpathi & Satpathi, 2010:598; Hemminger *et al.*, 2007:2215; East, 2005:137). Some academic researchers prefer more tailored products, such as ResearcherID ([www.researcherid.com](http://www.researcherid.com)) (Rotenberg & Kushmerick, 2011:511) and Academia ([www.academia.edu](http://www.academia.edu)), which enhance collaboration through the availability of online research profiles.

Although these online communication and collaboration channels have the potential to transform interaction, some studies confirmed their limited use among academic researchers (Nariani & Fernandez, 2012:191; Harley *et al.*, 2010:14; Schonfeld & Housewright, 2010:25). In earlier studies engineering researchers have also indicated below average use of electronic bulletin boards, blogs, wikis, instant messaging and online discussion lists (Patterson, 2009:13; Chu & Law, 2007:35; Wang *et al.*, 2007:25). They do, however, regard electronic mail as an important source of collaboration (Robbins, Engel & Kulp, 2011:523; Wang *et al.*, 2007:9).

### (b) Face-to-face discovery of information

Apart from electronic collaborative contact, face-to-face interaction is very important among academic researchers from various disciplines (McAlpine & Amundsen, 2011:3; Harley *et al.*, 2010:14; Niu *et al.*, 2010:874). They consider personal discussions and networks as critical information sources (Robbins *et al.*, 2011:523; Engel *et al.*, 2011:551; Chu & Law, 2007:34; Foster, 2005:7; Bozeman & Corley, 2004:612; Kerins, Madden & Fulton, 2004:7) and they value especially the interaction and networking at conferences, with colleagues and experts (Sampson & Comer, 2011:7; Bennett & Buhler, 2010:8; Wang, *et al.*, 2007:23; HEFCE, 2002:27; Lilja, 1997:2). Academic researchers must be able to identify forthcoming conferences relevant to their area of research (East, 2005:137) to take advantage of these networking opportunities. Engineering researchers also consider interaction with their supervisors as important for the discovery of information (Chu & Law, 2007:34). Library staff are, however, often not considered as essential information resources (Engel *et al.*, 2011:554; Tucci, 2011:4; George, *et al.*, 2006:9; Du Bruyn, 2004:116; HEFCE, 2002:6).

#### 3.3.4.3 Structured information discovery

Structured information discovery refers to more formal strategies, such as making use of libraries, electronic networks, research firms and government agencies (Marchionini, 1995:7). Researchers are often required to have planned search strategies to retrieve relevant information from such information resources. Academic engineering researchers have indicated that they consider the use of correct keywords as a critical factor for the discovery of information (Sampson & Comer, 2011:5; du Bruyn, 2004:95). Studies indicate, however, that although engineering researchers often conduct relatively simple keyword searches (Chu & Law, 2008:174), they still experience challenges regarding the identification of suitable keywords and search terms, planning a good search strategy, refining results and managing extensive information (Sampson & Comer, 2011:5; Patterson, 2009:15; Chu & Law, 2008:174; Hoffmann, Antwi-Nsiah, Feng & Stanley, 2008:7; Randall, Smith, Clark & Foster, 2008:2; Antwi-Nsiah, Feng, Hoffmann & Stanley, 2006:1; Ngatai, 2006:27). According to Chu and Law (2008:175), training for effective structured discovery of information is thus essential.

Although academic engineering researchers use a variety of information resources, the internet, scholarly journals and books are the most popular research information sources (Engel, *et al.*, 2011:562; Bennett & Buhler, 2010:4; Niu, *et al.*, 2010:874; Chu & Law, 2007:31). These formats will be discussed in more detail in the next paragraphs.

(a) Internet

As mentioned in earlier sections, the internet transformed scientific communication worldwide in all disciplines and affected how researchers acquire information (Guruprasad, *et al.*, 2011:65; Mutula, 2011:262; Niu *et al.*, 2010:869; Hemminger *et al.*, 2007:2214). Studies indicate that academic engineering researchers consider the internet as an essential source of information, since it allows working across continents, in different time zones, while offering convenience, speed and currency (Engel *et al.*, 2011:551; Tucci, 2011:5; Wang *et al.*, 2007:24; George *et al.*, 2006:10; Kerins *et al.*, 2004:5). More specifically, studies indicate that engineering researchers show a strong preference for Google (Tucci, 2011:8; Bennett & Buhler, 2010:13; Chanson, 2009:118; George, *et al.*, 2006:9) and they prefer to visit other academic institutions' and researchers' websites (Tucci, 2011:4; du Bruyn, 2004:95). Academic researchers should therefore be able to perform searches on the internet effectively, in order to retrieve up-to-date research information (Blignaut & Els, 2010:102).

(b) Scholarly journals

Online electronic journals transformed scholarly communication practices and soon became a primary information source among academic researchers (Niu *et al.*, 2010:874; Schonfeld & Housewright, 2010:2; Hemminger *et al.*, 2007:2214). Scholarly journals are very important information sources among academic engineering researchers (Okafor & Ukwoma, 2011:58; Hiller, 2002:9). They prefer electronic information resources rather than print formats (Engel *et al.*, 2011:554; Robbins *et al.*, 2011:523; Tucci, 2011:4; HEFCE, 2002:9). Online databases are therefore consulted frequently among academic engineering researchers (Engel *et al.*, 2011:554; Tucci, 2011:4; Bennett & Buhler, 2010:13; George, *et al.*, 2006:16; ALA, 2005:1; HEFCE, 2002:52). Some popular databases include EI Compendex, Kluwer Online, Science Direct, Scirus, Reuters Web of Knowledge and Inspec (Waters, *et al.*, 2012:126; Engel *et al.*, 2011:555; Tucci, 2011:4; Chanson, 2009:117; Chu & Law, 2008:173; Chanson, 2007:263; Chanson, 2006:4). Engineering researchers also need to consult databases in other disciplines, because of their research becoming more interdisciplinary. Such databases include Environmental Abstracts, Biological Abstracts and Chemical Abstracts (Chu & Law,

2008:173). Although bibliographic resources are popular, library catalogues are rarely used (Engel *et al.*, 2011:553; Tucci, 2011:4; Hemminger *et al.*, 2007:2214; HEFCE, 2002:53). A study by Tucci (2011) found that academic engineering researchers are showing stronger preferences for full-text databases. It is therefore important that academic researchers are able to perform searches effectively on different electronic databases in order to retrieve up-to-date research information (Blignaut & Els, 2010:102).

### (c) Books

Researchers across all disciplines are still using physical resources, including hard copies of books, textbooks and reference materials (Du & Evans, 2011:116; Niu *et al.*, 2010:874; George, *et al.*, 2006:16). These are acquired from libraries, or physical or online bookshops/stores. According to Thomas, Satpathi and Satpathi (2010:597), recent trends indicate a dramatic swing towards the acceptance of electronic books among academic researchers.

Engineering researchers regard physical books as essential information sources (Engel *et al.*, 2011:554; Robbins *et al.*, 2011:523; Chu & Law, 2007:33; ALA, 2005:1; Tenopir & King, 2004:80; HEFCE, 2002:53). A study performed among engineering researchers from 20 academic institutions in the USA showed that electronic books are regarded as less important than physical books (Engel *et al.*, 2011:554). Because of engineers' strong preference for online information formats, the use of electronic books may increase in future (Tucci, 2011:7).

In addition to these formats, academic engineering researchers also use trade literature, such as patents, standards and technical reports (Chanson, 2009:117; Chu & Law, 2008:174; Chu & Law, 2007:36; Tenopir & King, 2004:80) and three-dimensional shapes (Blumel, Berndt, Ochmann, Vock & Wessel, 2010:2; Iyer, Jayanti, Lou, Kalyanaraman & Ramani, 2005:509). Although trade literature is important to academic engineering researchers, there is limited evidence of the inclusion of patent searching skills in information literacy support programmes for researchers (Emanuel & Roh, 2013:536; Jeffryes & Lafferty, 2012:3; MacMillan & Thuna, 2010:418; Zhang, 2009:261; Antwi-Nsiah *et al.*, 2008:7; Chu & Law, 2007:37; Antwi-Nsiah *et al.*, 2006:1). The same applies to skills in searching for technical reports (Jeffryes & Lafferty, 2012:3; Hoffmann *et al.*, 2008:7).

#### 3.3.4.4 *Keeping abreast with current information*

Researchers should ensure that they manage the currency of literature throughout the lifecycle of the research project (Lubbe, Worrall & Klopper, 2005:246). Keeping abreast with the latest developments is considered a primary responsibility (Engel *et al.*, 2011:553). The discovery of information is an ongoing process and academic researchers are increasingly under pressure to keep up to date with the latest trends in their fields (Rotenberg & Kushmerick, 2011:504). Researchers should therefore be able to identify databases, blogs and websites that offer services for keeping updated with new information, and also need to employ Real Simple Syndication (RSS) feeds and electronic mail alerts effectively (Newby, 2011:228).

Various methods can be used to keep with new information and findings, for example personal communication with colleagues, conference attendance, browsing through conference programmes, visiting web sites of colleagues and other researchers to track experts, browsing tables of contents of journals, following references from articles, searching databases and search engines, serving as a journal editor, serving as a referee, browsing through flyers and advertisements, e-mail communication, listservs, and digital libraries (Robbins *et al.*, 2011:523; Bennett & Buhler, 2010:14; Wang *et al.*, 2007:15). Subscription to current awareness services such as TOC services and selective dissemination of information profiles run against databases can also be used (Fourie, 1999).

It seems as if it may be possible that academic engineering researchers prefer more traditional ways to keep current with new developments instead of blogs, RSS feeds and electronic discussion lists (Engel *et al.*, 2011:553; Robbins *et al.*, 2011:523; Bennett & Buhler, 2010:8). Although keeping abreast with current information may be associated more with some phases in the life cycle of a research project (Mueller, *et al.*, 2005:2), some engineers prefer to keep up to date with developments during the whole life cycle of a project (Ellis & Haugan, 1997:397).

#### 3.3.4.5 *Evaluation of information*

The use of electronic information resources in educational contexts gave rise to many studies on the effective evaluation of scholarly information (Brand-Gruwel & Stadtler, 2011:176; Wopereis & Merrienboer, 2011:232). According to Bent, Gannon-Leary, Goldstein and Videler (2012:10), the effective evaluation of information assists researchers in managing information overload, to ensure that researchers read only quality information. The ability to

evaluate textual and multimedia information sources critically is therefore important (Wopereis & Merrienboer, 2011:236; Booth, Colomb & Williams, 2008:10). It may involve the ability to apply criteria relevant to the currency, relevancy, authority, accuracy and purpose of the information at hand (Seely, Fry & Ruppel, 2011:81). According to Cullen (2013:3), the use of the RADAR tool can assist researchers with evaluating information. RADAR is the acronym for relevance, authority, date, appearance and reason for writing. The effective evaluation of information in order to identify quality resources may be challenging for some students (Badke, 2012:47; Head, 2007:2), in view of the “uncertain quality and expanding quantity” of information (Okiki & Mabawonku, 2013:10).

Some studies also identified lack of information evaluation skills among academic engineering researchers. This confirms the perception that these skills and competencies need to be developed in academic institutions (Patterson, 2009:13; Kong, *et al.*, 2007:153; Ngatai, 2006:27). There is concern about especially the reliability of information retrieved from the internet and problems experienced as a result of information overload and the difficulty of finding specific information (Kerins *et al.*, 2004:5).

Although many studies have reported on the information *discovery* behaviour of engineers in an academic context (Sampson & Comer, 2011:5; Pikas, 2007:1; Tenopir & King, 2004:57), less is known about some of the other phases addressed in sections 3.3.4 – 3.3.11.

### **3.3.5 Data collection and analysis**

Effective application of data collection and analysis methods is very important in research studies (Blaxter Hughes & Tight, 2006:29). Specific methods need to be followed in order to obtain valid and reliable answers to specific types of research questions (Solmon, 2009:78; Ellis & Levy, 2008:21). It is important for researchers to be aware of the methods prescribed or preferred in their specific discipline and field of study. Sometimes established traditions and methodologies are evident (Badke, 2012:9; Blaxter Hughes & Tight, 2006:22).

Researchers must be aware of the different data collection and analysis techniques associated with qualitative and quantitative approaches (Solmon, 2009:78; Blaxter Hughes & Tight, 2006:59), as well as a combination of both (i.e. mixed methods studies) (Blaxter Hughes & Tight, 2006:64).

Many researchers may also need additional skills with regard to research methodologies (Bradbury & Brochert, 2010:8). Blumenstein (2015:34) refers to a need for quantitative literacy. Knowledge and the ability to apply sampling procedures, perform pilot studies, power analysis and perform experiments, delineate variables and address threats to internal and external validity have also been noted (Solmon, 2009:78).

Although the effective application of research methodologies is considered an important skill among academic engineering researchers (Male *et al.*, 2009:1; Manathunga & Lant, 2006:80), they often employ “trial and error” approaches and therefore need assistance or training during this specific research phase (Chakrabarti, 2010:318; Harley *et al.*, 2010:27; Kong, Hunter & Lin, 2007:153; University of Minnesota Libraries, 2006:43; Thomas, 2011:44).

Data collection and data analysis are briefly discussed in the following two sections.

#### 3.3.5.1 *Data collection*

Data can be collected in the form of words, pictures, drawings, paintings, photographs, films, music or sound tracks (Struwig & Stead, 2001:13; Brink, 1996:13). These are often collected from people or documents (Denscombe, 2003:7; Struwig & Stead, 2001:11) through the use of techniques such as interviews and observation (Blaxter Hughes & Tight, 2006:64). Qualitative data collection can use questionnaires, interviews and observation (Msweli, 2011:64). Quantitative data collection may be based on experimental designs and non-experimental designs, where popular experimental designs include pretests-posttests, rather than surveys, which are widely used in non-experimental designs (Maree & Pietersen, 2007a:149).

Although many of the data collection methods can be performed with pen and paper, ICT developments have resulted in new options (Denscombe, 2003:236). It might be important that researchers can conduct online surveys effectively, since postgraduate researchers have indicated a need for assistance in this regard (Bradbury & Brochert, 2010:5).

Data collection methods typically used by engineers include experimental studies where variables are manipulated in a regulated environment (Runeson & Host, 2009:132; Vardeman & Jobe, 2001:5), simulation research (Panas & Pantouvakis, 2010:70), questionnaire surveys (Soni & Kodali, 2012:776), historical archive analysis, participant observation, interviews and content analysis (Soni & Kodali, 2012:772) and case study research (Runeson & Host,

2009:132), as well as combinations of these methods of collecting qualitative and quantitative data (Soni & Kodali, 2012:772; Panas & Pantouvakis, 2010:79). Although engineering researchers also apply qualitative data collection and analysis techniques (Runeson & Host, 2009:132; Vardeman & Jobe, 2001:8), they tend to lean towards collection and analysis methods used for quantitative data (Soni & Kodali, 2012:776; Panas & Pantouvakis, 2010:79; Runeson & Host, 2009:132).

Although the collection of good and valid data is important during the research process, it is not sufficient on its own to produce good research (Solmon, 2009:78). Data analysis is equally important.

### 3.3.5.2 *Data analysis*

The collection of data ultimately “culminates in the analysis and interpretation” of data, which involves the breaking up of data into manageable “themes, patterns, trends and relationships” (Mouton, 2001:108). Data analysis procedures are often performed to convert raw data “into meaningful or interpretable data” (Struwig & Stead, 2001:150). This can involve editing, categorising and coding processes. Although some research projects may be on a small scale where sophisticated computer software is not required to analyse data, data analysis methods performed on computer-based software may result in quicker and more accurate analysis (Blaxter, Hughes & Tight, 2006:204). Importing data to different software is considered fundamental to the research process (Blignaut & Els, 2010:102), and researchers may need to employ word processor software, as well as software that can accommodate spreadsheets (Struwig & Stead, 2001:151). In addition, specialised computer software can be used to analyse qualitative data, for example ATLAS.ti, ETHNOGRAPH, HyperRESEARCH and Non-numerical Unstructured Data Indexing Searching and Theorizing (NUD.IST) (Lee & Fielding, 2004:532, Mouton, 2001:79; Struwig & Stead, 2001:169). The Statistical Package for the Social Sciences (SPSS), Statistical Analysis Software (SAS) (Struwig & Stead, 2001:169), MINITAB (Blaxter, Hughes & Tight, 2006:204), and Statistica (Mouton, 2001:79) are used for the analysis of quantitative data.

It is therefore important that researchers are able to analyse research data effectively, although many may require additional skills with regard to data analysis techniques, with special reference to statistical analysis software and qualitative data analysis tools (Bradbury & Brochert, 2010:5). Researchers can perform statistical techniques in the “cloud”, which is open and free, without requiring regular updates or installation space (Yang, Shia, Wei & Fang, 2012:2189).

In addition to the analysis of research data, effective computational visualisation and presentation of research data are important during this phase (Covert-Vail & Collard, 2012:8; Blignaut & Els, 2010:102). Tables, charts and maps are inserted into documents or presentation applications (Gaiser & Schreiner, 2009:146). Although Excel spreadsheets are a popular tool to display and visualise research data effectively (Bradbury & Brochert, 2010:6), more sophisticated software is also available. Many academic researchers across disciplines have indicated a need for additional skills and technical support in this regard (Bradbury & Brochert, 2010:6; Harley *et al.*, 2010:27).

Data is analysed to draw conclusions from empirical data, as well as to generalise those conclusions in order to “establish a new theory or to verify an existing theory” (Soni & Kodali, 2012:770). Popular data analysis software packages used by engineers include C++, JAVA and FORTRAN (Moore & Bhat, 2013:18), as well as *Basic* (Jaluria, 2012:5), although MATrix LABoratory (MATLAB) is regarded as the most commonly used software (Jaluria, 2012:5). Data analysis techniques often performed by engineers include descriptive statistics, regression analysis and factor analysis (Soni & Kodali, 2012:770). In addition to datasets collected and analysed by individual engineers, huge datasets are becoming increasingly popular and can be managed with high-performance computing (HPC) technologies (Mauch, Kunze & Hillenbrand, 2013:1408). Although the effective use of quantitative data analysis tools is important, engineering researchers also need to use qualitative data analysis tools and techniques (Bradbury & Brochert, 2010:5).

### **3.3.6 Managing and organising information**

In addition to the technical activities associated with the actual collection and analysis of data, researchers also need to manage information and data obtained during the research process effectively. Research information such as references to the literature often needs to be organised and managed, to enable easy finding of information at a later stage, to cite information, to create bibliographies and to support organised information sharing (Fourie,

2011a:388). In addition, researchers should ensure that important documentation relevant to their research project is available for future academic audits (Lubbe, Worrall & Klopper, 2005:257). Careful management of valuable information should therefore enhance future access to personal documents, electronic mail messages, photos and Web addresses and also references and literature used (Whittaker, 2011:5).

Digital material is susceptible to technological failure “from the moment of creation” (Higgins, 2008:135), and some file formats have a high likelihood of usability over a period of time, for example PDF, Postscript, HTML, XML, ASCII, and Rich Text. The opposite may be true for MS Word, Word Perfect, MS Excel, Photoshop and MS PowerPoint formats (Fyffe & Walter, 2005:50). Academic researchers should therefore be aware of the expected lifespan of file formats, since it may affect future access to information.

There are some challenges associated with the organisation and management of information. The following has been confirmed by researchers from various academic disciplines: *ad hoc* practices, inconsistent and limited organisational schemes, simultaneous use of different computers, the use of paper as well as electronic information formats, time limits, digitising non-digital materials, as well as privacy and security issues (Feijen, 2011:27; Ward, Freiman, Jones, Molloy & Snow, 2011:11; Connaway & Dickey, 2009:3; Hepworth & Smith, 2008:221; Randall *et al.*, 2008:2; University of Minnesota Libraries, 2006:19; Jones & Bruce, 2005:2).

Engineering researchers have also confirmed difficulties with the organisation of information due to frequent hardware and software updates, as well as the use of multiple computers (Wang *et al.*, 2007:24). The organisation and management of information is therefore considered an important competency that academic engineering researchers should master (Male, *et al.*, 2009:4). Apart from the importance of the effective organisation of electronic information, academic researchers also need to manage documents in print format (Whittaker, 2011:5; Hemminger *et al.*, 2007:2214). Wang *et al.* (2007:14) report on a study where researchers confirmed that they organise information by making use of traditional binders or file cabinets, or simply in stacks of paper. Very traditional as well as electronic methods are thus used to organise information. Electronic file management systems, adding metadata to documents, and the use of reference management software have been noted.

### 3.3.6.1 *Electronic file management*

The organisation of information requires competencies in filing systems (Randall *et al.*, 2008:2). Researchers should also implement systematic and meticulous file management strategies, to avoid incoherent version control, waste of time and effort, loss of documents, and to ensure future retrievability of information (Blignaut & Els, 2010:102). According to Whittaker (2011:19), digital information can be organised through the labelling of directories, folders or subfolders, as well as through the tagging of electronic files, which provide for multiple label allocations that may in turn provide richer retrieval cues and enhanced filtering options (Whittaker, 2011:22). Information from the web can also be organised by making use of electronic bookmarking or even social tagging systems, where multiple tags for the same data are created and then shared between users (Whittaker, 2011:26). File management strategies should also provide for the effective management of electronic mail communication with important information and messages that need to be acted upon (Whittaker, 2011:13).

According to Jones and Bruce (2005:43), some academic researchers experience challenges with the effective organisation of electronic mail. Another important aspect regarding effective file management is keeping and managing information on personal contacts, for example using address books, rolodexes, calendars and contact management programmes (Whittaker, 2011:15).

Although academic engineering researchers use electronic folders and subdirectories, personal databases, group servers, removable storage devices or discipline-specific repositories to store information (Lage *et al.*, 2011:921; Wang *et al.*, 2007:14), they still have difficulty finding the same information at a later stage (Wang *et al.*, 2007:14). Like researchers from many other academic disciplines, academic engineering researchers often do not use cost-effective approaches to the organisation of digital information, since they use multiple computers, as well as hardware and software that need frequent updates (Wang *et al.*, 2007:24). Academic engineering researchers should be skilled in the effective management of electronic mail, since they frequently use this technology to collaborate with other researchers (Robbins *et al.*, 2011:523; Wang *et al.*, 2007:9). They therefore also generate and store a lot of data in this medium.

### 3.3.6.2 *Allocating metadata*

The accurate allocation of metadata to electronic documents is considered an effective method in the management of research documents (Connaway & Dickey, 2009:3; Bothma, Cosjin, Fourie & Penzhorn, 2008:111). Apart from electronic documents, photos may also need to be organised by placing them in folders and annotating them with metadata, in order to enhance future retrievability (Whittaker, 2011:37).

### 3.3.6.3 *Bibliographic reference management*

It is general practice among academic researchers to cite the references they used (Bent *et al.*, 2012:11). There are many different referencing styles, of which some are specifically prescribed and preferred by certain academic disciplines. Modern referencing software can assist researchers with managing, organising and storing information, by allowing them to build their own digital collections in electronic bibliographic databases (Hemminger, *et al.*, 2007:2214). This may require the development of certain competencies (Bent *et al.*, 2012:13; Saw, Lui & Yu, 2008:64; Randall *et al.*, 2008:2; Doskatsch, 2007:470; Pikas, 2007:9; East, 2005:138; Macauley, 2001:245). Providing support with citing and managing bibliographic references has often been noted by academic librarians in recent years (Aucland, 2012:20). Some referencing management tools are freely available on the internet, of which Mendeley (<http://www.mendeley.com>) is a popular platform, since it allows users to import citations from other referencing software platforms, including RefWorks and EndNote (MacMillan, 2012:1; Petre & Rugg, 2010:84). According to Harrison *et al.* (2002:220), bibliographic reference management tools may, however, present difficulties since there are several packages available, which can be time-consuming to learn.

Research confirms that academic engineering researchers regard the effective use of bibliographic reference management systems as important (Zhang, 2009:265; Hoffmann *et al.*, 2008:12; Doskatch, 2007:468; Poirier, 2005:8), although they acknowledge having limited knowledge of the effective use of bibliographic reference management tools (Hoffmann *et al.*, 2008:12). As a result, they often do not use tools such as ProCite ([www.procite.com](http://www.procite.com)), EndNote ([www.endnote.com](http://www.endnote.com)) or RefWorks ([www.refworks.com](http://www.refworks.com)) (Randall *et al.*, 2008:9; Wang *et al.*, 2007:14). Reasons include the poor management of conference papers, standards and technical reports, the time required to learn new competencies and interfaces and to convert files to other systems (Pikas, 2007:11; Wang *et al.*, 2007:14).

### 3.3.7 Data curation

Researchers also need skills in data curation. Data is considered “building blocks of knowledge” (Mooney & Newton, 2012:2), and is increasingly being created in all academic disciplines (Simons, 2012:1; Feijen, 2011:26). The realisation that data should be regarded as a valuable asset in future scientific research (Mooney & Newton, 2012:2; Fear, 2011:54), resulted in various funding agencies stipulating that researchers should compile data management and sharing plans (Johnston, Lafferty & Petsan, 2012:80; Tenopir, Birch & Allard, 2012:3). Data curation entails the management and preservation of data from the moment it is created until it is either disposed of or selected to be reused in the long term (Higgins, 2008:135).

Although ICT developments have transformed the way in which research data can be stored, preserved and organised (Bailey, 2012:22; Randall *et al.*, 2008:2; Genoni, Merrick & Willson, 2006:734; Marchionini, 1995:6), large parts of data on which research publications are based went lost in the past (Simons, 2012:1). Many researchers have lost important data because of a preference to store data on unsecure devices such as USB flash drives, CDs, DVDs (Johnston, Lafferty & Petsan, 2012:79; Ward *et al.*, 2011:11), free electronic mail accounts (Ward *et al.*, 2011:11), office, laboratory or home computers and external hard drives (Scaramozzino, *et al.*, 2012:361).

Current and past research data should therefore be curated over the long term (Scaramozzino, *et al.*, 2012:353) to prevent it from becoming unreadable, lost data (Heidorn, 2011:663; Walton, 2010:1; Atkinson *et al.*, 2009:31; Kuipers & Van der Hoeven, 2009:23). Unavailable research data may impede the progress of science (Witt, 2012:173; Heidorn, 2011:664; Tenopir *et al.*, 2011:7; Kuipers & Van der Hoeven, 2009:37). Long-term access to research data is also important, in view of the growing interdependence among different disciplines, and the availability of new networked computers and infrastructure, which indicates that the archiving and preservation of data should be part of the daily practice of researchers (Anderson, 2004:194).

The benefits of preserving data are significant (Fear, 2011:54). It concerns the storing of digital information to ensure accessibility, understandability and usability for a long time (Kuipers & Van der Hoeven, 2009:11). There is limited evidence, however, of the inclusion of data management skills in postgraduate courses (Inskip, 2013:21; Molloy & Snow, 2012:102) or of academic librarians supporting the long-term preservation of research data (Aucland, 2012:29). Many academic researchers therefore do not understand what digital curation entails (Bracke, 2011:72). They are not familiar with data preservation strategies, and regard long-term preservation as equal to the mere backing up of research data (Ward *et al.*, 2011:11). In addition, many academic researchers have indicated that they are not satisfied with their own long-term data storage processes (Tenopir *et al.*, 2011:7). Some challenges include lack of time, adding metadata, privacy and ownership of dataset issues, migrating data to new formats, lack of funding, ignorance of the advantages of preservation, lack of IT skills and lack of institutional support, storage space and expertise (Alvite & Barrionuevo, 2011:141; Harley *et al.*, 2010:14; University of Minnesota Libraries, 2006:19; Anderson, 2004:195).

Engineering research is dependent on different data types, including images, scanned documents, spreadsheets and text (Peters & Dryden, 2011:392). These often carry observational and experimental data (Anderson, 2004:191). Data can be used and collected through digital ASCII files, field instruments, software modelling programmes and large video and image files (Lage, Losoff & Maness, 2011:921). Researchers often keep data in their own private collections of information sources (Wang *et al.*, 2007:16; Du Bruyn, 2004:142; HEFCE, 2002:27), stored on hard drives of personal computers (Peters & Dryden, 2011:393). Effective data management is regarded as a burden by many engineers (Fear, 2011:54), with high levels of uncertainty and discomfort associated with the backing up of data (Peters & Dryden, 2011:394). Some challenges regarding the management of massive amounts of data include difficulties with organising and accessing datasets (Mullins, 2007:1), fear that technology may fail (Randall *et al.*, 2008:2), idiosyncratic faculty practices regarding personal data preservation (Harley *et al.*, 2010:26) and time constraints (Peters & Dryden, 2011:395). Effective data management is therefore regarded as a crucial skill for academic engineering researchers (Kentish, Sharkey, Gravina & Shallcross, 2006:62). Formal training in data management is often lacking, resulting in self-taught practices, reading of manuals and contacting peers as methods to keep informed (Carlson, Johnston, Westra & Nichols, 2013:210).

Strategies to preserve data should ensure authenticity, reliability and usability of data “while maintaining integrity” (Higgins, 2008:138). Knowledge of specific data preservation techniques is therefore essential.

### 3.3.7.1 *Allocating metadata*

According to Gold (2010:24), the allocation of metadata is a great challenge in data curation, since it should ensure that data remains meaningful within and across disciplines. Metadata describes data by attaching meaning to it (Tous, Guerrero & Delgado, 2011:26; Anderson, 2004:193), and is often described as “data about data”. Academic researchers can add metadata to documents by including information on the origin of the data, how it has been stored, which file formats were used, as well as information on special terminology needed to interpret and use the data. This provides context to the information (Kuipers & Van der Hoeven, 2009:23; Jones & Bruce, 2005:36). Metadata can improve the quality of research data, which may ensure efficient future retrieval (Jeffery & Asserson, 2008:76; Jones & Bruce, 2005:34; Anderson, 2004:193). Appropriate metadata standards should therefore be adhered to to ensure adequate description (Higgins, 2008:137).

Although adding metadata to documents and datasets may result in data being more accessible to others in future, academic researchers often fail to annotate datasets. This may result in losing access to these datasets, as well as information on the context in which the data was created (Tenopir, Allard, Douglass, Aydinoglu, Wu, Read, Manoff & Fame, 2011:3; Anderson, 2004:197). Apart from the importance of metadata, academic researchers have identified the allocation of metadata as a barrier in depositing data to repositories (Ward *et al.*, 2011:11). According to Tenopir *et al.* (2011:6) and Peters and Dryden (2011:395), metadata standards are not frequently used among academic engineering researchers and there is a general lack of awareness of the importance of metadata among engineers (Tenopir *et al.*, 2011:20). There thus is a need to educate all academic researchers (not only engineering researchers) to add appropriate metadata to datasets (Borchert & Callan, 2011:11; Carlson, 2011:3; Hagen, 2011:3).

### 3.3.7.2 *Refreshing, migrating and emulation*

Academic researchers can employ digital data preservation methods such as refreshing (periodically transferring data from one storage medium to another), migrating (converting from a given format into another format) and emulation (using software that ensures recovery of the original document with no alterations) (Alvite & Barrionuevo, 2011:165; Anderson, 2004:195).

### 3.3.7.3 *Digital object identifiers*

Inactive and unstable internet addresses may pose problems with the long-term preservation of and access to digital research data (Socha, 2013:33, Anderson, 2004:199). A number of systems have been developed to address this issue, namely resolvable digital object identifiers (DOIs), universal resource identifiers (URIs), universally unique identifiers (UUIDs) and handles (de Smaele, Verbakel & Potters, 2013:222; Socha, 2013:34). The benefits of these systems include that they can assist with “consistence, credit, and findability of data” (Socha, 2013:34). Academic researchers need to be aware of the benefits of permanent unique identifiers that can ensure the preservation of digital resources (Hemminging *et al.*, 2007:2215).

### 3.3.7.4 *Cloud technology*

Researchers can also migrate their personal data to the “cloud”. Data is then stored, accessed and processed across “multiple jurisdictions by multiple parties” over the internet (Flaherty & Ruscio, 2012:1). Some benefits for academics include that the “cloud” can be used as a personal workspace. It is argued that there is no need for backing up and copying files from one personal computer to another, and large amounts of processing power are available (Masud, Yong & Huang, 2012:552). There is also access to specialised expertise and advanced services with less costly development and maintenance fees (Flaherty & Ruscio, 2012:2). As for backup, researchers would be well advised to still use alternative backup methods as well. Although there are many advantages to using cloud technology, researchers should take note of potential privacy and data protection risks, because data is transferred to third parties (Flaherty & Ruscio, 2012:3).

### 3.3.7.5 *Institution- and discipline-specific repositories*

IRs (Gold, 2010:23), national and global discipline repositories (Gold, 2010:23) and other archives and data centres (Higgins, 2008:138) may also be employed to curate data. Such data can be open for free (open access) or may be commercially available (Borchert,

Bradbury & Broadley, 2013:6). Researchers may therefore benefit from skills that can assist them with the effective location and accessing of data collections and repositories that inform scholarly research (Bracke, 2011:71; Feijen, 2011:27), and the correct citing of datasets (Tenopir, Birch & Allard, 2012:7). Skills to submit datasets repositories to and deselect from them (Tenopir, Birch & Allard, 2012:7) are also important. Some researchers may, however, prefer not to make their data accessible to others because of a desire to retain IP ownership (Gold, 2010:24). They must still be informed about and take note of requirements from grant and funding agencies on open access to research results.

#### 3.3.7.6 *Data management plans*

The effective management of research data hinges on a well-designed data management plan (Ward *et al.*, 2011:12). According to Cox, Pinfield and Smith (2016:3), research funders are increasingly requiring data management plans as part of funding applications. Academic researchers may therefore be expected to compile formal data management plans, which should address issues regarding different file formats, metadata, ownership, access, software for analysis, anticipated outputs, copyright and IP rights, the volume of expected data, retention periods and post-project storage (Thomas, 2011:43; Henty, 2008:2). Academic researchers may therefore need advice, assistance and structured support regarding the formulation of data management plans, organising and describing datasets, developing and contributing to data repositories. They may also need assistance with regard to digital preservation and copyright and legal issues concerning data management (Tenopir, Birch & Allard, 2012:5; Witt, 2012:173; Ward *et al.*, 2011:12; Thomas, 2011:44), as well as support tailored to the requirements of disciplines and the needs of the research team (Ward *et al.*, 2011:13). Libraries are in a good position to offer such support.

#### 3.3.8 **Creation of research documents**

The creation of new knowledge is based on well-designed and planned data gathering and data analysis techniques employed by researchers (Lawrence, Jones, Matthews, Pepler & Callaghan, 2011:5). The successful and effective application of research methodologies empowers researchers to contribute to an existing body of knowledge, through writing conference abstracts, conference papers, funding proposals, theses, journal articles, technical reports, theses and dissertations, books and chapters in books (Franklin, 2012:1; Okafor, 2010:181; Wright, 2010:98), as well as by means of online platforms (Franklin, 2012:1; Coleman, Sabone & Nkhwanana, 2010:384; Wilkinson & Huberman, 2007:1). These documents can be the result of either individual or collaborative efforts. The latter may

require researchers across disciplines and countries to work together on a specific document (Zutshi, McDonald & Kalejs, 2012:28). Effective writing skills are thus an integral part of academic research (Ligthelm & Koekemoer, 2009:28). Academic writing may, however, be a challenge for many researchers (Covert-Vail & Collard, 2012:8; Johansen & Harding, 2013:368; Ssegawa & Rwelamila, 2009:305). Many academic institutions thus assist postgraduate researchers to develop more “sophisticated and accurate levels of academic language use” (Sanavi, Tavakolli, Dorri & Soufiany, 2012:60). This entails not only the creation of academic publications, but increasingly also involves style and etiquette pertaining to electronic mail communication (Lewin-Jones & Mason, 2014:88; Lancaster, 2011).

Apart from the effective use of English, which is becoming the accepted “international language of research publication” (Johnson, 2011:44), many other competencies are required during the writing process. These include the ability to annotate, that is, attaching notes to print and digital documents, or even passages, elements or phrases within documents (Jones & Bruce, 2005:33). Annotation skills are closely related to effective academic reading skills, which are again important during the writing and synthesis process (Itua, Coffey, Merryweather, Norton & Foxcroft, 2012:15). Newton and Pullinger (2012:9) argue that postgraduate researchers may need assistance with these two specific skills.

Another useful competency is the ability to map information, that is, the “visual displays of information, concepts and relations between ideas” (Davies, 2011:279). The use of concept mapping, mind mapping and argument mapping can assist researchers during the writing process (Beel & Langer, 2011:81; Davies, 2011:296; Fourie, 2011b:769), although many researchers may need support in this regard (Covert-Vail & Collard, 2012:8). The effective employment of specific technologies during collaborative writing processes may also be important during the writing process and may include electronic mail, virtual research environments (VREs), project management software, videoconferencing, wikis, blogs and file sharing (Markauskaite, Kennan, Richardson, Aditomo & Hellmers, 2012:22), as well as word processors (Microsoft Word), Corel WordPerfect, xyWrite and WinEdit (Latex), of which the last-named can accommodate important activities such as tracking changes, version control, adding comments and identifying the contributor (Noel & Robert, 2004:72).

Another important competency during the writing process includes effective citation skills, which involve the comprehensive and objective use of published literature. Effective citation skills can also avoid plagiarism, which is widespread in academic institutions (Thomas & de Bruin, 2015:2; Yang, 2012:232) and has attracted increasing attention in recent years (Flick, 2011:40). Techniques to avoid plagiarism may include effective referencing and quoting of resources consulted (Flick, 2011:41), as well as effective paraphrasing, translating and summarising of information (Fartousi, 2012:574; Shi, 2012:136). Postgraduate researchers across disciplines, however, lack confidence regarding the citing of resources consulted, with specific reference to webpages (Patterson, 2009:13), as well as with the correct citing of datasets (Mooney & Newton, 2012:14). Knowledge regarding citation style guides, which include the IEEE, Chicago Manual of Style, the American Psychological Association (APA) style and the Harvard referencing system, may therefore be important (Franklin, 2012:255), as well as of data citation standards (Socha, 2013:1). In addition to citation style guides, researchers may also have to be aware of standard citing conventions (Franklin, 2012:254; Dames, 2007:27), which may include referential citations, where research output is used “for what it contributes to the field”, critical citations, which refer to the citing of output that is considered a flaw in previous research output (West & Stenius, 2008:98), correct verbatim quoting, citing of conversations, and the citing of sources cited by others (Franklin, 2012:254). Academic researchers may therefore also need to be aware of electronic anti-plagiarism software, which includes Turnitin (<http://www.turnitin.com>), Easy Verification Engine (<http://www.canexus.com>) and CiteMaster ([www.citemaster.com](http://www.citemaster.com)) (Fyffe & Walter, 2005:14) and can be used to detect plagiarism before their manuscripts are submitted for publication. Although correct citations and referencing are important issues for engineering researchers during the writing process (Chakrabarti, 2010:327), some engineering researchers display lenient attitudes to issues of self-plagiarism and the falsification of results (Yang, 2012:233). Many academic institutions are consequently offering tailored support with the ethical use of information and the prevention of plagiarism to engineering researchers (Doskatch, 2007:468; Antwi-Nsiah *et al.*, 2006:2).

According to House, Watt and Williams (2009:3), engineering researchers consider the technical content, accommodation of the audience, and grammatical and mechanical correctness as the three most important aspects relevant to the writing process. These three aspects will be briefly discussed in the next paragraphs, followed by some relevant ethical issues of importance during the writing process.

#### 3.3.8.1 *Technical content*

Adequate knowledge is important in preparing a publishable research report (Wills, 2000:5). According to academic engineering researchers, technical content is *the* most important criterion when writing a document, which implies the depth and accuracy of information, the clarity of content, logical development of ideas and well-structured arguments (House *et al.*, 2009:3). In order to write professionally, effective communication skills are therefore important; these have been identified as a crucial skill for engineering researchers (Rajala, 2012:1377; Gider *et al.*, 2011:334; Sampson & Comer, 2011:5; Wright, 2010:98; Riemer, 2007:89; Kentish *et al.*, 2006:62). Although some academic institutions offer workshops on the “writing for publication” process (Thomas, 2011:45; Kong *et al.*, 2007:151; Hemmings, Rushbrook & Smith, 2006:326; Wills, 2000:8), insufficient assistance is offered to academic engineers in this regard (Steiner, 2011:55; Knievel, *et al.*, 2010:61; Prevatt, 2010:79; Tenopir & King, 2004:101).

#### 3.3.8.2 *Accommodating the audience*

Most academic researchers aim at maximising visibility to a specific audience, or among their peers (Nariani & Fernandez, 2012:190; Harley *et al.*, 2010:11; Schonfeld & Housewright, 2010:26; Knight & Steinbach, 2008:1; Harrison *et al.*, 2002:211). It is therefore important that researchers consider their potential audience, since it will have implications for the style of presentation (Flick, 2011:239).

Engineering researchers also regard the accommodation of a specific audience (readers or listeners) as very important, and are of the opinion that technical content should be tailored for target audiences, by ensuring that readers or listeners understand what is being communicated, and that the researcher is able to persuade and inspire the audience by capturing their interest (House *et al.*, 2009:4). Apart from the technical content and how it is communicated, academic engineers also consider the grammatical and mechanical correctness of documents as important aspects during the writing process, which will be discussed in the next paragraph.

#### 3.3.8.3 *Grammatical and mechanical correctness*

Academic researchers often need to adhere to an appropriate style of writing and other requirements prescribed by a particular type of publication (Harrison *et al.*, 2002:219). The effective use of word processing software is therefore important, since it can assist academic researchers in writing dissertations, theses and articles, and in reporting research findings, by

making use of some features that may include basic alignment, inserting tables and spell checking (Blignaut & Els, 2010:102). Engineering researchers have been reported to prefer Microsoft Word (Riemer, 2007:97), although LaTeX, according to Wright (2010:103), is specifically designed for technical writing. Engineering researchers can use it to produce reports, dissertations, journal and conference papers, presentations, posters, business cards, memos, quizzes and full-length books. It is therefore important for academic researchers to be aware of specific and applicable software that can assist them during the writing process; they often produce many drafts before a document can be reviewed for publication. This can make the writing process time-consuming (Garnett & Mohamed, 2012:81; Hemmings *et al.*, 2006:311). Effective time management is regarded as an important skill for academic researchers during the writing process (Hemmings *et al.*, 2006:311; University of Minnesota Libraries, 2006:44; Wills, 2000:10). This has also been confirmed for engineering researchers in academic institutions (Sampson & Comer, 2011:5).

#### 3.3.8.4 *Ethical issues*

Apart from plagiarism, there are other ethical considerations, such as collaborative authoring and academic-industry partnerships. The writing process in academic institutions is often facilitated by collaborative ventures between authors to enhance the quality as well as the quantity of publications (Zutshi, McDonald & Kalejs, 2012:28). Collaborative writing is, however, associated with many challenges such as author attribution, author omissions, the order of authorship, authorship with students and research assistants (Zutshi, McDonald & Kalejs, 2012:33), the reconciliation of different writing styles, longer completion periods, difficulties with coordination, conflict between members (Noel & Robert, 2004:73) and sometimes the potential for commercialisation (Markauskaite, Kennan, Richardson, Aditomo & Hellmers, 2012:20). Valuable information on responsible research and authorship practices is provided in professional codes and academic journal guidelines (Borenstein, 2011:363). These provide direction regarding issues of multiple authorship and dealing with significant contributions made by other authors (Bent *et al.*, 2012:11; Borenstein, 2011:357; Speight & Foote, 2011:58). They also give guidelines on aspects pertaining to self-plagiarism, “ghost authorship”, “gift authorship” and the securing of IP rights (Borenstein, 2011:357). Although it is important that authorship practices ensure the integrity of research projects, many researchers are unaware of ethical issues that may come up during the writing process (Street, Rogers, Israel & Braunack-Mayer, 2010:1463).

Guidelines for multiple authorship are especially important for engineering researchers in an academic context, since they are expected to collaborate on an international scale (Markauskaite, Kennan, Richardson, Aditomo & Hellmers, 2012:22). Statistics confirm that South African engineering researchers are increasingly collaborating with international authors (Soorymoorthy, 2011:214). In addition, academic-industry partnerships in engineering research may involve ethical issues such as lower numbers of publications because of information that cannot be disclosed, projects selected for their perceived practical value and dealing with issues regarding the control of research information (Borenstein, 2011:361; Hottenrott & Thorwarth, 2011:534; Lage *et al.*, 2011:922).

Apart from effective writing skills, academic researchers also need to know how to protect the new knowledge they create.

### **3.3.9 Management of intellectual rights**

Academic researchers may want to restrict access to some or all of the knowledge they created, as well as to their research data (Bent *et al.*, 2012:13; Carlson, 2011:2; Cragin, Palmer, Carlson & Witt, 2010:4029; Connaway & Dickey, 2009:2). Various entities and traditions may prevent them, however, for example stipulations by funding agencies (Witt, 2012:173; Carlson, 2011:3; Heidorn, 2011:665; Tenopir *et al.*, 2011:7), journal publishers requesting research data for publication (Tenopir *et al.*, 2011:2; Hrynaszkiewicz, Norton, Vickers & Altman, 2010:1) and long-standing traditions among academia regarding the reuse of and building on available research data of others (Tenopir *et al.*, 2011:1). Academic researchers should therefore be aware of methods to restrict access to their work, which may be temporary in the form of embargo periods (Cragin, *et al.*, 2010:4035), as well as of methods to licence their own work (Hagen, 2011:3; Rempel, 2010:544). Many researchers are uncertain and lack confidence regarding IP rights, data protection and copyright (Aucland, 2012:28).

Confidentiality and privacy of research information are of concern for many academic engineering researchers. They need to prevent possible misuse by others, and may therefore have to place conditions regarding access to their research data (Lage *et al.*, 2011:922; Peters & Dryden, 2011:395; Tenopir *et al.*, 2011:9; Kuipers & Van der Hoeven, 2009:76). In addition, outside parties may require confidentiality of information (Lage *et al.*, 2011:922; Szelenyi & Goldberg, 2011:780; Soetendorp, 2004:365). Academic researchers should

therefore be aware of methods to protect the knowledge they create and to guard against the exploitation of their knowledge. One method may be the securing of IP rights.

### 3.3.9.1 *Intellectual property*

There is a strong focus on the commercialisation of IP in academic institutions (D’Este & Perkmann, 2011:327; Zhang, 2009:261; Golde & Dore, 2001:15). As a result, entrepreneurial skills have been identified as important for academic engineering researchers (Rajala, 2012:1377; Gider *et al.*, 2011:334; Riemer, 2007:93). IP mechanisms allow inventors to secure rights to their inventions for a fixed period. Inventions may include designs, trade secrets and confidential information.

Knowledge of IP rights is therefore very important, since engineering is regarded as one of the disciplines with most patentable technological and commercially valuable breakthroughs (Soetendorp, 2004:363; Kaplan & Kaplan, 2003:9; McCorquodale & Brown, 2003:1). Copyright, trademarks and patents can be used to secure IP (Squicciarini, Millot & Dernis, 2012:2; Speight & Foote, 2011:114; Kaplan & Kaplan, 2003:1). Patents refer to exclusive rights to new products, processes or devices (SABS, 2008:11). Trademarks (TMs) are considered valuable marketing tools, which should be protected. These include signs, labels, names, signatures, words, letters, shapes, configurations, patterns, ornamentations, containers, or any combination of these (SABS, 2008:15). For the registration of patents and trademarks, specialised searches needed to be performed or requested, as part of the registration process (SABS, 2008:14). Academic engineering researchers may benefit from support in these “novelty searches”, since they have to ensure that their invention or trademark is novel and inventive. They also need to be aware of university policies and legislation regarding the protection of their IP.

IP management plans are gaining importance. Such plans require that researchers plan and stipulate ways in which IP issues will be addressed in their research. Although there is evidence of initiatives to boost innovation among academic engineering researchers (Gider *et al.*, 2011:334), engineering researchers often lack adequate knowledge and understanding of IP rights. Commercialisation processes are also often perceived as a daunting challenge (Kaplan & Kaplan, 2003:9; McCorquodale & Brown, 2003:1). According to Aucland, (2012:31), there is limited evidence of academic librarians offering support with the commercialisation of research outputs.

One of the most common forms of protection of IP is copyright (Kaplan & Kaplan, 2003:2); this is discussed in the next section.

### 3.3.9.2 *Copyright*

Copyright refers to the exclusive right of the author or inventor to publish and distribute a work (Nariani & Fernandez, 2012:189; Kaplan & Kaplan, 2003:1). There are many types of work that qualify for copyright; engineering and technical drawings fall under artistic work (SABS, 2008:4). Although copyright automatically applies after the creation of a piece of work, researchers often employ additional mechanisms to protect, enforce and retain copyright to their work. For example, they use Creative Commons (CC) licensing, which offers flexible initiatives, including a range of standardised IP licences to grant certain rights of use, and access to research information (Paterson, Lindsay, Monotti & Chin, 2007:117; Fyffe & Walter, 2005:42). Although academic researchers need to be familiar with the principles and use of CC licensing (Hagen, 2011:3), many may be unaware of practices related to these licences (Bradbury & Brochert, 2010:4).

Another method to secure copyright includes an author's addendum, through which additional information is added to publishing agreements. This may include the author's rights to "use, reproduce, distribute and create derivative works", and to make available research information in repositories or on personal websites (Hanlon & Ramirez, 2011:688; Wirth, 2011:97). Some rights can be retained by academic authors to ensure the wider distribution of their work (Fyffe & Walter, 2005:40). Academic researchers thus need to be aware of publisher's copyright policies (Bent *et al.*, 2012:16). They can refer to the Securing a Hybrid Environment for Research Preservation and Access (SHERPA) website (<http://www.Sherpa.ac.uk/romeo.php>), to assist them with this (Hanlon & Ramirez, 2011:687; Fyffe & Walter, 2005:40).

Studies indicate that academic engineering researchers are uncertain regarding copyright and journal permissions with regard to self-archiving in IRs (Mischo & Schlembach, 2011:449). Academic researchers from other disciplines have also reported that they are often unaware of authors' addenda. As a result they often transfer key rights to their work in whole or in part (Wirth, 2011:97; Striphos, 2010:6).

Academic researchers therefore need to be aware of methods to retain rights to their IP, before they can continue to share their research information with others, which is another important research activity discussed in the next paragraphs.

### 3.3.10 Dissemination of research findings

“The outcome of any research must be published as a form of information” (Okafor & Ukwoma, 2011:58). There are several reasons why academic researchers share their research findings, among others the need to contribute to national development (Okafor, 2010:182), pressure from the public and home institutions (Sampson & Comer, 2011:8; Gannon-Leary & Bent, 2010:31; Kennan, 2010:87; Chanson, 2006:2) and to receive incentives (Hemmings *et al.*, 2006:324). One of the important decisions researchers need to take during the sharing of their research findings is whether they support a traditional or an open access publishing model. These two publishing models will be discussed briefly in the next paragraphs.

#### 3.3.10.1 Traditional publishing model

Traditional publication practices dominate among academic researchers (Harley *et al.*, 2010:22; Schonfeld & Housewright, 2010:30; University of Minnesota Libraries, 2006:19). They consider these as well-established routines and practices, which are accepted and preferred for academic tenure and promotion systems; effective and reputable peer review systems are in place, authors do not need to pay publication fees and the dissemination systems are well established (Joseph, 2012:85; Cullen & Chawner, 2010:134; Harley *et al.*, 2010:7; Schonfeld & Housewright, 2010:26; Turk & Bjork, 2008:167; University of Minnesota Libraries, 2006:19).

#### 3.3.10.2 Open access model

ICT developments, the internet and WWW, open source communities, search engines and repositories resulted in new possibilities to share information (Kelly & Eells, 2015:265; Kennan, 2010:86; Bjork, 2004:1). Intellectual content in electronic format can be made available freely to everybody, without usage restrictions (Mischo & Schlembach, 2011:433; Wirth, 2011:96; Jan & Khan, 2010:464; Utter & Holley, 2009:7). Many academic librarians have become actively involved with training and advising researchers on publishing options and scholarly communication methods related to open access (Aucland, 2012:27).

Various open access models have developed as a result of the need to make academic information available and visible to a wider audience (Nariani & Fernandez, 2012:186; Wirth, 2011:96; Utter & Holley, 2009:8). The two most common models are the gold model, where researchers publish in open access journals, and the green model, where researchers archive final peer-reviewed manuscripts themselves in a repository (Harnad, 2011:1; Wirth, 2011:96). Academic researchers should decide beforehand whether they support a traditional

or an open access model, and should also be informed of the scholarly publication process, as well as the benefits of publishing in an open access environment (Thomas, 2011:44; Hagen, 2011:3; Houghton, Rasmussen, Sheehan, Oppenheim, Morris, Creaser, Greenwood, Summers & Gourlay, 2009:1; Utter & Holley, 2009:8; Bjork, 2004:19).

According to Mischo and Schlembach (2011:444), academic engineering researchers do not strongly support the gold open access model, and at the time of their study, seldom published in journals requiring publication fees. Their study found misconceptions among academic engineering researchers regarding the principles of the gold open access model, even though they regarded knowledge about scholarly communication processes as important. Researchers in an academic context may therefore need additional support regarding publishing processes and models (Hoffmann *et al.*, 2008:12; Antwi-Nsiah *et al.*, 2006:2).

Apart from being aware of scholarly communication models, academic researchers should be familiar with established publication channels to share research findings. Since scholarly communication is multifaceted, formal and informal sharing practices must be explored (Riemer, 2007:89; Genoni *et al.*, 2006:735).

### 3.3.10.3 Oral communication channels

Informal ways to share research findings include departmental seminars (Hartley & Betts, 2009:35), oral examinations and engagements with the general public (Bent *et al.*, 2012:11; Martin, 2011:457; Oliver, 2010:16) where research findings are shared through presentations and talks to local communities, displays at open days or festivals, interviews with the media, newspaper articles and by providing advice to organisations (Duncan & Spicer, 2010:4; Oliver, 2010:16; Nisbet & Scheufele, 2009:1774).

Some research methodology courses designed for engineering researchers prepare them to present and defend their research individually, to handle comments and questions from peers regarding the structure of their presentation effectively, to enhance the quality of PowerPoint slides, and to improve the overall quality of oral presentations (Chakrabarti, 2010:322).

More formal ways to share academic research findings are conferences (most popular), press releases and research briefs.

### (a) Conferences

Conferences are important communication channels for academic researchers (McAlpine & Amundsen, 2011:9), since they facilitate the sharing of information via oral presentations and through conference workshops (Rowe & Ilic, 2009:1). Research results can also be presented through teleconferences, webinars and virtual workshops by using webcams and fast network connections (Khatibi & Montazer, 2012:72).

Engineering researchers accept conference presentations as important communication channels (Sampson & Comer, 2011:8; Guruprasad, Nikam, Marimuthu & Mudkavi, 2009:212; Foster, 2005:7). Some academic institutions even offer modules specifically focusing on helping engineering research students to develop good oral communication skills (Gider *et al.*, 2011:334; Nair, *et al.*, 2009:135; O’Sullivan & Cochrane, 2009:1; Tenopir & King, 2004:101).

Apart from the oral sharing of information at conferences, findings can be shared as graphical presentations (Blignaut & Els, 2010:102), for example posters, visual presentations, schematic diagrams, drawings and pictures (Riemer, 2007:93; Larive & Bulska, 2006:1347; Butz, Kohr & Jones, 2004:45). Digital interactive poster presentation (DIPP) systems allow for more flexibility, participation, enhanced illustrations of images and data and interactivity (Rowe & Ilic, 2009:5). Digital posters can have embedded links to information where authors may enable access to “as much or as little supporting data and material as is appropriate” (Rowe & Ilic, 2009:6). Various open source as well as commercially available software packages can assist researchers with the design of posters. Examples of software include QuarkXPress ([www.quark.com](http://www.quark.com)), InDesign ([www.adobe.com](http://www.adobe.com)), LaTeX ([www.latex-project.org](http://www.latex-project.org)), Illustrator ([www.adobe.com](http://www.adobe.com)) and CorelDRAW ([www.corel.com](http://www.corel.com)). Academic researchers should be aware of appropriate software and guidelines for the design, outline, preparation, uploading and presentation of electronic posters at conferences. Poster design courses (Gider *et al.*, 2011:334; Jennings & Ferguson, 1995:307), and instruction in the use of CorelDraw software (O’Sullivan & Cochrane, 2009:6) have been reported.

#### 3.3.10.4 Written communication channels

Researchers often publish their findings in accredited reports, conference papers, journal articles, books (Franklin, 2012:1), and web-based formats (Hammond & Wellington, 2013:156; Franklin, 2012:1). Scholarly journals, however, take prominence (Oliver, 2010:145). This also applies to engineering researchers (Johnson, 2011:44; Okafor &

Ukwoma, 2011:59; Speight & Foote, 2011:241). In South Africa academic engineering researchers prefer to publish in internationally accredited journals (Soorymoorthy, 2011:217). This specific preference corresponds with findings that engineering researchers prefer to publish where accessibility is greatest, and where peers are publishing (Tucci, 2011:7).

Researchers share data and image transmissions, electronic mail messages, laboratory notes, technical reports, conference proceedings, consultancy reports, patents, book chapters and books (Mischo & Schlembach, 2011:443; Guruprasad *et al.*, 2009:212; Wang *et al.*, 2007:23; Chanson, 2006:2; Harrison *et al.*, 2002:223), web pages (Peters & Dryden, 2011:396) and discipline-specific repositories (Jan & Khan, 2010:474).

#### (a) Scholarly journals

Electronic journals have transformed the dissemination of scholarly communication on a global scale (Guruprasad & Nikam, 2010:373). Peer-reviewed journal articles hold the highest prestige among academic researchers (Bent *et al.*, 2012:15; Speight & Foote, 2011:241; Ward *et al.*, 2011:11; Schonfeld & Housewright, 2010:29). They provide an important means to disseminate knowledge among engineering researchers in an academic context (Okafor & Ukwoma, 2011:59; Speight & Foote, 2011:241). Engineering researchers value the prestige of journals as well as the scope of readership when identifying a journal for publication (Johnson, 2011:57). Furthermore, advancement in many engineering disciplines often depends on publishing in high-impact English-language journals (Speight & Foote, 2011:241). According to Tucci (2011:7), engineering researchers tend to publish in a limited number of journals where full text retrieval is guaranteed, and where their peers also publish. IEEE Xplore (<http://www.ieee.org>) and ACM Digital Library (DL) (<http://www.acm.org>) are therefore popular. Most journals have very specific guidelines and criteria regarding article submissions, which academic researchers should be aware of to ensure that their articles are at least considered for publication.

Academic researchers need strategies on how to maximise visibility to a specific audience (Bent *et al.*, 2012:15; Nariani & Fernandez, 2012:190; Harley *et al.*, 2010:11; Schonfeld & Housewright, 2010:26; Knight & Steinbach, 2008:1; Harrison *et al.*, 2002:211) and to increase readership for their online articles through academic search engine optimisation (ASEO) which is the “creation, publication, and modification of scholarly literature in a way that makes it easier for academic search engines to both crawl and index it” (Beel, Gipp & Wilde, 2010:176). Other important aspects of a publication strategy include choosing to

publish in general scientific, disciplinary or speciality journals; article acceptance policies; impact factors; circulation information (Babor, Morisano, Stenius, Winstanley & O'Reilly, 2008:22); author charges; technical features of a journal; publication delay and service levels of journals (Bjork & Holmstrom, 2006:149), as generating subsidy income for the academic institution where applicable (Ligthelm & Koekemoer, 2009:28). Prospective authors need complete information about the journals in which they consider to publish (Bjork & Holmstrom, 2006:147).

Researchers need to decide if they want to publish in electronic or in traditional paper journals. They must be aware of the advantages of electronic journals, such as eco-friendliness, faster publication speed (Moher, Stewart & Shekelle, 2012:2), cheaper publication costs, easier distribution, likelihood of publishing supplementary information, and efficient alerting and search services (Shotton, 2009:86).

The selection of an appropriate journal may be challenging for younger researchers, and the weighting of the issues noted in this section are important, but also “highly dependent on individual preference due to career stage” (Bjork & Holmstrom, 2006:149).

In addition to the communication of the findings and conclusions of research projects, the need to share research data is gaining momentum (Mooney & Newton, 2012:2) in response to increased demands from taxpayers, government funding agencies and other researchers for the open availability of datasets that allow for verification, critical evaluation and future replication (Dietrich, Adamus, Miner & Steinhart, 2012:1; Ferguson, 2012:51; Scaramozzino, *et al.*, 2012:349). Some scientific journals are also mandating the submission of openly accessible data sets as supplements to manuscripts (Ferguson, 2012:51; Scaramozzino, *et al.*, 2012:350). Academic researchers should therefore be aware of data submission and sharing methods. However, it seems as if many may need guidance and training in this regard (Scaramozzino, *et al.*, 2012:350). The issue of reluctance to share data for fear that data will not be understood, will be interpreted differently or that mistakes will be noted must also be addressed (Doorn, Dillo & van Horik, 2013:238).

Journal publication also involves ethical issues, which are increasingly taken more seriously (Campbell & Meadows, 2011:177). Issues include the quality and integrity of data, plagiarism, conflicts of interest, correct acknowledgement and multiple publications of the same paper in different journals (Campbell & Meadows, 2011:178; Speight & Foote, 2011:248). Publishing ethics is also important for engineering researchers and there has been

increasing interest in ethical issues in engineering disciplines owing to blurring lines caused by interdisciplinary research (Borenstein, 2011:355). Incidents of engineering researchers submitting identical manuscripts to different journals and plagiarism have been reported (Yang, 2012:233; Chanson, 2008:4).

(b) Internet

Many academic researchers regard personal websites as effective publishing channels to disseminate research information (Cullen & Chawner, 2010:136; Harley *et al.*, 2010:24; Turk & Bjork, 2008:165; Fyffe & Walter, 2005:45). This has also been confirmed for engineering researchers (Mischo & Schlembach, 2011:447; Wang *et al.*, 2007:25). The design and maintenance of webpages might be important skills needed by academic researchers in future (Harley, *et al.*, 2010:27).

Internet technology, however, has also resulted in the availability of more formal sharing possibilities and online repositories (Donovan & Watson, 2012:12). As a result many IRs were developed. These are regarded as digital collections containing and showcasing the scientific output of a specific institution (Brown & Abbas, 2010:181; Utter & Holley, 2009:9). Academic researchers may benefit from publishing in IRs, since their research findings may be made available freely in full-text format, which may result in wider exposure, possibly more citations, and with the benefit of preserving their research publications (Wirth, 2011:97; Cullen & Chawner, 2010:133; Schonfeld & Housewright, 2010:28; Jeffery & Asserson, 2008:76; Hemminger *et al.*, 2007:2215). Some academic institutions implemented mandates in support of the open accessibility of scholarly information and they have policies promoting open access (Yang & Li, 2015:13; Kennan, 2010:87). Such initiatives have, however, not gained much enthusiasm among the academic community (Yang & Li, 2015:14; Cullen & Chawner, 2010:133).

Engineering researchers in academic institutions are among those who are slow to embrace IRs (Mischo & Schlembach, 2011:446; Wang *et al.*, 2007:15). Reasons reported for this include confusion about copyright and plagiarism issues, publication in journals prohibiting self-archiving, slow uploading processes, a need for easier and clearer depositing processes, uncertainty about the number of repositories in which to submit, and ignorance of the existence of a repository (Mischo & Shlembach, 2011:449; Wang *et al.*, 2007:15).

ICT developments and the internet also made publishing channels through Web 2.0 technology possible (Campbell & Meadows, 2011:177; Harley *et al.*, 2010:22; Turk & Bjork, 2008:165). Many academic researchers create “personal information with public sharing in mind”, which refers to how personal information is shared and managed in a group (Erickson, 2006:74). Group information management (GIM) involves a wide array of applications, namely shared calendars, blogs, social network services, electronic medical records, peer-to-peer file sharing, tagging, online reviewing and rating, and event organising applications (Erickson & Grudin, 2005:2). Microsoft SharePoint, Confluence Wiki, Google Groups, Google Docs and social bookmarking and tagging tools are popular for document sharing (Borchert & Young, 2010:7). The possibility of sharing creates new opportunities as well as challenges for academic researchers. Many academics, however, do not regard Web 2.0 technology as important to broadcast and receive academic information (Nariani & Fernandez, 2012:191; Schonfeld & Housewright, 2010:31; Harley *et al.*, 2010:14). Slow uptake of Web 2.0 technology has been noted among engineering researchers (Niu *et al.*, 2010:880; Chu & Law, 2007:35). This may partly be due to concerns about confidentiality (Harley *et al.*, 2010:13).

### **3.3.11 Measuring of impact**

Academic researchers publish their research findings not only to communicate with specific audiences and peers, but also to advance their careers. Their performance appraisal is increasingly related to their research output and their contributions in a specific field (Jeffery & Asserson, 2008:72; Gonzalez-Brambila & Veloso, 2007:1035; Chanson, 2006:2). Research assessment is based on peer review, academic prizes won, editorial positions, citations converted to impact factors, the number of postgraduate students supervised and the amount of external research funding secured (MacColl, 2010:158).

#### *3.3.11.1 Citation metrics*

Citation metrics is a quantitative method to measure impact. Metrics are used to measure academic performance, with many reports on efforts to improve the use of metrics in this regard (Hendrix, 2010:185; Moed, 2005:2). Metrics are also used to rank individuals and higher education institutions (MacColl, 2010:7; Tijssen & Hollanders, 2006:1; Vincent-Lancrin, 2006:18), academic departments, countries and research groups (Martin, 2011:459; Moed, 2005:7), and even conferences (Johnson, 2011:47). Academic librarians are increasingly becoming involved in this area (Aucland, 2012:30). Metrics are also used by national government initiatives to measure research excellence, for example Excellence in

Research for Australia (ERA) in Australia, and the Research Excellence Framework (REF) in the UK (Aucland, 2012:29; Rotenberg & Kushmerick, 2011:506), the Performance Based Research Fund Quality Evaluation in New Zealand, and the Research Assessment Exercise in Hong Kong (Browning, Thompson & Dawson, 2014).

Metrics include bibliometrics, scientometrics and infometrics. Bibliometrics are applied to media in written form (Tous *et al.*, 2011:33; Zitt & Bassecouard, 2008:49) and scientometrics to the study of science and technology literature and scientific activities (Zitt & Bassecouard, 2008:49; Hood & Wilson, 2001:293). Infometrics is an encompassing term for bibliometrics and scientometrics (Hood & Wilson, 2001:300).

### 3.3.11.2 Bibliometrics

Bibliometrics is a performance assessment method, which is based on the assumption that the number of citations received by a specific publication can be regarded as a measure of its impact in a scientific community (Neuhaus & Daniel, 2008:193). It is therefore directed at quantifying research output, to assist in identifying the most prolific journals, authors and institutions (Hendrix, 2010:185; Martin, 2011:459; Daim, Rueda, Martin & Gerdri, 2006:984; Royal Academy of Engineering, 2000:15). Several bibliometric tools are available, of which the most popular include the H-Index (Bent *et al.*, 2012:17; Hendrix, 2010:183), SCImago (SJR) and the journal impact factor (IF) ([www.scimagojr.com](http://www.scimagojr.com)) (Nariani & Fernandez, 2012:190; Chanson, 2006:2). Although bibliometric analysis tools are considered important objective tools to measure research productivity, citation-based statistics should never be used in isolation, in order to avoid incomplete views regarding research quality (Tatavarti, Sridevi & Kothari, 2010:1015; Moed, 2005:3; Royal Academy of Engineering, 2000:16).

Several electronic databases and websites provide citation analysis information: WOS citation indexes, Scopus, Google Scholar, Publish or Perish (PoP), Citeseer, and Journal Citation Reports (JCR) (Martin, 2011:459; Soorymoorthy, 2011:213; Tous *et al.*, 2011:24; Hendrix, 2010:185; Tatavarti *et al.*, 2010:1015; Baneyx, 2008:364; Neuhaus & Daniel, 2008:193; Chanson, 2006:2; Harrison *et al.*, 2002:227).

There is also growing interest in measuring webpages and websites, owing to the rapid increase in literature on the web (Noruzi, 2005:170). Webometrics was coined as a term that refers to a research field where quantitative measures are used to measure network-based communication (Almind & Ingwersen, 1997:404). According to Priem and Hemminger

(2010:2), Web 2.0 tools should be implemented to analyse bookmarking, reference managers, recommendation services, comments on articles, microblogging, Wikipedia and blogging trends among academics. Impact and influence may therefore be revealed, which could not be determined previously, and which can show “how conversations and connections evolve from week to week” (Priem & Hemminger, 2010:10). Although the tools mentioned can provide excellent information on impact, there seems to be limited support from researchers for bibliometric services (Hendrix (2010:184).

Academic engineering researchers employ Chemical Abstracts Service (CAS) in addition to the citation databases mentioned above (Neuhaus & Daniel, 2008:198; Moed, 2005:3). Patent citation analysis enables researchers to determine the technological impact of a specific patent (Hottenrott & Thorwarth, 2011:541; Marco, 2007:290; Karki & Krishnan, 1997:270). However, not all engineering researchers may be competent in performing systematic citation searches (Wang *et al.*, 2007:17) and may need assistance with the identification of key research papers (Hoffmann *et al.*, 2008:17; Antwi-Nsiah *et al.*, 2006:2). They may also need help with setting up citation alerts to follow developments in their fields.

#### 3.3.11.3 Data citation analysis

Researchers can benefit from data citation practices owing to the infrastructure these provide for recognition and rewarding, the facilitation of future access to data and fostering cross-collaboration and investigation (Socha, 2013:6). The impact of research data can currently be measured by commercial databases (e.g. Data Citation Index (DCI) and [http://www.wokinfo.com/products\\_tools/multidisciplinary/dci/](http://www.wokinfo.com/products_tools/multidisciplinary/dci/)) not-for-profit resources (e.g. DataCite (<http://datacite>) and Open Citations Corpus (<http://opencitations.net>) (Costas, Meijer, Zahedi & Wouters, 2013:25; Socha, 2013:37). In addition, blog posts, Twitter, bookmark managers and Wikipedia can also be considered (Socha, 2013:37).

#### 3.3.11.4 Academic peer review

Peer review is an essential component of scholarly communication and lies “at the heart of the scientific method” (Speight & Foote, 2011:254; Chanson, 2006:2). According to Harley *et al.* (2010:21), peer review is an indicator of “quality, relevance and likely impact of a piece of scholarship”, and strongly influences the reputation and opportunities of academic researchers. This is also true of academic engineering researchers, since many prefer and support a traditional peer review system (Tucci, 2011:6). There are different systems of peer review: (1) for “partially blinded” peer review the identity of the reviewer is concealed, but

the author's identity is known; (2) for "completely blind/double blind" the name of the reviewer as well as the identity of the author is concealed; (3) for open review both the author and reviewer's names are known to each other (Sen, 2012:294). Although the traditional peer-review process is often performed *before* a piece of work is published, post-publication peer review is also possible through more open processes, for example commenting on and rating of blogs, video, and even public dialogues between authors (Stewart, Procter, Williams & Poschen, 2012:9). Online fora are also created by some scholarly journals (Swartz, 2013:1). The widespread adoption of open peer review, however, is "unlikely for a number of reasons related particularly to time and credit" (Acord & Harley, 2012:9). Although scientific findings in text format are often critiqued, the peer review of research data is becoming crucial in order to verify larger and more complex datasets, and to confirm the link between the data and the publication (Socha, 2013:8). This interrogation of data can be challenging, however, and can involve raw data, metadata, and pre- or post-publications, implying increased difficulty, time and costs associated with these processes (Callaghan, Tedds, Kunze, Mayernik, Murphy, Allan, Lawrence & Whyte, 2013:202).

In addition to the peer review of text or data, researchers themselves can be reviewed by peers, in order to obtain a rating relevant to their achievements. Higher education institutions in South Africa adopted a rating system for academic researchers by means of a formal classification system, which is based on an extensive international multiple peer-review process. This rating system can be regarded as a benchmarking tool, where researchers can assess their own standing against peers worldwide (NRF, 2011:21). It is therefore important for academic engineering researchers to be aware of the details of rating systems employed in their countries, and those supported by their institutions.

### **3.3.12 ARIL definition – grounded on basic information literacy and research processes**

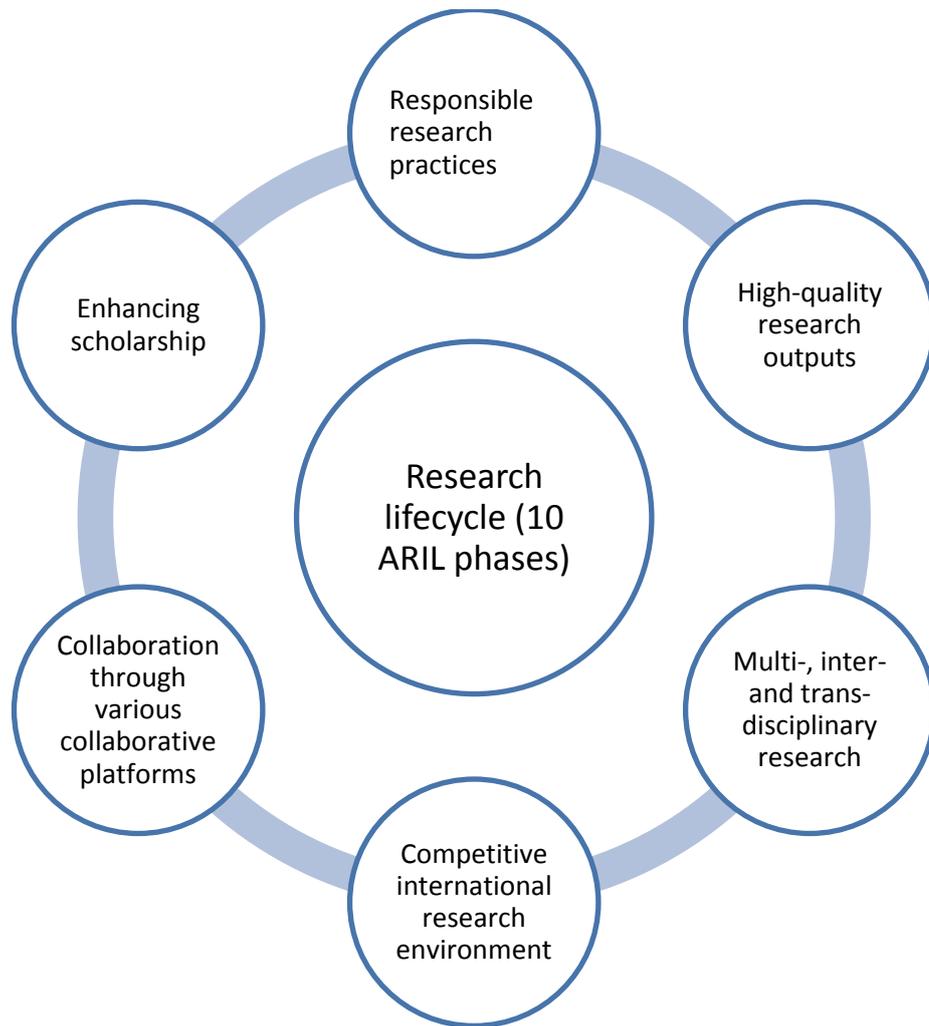
From the discussion in this chapter it is evident that various processes relevant to the ten phases identified during a research lifecycle need to be taken into consideration when ARIL programmes are planned for engineering researchers in an academic context.

The researcher therefore proposes the following definition, which will guide the empirical phase of this study: ARIL includes all traditional information literacy skills, and expands on these by including the ability to identify research gaps in the spectrum of international and interdisciplinary literature that can meet with the needs of society, access and consult literature across disciplines (multi-, inter- and trans-disciplinary) to support various facets of

the research process, analyse and synthesise information from secondary as well as primary resources (i.e. empirical data), generate new knowledge, and disseminate findings and new knowledge through appropriate channels, while networking and collaborating with other researchers across different collaborative research platforms, focused on enhancing scholarship. Advanced research information literacy skills therefore manifest in all the typical research phases, namely identifying a researchable topic, obtaining research funding, discovering information, managing and organising information, collecting and analysing data, storing and curating data, writing up findings, managing IP, publishing results through various channels and advocating the research results (e.g. through social media), as well as measuring the impact through different metrics, where each phase is associated with various processes aimed at achieving specific goals relevant to that phase.

This ARIL definition is illustrated in Figure 0.1 with the ten research phases in the centre of the image, surrounded by important aspects relevant to the context in which postgraduate engineering researchers have to perform those ten phases with their associated processes.

**Figure 0.1 Visual presentation of issues important to the advanced research information literacy definition**



### 3.4 CONCLUSION

In this chapter several issues underlying the proposal of a definition of ARIL were explored. These included the current practices of researchers in an academic context, with special reference to engineering researchers. The ten core research phases identified in the initial conceptualisation of advanced research information literacy were also explored further and several processes associated with each process were identified, which were derived from the literature. It was evident that information literacy competencies were embedded in each research phrase and the processes it entailed.

Most studies cited in this chapter were performed in international contexts, with limited information available regarding how academic engineering researchers in South Africa approach and manage each research phase.

The literature analysis performed in this chapter, together with the literature analysis in chapter two, is the first step in answering the central research question of this study, namely: “How can an advanced research information literacy framework inform the developing of programmes supporting the scholarly research process of engineers in a South African higher education environment?” It will also guide the preparation and decisions for the empirical part of this study, which will be discussed in the next chapter.

## CHAPTER 4: RESEARCH DESIGN AND METHODOLOGY

### 4.1 INTRODUCTION

In the previous two chapters the groundwork was done for the conceptualisation of ARIL (see section 3.3.11). ARIL skills are needed in all the typical research phases (see section 3.3). Each phase is associated with several processes (discussed in sections 3.3.2 – 3.3.11).

Two of the research sub-questions (see section 1.4.1) could already be addressed in Chapters 2 and 3. These questions are: “What are the characteristics of introductory and advanced research information literacy programmes as reported in the subject literature?”, and “What are the current documented needs, behaviours and experiences of engineering researchers in an academic environment?” The remaining research sub-questions (see section 1.4.1) had to be answered through empirical investigation, which implies “the quest for details of tangible things – things that can be measured and recorded” (Deniscoombe, 2003:6). These questions included: “What are the current self-reported ARIL skills of South African postgraduate engineering researchers?” and “How do ARIL skills, knowledge and practices of engineering researchers differ between the master’s, doctoral and post-doctoral stage, established researchers, and those considered as experts according to NRF rating categories?” Data collected from the empirical investigation in addition to the findings from the literature analysis were aimed at answering the research question:

“How can an advanced research information literacy framework inform the development of programmes supporting the scholarly research process of engineers in a South African higher education environment?”

The purpose of this chapter is to explain the research design and methodology that were employed in the empirical part of this study, by first discussing the rationale behind the selection of a suitable research design, followed by specific data collection and analysis strategies employed. Sampling, dealing with ethical issues, reliability and validity will also be discussed. The chapter will conclude by indicating how findings will be presented.

## 4.2 RESEARCH DESIGN

A research design can be regarded as a strategy that guides the process of information collection in order to answer a research question (Leedy & Ormrod, 2010:85; Welman & Kruger, 2001:46, Brink, 1996:100). It includes detailed cover of planning and executing aspects (Punch, 2009:112), and addresses various procedures: collecting, analysing, interpreting, and reporting of research data (Creswell & Plano Clark, 2011:53).

Different types of research designs developed over many years, with quantitative designs being the only choice in the nineteenth century. Quantitative designs employ instruments such as questionnaires, experiments, historical documents and observation to measure factual information in the form of numbers (Creswell & Plano Clark, 2011:177; Mertens, 2008:81). It focuses on the objective measuring of objects (Morgan, 2007:73). As a result, quantitative research designs are often referred to as studies conducted in a positivist or a post-positivist paradigm (Mertens, 2008:75).

Quantitative research designs are popular in library and information science studies to assess the information needs and satisfaction of users with library services (Robbins, *et al.*, 2011:518; Powell, 1999:92). Questionnaires are the most popular method to determine how researchers use libraries (Hart & Kleinveldt, 2011:39). Researchers investigating the information needs of engineers specifically, also often employ quantitative designs (Guruprasad *et al.*, 2011:69; Mischo & Schlembach, 2011:441; Robbins, *et al.*, 2011:518; Bennett & Buhler, 2010:4; Niu *et al.*, 2010:871; Ward, 2001:170). The use of questionnaires in user behaviour studies, however, has decreased slightly in recent years (Vakkari, 2008:6).

The turn of the twentieth century marked the implementation of qualitative research designs (Leech & Onwuegbuzie, 2009:266). Qualitative research designs focus on collecting data in the form of words or images (Creswell & Plano Clark, 2011:177). They are often associated with focus group interviews, case studies, ethnographic research and participatory models of research (Mertens, 2008:81). These are data collection techniques associated with a “constructivist paradigm”.

Qualitative research designs are becoming increasingly popular in information behaviour and library and information science research studies (Vakkari, 2008:6; Powell, 1999:101). Personal contact between librarians and postgraduate students is considered an effective communication method (Hart & Kleinveldt, 2011:39), with special reference to the value of focus group interviews (Covert-Vail & Collard, 2012:16; Bradbury & Brochert, 2010:10;

Sadler & Given, 2007:125). Focus group interviews are also a popular data collecting technique in studies focusing on engineers in academic contexts (Tucci, 2011:3; Adams, Zander & Mullins, 2006:28; Antwi-Nsiah *et al.*, 2006:1). Individual interviewing is also often reported (Kraaijenbrink, 2007:1371; George *et al.*, 2006:3; Kerins, *et al.*, 2004:4; Ellis & Haugan, 1997:385).

More complex research problems and a consequent need for multiple forms of evidence to inform answers to research problems resulted in a research design where both quantitative and qualitative designs are combined, also referred to as mixed methods designs (Creswell & Plano Clark, 2011:21; Tashakkori & Teddlie, 2009:283). The rationale for combining two different kinds of research designs in the same study developed from an assumption that neither quantitative nor qualitative data collection methods are sufficient on their own to capture all trends and details of a specific situation (Ivankova, Creswell & Stick, 2006:3). Mixed methods designs involve a combination of qualitative and quantitative approaches in the same study (Plano Clark & Badiee, 2010:276; Leech & Onwuegbuzie, 2009:267; Fidel, 2008:265; Morse, 2003:191). This is often based on three key dimensions: the number of phases, the sequence of the phases, and the stage of integration (Tashakkori & Teddlie, 2009:288). Mixed method designs are mostly associated with a “pragmatic approach” (Biestra, 2010:95; Morgan, 2007:71), which is based on “what works” (Creswell & Plano Clark, 2011:42). It takes a practical orientation to a problem in order to find a solution “that is fit for a particular context” (Hammond & Wellington, 2013:125).

Mixed methods research designs gradually became popular among social science researchers (Ivankova, Creswell & Stick, 2006:3; Kemper, Stringfield & Teddlie, 2003:273), as well as library and information science studies in a wider context (Powell, 1999:112). Hiller (2002:2) recommends that survey results should be used together with other measures, to promote “a more comprehensive view of library performance and user behaviour.” This tendency is also evident in studies focusing on engineers, where questionnaires are combined with either focus group interviews (Hoffmann, *et al.*, 2008:4) or with individual interviews (Emanuel & Roh, 2013:533; Leckie & Fullerton, 1999:12). According to Fidel (2008:269), qualitative data is commonly employed to support a predominantly quantitative approach in library and information science studies. According to Case (2012:4), there is also growing interest in qualitative data in information behaviour studies.

The different research designs mentioned above were evaluated to identify the most suitable design, which could assist with the gathering of quality data to address the research question and sub-questions in this study. According to Tashakkori and Teddlie (2009:283), this is important in driving the selection of a research design. A mixed methods design combining quantitative and qualitative approaches was selected for this study. This is in line with the views of Flick (2011:185) that complex problems increasingly require a combination of both designs.

#### **4.2.1 Case study design**

Case study designs have been performed successfully in library and information science research studies (Bryant, Matthews & Waltin, 2009:7-18), information behaviour studies (Kuhlthau, 1991:361-371), and studies focusing on specifically information literacy (Czerniewicz & Goodier, 2014: 1-9; Natalie & Crowe, 2013:97-104; Johnston & Webber, 2003:335-352).

Yin (2014:16) defines a case study as an “empirical inquiry that investigates a contemporary phenomenon (the “case”) in depth and within its real-world context, especially when the boundaries between phenomenon and context may not be clearly evident.” Tellis (1997:6) also confirms that case studies are applicable when “an empirical investigation of a contemporary phenomenon within its real-life context” is planned. Several other authors also confirm that case studies are in depth-investigations (Pickard, 2013:108; Case, 2012:224; Rule & John, 2011:4), in order to gain “rich insights into particular situations” (Rule & John, 2011:1), and to unravel the complexities of a given situation (Yin, 2012:5) in a specific context (Pickard, 2013:102).

For this study a case study based on a single institution was selected. This met with the criteria proposed by Rule and John (2011:21): the institution must be an outstanding example of its kind, it must be possible to study the case in great depth, and there must be easy access to people who can reveal information relevant to the study. The selection of a single institution is often associated with case study research (Babbie, 2010:309; Nieuwenhuis, 2007:75) where the qualities of a single case “can promote understanding or inform practice for similar situations” (Leedy & Ormrod, 2010:137). An in-depth study may help to discover the reasons for the successes and failures of a specific institution (Lues & Lategan, 2006:19), rather than studying multiple institutions superficially (Rule & John, 2011:7).

The nature of the research question is very important when selecting a case study approach. Baxter and Jack (2008:556), and Yin (2014:10) claim that case study approaches are more suitable when “how” or “why” questions need to be answered. A case study approach was therefore considered appropriate for this study, since the central research question aimed at determining *how* an advanced research information literacy framework can inform the development of programmes supporting the scholarly research processes of postgraduate engineering researchers in a South African higher education environment. This central research question may also be answered better when the perspectives of all relevant stakeholders is required. This is another important characteristic of a case study approach (Pickard, 2013:108; Tellis, 1997:5).

Multiple sources of evidence are often associated with case study research (Yin, 2014:17; Pickard, 2013:104; Case, 2012:224; Rule & John, 2011:61). This could include any combination of observations, interviews, audiovisual material, documents (Leedy & Ormrod, 2010:137) and questionnaires (Pickard, 2013:106; Rule & John, 2011:63), which lends itself to the possibility of triangulating data (Pickard, 2013:102; Tellis, 1997:5). The advantages of triangulation include that it allows the researcher to be more confident of results, it provides strength to the design, and it allows for data from different viewpoints, which can enrich the research findings (de Vos, 2005:362).

Leedy and Ormrod (2010:99) describe triangulation as the collection (and analysis) of data from multiple sources “with the hope that they will all converge to support a particular hypothesis or theory.” A researcher can triangulate data by combining different *methods* of data collection (qualitative and quantitative), as well as by combining *data* gathered from a questionnaire survey, focus group and individual interviews, with findings documented in the literature.

The selection of a case study approach in this study was thus aligned with several advantages associated with both quantitative and qualitative research designs. Some advantages associated with quantitative designs include that structured data collection procedures can be employed (Struwig & Stead, 2001:4; Brink, 1996:13), which allows researchers to describe trends and explain relationships between variables, and to study large numbers of respondents in a short period of time (Flick, 2011:13).

Advantages associated with qualitative research designs, where more personal descriptions, experiences, and perspectives can be gathered to understand the complex behaviour and experiences of humans (Morse, 2003:189), were important to ensure that richer data can be obtained through closeness to the situation (Jick, 2008:115). This could “add life to the numbers, and meat to the bones of quantitative data” (Jankowska, Hertel & Young, 2006:67). Combining quantitative and qualitative designs in a single study therefore results in obtaining data with “both depth and breadth regarding the phenomenon under study” (Teddlie & Yu, 2008:209). This increases the scope and comprehensiveness of the study (Creswell & Plano Clark, 2007:9; Ivankova, Creswell & Plano Clark, 2007:259; Morse, 2003:192; Hiller, 2002:2). Other advantages of combining the two approaches include enhanced flexibility, which may result in creating new insights and possibilities that one method alone could not provide (Fidel, 2008:267; Srnka & Koeszegi, 2007:30), offering opportunities for triangulation through complementary findings (Jick, 2008:107; Thurmond, 2001:257) and refining statistical (quantitative) data by explaining ambiguous results by means of qualitative data (Tashakkori & Teddlie, 2009:287).

Although the selection of a mixed methods design case study approach was aligned with the many advantages associated with such an approach, disadvantages were also noted. These include the danger of researcher bias (Yin, 2014:20; Rule & John, 2011:21; Denscombe, 2007:46), difficulties associated with establishing boundaries to a case (Denscombe, 2007:46), difficulties in getting access to a site (Denscombe, 2007:46) and the possibility that processes of collection and analysis may become unmanageable because of massive amounts of documents to analyse (Yin, 2014:21). In this study the researcher attempted to address disadvantages by firstly ignoring her own assumptions and by taking comprehensive notes, as suggested by Pickard (2013:106), in order to avoid researcher bias. She also ensured that access to the site was not compromised by obtaining approval from all relevant parties in advance. In order to avoid the case study from becoming unmanageable, she remained focused and defined time and resource constraints before the study commenced (Pickard, 2013:103).

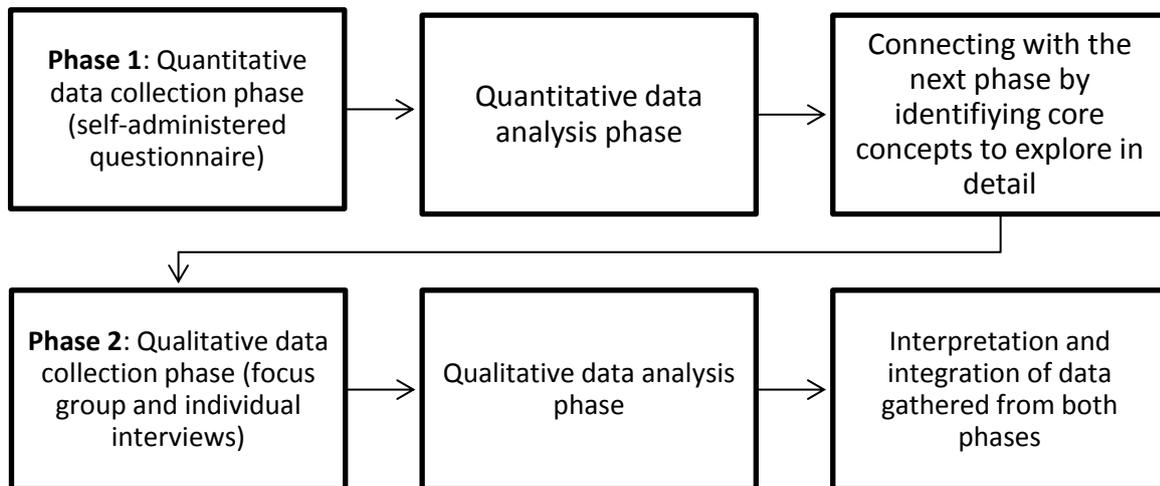
A further weakness often associated with case study research is inability to generalise empirical results to larger populations or to other situations (Case & Light, 2011:191, Rule & John, 2011:21; Leedy & Ormrod, 2010:137). It is important to note, however, that it was not the intent of the researcher to generalise findings from this case study to larger populations, but rather to “gain insight and understanding of the dynamics of a specific situation”

(Nieuwenhuis, 2007:67). Yin (2014:21) also confirms that case study researchers are generalising to theoretical propositions rather than to a population. Case and Light (2011:191) add to this debate by confirming that the methodological strength of case studies lies in the context-dependent knowledge obtained. As will be shown in section 8.6.1, findings from this study can indeed have value for other contexts.

According to Yin (2014:238), case study designs can be categorised into exploratory studies where the purpose is to explore research questions for subsequent studies, descriptive studies where the purpose is to describe a phenomenon, and explanatory studies where the purpose is to explain a specific situation through posing “how” or “why” questions. An explanatory design was selected for this study in an attempt to explain how and why events occur in a single specific case. Explanatory designs are often also referred to as instrumental case study designs (Fouche & Schurink, 2011:321) where a particular phenomenon or issue is the focus of the study, while the case itself becomes only a vehicle for the investigation (Pickard, 2013:102). Quantitative data was collected first by means of a self-administered questionnaire, followed by a second qualitative phase where focus group interviews as well as individual interviews were used to collect data. Data were collected, analysed, and interpreted in the first (quantitative) phase of this study, followed by the subsequent collection, analysis and interpretation of qualitative data. The quantitative and qualitative findings were then integrated, compared, contrasted and incorporated at the end of the study (Tashakkori & Teddlie, 2009:307). This was achieved by stepping back from detailed results, and by looking at the larger meaning of the data obtained, while keeping the research problem, specific questions, the literature, as well as personal experiences in mind (Creswell & Plano Clark, 2011:209; Tashakkori & Teddlie, 2009:307).

The process that was followed in the case study design is depicted in Figure 0.1, which specifies the phases in which the selected data collection instruments were implemented. (The choice and use of the instruments are dealt with in more detail in section 4.3.1.)

**Figure 0.1 Processes in the case study design followed for this study**



Knowledgeable information sources were essential to gain rich and detailed insights (Pickard, 2013:104) and in order to answer the research question and sub-questions of this study effectively. The first step was the selection of a suitable site for the case study.

#### 4.2.1.1 Selection of a site

The collection of quality data regarding the ARIL skills of South African postgraduate engineering researchers during different career stages required the identification of a highly productive academic institution with specific reference to postgraduate engineering research.

An empirical study performed in 2010 by the Centre for Higher Education Transformation (CHET, 2010:10) analysed all 23 public higher education institutions in South Africa according to the following nine variables: percentage of headcount enrolments in science, engineering and technology (SET), percentage of master's and doctoral headcount enrolments, student to academic/research staff ratio, percentage of permanent academic/research staff with a doctoral degree, percentage of private income, government/student fee income per full-time equivalent (FTE) student, success rates, graduation rates, and weighted research output units per permanent/research staff member. This extensive analysis identified five "research-intensive" universities as producing the bulk of postgraduate researchers in South Africa: Rhodes University (RU), Stellenbosch

University (SU), University of Cape Town (UCT), University of Pretoria (UP), and the University of the Witwatersrand (Wits) (CHET, 2010:12; MacGregor, 2010:1).

In 2010 a study by the Centre for Higher Education Transformation was reported on institutions most productive in the field of engineering research, excluding other sciences (CHET, 2010:10). It was found that Rhodes University does not offer any engineering courses, and it was consequently excluded from further analysis processes. The remaining four institutions were analysed according to the *impact* of their research in the field of engineering, in contrast to only considering the number of units published, which were the criteria used in the Centre for Higher Education Transformation study (CHET, 2010:10). The decision to focus on impact was based on the assumption that the number of citations a paper receives over time can be regarded as a “direct measure of its usefulness to other scientists” (Bornmann & Marx, 2013:226). High-impact research can therefore be associated with a high level of skills and knowledge regarding various academic research processes, which should in turn ensure that respondents are selected who are best able to provide useful information for the survey. The focus was mainly on journal article outputs, which are “likely to remain the primary vehicle by which research is evaluated” (Joseph, 2012:85). Engel *et al.*, (2011:554), Okafor and Okwoma (2011:59), Speight and Foote (2011:241) and Tucci (2011:4) also consider articles as a primary publication medium among engineering researchers. Two local studies guided the researcher with regard to the specific behaviour of South African engineering researchers; these studies confirmed that they prefer to publish in international journals (Sooryamoorthy, 2011:217; CHE, 2009:54), and specifically in those listed in the Thomson Reuter’s WOS indexes (CHE, 2009:55).

InCites, a customised objective web-based research tool, was used to analyse institutional performance by comparing the impact of South African engineering researchers’ output in a global context. Engineering as a subject category was selected from the 22 scientific fields as suggested by the Essential Science Indicators (ESI) database. This provides information on the most cited institutions worldwide, and contains data for 4 050 institutions globally (Pouris & Pouris, 2010:518). Both databases are available on the Thomson Reuter’s WOS platform, which is considered the largest multidisciplinary peer-reviewed citation database available (Niehaus & Daniel, 2008:207). A search was performed and the most research-intensive South African higher education institution with the highest impact globally in the field of engineering was selected.

#### 4.2.1.2 Selection of sources for information/data (i.e. participants)

An important characteristic of case study research is that a sampling process is not required, since the goal is rather to maximise what can be learned during a specific allocated period (Tellis, 1997:3). Engineering postgraduate researchers were selected for the first (quantitative) as well as the second (qualitative) phase of the study. For each phase it was foreseen that the participants could make a useful contribution by responding to questionnaire questions (quantitative) and participating in discussions (qualitative) (Oliver, 2010:6). The engineering postgraduate researchers included both staff and students enrolled for master's and doctoral qualifications, as well as those who held a doctoral degree. In an academic context the last-mentioned include researchers appointed in a post-doctoral position in an academic department, academics without an NRF rating and the various levels of NRF-rated researchers, namely Y, P, C, B and A. Y and P ratings are awarded by the NRF to researchers below the age of 40, holding a doctoral qualification, who have the potential to establish themselves as researchers in the near future. For the purpose of the study established researchers refer to researchers with C (nationally established) and B (internationally established) ratings. Expert researchers are those who have an A rating. Bent, Gannon-Leary and Webb (2007:85) divided researchers according to seven "ages", namely master's, doctoral, contract, early career, established, senior and expert researchers. This study categorised participants as master's, doctoral, post-doctoral (post-doctoral appointees and participants with a doctoral degree, with or without an NRF rating), established researchers (nationally and internationally according to NRF C and B ratings) and expert researchers (according to NRF A rating), as illustrated in Table 0.1.

**Table 0.1 Categories of respondents (qualitative phase)**

Master's level researchers	Faculty staff <sup>2</sup> and students
Doctoral level researchers	Faculty staff and students
Post-doctoral researchers	Post-doctoral appointees in the engineering departments P- and Y-rated staff members <sup>3</sup> Staff members holding a doctoral degree but without an NRF rating
Established researchers	C-rated staff members B-rated staff members
Expert researchers	A-rated staff members

<sup>2</sup> Faculty staff include people registered for a master's or doctoral study at institutions other than the selected institution.

<sup>3</sup> Categories according to the NRF. A, B and C are also categories of NRF rating.

### **4.3 QUANTITATIVE PHASE**

For the quantitative phase of the study the identification of a suitable data collection instrument, questionnaire design, administration and planning, data analysis, and methods to ensure the validity and reliability of the data collection instrument are discussed.

#### **4.3.1 Quantitative phase (identification of a data collection instrument)**

A variety of data collection methods can be employed during quantitative research studies: structured observations, closed-ended interviews, questionnaires, experiments and tests (Teddlie & Tashakkori, 2009:97; Blaxter, Hughes & Tight, 2006:60). A self-administered questionnaire (Addendum D) was selected as a data collection instrument in this phase of the study. Questionnaires are associated with survey research (Gaiser & Schreiner, 2009:69; Watson-Boone, 2000:90). They are suitable for big samples and the measurement of multiple variables (Maree & Pietersen, 2007b:155).

Advantages of self-administered questionnaires that were noted included that respondents are offered the opportunity and freedom to complete these in their own time (Delpont, 2005:167), while their anonymity is ensured (Ghosh & Chopra, 2003:7). In addition the implementation costs are relatively low (Delpont, 2005:167; Denscombe, 2003:7), which offers researchers the opportunity to reach vast numbers of participants in a short period of time (Delpont, 2005:167). Other advantages include the possibility of offering standardised answers (Denscombe, 2003:159), which allows for quick analysis of results with low error rates (Wilkinson & Birmingham, 2003:39).

However, certain limitations are associated with questionnaires as data collection instruments, such as low response rates (Couper & Bosnjak, 2010:539; Leedy & Ormrod, 2010:101; Delpont, 2005:167; Struwig & Stead, 2001:4), unanswered or wrongly interpreted answers (Leedy & Ormrod, 2010:101; Delpont, 2005:167; Struwig & Stead, 2001:4), frustrations associated with the answering of pre-coded questions (Denscombe, 2003:160), and lack of personal contact between the researcher and respondents (Dillman, Smyth & Christian, 2009:69; Delpont, 2005:167; Wilkinson & Birmingham, 2003:39). There is also limited to no opportunity to confirm the truthfulness of answers provided by respondents (Leedy & Ormrod, 2010:101; Delpont, 2005:167; Denscombe, 2003:160; Struwig & Stead, 2001:4).

Technological developments, with specific reference to the internet and the WWW, provided new opportunities for researchers to conduct surveys electronically (Fyffe & Walter, 2005:19; Shannon, Johnson, Searcy & Lott, 2002:2; Schmidt, 1997:274). These are referred to as “internet surveys”, “web surveys” or “online surveys” (Couper & Bosnjak, 2010:528). A web-based questionnaire was selected for this study. It allowed for researching a large number of respondents (Denscombe, 2003:7; Schmidt, 1997:274), and was suitable for the specialised population (i.e. engineers) (Best & Harrison, 2009:414; Shannon, *et al.*, 2002:8; Schmidt, 1997:278). Various types of questions could be accommodated (Couper & Bosnjak, 2010:540; Leedy & Ormrod, 2010:203). Other advantages include that instant feedback could be provided on the completion rate (Couper & Bosnjak, 2010:540; Schmidt, 1997:275), data entry errors were eliminated, and automated data processing, immediate access to data, interactive checking for validity and completeness of responses, and the automatic tabulation of data were possible (Case, 2007:207; Wilkinson & Birmingham, 2003:19; Zhang, 2000:58; Schmidt, 1997:275). Tabulated data could be downloaded into spreadsheets and other software programs (Shannon, *et al.*, 2002:3). The web-based survey therefore allowed for a dynamic and interactive instrument (i.e. a questionnaire) (Couper & Bosnjak, 2010:527; Zhang, 2000:65; Schmidt, 1997:275), which was also cost-effective (Couper & Bosnjak, 2010:527; Leedy & Ormrod, 2010:203; Dillman, Smyth & Christian, 2009:195).

There are, however, challenges associated with web-based questionnaires. Survey invitations might not be noticed by respondents because of high volumes of electronic mail messages often received on a daily basis (Couper & Bosnjak, 2010:538). Biased samples and coverage errors (Case, 2012:239; Couper & Bosnjak, 2010:527; Denscombe, 2003:7; Zhang, 2000:58), multiple submissions (Case, 2012:239; Zhang, 2000:66; Schmidt, 1997:277), and doubts about data integrity (Schmidt, 1997:277) have also been noted as challenges. In addition, web-based surveys require technological knowledge and skills from researchers as well as respondents (Case, 2012:239; Case, 2007:208; Shannon, *et al.*, 2002:3; Zhang, 2000:60). Incomplete and unacceptable responses (Case, 2012:239; Schmidt, 1997:276), the impersonal appearance of the questionnaire (Case, 2012:239) and low response rates (Case, 2012:238; Couper & Bosnjak, 2010:527; Zhang, 2000:66) have also been noted.

### 4.3.2 Quantitative phase (questionnaire design)

According to Creswell and Plano Clark (2011:178), data collection involves the systematic gathering and recording of information. Researchers therefore need to plan in advance how, when, who and where data will be collected (Brink, 1996:148). Important guidelines provided in the literature regarding questionnaire design were adhered to in this study, namely keeping the respondent's task simple, asking one question at a time, using limited and familiar words, using simple sentence structures, making response options exhaustive and mutually exclusive and avoiding ambiguous meanings as well as leading and vague questions (Krosnick & Presser, 2010:264; Leedy & Ormrod, 2010:194; Dillman, Smyth & Christian, 2009:105; Denscombe, 2003:7). In addition, a logical sequence of questions was used, where related questions were grouped together. Questions proceeded from general to specific ones (Krosnick & Presser, 2010:264; Dillman, Smyth & Christian, 2009:157; Peterson, 2000:108). In an attempt to increase response rates, a short survey instrument was designed (Leedy & Ormrod, 2010:194; Best & Harrison, 2009:427; Dillman, Smyth & Christian, 2009:26; Shannon, *et al.*, 2002:9), with a neat overall appearance, without appearing cluttered; it had adequate margins as well as a user-friendly appearance (Maree & Pietersen, 2007b:159; Brink, 1996:157).

Apart from adhering to the general guidelines described above, researchers should identify the specific kinds of quantitative data that will be collected during the design stage of a survey (Denscombe, 2003:156), and therefore need to consider the type of information required to answer the research questions (Brink, 1996:148). Scales are considered useful in measuring attitudes and specific behaviour of respondents (Leedy & Ormrod, 2010:189; Maree & Pietersen, 2007b:167), for example, nominal, ordinal, interval and ratio scales (Delport, 2005:164; Struwig & Stead, 2001:153). Likert scales are also commonly used in questionnaires (Maree & Pietersen, 2007b:167; Ghosh & Chopra, 2003:27).

Responses in this questionnaire were primarily based on predetermined response scales provided with closed-ended ordinal questions, which is an effective way of measuring the levels of opinions, attitudes, behaviours and attributes (Dillman, Smyth & Christian, 2009:135). The use of closed-ended questions ensured immediate data analysis and quick production of results (Dillman, Smyth & Christian, 2009:72). Closed-ended questions, however, often provide very simple answers with limited detail. They restrict respondents with regard to possible answers, and may even suggest answers respondents may not have thought of. Close-ended questions can also prevent respondents from providing detailed

answers to more complex questions (Maree & Pietersen, 2007b:164). To compensate for such shortcomings, respondents were invited to add comments to the answers of many of the questions. This collected supplementary qualitative data.

The questionnaire was divided into two broad categories, with the first section covering questions focusing on demographic details of respondents. According to Peterson (2000:111), demographic details require relatively little effort to answer and such questions usually have low refusal rates. Questions (see Addendum D) covered the engineering field in which respondents conducted their research, their highest qualification, how long they had been holding their highest qualification, the phase according to a typical research lifecycle that best reflected their progress at the time of data collection, current position in the faculty, involvement with the supervision of researchers, the nature of collaborating with other researchers and their rating according to the NRF categories<sup>4</sup>.

The second, and primary, part of the questionnaire focused on the ARIL skills of postgraduate engineering researchers as, defined in section 2.4

Each research phase and its associated processes and skills is portrayed in Table 0.2 (stretching over several pages); these were all covered in the questionnaire (Addendum D). Processes are indicated in the left column and skills and knowledge in the right column.

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<sup>4</sup> (NRF) categories, namely: P/Y (young promising researcher – younger than 40), C (established researcher), B (internationally recognised researcher), and A (leading international researcher)

**Table 0.2 Research phases, processes and skills relevant to postgraduate engineering research**

<b>Research Phase: Identification of a Researchable Topic</b>	
Conceptualisation	Effective defining, construction, formulation and articulation of research problems
Identification of a gap in existing literature	Effective systematic investigation of literature Effective scanning of printed and electronic literature (books, journal articles, dissertations, theses, conference papers, unpublished research reports, online scholarly databases, internet, research performance management tools) Effective location of review articles Effective identification of key authors Effective location of key information sources Effective location of latest publications and retrospective searching Effective synthesis of information Effective time management
Information mapping	Effective employing of concept, mind, and argument mapping techniques (Paper and pencil and electronic)
<b>Research Phase: Obtaining Funding</b>	
Discovering funding opportunities	Effective identification of suitable funding programmes and opportunities (scholarships, fellowships, conference funding, travel grants) Effective location of funding sources (government, industries, internet, online databases and organisations, crowdfunding) Effective setting up of funding alerts/updates
Identification of collaborators	Effective identification and location of collaborators across disciplines (internet, social media, academic communities) Effective employment of social and professional networks Effective creation and maintenance of personal online profiles
Writing of funding proposals	Application of funding proposal guidelines and layout requirements Application of assessment criteria of different funding bodies Effective time management
Budgeting	Effective budgeting Effective management and reporting of research funds received Adherence to relevant ethical issues
<b>Research Phase: Discovery and Evaluation of Information</b>	
Serendipitous discovery	Effective browsing (electronic and print formats) Effective forward and backward reference chaining Effectively cited reference searching
Collaborative discovery	Effective electronic collaborative discovery (communities of practice, Web 2.0 technology, e-mail, video and teleconferencing, FTP, websites) Effective identification and location of subject experts Effective networking (conferences, supervisors, internet, Web 2.0) Effective creation and maintenance of online profiles Effective identification of relevant conferences and setting up of conference alerts

Structural discovery	<p>Effective searching (discipline and inter-discipline scholarly databases, internet, libraries)</p> <p>Effective location of scholarly journals, articles, books (paper and electronic formats), trade literature, patents, standards, three-dimensional shapes, technical reports)</p> <p>Designing of effective search strategies</p>
Keeping abreast with new information	<p>Keeping abreast (electronic alerts, personal communication, conference programmes, websites of experts, journal table of contents, databases, search engines, serving as journal editors, refereeing, Web 2.0 technology, libraries (digital and physical))</p>
Evaluation of information	<p>Effective critical evaluation of print and electronic information formats (currency, relevance, authority, accuracy and purpose)</p>
<b>Research Phase: Collecting and Analysing of Data</b>	
Selection and application of research methodologies	<p>Effective application of suitable methodologies</p> <p>Effective application of qualitative, quantitative and mixed methods approaches (as needed for a research project)</p>
Data collection	<p>Knowledge of relevant data collection techniques (experimental, simulation, survey, document analysis, observation and case studies, mixed method designs)</p> <p>Effective use of survey tools (online and paper)</p>
Data analysis	<p>Effective conversion of raw data (word processors and spreadsheets)</p> <p>Effective use of relevant data analysis techniques (software and “cloud”)</p> <p>Knowledge of quantitative and qualitative data analysis tools</p> <p>Effective interpretation of data</p> <p>Effective use of computerised visualisation tools (Excel, tables, charts, maps)</p> <p>High-performance computing</p>
<b>Research Phase: Management and Organising Information</b>	
Personal file management	<p>Effective organising and managing of print formats (cabinets, binders, contact details)</p> <p>Effective organising and managing of electronic formats (directories, folders and sub-folders, tagging, electronic bookmarks, electronic mail, contact details, personal databases, discipline-specific repositories, servers, USB, DVD, CD, external hard drives, office computers, digitising)</p> <p>Awareness of different file formats (lifespan and storing capabilities)</p> <p>Effective securing of confidential information</p> <p>Effective allocation of metadata to documents and images</p>
Bibliographic reference management	<p>Effective use of digital reference management tools</p> <p>Awareness of and correct application of relevant reference styles and guidelines</p>
<b>Research Phase: Data Curation</b>	
Data curation	<p>Effective long-term data preservation strategies (refreshing, migrating and emulation, metadata and metadata standards, storage, backing up, DOI, cloud, data repositories, archives, data management plan)</p> <p>Effective identification and accessing of dataset repositories (open and commercial)</p> <p>Effective depositing of data into digital data repositories</p> <p>Awareness of discipline-specific metadata standards</p> <p>Effective ensuring of privacy of datasets (copyright and IP)</p>

<b>Research Phase: Creation of Research Documents</b>	
Academic writing	<p>Effective academic writing skills (English grammar, accommodation of audiences, technical writing, mechanical correctness)</p> <p>Effective creation of scholarly documents (conference abstracts, conference papers, funding proposals, theses, dissertations, journal articles, technical reports, books, chapters, Web 2.0 platforms)</p> <p>Effective electronic mail communication (style and etiquette)</p>
Writing techniques	<p>Effective application of collaborative writing tools and technologies (track changes, version control, adding comments and contributor identification, e-mail, VRE, project management software, videoconferencing, wikis, blogs, file sharing, word processors)</p> <p>Effective employment of writing techniques (annotation, mind, concept and argument mapping)</p> <p>Effective application of discipline-specific citation styles and conventions (physical, electronic and datasets)</p> <p>Awareness of data citation standards</p> <p>Effective time management</p>
Responsible authorship principles	<p>Effective avoidance of plagiarism (paraphrasing, translating and summarising of information, use of anti-plagiarism software)</p> <p>Awareness of academic-industry partnerships and ethical conduct (restrictions to certain publications, non-disclosure of information, selection of projects)</p> <p>Awareness of ethical issues during collaborative writing projects (author attribution and omissions, order of authorship, authorship with students/assistants, commercial potential)</p> <p>Awareness of professional codes and journal guidelines regarding responsible authorship</p>
<b>Research Phase: Management of Intellectual Rights</b>	
Retaining of confidential information	<p>Knowledge of various techniques to place access conditions on confidential information (passwords, embargoes, licensing)</p>
Addressing IP	<p>Knowledge of commercialisation processes</p> <p>Effective application of IP mechanisms (trademarks, designs, trade secrets, copyrights and patents)</p> <p>Effective searching and location of patent and trademark information</p> <p>Awareness of IP legislation and policies (university, local and international)</p> <p>Designing IP management plans</p>
Addressing copyright protection	<p>Effective employment of copyright protection techniques (CC licensing, authors' addenda)</p> <p>Ability to acquire copyright permissions</p> <p>Awareness of publishers' copyright policies</p>
<b>Research Phase: Disseminating Research Findings</b>	
Considering and choosing publishing models	<p>Awareness and ability to select a suitable publishing model (traditional or open access)</p>
Using appropriate scholarly publication channels	<p>Effective oral sharing of research (informal presentations, conference presentations, workshops, communicating with the media, community and public)</p> <p>Effective electronic sharing of research (teleconferences, webinars and virtual workshops)</p> <p>Effective graphical sharing of research (posters)</p>

	Effective publication of written research formats (newspapers, internet and webpages, social media platforms, articles, books, chapters, conference papers, institutional and disciplinary repositories) Effective publication of research data (datasets) Effective increasing of visibility (academic search engine optimisation) Effective choosing of a publication strategy Awareness of scholarly journal publication guidelines/procedures Adhering to publication ethics (quality and integrity, multiple submissions, acknowledgement, conflicts of interests) Effective techniques to share in groups (shared calendars, blogs, social networks and bookmarking, file and document sharing, online reviewing and rating, event organisation)
<b>Research Phase: Measuring Impact</b>	
Researcher assessments	Awareness of various assessment practices (impact factors, peer review, awards, editorial positions) Awareness and understanding of relevant national rating systems
Bibliometrics	Awareness of different bibliometric tools (H-Index, journal and article impact factors) Effective measurement of personal impact on scholarly databases, internet and Web 2.0 Employment of systematic citation searches (articles, books, datasets, conference and patents, individuals, institutions, countries and research groups) Setting up of citation alerts (papers and patents)
Peer review	Awareness and knowledge of the academic peer-review processes (partially blind, completely blind and open peer reviewing) Effective peer reviewing (pre-publication and post-publication) Effective peer reviewing of research data

Many of the above skills were covered in the questionnaire. Although there might be more aspects relevant to ARIL skills, only key issues that surfaced in the literature analysis and the definition of ARIL were included in the questionnaire. The intention was to keep the questionnaire manageable in terms of the time respondents would need to complete it. Questions are briefly explained in sections 4.3.2.1 – 4.3.2.10.

#### 4.3.2.1 Questions regarding the identification of a researchable topic

The first sub-question dealt with skills relevant to the identification of a researchable topic to “advance the frontiers of knowledge” (Leedy & Ormrod, 2010:45). A second sub-question dealt with the ability to search the literature in this regard.

#### 4.3.2.2 *Questions relevant to obtaining funding*

Obtaining funding is a key element in the performance of scientific research (Koppelman & Holloway, 2012:63; Jowkar, Didegah & Gazni, 2011:599; Szelenyi & Goldberg, 2011:775; Arnett, 2009:2607; Berg, Gill, Brown, Zerzan, Elmore & Wilson, 2007:1588). The first sub-question assessed respondents' ability to identify funding opportunities. The second sub-question focused on specific skills relevant to obtaining research funding; respondents had to rate their skills. An option of "not applicable" was provided.

#### 4.3.2.3 *Questions relevant to the discovery and evaluation of information*

Several strategies for discovering information were discussed in chapter three, namely serendipitous information discovery (Case, 2007:32; Barrett, 2005:326; Foster & Ford, 2003:321), collaborative information discovery (Shah & Marchionini, 2010:1970; Hertzum, 2008:1) and structured information discovery (Ramirez, 2006:1; Leckie *et al.*, 1996:165). Effective discovery strategies are also associated with strategies to stay informed of new information in disciplines (Rotenberg & Kushmerick, 2011:504), as well as with the evaluation of information obtained to ensure that good quality information is identified and used (Seely, Fry & Ruppel, 2011:81).

Five sub-questions were included. Respondents had to rate their skills in individual and collaborative information discovery, their ability to use different platforms and email for collaboration, and a variety of information search skills, including searches for different formats. They could specify their own choice of methods for collaboration in discovering information. Skills in the evaluation of information and staying abreast with new information also had to be rated.

#### 4.3.2.4 *Questions relevant to data collection and analysis*

Data collection and analysis methods are key parts of research studies (Blaxter Hughes & Tight, 2006:29), since valid and reliable data assists researchers to create new knowledge, which should be based on well-designed and planned data gathering and analysis techniques (Lawrence, Jones, Matthews, Pepler & Callaghan, 2011:5). One sub-question on data collection and one on data analysis were included. Respondents had to self-rate their skills.

#### 4.3.2.5 *Questions relevant to the management and organisation of information*

Research information and data are often valuable and need to be managed carefully to enhance future access to various information formats (Whittaker, 2011:5). Three sub-questions assessed respondents' skills in managing and organising research information, namely knowledge of the lifespan of digital documents, the use of technology for information organisation and management, skills in the use of appropriate software and skill in organising specific formats. Respondents had the option to note alternatives.

#### 4.3.2.6 *Questions relevant to data curation*

The curation of research data is increasingly becoming important during the research lifecycle. Sub-questions covered the frequency of data curation and skills in data curation. Respondents could note other skills they considered important to data curation.

#### 4.3.2.7 *Questions relevant to the creation of research documents*

Four sub-questions covered how research documents are created individually, in contrast to collaborative writing, specific writing skills such as adapting work for different audiences and creating documents in different formats. Options were included to note other collaborative tools.

#### 4.3.2.8 *Questions relevant to the management of intellectual rights*

Academic researchers should be aware of methods to license their own work (Hagen, 2011:3; Rempel, 2010:544). Knowledge of IP rights is very important for especially engineering researchers, since engineering is considered one of the disciplines with the most patentable technological and commercially valuable breakthroughs (Soetendorp, 2004:363; Kaplan & Kaplan, 2003:9; McCorquodale & Brown, 2003:1). Five sub-questions were set. The first two dealt with restrictive access to research documents and findings and abilities to identify potential IP rights. Managing intellectual rights, document confidentiality and retaining copyright were also covered.

#### 4.3.2.9 *Questions relevant to the dissemination of research findings*

“The outcome of any research must be published as a form of information” (Okafor & Ukwoma, 2011:58). Sub-questions covered tools available when disseminating information and findings and skills in selecting dissemination strategies for findings as well as data. Respondents could list other ways in which they preferred to share research data.

#### *4.3.2.10 Questions relevant to measuring impact*

The performance of academic researchers is increasingly based on research output and their contributions in a specific field (Jeffery & Asserson, 2008:72; Gonzalez-Brambila & Veloso, 2007:1035; Chanson, 2006:2). Three sub-questions addressed impact measuring, namely knowledge of the most common indicators of impact, self-rating of skills in searching citation databases, and skills in setting up a personal profile.

Respondents were thanked for spending time to complete the questionnaire, and invited to provide their contact details if they were willing to take part in focus group interviews, which formed the second round of data collection in this study.

### **4.3.3 Quantitative phase (administration and planning)**

Before implementing the questionnaire, ethical clearance had to be obtained. This is very important in all academic and often also other research projects (Teddlie & Tashakkori, 2009:198; Blaxter, Hughes & Tight, 2006:154). Other administrative matters also had to be addressed.

#### *4.3.3.1 Ethical approval*

“Good ethical practice is mandatory for conducting sound social science research” (Choy, Li & Singh, 2015:175). Researchers therefore need to obtain special permission to collect data from individuals and sites, which often involves getting permission from several individuals, as well as campus-based institutional review boards (IRBs) (Salkind, 2012:42; Creswell & Plano Clark, 2011:175). The background of this study, methods that would be employed to secure data, and the benefits of the study were explained to all parties in order to obtain permission to continue with the survey at the selected institution. Approval to continue with the survey was consequently obtained from the relevant institution’s ethical board (Addendum A), the institution’s survey committee (Addendum C), as well as from the engineering faculty at the institution (Addendum B).

#### *4.3.3.2 Pretesting and piloting of the questionnaire*

The pretesting of survey instruments is an important part of the planning and administration process, since it is a formal evaluation carried out before the main survey questionnaire is distributed (Krosnick & Presser, 2010:294; Peterson, 2000:118). Pretesting implies that all the possible combinations of settings that respondents may select are systematically tested (Dillman, Smyth & Christian, 2009:217). It offers researchers the opportunity to rectify

mistakes beforehand (Strydom, 2005:210; Wilkinson & Birmingham, 2003:19; Welman & Kruger, 2001:141).

Pretesting is especially important before implementing web-based surveys; technical problems may limit response rates (Couper & Bosnjak, 2010:538; Best & Harrison, 2009:418), and problems may arise regarding different browsers used by respondents (Couper & Bosnjak, 2010:527; Best & Harrison, 2009:422; Dillman, Smyth & Christian, 2009:232; Zhang, 2000:58; Schmidt, 1997:278). The questionnaire therefore had to be tested on a variety of web browsers beforehand (Schmidt, 1997:278); the focus was on the appearance and functioning of the survey instrument.

The pretesting process also provided an opportunity to check instructions for completing each question, which is especially important (Leedy & Ormrod, 2010:194; Best & Harrison, 2009:427; Dillman, Smyth & Christian, 2009:286; Denscombe, 2003:152; Wilkinson & Birmingham, 2003:16; Mouton, 2001:103). A pilot study is a small-scale version of the main study (Peterson, 2000:117; Brink, 1996:174), which is performed “under simulated or actual research project conditions” (Peterson, 2000:117). A pilot study was used to check the clarity of the questions and the quality of the questionnaire. Pilot studies are performed with a small number of respondents from the same population as the one identified to complete the actual survey (Welman & Kruger, 2001:141; Peterson, 2000:117; Brink, 1996:174), although not from the sampling frame. Data obtained from a pilot study can be analysed by using specific techniques to test the reliability of responses, for example test-retest, equivalent form, split-half, and internal reliability tests (Pietersen & Maree, 2007b:215). A small number of postgraduate engineering researchers from an academic institution other than the one selected for the case study participated in the pilot study.

#### *4.3.3.3 Inviting respondents to participate*

An invitation letter introducing the research project and purpose of the study accompanied the invitation and questionnaire (Addendum F). It established the first connection with the respondents (Dillman, Smyth & Christian, 2009:272), and was used to encourage them to participate in the survey (Peterson, 2000:103). Guidelines from the literature regarding invitation letters were adhered to, such as giving an overview of the purpose and importance of the study, evidence of the approval date of the instrument, a motivation to respond, a printable version of the informed consent form for respondents’ own records, and the contact

details of the researcher (Dillman, Smyth & Christian, 2009:16; Fyffe & Walter, 2005:22; Wilkinson & Birmingham, 2003:16; Shannon *et al.*, 2002:10).

The informed consent form had to be completed and signed. It was stressed that participation was voluntarily and participants were free to decline, participate or withdraw from the study at any stage (Struwig & Stead, 2001:67). The informed consent form was available on the opening page of the web-based questionnaire. Respondents had to state that they agreed to provide information requested to assist the researcher with this study. It was stipulated that the questionnaire should not be submitted unless the informed consent form had been read and signed (Schmidt, 1997:277). The consent form explained the nature of the study and what participation involved, the voluntary nature of the survey, a guarantee of the confidential treatment of information provided, the researcher's name and contact details and a space for the participant to indicate his/her agreement to participate (Leedy & Ormrod, 2010:102). The form addressed the rights and responsibilities of both parties (Fyffe & Walter, 2005:20) (Addendum F). As motivation to participate in this survey, the researcher offered to share findings with respondents after the completion of the study; this could help to maximise the return rates (Leedy & Ormrod, 2010:202).

#### **4.3.4 Quantitative phase (data analysis)**

Quantitative data would have been a chaotic mass of meaningless numbers without the aid of statistics, which can enable researchers to “reduce, summarize, organise, manipulate, evaluate, interpret and communicate” data (Brink, 1996:179). Researchers should therefore be able to draw meaningful conclusions from data obtained during empirical research projects (Leedy & Ormrod, 2010:97), which may be subjected to various analysis processes (Brink, 1996:60).

The data obtained from the questionnaire was analysed by starting with the examination of the completeness and accuracy of all questionnaires received. Inaccurately completed questionnaires were discarded (Brink, 1996:61). Raw data was further screened and organised to reveal outlying cases, which could provide distorted statistics (Creswell & Plano Clark, 2011:204; Leedy & Ormrod, 2010:253; Struwig & Stead, 2001:150, 158).

There are various levels of quantitative analysis: descriptive statistics, inferential statistics, simple inter-relationships and multivariate analysis (Blaxter, Hughes & Tight, 2006:215). They all involve some summary of the data (Leedy & Ormrod, 2010:31). Descriptive statistics are associated with providing an overall coherent picture of large amounts of data

for easy understanding, comparison and communication (Leedy & Ormrod, 2010:260; Tashakkori & Teddlie, 2009:302; Struwig & Stead, 2001:158). Inferential statistics can assist researchers to test hypotheses and to make inferences about larger populations (Leedy & Ormrod, 2010:260; Tashakkori & Teddlie, 2009:302; Struwig & Stead, 2001:159).

#### **4.3.5 Validity and reliability of data**

Both validity and reliability of data refer to the degree of error (Leedy & Ormrod, 2010:29), which may influence the quality of conclusions that can be drawn at the end of a research study (Creswell & Plano Clark, 2011:210). Reliability refers to the replication and consistency of measurements (Hammond & Wellington, 2013:131; Alwin, 2010:408; Leedy & Ormrod, 2010:29; Pietersen & Maree, 2007b:215; Golafshani, 2003:599), while validity refers to the accuracy of measurement, and whether elements are measured that were intended to be measured (Alwin, 2010:409; Golafshani, 2003:599). A relationship between reliability and validity is therefore evident (Alwin, 2010:409; Struwig & Stead, 2001:130; Brink, 1996:172), since something can be measured accurately only when it can also be measured consistently, although consistency does not necessarily imply accuracy (Leedy & Ormrod, 2010:29)..

##### *4.3.5.1 Validity of the research study*

The validity of research studies are often associated with internal validity, which refers to the specific design employed, as well as whether data obtained allows for drawing accurate conclusions about the relationships within data (Leedy & Ormrod, 2010:97; Struwig & Stead, 2001:136).

The research design to collect data in this study was discussed earlier in this chapter. The data collection and analysis techniques should contribute to the internal validity of the study. External validity of research studies refers to the extent to which researchers can generalise results to larger populations (Leedy & Ormrod, 2010:99; Struwig & Stead, 2001:136). External validity is associated with suitable sampling techniques, since inadequate or inappropriate samples can be a threat to validity (Morse, 2008:151). A sample was not drawn for the study. Respondents were often purposefully selected based on their level of studies and involvement with research in an engineering department. They were invited to participate through their respective heads of departments, as well as through the dean of the faculty's office.

#### 4.3.5.2 *Validity of the measuring instrument*

The validity of measuring instruments refers to the extent to which they measure what they are supposed to measure, which can be ensured by designing an accurate instrument (Leedy & Ormrod, 2010: 28; Delpont, 2005:160). Literature refers to different types of instrument validity, including face, content, criterion, construct, and convergent and discriminant validity (Delpont, 2005:160; Struwig & Stead, 2001:139). Face validity is associated with how the instrument “looks”, and if it appears to measure the attributes accurately which the test claims to measure (Delpont, 2005:161; Struwig & Stead, 2001:139). Content validity refers to the extent to which items reflect the complete theoretical content of the construct (Delpont, 2005:161; Struwig & Stead, 2001:139) and criterion validity to the relationship between two or more tests (Struwig & Stead, 2001:139). Construct validity is associated with the standardisation of an instrument to ensure that “combined responses provide a measure for the factor”, which can be determined by performing factor and item analyses (Pietersen & Maree, 2007b:217), which indicate the degree to which the intended theoretical construct is successfully measured (Delpont, 2005:162; Struwig & Stead, 2001:141). Convergent and discriminant validity refer to the relationship between a specific test and other tests measuring the same constructs (Struwig & Stead, 2001:142).

Experts from a variety of disciplines were invited during the development phase of the questionnaire to comment on the content and face validity of the questionnaire. This was a step in establishing the accuracy of data for which the questionnaire served as gathering instrument (Brink, 1996:168). Engineering researchers from the researcher’s own institution were also regularly approached to comment on the validity of the questions and overall content of the questionnaire. Construct validity was achieved through the use of multiple sources of evidence, which made it possible for the researcher to triangulate data.

#### **4.4 SECOND PHASE OF DATA COLLECTION (QUALITATIVE PHASE)**

Since the study followed a mixed methods approach the quantitative data was supplemented with qualitative data, which can be obtained through interviews, observations and content analysis (Leedy & Ormrod, 2010:147; Blaxter, Hughes & Tight, 2006:64; Struwig & Stead, 2001:11). Focus group interviews as well as individual interviews can effectively be employed in addition to surveys to gather information (Franklin, 2012:193; Creswell & Plano Clark, 2011:185). They specifically draw upon participant’s “beliefs, attitudes and feelings by exploiting group processes” (Freeman, 2006:493). In the qualitative phase of the study, data was mostly generated as a result of group interactions and dynamics (Freeman, 2009:492;

Struwig & Stead, 2001:99). According to Punch (2009:147), “well-facilitated group interaction” can result in raising aspects that might not have been exposed otherwise.

Focus group interviews are considered a popular method to employ during the identification of core needs among postgraduate researchers, since they not only highlight core issues and concerns, but also allow researchers to ask important questions (Covert-Vail & Collard, 2012:17). The findings from focus groups and individual interviews were combined with the questionnaire survey; this necessitated multiple visits to the study site (Pickard, 2013:106). Such visits were used to build and establish trust and rapport with participants, to explore salient issues within the context, and to identify key informants (Pickard, 2013:104).

Several advantages are associated with focus group interviews. These include the capturing of spontaneous reactions, verbatim recording of responses and opportunities to uncover underlying reasons (Case, 2007:217). In addition, focus group interviews can provide context and depth in research studies; data is obtained from open-ended research questions, gathered from small sample sizes (Ivankova, Creswell & Plano Clark, 2007:257; Greeff, 2005:301; Morgan, 1998:13). With focus groups a large amount of interaction can be observed, and multiple viewpoints on a topic can be gathered in a limited period of time (Franklin, 2012:193; Greeff, 2005:312; Babbie & Mouton, 2001:292; Morgan, 1998:9).

Challenges of focus group interviews were also noted: increased costs of employment, time-consuming execution, possible influences by interviewers, possible inhibitions of respondents regarding group discussions, perceived invasion of privacy and problems relating to researcher bias (Greeff, 2005:312; Denscombe, 2003:190). It is important to address such problems.

#### **4.4.1 Qualitative phase (selection of information sources)**

Qualitative research designs are associated with sampling techniques that ensure that “information-rich” participants are selected (Teddlie & Yu, 2008:209), and can be based on existing knowledge a researcher has of a population (Uys & Puttergill, 2003:107). Small sample sizes are therefore often selected by employing purposive techniques, which are based on specific criteria or purposes associated with a research study’s objectives (Teddlie & Yu, 2008:200; Kemper, Stringfield & Teddlie, 2003:273). Various purposive sampling techniques are documented in the literature and include convenience sampling, extreme/deviant case sampling, confirming/disconfirming and typical case sampling, homogeneous sampling, stratified purposive sampling and random purposive sampling, or opportunistic and snowball

sampling techniques (Kemper, Stringfield & Teddlie, 2003:278). Suitable participants from each career stage were included, namely master's, doctoral, post-doctoral and established researchers, as well as expert researchers in engineering, and care was taken to ensure a healthy spread between engineering departments. Participants specifically had to be enrolled for a master's or doctoral degree, or to be appointed in a post-doctoral position, or be a staff member with a doctoral degree. Established researchers needed to hold either a C or a B rating from the NRF, and expert researchers needed to hold an A rating from the NRF.

Effective conducting of focus group interviews is associated with carefully selected individuals (Freeman, 2009:492; Barbour, 2007:58). Participants were therefore selected from the same population identified in the quantitative phase of this study. The intention was to use qualitative data to explore quantitative results, and to select participants who could best provide detailed information (Creswell & Plano Clark, 2007:122). Master's and doctoral researchers were grouped together, and post-doctoral, established and expert researchers were either grouped together, or were accommodated individually in order to avoid influences of current relationships on contributions. Individual sessions were arranged to meet the schedules of researchers and depended on personal preference and times available in order to accommodate most of the engineering researchers.

The number of participants per focus group ranged between five and ten, since a group smaller than eight persons will not provide the critical mass needed, and groups larger than 12 may result in more difficult participation and observation (Case, 2007:218).

Some specific planning and administration processes had to be addressed before the actual gathering of data could commence.

#### **4.4.2 Qualitative phase (administration and planning)**

Because of the organisational effort and coordination associated with focus group interviews (Flick, 2011:118), recording equipment, reliable power sources and back-up equipment were set up and checked before every interview, together with tapes of sufficient length to cover the complete duration of each focus group interview (Denscombe, 2003:176). The venues for the focus group interviews also needed to be selected carefully beforehand, since it was important to secure private rooms without distractions and with good acoustics (Case, 2007:218; Denscombe, 2003:173). Seating arrangements were set up beforehand, to allow for comfortable interaction between all parties (Denscombe, 2003:173).

Researchers were invited through the dean of the engineering faculty's office, and through heads of departments from different engineering departments. Each participant was informed about the background and purpose of the study, and why their input was important (Addendum G). According to Creswell and Plano Clark (2011:176), explaining procedures regarding how data will be collected is important, since personal questions may be asked and recorded where participants work. Unwanted behaviour may be disclosed, and participants may regret making revelations afterwards (Barbour, 2007:81). Participants were therefore ensured that data they provided would be treated as confidential, and that direct quotes would be anonymised during publication and when reporting findings.

A pilot study was performed on a group of engineering researchers on master's, doctoral and post-doctoral levels, as well as on individual engineering researchers from an academic institution other than the one selected for the case study, before the actual focus group interview sessions were scheduled. This allowed for the testing of the order of the questions, the timing of each session, the clarity of questions and identifying possible probing questions.

#### **4.4.3 Qualitative phase (data collection)**

The ARIL skills of engineering researchers for master's, doctoral, post-doctoral, established and expert level research were explored during the qualitative phase of the study. As for the questionnaire, the questions were guided by the ARIL definition (Section 2.4). A list of open-ended, semi-structured questions was developed to guide every focus group interview session (Addendum E). The list helped the researcher to stay focused on the topic (Leedy & Ormrod, 2010:148). For open-ended questions there were no predetermined categories or scales (Creswell & Plano Clark, 2011:176). Questions were, however, still focused on the research question. There was a limited set of predetermined questions (Leedy & Ormrod, 2010:152), which revolved around a trigger or stimulus (Denscombe, 2003:169).

Each focus group session was structured into four phases, which commenced with administrative issues and an introduction to the project, followed by a short explanation and introduction of core advanced research information literacy phases. Since focus group conversations should commence with the researcher establishing rapport between herself and all participants (Leedy & Ormrod, 2010:151), each session started with the researcher introducing herself, followed by a short discussion of the background and objectives of the research project.

The confidentiality of information provided by participants was confirmed. This is a crucial aspect at the start of a focus group interview (Barbour, 2007:81). It was ensured that the rights of participants were not violated, and that all data was collected on the principle of informed consent (Strydom, 2005:58). A letter of consent (Addenda G) was handed to every respondent before the focus group interviews commenced. Participants were requested to read the document, to ask questions if necessary and then to sign the form. Specific strategies employed to assist respondents who perceived recording instruments as intimidating entailed that tape recorders were placed within reach of all participants to allow them to use the pause button at any time, and a play-back opportunity was provided at the end of each interview session to rectify or expand information through further discussion (Oliver, 2010:47). Verbatim notes were taken regarding participants' comments, behaviour and non-verbal reactions during the focus group interview sessions. These were added to the recorded data obtained from every focus group interview. This procedure confirmed that qualitative data collection techniques are time-consuming, since researchers need to record any potential useful data thoroughly, accurately and systematically (Leedy & Ormrod, 2010:145; Denscombe, 2003:175).

The first question aimed to gather data on what participants considered the most *critical* information literacy skill(s) needed during their particular career stage, namely master's, doctoral, post-doctoral, established and expert levels. The second question obtained comments on possible barriers and challenges encountered during the career stages. Probing questions were prepared to stimulate discussions further, as well as to ensure that the ten phases identified for ARIL, issues relevant to collaborating with other researchers, conducting inter-disciplinary, multi-disciplinary and trans-disciplinary research, and the planning of a research career were covered. A third question covered the importance of auxiliary skills associated with information literacy and research processes such as time management, project management, notetaking and budgeting. Participants could mention auxiliary skills. The final question enquired about participants' perceptions of an ARIL framework. Each focus group interview session took approximately 60 minutes, which fell in the recommended time limit (Franklin, 2012:195).

#### **4.4.4 Qualitative phase (data analysis)**

Recorded comments from participants had to be coded and analysed to reflect the views of participants accurately (Wilkinson & Birmingham, 2003:10). The audiotapes and detailed handwritten notes taken during each session were thoroughly analysed. This analysis was performed by following the four phases of qualitative data analysis: breaking up large units into smaller ones (organisation), getting an overall sense of the data (perusal), grouping of data into categories or themes to find meaning (classification) and using tables, diagrams and graphs to explain findings (synthesis) (Leedy & Ormrod, 2010:153). Open and axial coding techniques were used. Open coding involved the division of data into segments and scrutinising it for commonalities. Axial coding concerned the making of interconnections among categories (Leedy & Ormrod, 2010:143). This assisted with the interpretation process where meaning was given to raw data, which can provide readers “with reasonable insights that were not obvious at first glance” (Struwig & Stead, 2001:172). Data was typed into a word processing programme, whereafter it was imported into qualitative data analysis software (Struwig & Stead, 2001:169). The researcher employed AtlasTi software to analyse qualitative data, whereafter an independent external coder commented on and confirmed the main findings.

#### **4.4.5 Qualitative phase (trustworthiness of data)**

Strategies to indicate that qualitative studies are trustworthy include assurance that the study is credible, dependable, confirmable and transferable (Shenton, 2004:64; Golafshani, 2003:601; Krefting, 1991:8; Guba, 1981:80). Assurance of each of these four issues is briefly discussed in the next paragraphs, together with how the strategies were applied to this part of the study.

Credibility implies that a study measures what it is intended to measure (Shenton, 2004:64), and depends on the “ability and effort of the researcher” (Golafshani, 2003:600). The researcher has been serving as a librarian in an academic institution for 20 years, where the primary part of her work is to engage and assist academic staff, undergraduate as well as postgraduate students affiliated with the engineering faculty of a university of technology. Specific strategies can be employed to achieve credibility. Examples are prolonged engagement at a research site (Krefting, 1991:7; Guba, 1981:84), persistent observation and detailed descriptions of events (Leedy & Ormrod, 2010:100; Babbie & Mouton, 2001:277; Krefting, 1991:11; Guba, 1981:84), triangulation through employing various data sources (Shenton, 2004:64; Krefting, 1991:8; Guba, 1981:84), member checks (Shenton, 2004:69;

Krefting, 1991:8; Guba, 1981:84), the adoption of suitable research methods (Shenton, 2004:64), and encouragement of peer examination where impartial colleagues with experience of qualitative methods are involved (Shenton, 2004:67; Krefting, 1991:12). Multiple credibility strategies were implemented in this phase of the study, namely the selection of a suitable data collection method, employing member checks after every focus group interview, providing detailed descriptions to convey findings and using peer examination.

Researchers must also demonstrate that the findings can be applied to a wider population (Shenton, 2004:69). This is referred to as the transferability of findings. Transferability may be difficult in qualitative studies, since social behaviour is often context-bound (Krefting, 1991:14; Guba, 1981:86). Dense and precise descriptions of data obtained were therefore provided in this study, as well as detailed information on the context in which the study took place (Shenton, 2004:70; Babbie & Mouton, 2001:277; Krefting, 1991:8; Guba, 1981:86).

Although qualitative research methods may be problematic to replicate (Jick, 2008:116), it is important to ensure that future researchers will be able to repeat qualitative studies. The dependability of data obtained in this study was addressed by reporting on the research process and design in detail (Shenton, 2004:71; Krefting, 1991:8), and by providing instructions for replicating the study step by step (Krefting, 1991:8; Guba, 1981:87). In addition, peer examination was promoted (Krefting, 1991:8) and an audit trial was established, which allowed external auditors to examine the data collection, data analysis and data interpretation processes (Krefting, 1991:8; Guba, 1981:87).

A final method to ensure trustworthiness included ensuring that participants' experiences and ideas were documented, instead of the researcher's own thoughts (Shenton, 2004:72). Findings may therefore need to be confirmed by others, which highlights the importance of objectivity during qualitative studies. The "audit trial" employed in this study allows others to trace the steps performed during the qualitative phase of the research study (Shenton, 2004:72; Krefting, 1991:8).

## 4.5 CONCLUSION

The research design and methodology employed in the empirical phase of this study were discussed in this chapter. An explanatory case study design was selected to gather quantitative data in the first phase of the study by means of a self-administered web-based questionnaire, followed by a qualitative phase where focus group and individual interviews were used. The second phase of the case study explored data in more depth to enable later triangulation between quantitative and qualitative data and findings from the literature.

The next chapter will focus on the data collected from South African postgraduate researchers affiliated with a research-intensive university with a strong presence globally in the field of engineering.

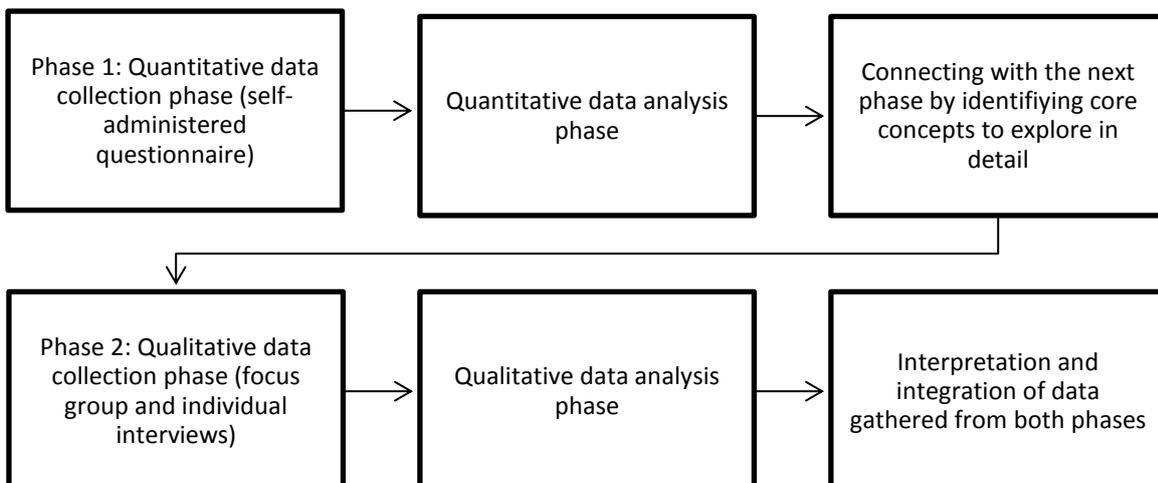
## CHAPTER 5: DATA ANALYSIS AND FINDINGS OF QUANTITATIVE DATA

### 5.1 INTRODUCTION

Chapter 4 outlined the research methodology followed in this study in detail, by describing how data would be collected during the different stages of the empirical component designed for this study. The methodology consisted of a mix of data collection strategies, including the use of an online self-administered questionnaire (Addendum D) in the quantitative phase, a semi-structured interview schedule (Addendum E) in the qualitative phase, and a short profile questionnaire for focus group and interview participants (Addendum H). The researcher will present data obtained during the empirical component of this case study over two chapters, with Chapter 5 covering quantitative data collected between September and December 2015 and Chapter 6 covering the data obtained during the qualitative phase of this study, which was collected between October and December 2015. The reporting on data collected during both phases will be followed by a discussion on data triangulation; findings from the phases as well as of the literature analysis discussed in Chapters 2 and 3 will be consolidated in Chapter 7.

Findings on the data collected in this study will be reported in the sequence suggested in Chapter 4; results of the quantitative data collection phase will be discussed first, followed by a discussion of the qualitative data collection phase. The process of reporting on findings in this study is illustrated in Figure 0.1.

**Figure 0.1 Visual presentation of the reporting on findings**



This chapter starts with a short summary of the overall data collection processes used in this study, followed by a short summary of specifically the quantitative data collection phase, ethical issues and validity and reliability matters. (The qualitative phase is covered in Chapter 6.) The next section of the chapter reports on the demographic data of respondents, followed by reporting on the results obtained from the questionnaire. The last part of this chapter provides a summary of the responses obtained in two separate tables, with the first summarising the skills at which respondents judged themselves as good or very good, and the second table summarising the respondents' skills that they felt were either fair or poor. These tables are followed by a short conclusion.

## **5.2 EXECUTION OF THE EMPIRICAL COMPONENT OF THE STUDY**

The aim of this study was to explore information literacy in a postgraduate context, with specific reference to engineering researchers. Several research questions were developed in Chapter 1, which served as building blocks in the process of exploring and answering the central research question developed for this study, namely: *“How can an advanced research information literacy framework inform the development of programmes supporting the scholarly research process of engineers in a South African higher education environment?”*

A literature analysis conducted in Chapter 2 addressed the first question, namely: *“What are the characteristics of introductory and advanced research information literacy programmes as reported in subject literature as well as on the WWW?”* The second research question was addressed in Chapter 3, namely: *“What are the documented information needs, information behaviour and information-related experiences of engineering researchers in academic institutions, as well as from industry?”* This was also answered by means of a literature analysis.

This chapter will address the third research question by presenting data obtained from the empirical study, namely: *“What are the current self-reported ARIL skills of South African postgraduate engineering researchers?”* and the following chapter will shed more light on the fourth research question: *“How does information literacy skills, knowledge and practices of engineers differ between master's, doctoral, post-doctoral, established and expert researcher levels?”* Arising from the findings presented in Chapters 5 and 6, Chapter 7 will address the last two research questions, namely: *“How can an advanced research information literacy framework assist to determine which skills need to be developed during various levels of the engineering research process?”* and *“Which guidelines and interventions are required to*

support the implementation of an ARIL framework for engineers?” Each research question, the research method used to address it and the chapter discussing the findings are shown in Table 0.1.

**Table 0.1 Addressing the sub-questions supporting the central research question of the study**

<b>Research Question</b>	<b>Addressed</b>	<b>Chapter</b>
<b>Sub-question 1:</b> What are the characteristics of introductory and advanced research information literacy programmes as reported in subject literature as well as on the WWW?	Literature analysis	2
<b>Sub-question 2:</b> What are the documented information needs, information behaviour and information-related experiences of engineering researchers in academic institutions, as well as from industry?	Literature analysis	3
<b>Sub-question 3:</b> What are the current self-reported ARIL skills of South African postgraduate engineering researchers?	Empirical data collected by means of a self-administered questionnaire	5
<b>Sub-question 4:</b> How do information literacy skills, knowledge, and practices of engineers differ between master’s, doctoral, post-doctoral, established and expert researcher levels?	Empirical data collected by means of focus group and individual interviews	6
<b>Sub-question 5:</b> How can an advanced research information literacy framework assist to determine which skills need to be developed during various levels of the engineering research process?	Researcher’s interpretation based on findings of sub-questions 1-4	7
<b>Sub-question 6:</b> Which guidelines and interventions are required to support the implementation of an ARIL framework for engineers?	Researcher’s interpretation based on findings of sub-questions 1-5	7

As already mentioned, various methods were employed to collect data during this mixed methods case study. Information was gathered sequentially by commencing with a self-administered questionnaire, followed by focus group as well as individual interviews in order to build on findings as the study matured. The execution of the empirical component of this study is illustrated Table 0.2.

**Table 0.2 Execution of the empirical component**

Method of Data Collection	Responses	Duration	Data Analysis
Questionnaire (quantitative): semi-structured, self-administered, web-based	68	22/09/2015 - 7/12/ 2015	Qualtrics Software
Focus group interviews (qualitative): semi-structured interview schedule and demographic information per questionnaire	19	01/10/2015 - 07/12/2015	Thematic analysis
Individual interviews (qualitative): semi-structured interview schedule and demographic information per questionnaire	12	01/10/2015 – 07/12/2015	Thematic analysis

The following paragraphs cover the data collection process with specific reference to the quantitative phase.

### 5.3 QUANTITATIVE DATA: FINDINGS AND ANALYSIS

The proposed working definition of ARIL as formulated and developed in earlier chapters guided the development of the questionnaire and stipulates that:

*Advanced research information literacy includes all traditional information literacy skills, and expands on these by including the ability to identify research gaps in the spectrum of international and interdisciplinary literature that can meet with the needs of society, access and consult literature across disciplines (multi-, inter- and trans-disciplinary) to support various facets of the research process, analyse and synthesise information from secondary as well as primary resources (i.e. empirical data), generate new knowledge, and disseminate findings and new knowledge through appropriate channels, while networking and collaborating with other researchers across different collaborative research platforms, focused on enhancing scholarship. Advanced research information literacy skills are therefore evident in all the typical research phases, namely identifying a researchable topic, obtaining research funding, discovering information, managing and organising information, collecting and analysing data, storing and curating data, writing up findings, managing intellectual property, publishing results through various channels and advocating the research results (e.g. through social media), as well as the measurement of impact through different metrics, where each phase is associated with various processes aimed at the achievement of specific goals relevant to that phase.*

The questionnaire (Addendum D) consisted of eight questions covering demographic information and 39 questions on advanced information literacy skills. Most of the questions (demographic information excluded) employed a four-point Likert scale through which skills could be rated, namely poor, fair, good, and very good, except for four questions testing how often certain functions were performed, by employing the following scales: never, rarely, often, always, or daily, weekly, monthly, annually or never (i.e. questions 23, 25, 29 and 36). Neutral positions were deliberately omitted from the Likert scales used in the questionnaire in order to avoid a mid-point answer. Respondents were invited to add additional information in text format to certain questions where the researcher thought they might want to elaborate on a specific aspect.

A pilot study was executed between 1 and 10 Aug 2015 at the VUT. The approximate time required to complete the questionnaire was again confirmed (i.e. 20 minutes), and no problems were reported with the clarity or sequence of the questions posed in the questionnaire.

A link to the self-administered web-based questionnaire (Addendum D) was sent to postgraduate engineering researchers (students and staff) through the offices of the respective heads of departments on 22 September 2015, along with an invitation letter to participate in the survey. A reminder was sent to all relevant heads of department on 29 September 2015 in an attempt to increase the response rate. The survey was closed on 7 December 2015. Sixty-eight questionnaires were (mostly) completed in full, and were considered acceptable for full analysis, even though some questions have not been completed in between 3% and 30% of the questionnaires. One respondent completed only the first question, which increased the number of responses to 69. This questionnaire was thus included only for this question; for all other questions only 68 responses were considered. In the literature various reasons are noted for incomplete answers to specifically web-based questionnaires. These may include technical problems (Couper & Bosnjak, 2010:538; Best & Harrison, 2009:418) and problems related to different browsers used by respondents (Couper & Bosnjak, 2010:527; Best & Harrison, 2009:422; Dillman, Smyth & Christian, 2009:232; Zhang, 2000:58; Schmidt, 1997:278). Initially, all questions were marked as compulsory (which might have caused people to withdraw from the study). After receiving feedback in the third week of the study, all questions, except the informed consent question, were marked “optional” from 27 October 2015 onwards, so that respondents felt themselves under less pressure. The number (N) for

each question will therefore differ according to individual preferences to answer the question, and will be indicated accordingly when reporting on each question.

Respondents (as referred to in the quantitative phase of the study) were invited to participate in the survey through their respective heads of department (Addendum F), who were individually approached by the researcher before the survey commenced in order to obtain permission to survey staff and students from their departments. In addition, the dean of the faculty where the study was conducted also gave permission to proceed with the survey in the engineering departments. The quantitative phase of this study adhered to requirements for the ethical conduct of research, since “good ethical practice is mandatory for conducting sound social science research” (Choy, Li & Singh, 2015:175). Researchers therefore need to obtain special permission to collect data from individuals and sites, which often involves several individuals, as well as campus-based IRBs (Salkind, 2012:42; Creswell & Plano Clark, 2011:175). Ethical approval was obtained from the Research Committee of the Department of Information Science on behalf of the institution granting the degree before the study commenced, the ethics committee of the relevant faculty (Addendum B), the vice-principal (research and post-graduate education) of the institution, as well as from the dean of the faculty where the study was conducted. All the respondents who completed the questionnaire were briefed about the nature and purpose of the study beforehand in writing (Addendum F) and everybody gave written informed consent (Addendum F) before they were allowed to proceed with the questionnaire. In addition, all questionnaire responses were treated as confidential, as was the academic institution involved.

Validity and reliability issues were addressed in this study by firstly describing the research design followed in detail. The case was explained, as well as data collection and analysis techniques that should contribute to the internal validity of this study. The external validity of a research study refers to the extent to which researchers can generalise results to larger populations (Leedy & Ormrod, 2010:99; Struwig & Stead, 2001:136), and is therefore associated with suitable sampling techniques (Morse, 2008:151). As mentioned earlier in this chapter, case studies are not associated with the drawing of sample sizes, but rather with the inclusion of information-rich sources, which are able to contribute meaningfully to the case study. As already stated, respondents were invited to participate through their respective heads of department, as well as through the office of the dean of the faculty. The validity of measuring instruments refers to the extent to which they measure what they are supposed to measure, which can be ensured by designing an accurate instrument (Leedy & Ormrod, 2010:

28; Delpont, 2005:160). The researcher invited experts from engineering departments of her own institution to judge the content and face validity of the questionnaire on a regular basis throughout the questionnaire design process. Construct validity was achieved through the use of multiple sources of evidence in this case study, which made it possible for the researcher to triangulate data obtained from a self-administered questionnaire, focus group and individual interviews, as well as from the literature.

The following section of Chapter 5 will report on the demographic information of respondents.

### **5.3.1 Demographic information of respondents**

The main purpose of this section of the questionnaire was to gather demographic information in questions 1-8 (Addendum D) of participating respondents regarding the following: the engineering field in which they were conducting research, their highest qualification, for how long they had been holding that qualification, the research stage reflecting their progress to date, their position in the department, involvement with postgraduate supervision, nature of their collaboration with other researchers, and whether they had an NRF rating. This data was collected through eight questions at the beginning of the questionnaire and is presented below. Responses regarding the engineering fields in which respondents were conducting research are illustrated in Table 0.3, the highest qualification of respondents together with the number of years they had been holding that qualification in Table 0.4*a* and *b*, the research stage reflecting their current progress in Table 0.5, and respondents' positions in the academic departments as well as their involvement with post-graduate supervision in Table 0.6*a* and *b*. Responses regarding the nature of research collaboration are illustrated in Table 0.7. None of the respondents replied to the last question on the NRF rating.

The association of respondents with the various engineering departments is illustrated in Table 0.3 below.

**Table 0.3 Association of respondents with respective engineering departments**

Engineering Department	Frequency (N=69)	%
Mechanical and Aeronautical Engineering	26	37.7
Chemical Engineering	19	27.5
Electrical, Electronic and Computer Engineering	11	15.9
Material Science and Metallurgical Engineering	7	10.1
Civil Engineering	4	5.8
Industrial and Systems Engineering	1	1.4
Mining Engineering	1	1.4

Table 0.3 reflects the responses to question 1 (Addendum D) on the various engineering fields in which the respondents were working. The majority of respondents 26/69 (37.7%) were from Mechanical and Aeronautical Engineering, followed by Chemical Engineering 19/69 (27.5%), and Electrical, Electronic and Computer Engineering 11/69 (15.9). The remaining departments included Material Science and Metallurgical Engineering 7/69 (10.1%), Civil Engineering 4/69 (5.8%) and Industrial and Systems Engineering, as well as Mining Engineering with 1/69 (1.4%) each. Some departments are smaller than others; data about the numbers of staff and post-graduate students for each department was not collected since the intention was not to draw a comparison between departments.

The highest academic qualifications and the number of years of holding that qualification at the time of completing the questionnaire are illustrated in Table 0.4 below.

**Table 0.4a Academic qualifications and Table b, Number of years of holding that qualification**

Table 0.4a			Table 0.4b		
Highest Qualification	Frequency N=68	%	Years of Holding Qualification	Frequency N=68	%
Honours	24	35.3	Less than 1 year	20	29.4
Master's	26	38.2	1-2 years	12	17.6
Doctorate	16	23.5	3-5 years	16	23.5
Not answered	2	2.9	6-10 years	4	5.9
			11-15 years	8	11.8
			16-20 years	3	4.4
			More than 20 years	4	5.9
			Not answered	1	1.5

Table 0.4a illustrates the responses obtained to questions 2 and 3 (Addendum D) on the highest qualifications of respondents, with a master's degree (26/68, 38.2%) being the highest qualification of most respondents, followed by an honours degree (24/68, 35.3%), and a doctoral degree (16/68, 23.5%). Two/68 researchers (2.9%) did not answer the question on their highest qualification.

Table 0.4b illustrates the responses to question 3 on the number of years of holding the highest qualification, with the majority (20/68, 29.4%) holding their qualification less than a year, followed by three to five years (16/68, 23.5%), one to two years (12/68, 17.6%), and 11-15 years (8/68, 11.8%). The remaining researchers indicated that they had held their highest qualifications for between six and 10 years (4/68, 5.9%), more than 20 years (4/68, 5.9%), and 16-20 years (3/68, 4.4%). One researcher/68 (1.5%) did not answer the question on the number of years of holding his/her highest qualification.

The research stages in which respondents found themselves at the time of completing the questionnaire are illustrated in Table 0.5.

**Table 0.5 Research stages of respondents**

<b>Research Stage</b>	<b>Frequency N=68</b>	<b>%</b>
Empirical phase (e.g. data collection, analysis and interpretation)	21	30.9
Publishing/disseminating of results	13	19.1
Editing and finalisation of dissertation/thesis	9	13.2
Choice of research methodology	7	10.3
Comprehensive literature analysis	6	8.8
Idea generation and initial literature scanning	5	7.4
Proposal writing	3	4.4
Other	3	4.4
Not answered	1	1.5

Table 0.5 illustrates the results obtained from question 4 (Addendum D) on the research stage. The majority of the respondents (21/68, 30.9%) were involved with empirical research, followed by those in the process of publishing (13/68, 19.1%). The rest of the respondents were in the process of editing and finalisation of a dissertation or thesis (9/68, 13.2%), making a choice of research methodology (7/68, 10.3%), doing comprehensive literature analysis (6/68, 8.8%), or generating ideas and initial literature scanning (5/68, 7.4%). The remaining group of respondents were either involved with proposal writing (3/68, 4.4%) or with other tasks (3/68, 4.4%). One researcher (1/68, 1.5%) did not answer the question.

The position respondents held in the engineering department at the time of the survey, and whether they were involved in postgraduate supervision respectively are illustrated in Table 0.6 (a, b) below.

**Table 0.6 Position in academic department and involvement with post-graduate supervision**

<b>Table 0.6a</b>			<b>Table 0.6b</b>		
<b>Position</b>	<b>Frequency N=68</b>	<b>%</b>	<b>Supervision Involvement</b>	<b>Frequency N=89</b>	<b>%</b>
Not a staff member	34	50	Not supervising	47	52.8
Senior lecturer	10	14.7	Supervising:		
Research assistant	5	7.4	Honours	12	13.5
Lecturer	4	5.9	Masters	16	18.0
Full Professor	3	4.4	Doctoral	11	12.4
Associate Professor	3	4.4	Post-doctoral	3	3.4
Junior lecturer	2	2.9			
Post-doctoral appointee	1	1.5			
Other	5	7.4			
Not answered	1	1.5			

Table 0.6a reflects the data obtained in question 5 (Addendum D) where respondents had to indicate their current position in their academic departments. Half of the respondents were not staff members (34/68, 50%), followed by senior lecturers (10/68 (14.7%). The rest of the respondents 5/68 (7.4%) were research assistants, lecturers 4/68 (5.9%), associate or full professors 3/68 (4.4%), or junior lecturers 2/68 (2.9%). One respondent was a postdoctoral appointee 1/68 (1.5%), and one researcher 1/68 (1.5%) did not answer the question on his/her position in the engineering department.

Table 0.6b illustrates the responses obtained from question 6 (Addendum D) on involvement in supervision, with the majority of respondents 47/89 (52.8%) indicating that they were not supervising students. Those who did supervise students were spread over master's level 16/89 (18.4%) and honours level 12/89 (13.5%), followed by those supervising students on doctoral level 11/89 (12.4%), and post-doctoral level 3/89 (3.4%).

The nature of collaboration between engineering researchers at the time of taking part in the survey is illustrated in Table 0.7 below. Respondents had the opportunity to mark all applicable options, which indicated the extent of collaboration activities.

**Table 0.7 Nature of collaboration between engineering researchers**

Nature of Collaboration between Researchers (N=87)	Number of Responses per Category	%
Academic institutions	26	29.9
Industry-specific	26	29.9
No collaboration	23	26.4
Government departments	10	11.5
Other sources of collaboration	2	2.3

Table 0.7 illustrates the responses obtained to question 7 (Addendum D) on the nature of collaboration among postgraduate researchers, and shows that where respondents did collaborate with other researchers, collaboration was spread between industry (26/87, 29.9%), academic institutions (26/87, 29.9%), and government departments (10/87, 11.5%). A total of 23/87 respondents (26.4%) indicated that they did not collaborate. Two/87 respondents (2.3%) indicated that they also collaborated with other sources.

None of the respondents answered the question on the NRF rating (question eight), since no rated researcher completed the questionnaire survey.

The following section of this chapter will cover the remaining questions asked in the questionnaire, and will start with responses obtained from question 9 onwards, which referred to the conceptualisation of a research topic and initial exploration of the literature.

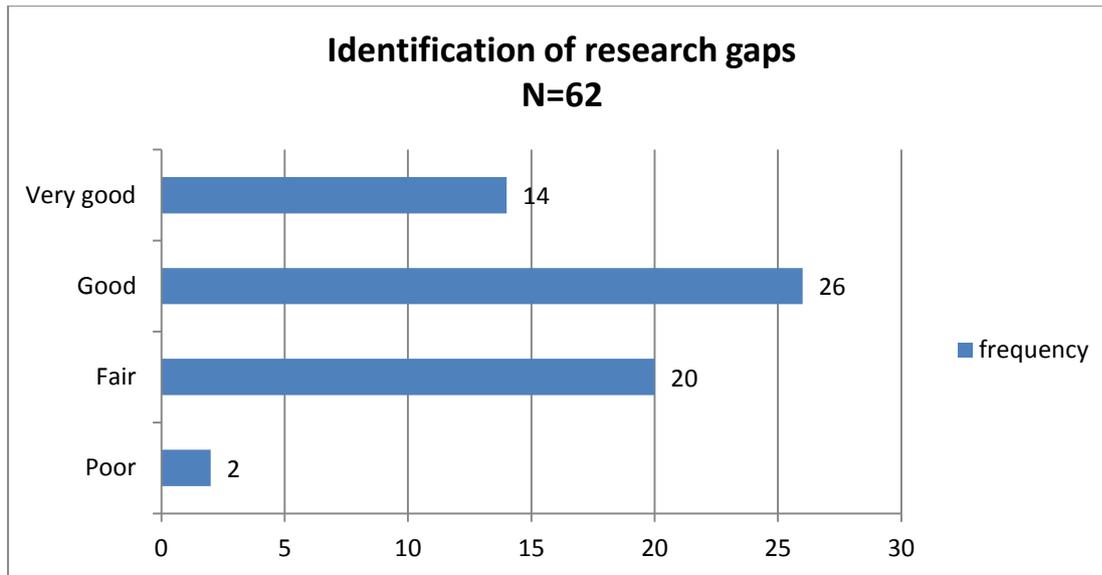
### **5.3.2 Conceptualisation of a research topic and initial exploration of the literature**

The following results cover the first research phase, namely the conceptualisation of a research topic and initial exploration of the literature. Questions 9 and 10 (Addendum D) explored skills relevant to conceptualising a research topic, with question 9 focusing on specifically the following skills: identification of a research gap from existing literature, determining if somebody else was working on a topic, refining the topic to be researchable, formulating a research problem, formulating a hypothesis, using electronic databases to identify a research topic, visualising relationships between concepts (e.g. mind maps or concept maps) and identifying experts in a field of study. Respondents were requested to rate their skills on a four-point Likert scale with the following options: poor, fair, good and very good. The results obtained from respondents regarding these eight skills are reflected in Figure 0.2 to Figure 0.9, and discussed in sections 5.3.2.1 to 5.3.2.10.

### 5.3.2.1 Identifying a research gap from existing literature

A total of 62/68 (91.2%) of the participants in the study answered the question on their skills in identifying a research gap from existing literature. N was 62. Figure 0.2 reflects the self-reported perceptions of skills in identifying a research gap from existing literature.

**Figure 0.2 Self-reported perceptions of skills in identifying research gaps from existing literature**

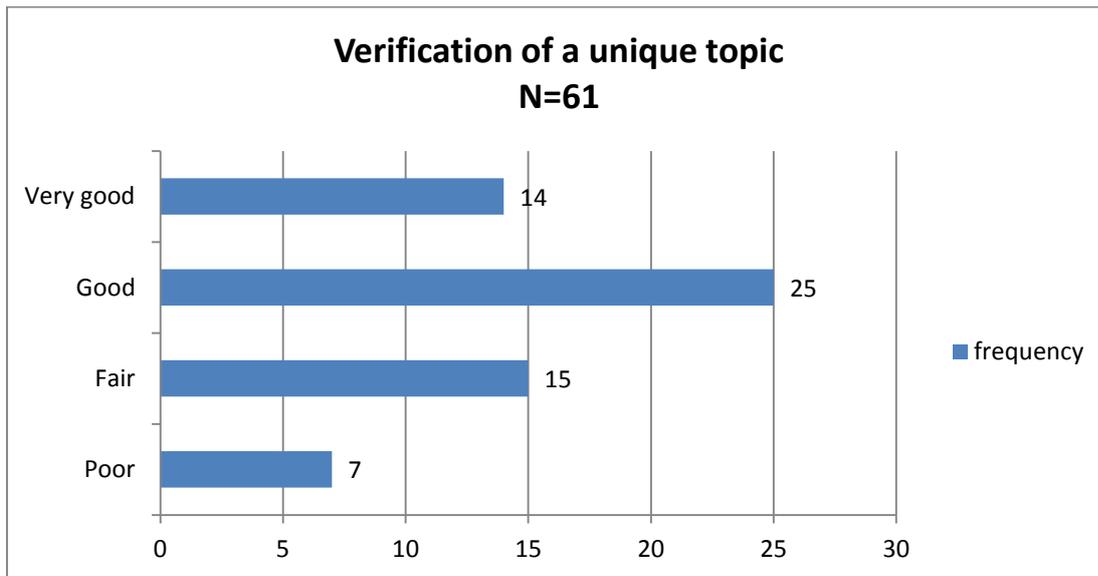


Fourteen of 62 (22.6%) respondents rated their skills in identifying a research gap from existing literature as very good, followed by those respondents who felt that their abilities were good (26/62, 41.9%), fair (20/62, 32.3%), and poor (2/62, 3.2%). The combination of good and very good (40/62, 64.5%) illustrates that most respondents felt that they were able to identify a research gap by exploring existing literature.

### 5.3.2.2 Determining if somebody else is working on a specific topic

Of the 68 participants in the study, 61 (89.7%) answered the question on their skills to determine if somebody else is working on the same topic. N was 61. The self-rated skills of respondents to verify a unique topic are illustrated in Figure 0.3.

**Figure 0.3 Self-reported perceptions of skills in verifying a unique research topic**

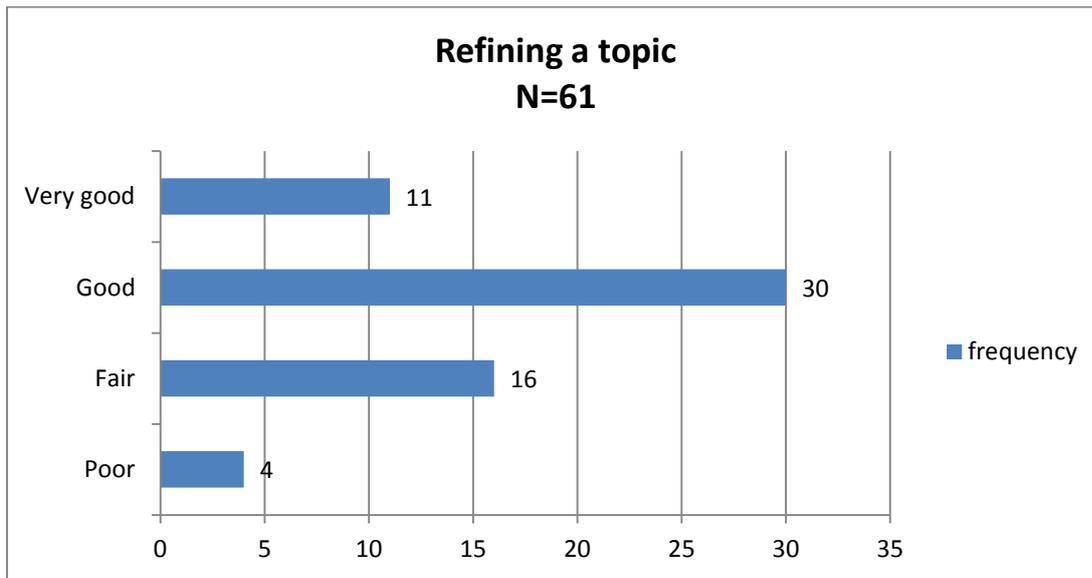


Of the 61 respondents who rated their skills to determine if others were working on a specific topic, 14/61 (23%) rated their skills as very good, followed by those who rated these skills as good (25/61, 41.0%), fair (15/61, 24.6%) or poor (7/61, 11.5%). The combination of good and very good (39/61, 64.0%) illustrates that the majority of respondents felt confident about the skill to determine if somebody else was working on a specific topic.

### 5.3.2.3 Refining a topic to be researchable

Of the 68 participants in the study, 61 (89.7%) answered the question where they had to rate their skills to refine a topic in order to be researchable (e.g. not too broad/general, not too narrow/specific). N was 61. The self-rated skills of respondents to refine a topic are depicted in Figure 0.4.

**Figure 0.4 Self-reported perceptions of skills in refining a topic**

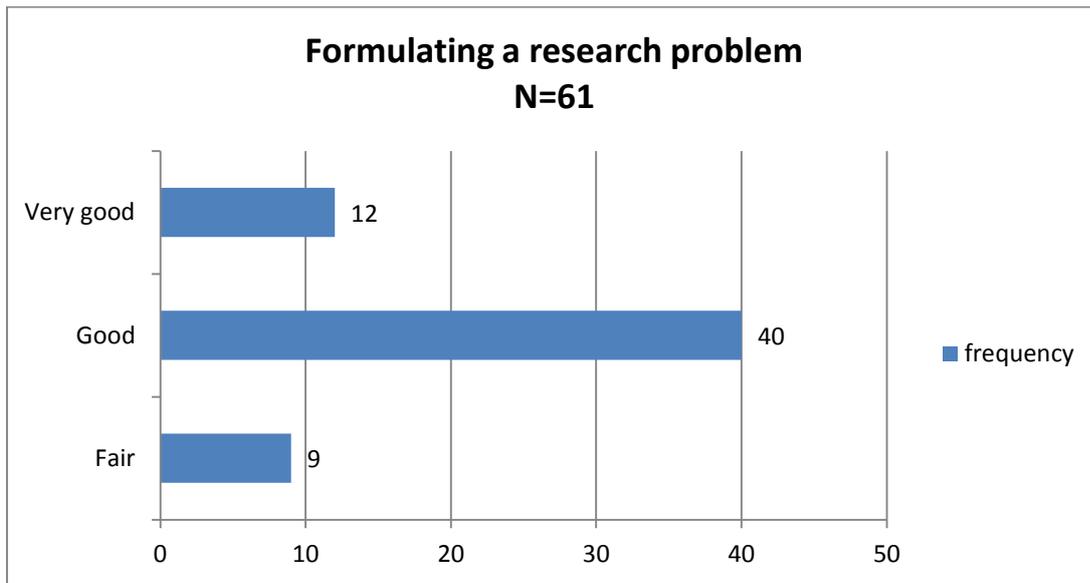


Eleven of 61 (18%) respondents rated their skills to refine a topic to be researchable as very good, followed by those who thought their skills were good (30/61, 49.2%), fair (16/61, 26.2%) or poor (4/61, 6.6%). The combination of good and very good (41/61, 67.2%) illustrates that the majority of researchers felt confident about their skills to refine a topic to be researchable.

#### 5.3.2.4 *Formulating a research problem*

Sixty-one of 68 (89.7%) participants in the study rated themselves regarding the formulation of a research problem. N was 61. The self-rated skills of respondents to formulate a research problem are illustrated in Figure 0.5.

**Figure 0.5 Self-rated perceptions of skills in formulating a research problem**

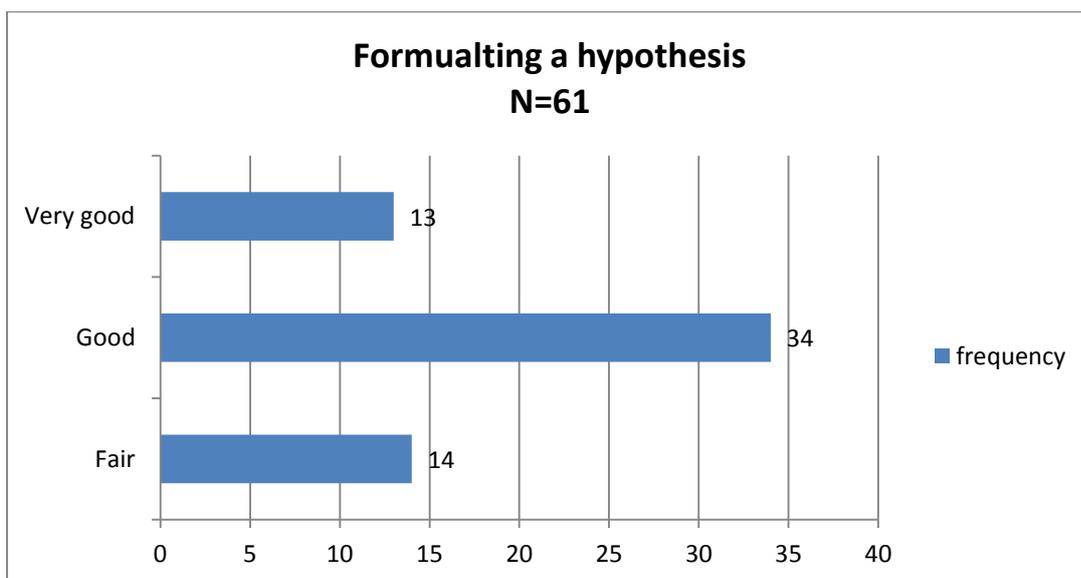


The combination of responses reported as good and very good demonstrated that most (52/61, 85.3%) respondents felt confident about their skills to formulate a research problem, with only (9/61, 14.8%) rating themselves as fair.

#### 5.3.2.5 Formulating a hypothesis

Of the 68 participants in this study, 61 (89.7%) answered the question on their skills to formulate a hypothesis. N was 61. The self-rated skills of respondents to formulate a hypothesis are illustrated in Figure 0.6.

**Figure 0.6 Self-reported perceptions of skills in formulating a hypothesis**

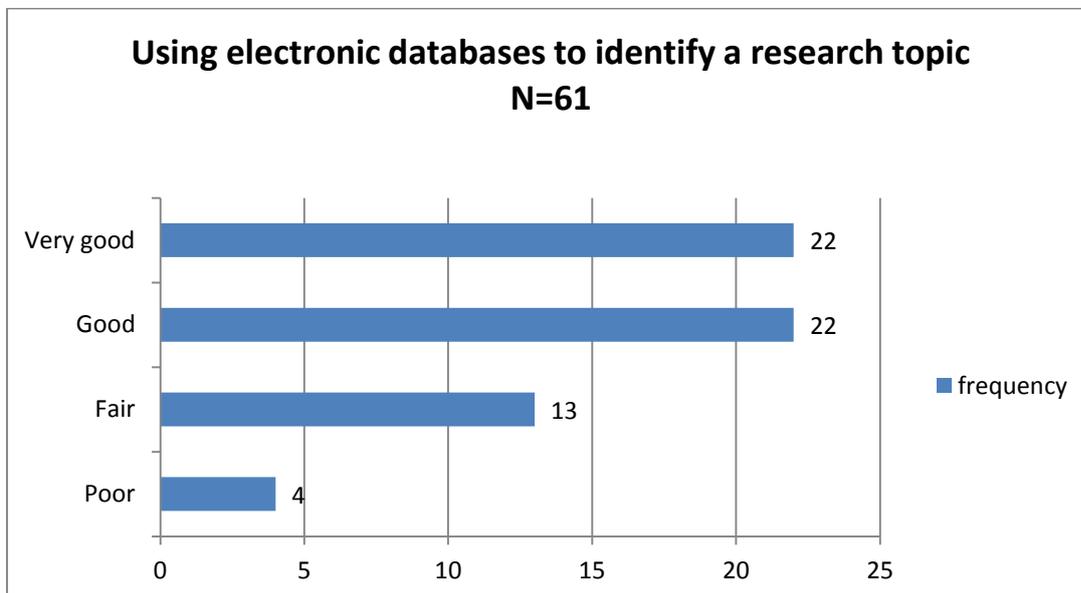


Respondents who rated their skills in formulating of a hypothesis as very good numbered 13/61 (21.3%), followed by those who rated themselves as good (34/61, 55.7%) or fair (14/61, 23%). The combination of good and very good at 47/61 (77.0%) illustrates that most respondents felt confident about their skills to formulate a hypothesis.

#### 5.3.2.6 *Using electronic databases to identify a research topic*

Sixty-one of 68 (89.7%) participants in the study answered the question on the use of electronic databases to identify a research topic. N was 61. The self-rated skills of respondents to use electronic databases to identify a research topic are depicted in Figure 0.7.

**Figure 0.7 Self-reported perceptions of skills in using electronic databases to identify a research topic**

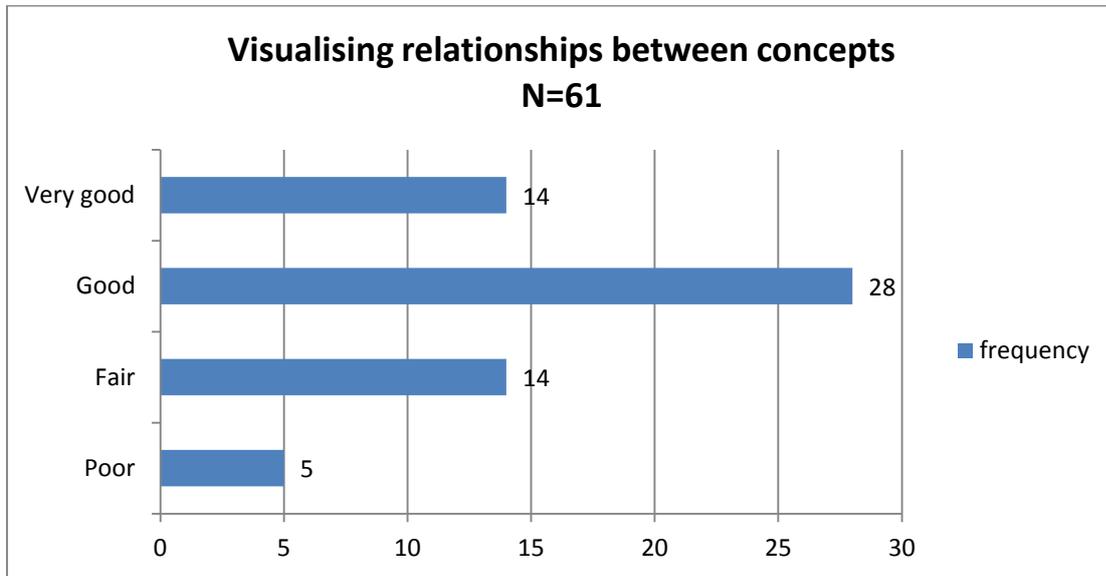


Twenty-two of 61 (36.1%) respondents rated their skills to use electronic databases to identify a research topic as very good, followed by 22/61 (36.1%) who rated this skill as good, with 13/61 (21.3%) rating it as fair and 4/61 (6.6%) as poor. When combining the results of good and very good (44/61, 72.2%), it shows that the majority of respondents were confident about this specific skill.

#### 5.3.2.7 *Visualising relationships between concepts*

Sixty-one of 68 (89.7%) participants in this study answered this question. N was 61. The self-rated skills of respondents to visualise relationships between concepts are depicted in Figure 0.8.

**Figure 0.8 Self-reported perceptions of skills in visualising relationships between concepts**

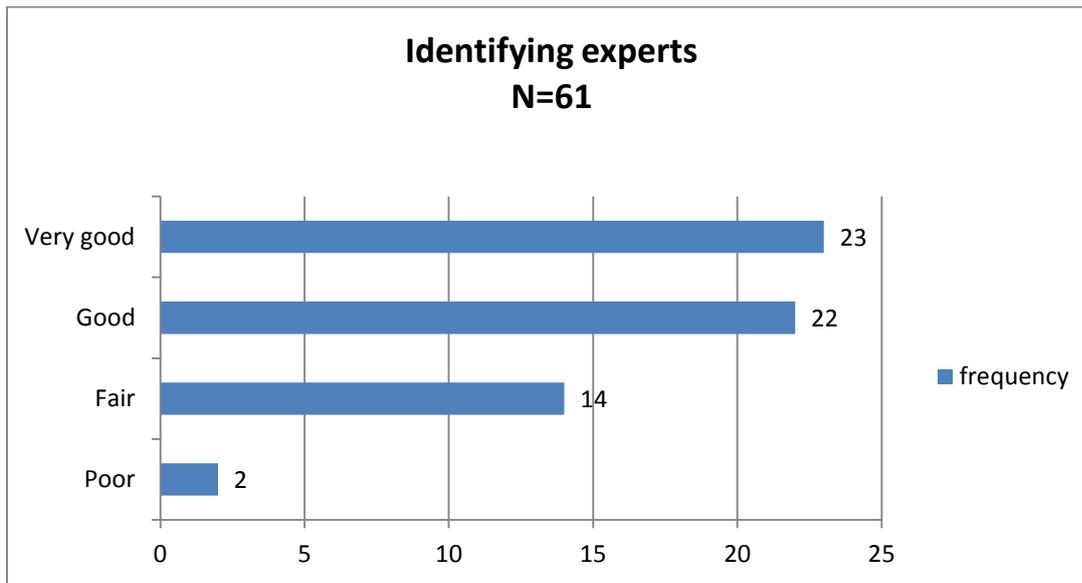


Of 61 respondents, 14 (23%) rated their skills to visualise relationships between concepts through mind/concept maps as very good, with 28/61 (45.9%) rating it as good, fair (14/61, 23%) or poor (5/61, 8.2%). The combination of good and very good (42/61, 68.9%) illustrates that the majority of respondents felt confident about their skills to visualise relationships between concepts.

#### 5.3.2.8 Identifying experts in a field of study

Of the 68 participants in this study, 61 (89.7%) answered the question on the identification of experts in their field of study. N was 61. The self-rated skills of respondents to identify experts in a field of study are illustrated in Figure 0.9.

**Figure 0.9 Self-reported perceptions of skills in identifying experts in a field**



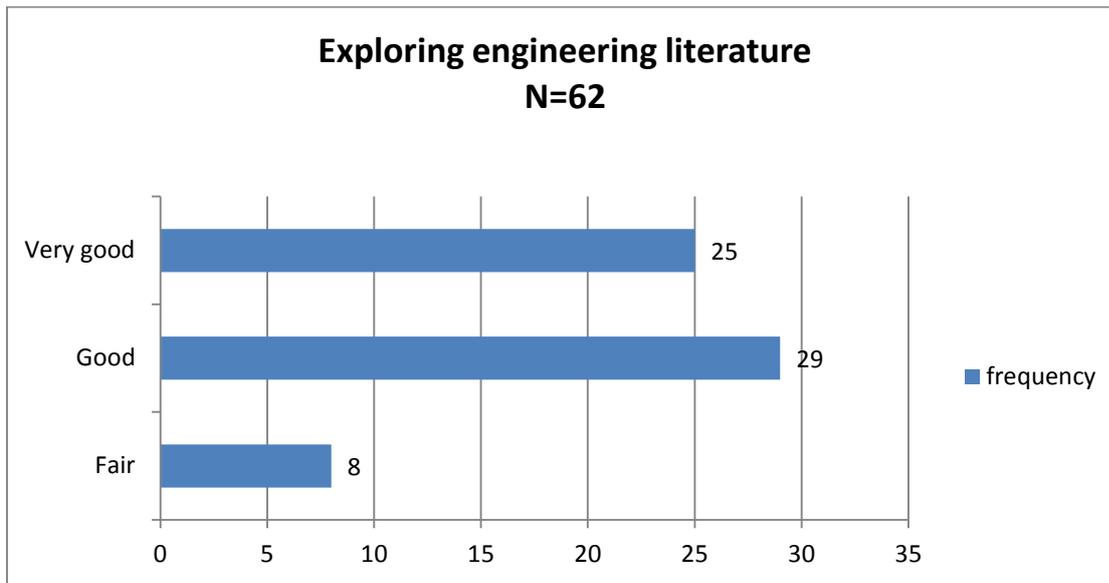
Twenty-three of 61 respondents (37.7%) rated their skills to identify experts in a field of study as very good, followed by those who rated them as good (22/61, 36.1%), fair (14/61, 23.0%) or poor (2/61, 3.3%). The combination of good and very good (45/61, 73.8%) illustrates that the majority of respondents felt confident about their skills to identify experts in a field of study.

#### 5.3.2.9 Exploring engineering literature

Question 10 (Addendum D) focused on skills relevant to the exploration of research literature. This question focused on literature in not only the engineering field, but also in other disciplines. The ability of researchers to explore literature in other disciplines (multi-, inter- and trans-disciplinary) was specifically mentioned in the proposed ARIL definition, and a question was consequently developed that requested respondents to rate their skills in exploring literature in both instances. Results of question 10 are depicted in Figure 0.10 and Figure 0.11.

Sixty-two of 68 (91.2%) participants in this study answered the question. N was 62. The self-rated skills of respondents to explore engineering literature are depicted in Figure 0.10.

**Figure 0.10 Self-reported perceptions of skills in exploring engineering literature**

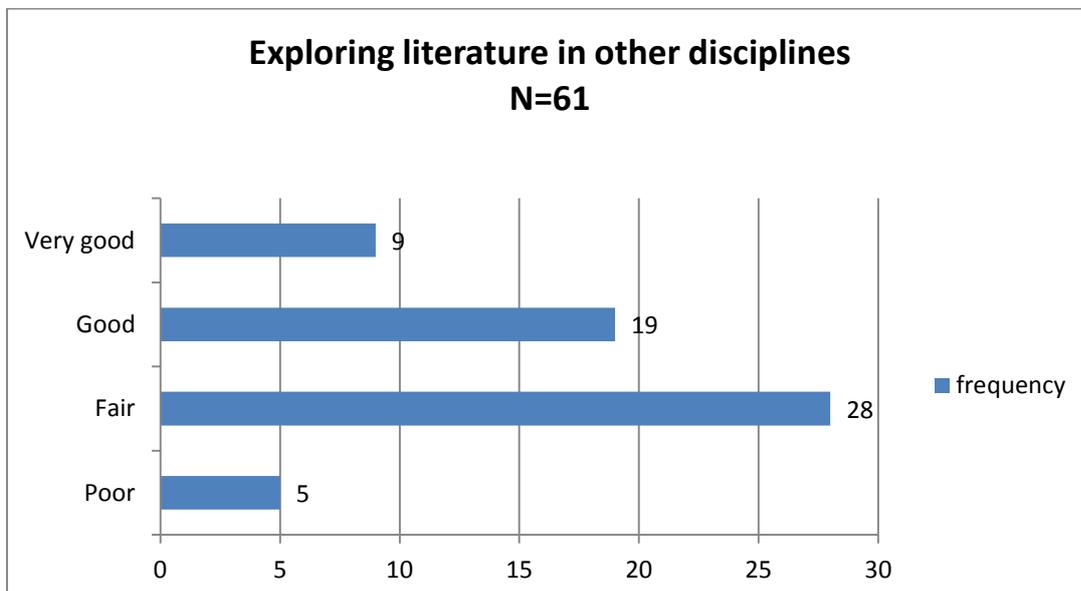


The question on skills to explore engineering literature was answered by 25/62 (40.3%) respondents who rated this skill as very good, 29/62 (46.8%) as good and 8/62 (12.9%) as fair. The combination of good and very good (54/62, 87.1%) illustrates that the majority of respondents were confident about their skills to explore engineering literature.

#### 5.3.2.10 Exploring literature in disciplines other than engineering

Of the 68 participants in the study, 61 (89.7%) answered the question. N was 61. The self-rated skills of respondents to explore literature in other disciplines are illustrated in Figure 0.11.

**Figure 0.11 Self-reported perceptions of skills in exploring literature in other disciplines**



Only 9/61 (14.8%) respondents rated their skills in exploring literature in disciplines other than engineering as very good. The rest of the respondents rated themselves as good (19/61, 31.1%), fair (28/61, 45.9%) and poor (5/61, 8.2%). An analysis of these responses revealed that an equal number of respondents (45.9%) indicated this skill as good and very good in comparison with those who rated their skill as fair.

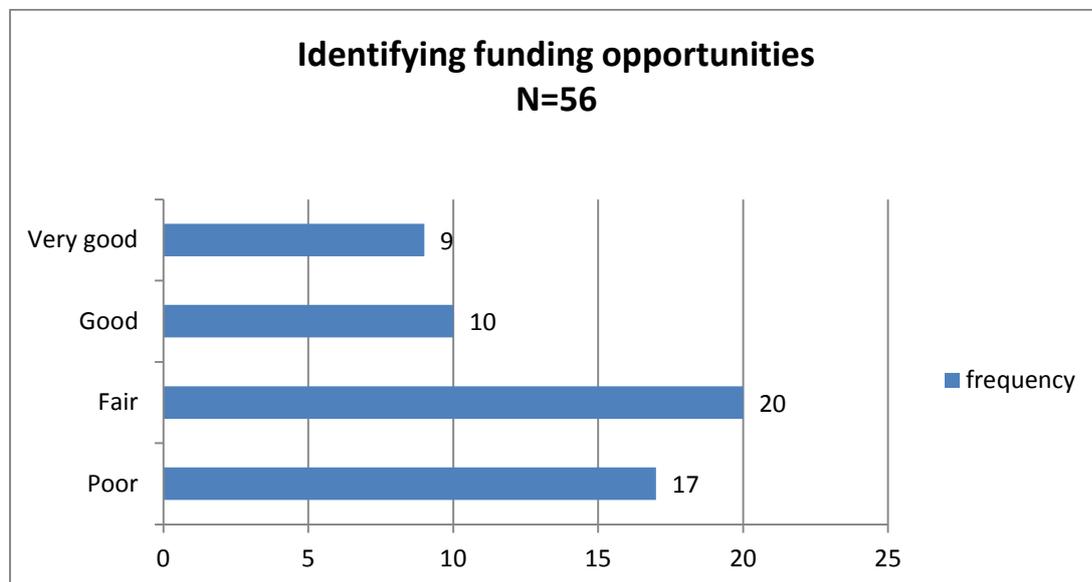
### 5.3.3 Research funding

Obtaining research funding was covered in the next set of questions posed in the questionnaire. Questions 11 and 12 (Addendum D) were formulated to test the skills of respondents in obtaining research funding; they had to rate their skills by marking the relevant option from a four-point Likert scale with the following scales: poor, fair, good and very good. Respondents were requested to rate their skills in identifying possible funding opportunities in question 11, and results are depicted in Figure 0.12.

#### 5.3.3.1 Identifying possible funding opportunities for research

Of the 68 participants in the study, 56 (82.4%) answered this question. N was 56. Figure 0.12 reflects the self-reported skills of respondents in identifying funding opportunities.

**Figure 0.12 Self-reported perceptions of skills in identifying funding opportunities**



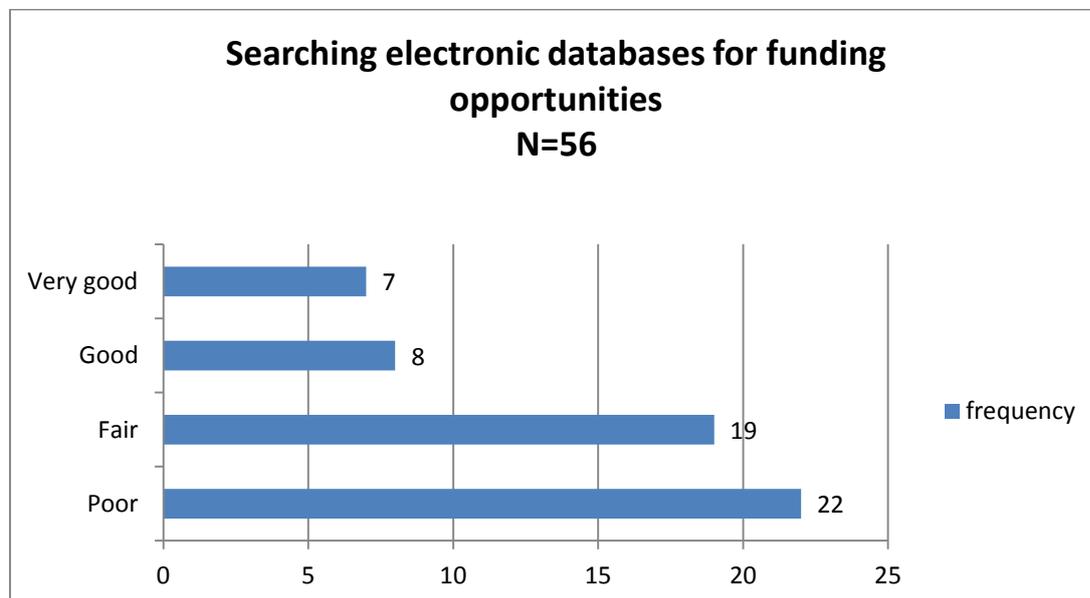
Of the 56 respondents, only nine (16.1%) rated their skills to identify possible funding opportunities as very good and 10 (17.9%) as good, whereas 20 (35.7%) and 17 (30.4%) respondents thought their skills were fair or poor, respectively. The combination of fair and poor (37/56, 66.1%) illustrates that the majority of respondents did not feel confident about their skills to identify possible funding opportunities.

### 5.3.3.2 Searching electronic databases to discover funding opportunities

Question 12 (Addendum D) requested respondents to rate their skills with specific reference to three processes, namely searching electronic databases to discover funding opportunities, creating alerts in order to receive funding alerts automatically and compiling funding proposals. The results of their responses are illustrated in Figure 0.13, Figure 0.14 and Figure 0.15 and discussed in sections 5.3.3.2 to 5.3.3.4.

Fifty-six of 68 (82.4%) participants in the study answered this question N was 56. Figure 0.13 reflects the self-rated skills of respondents in searching electronic databases to discover funding opportunities.

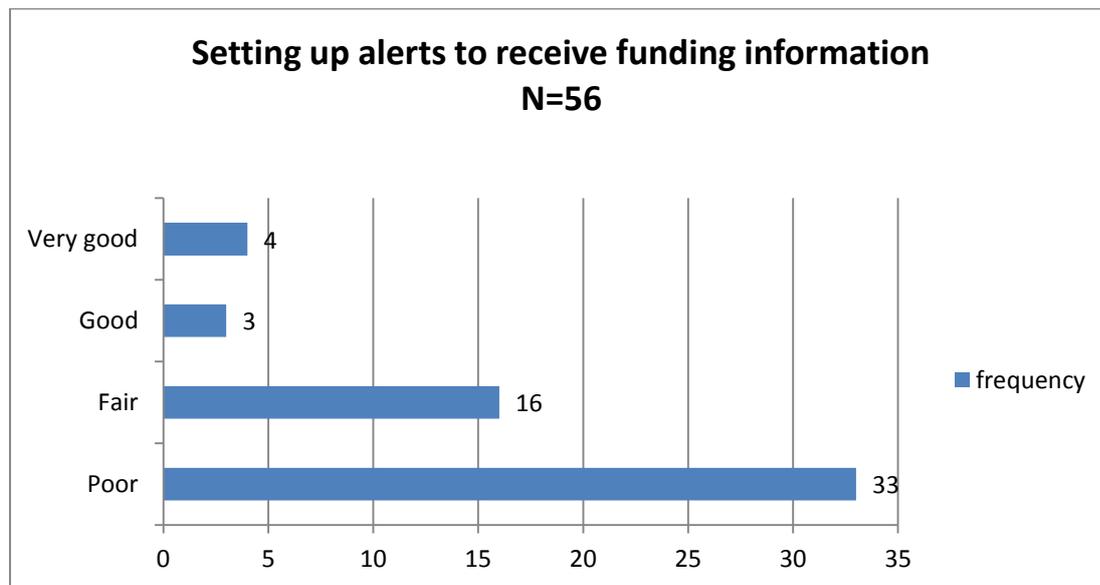
**Figure 0.13 Self-reported perceptions of skills in searching electronic databases to discover funding opportunities**



Of the 56 respondents to the question, 7/56 (12.5%) and 8/56 (14.3%) indicated that their skills to search electronic databases in order to discover funding opportunities were very good or good respectively. The combination of poor (22/56, 39.3%) and fair (19/56, 33.9%) illustrates that the majority of respondents (41/56, 73.2%) did not feel confident about searching electronic databases to discover funding opportunities.

5.3.3.3 *Setting up electronic alerts to receive updates of funding information automatically*  
 Fifty-six of 68 (82.4%) participants in the study answered the question about their skills to set up electronic alerts to receive updates of funding information automatically; 12/56 (17.6%) did not answer the question. The findings for this question are thus presented in relation to the number of responses to the question, namely N=56. Figure 0.14 depicts the self-rated skills of respondents in setting up electronic alerts for funding information.

**Figure 0.14 Self-reported perceptions of skills in setting up alerts to receive funding information**

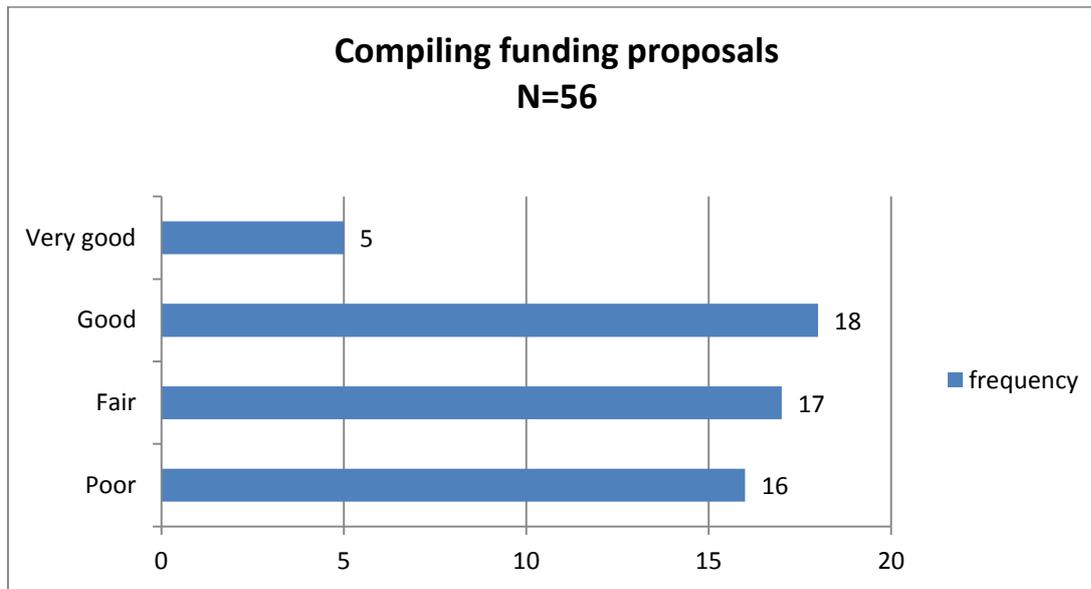


A small number of respondents rated their skills to set up electronic alerts to receive updates of funding information automatically as very good (4/56, 7.1%) or good (3/56, 5.4%). The remainder of the respondents indicated their skills in this regard to be fair (16/56, 28.6%) or poor (33/56, 58.9%). The combination of fair and poor (49/56, 87.5%) illustrates that the majority of respondents did not feel confident about their skills to set up electronic alerts in order to receive updates of funding information automatically.

#### 5.3.3.4 *Compiling funding proposals*

Respondents were asked to rate their skills to compile funding proposals, and 56/68 (82.4%) participants in the study answered the question. N was 56. Figure 0.15 reflects the self-rated skills of respondents in compiling funding proposals.

**Figure 0.15 Self-reported perceptions of skills in compiling funding proposals**



Responses regarding skills to compile funding proposals ranged between very good (5/56, 8.9%), poor (16/56, 28.6%), fair (17/56, 30.4%) and good (18/56, 32.1%). The combination of fair and poor (33/56, 59%) illustrates that just over half of the respondents did not feel confident about compiling funding proposals.

The following paragraphs will report on the self-reported skills of respondents regarding the discovery of information.

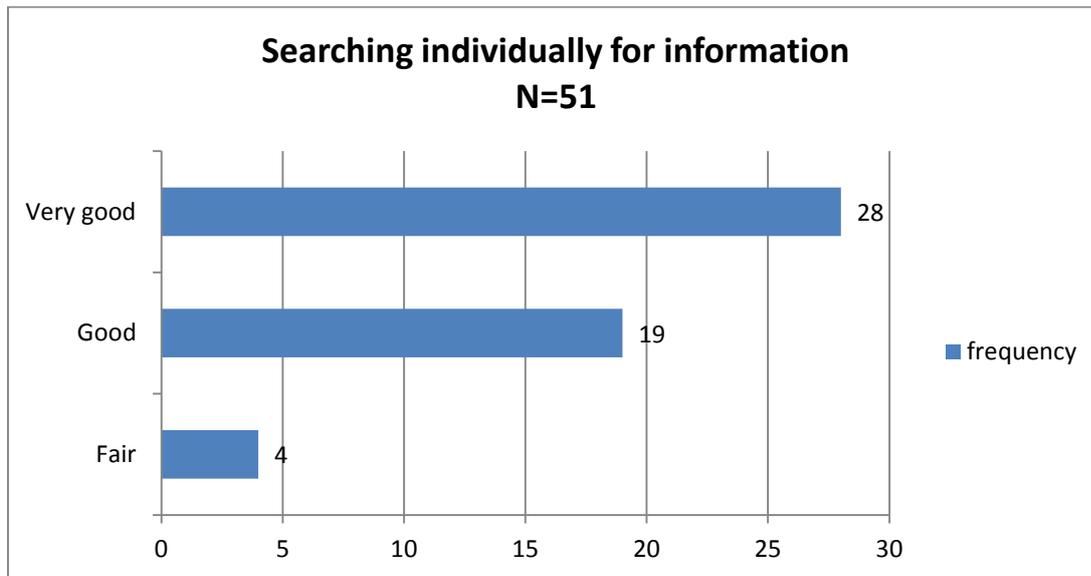
### 5.3.4 Information discovery

The discovery of information was the third research phase tested in the questionnaire, and five questions (Questions 13-17, Addendum D) were developed to assess participants' self-rated skills when searching for information relevant to their research topics. A four-point Likert scale with the options poor, fair, good and very good was provided to answer all the questions. Question 13 focused on skills when searching for information individually, as well as searching in collaboration with others. Results of responses are illustrated in Figure 0.16 and Figure 0.17 and discussed in sections 5.3.4.1 and 5.3.4.2.

#### 5.3.4.1 Skills to search for research information individually

Respondents were requested to rate their skills regarding searching for information individually. Fifty-one of 68 (75%) participants answered the question. N was 51. Figure 0.16 reflects the self-reported perceptions of skills in searching individually for information.

**Figure 0.16 Self-reported perceptions of skills in searching for information individually**

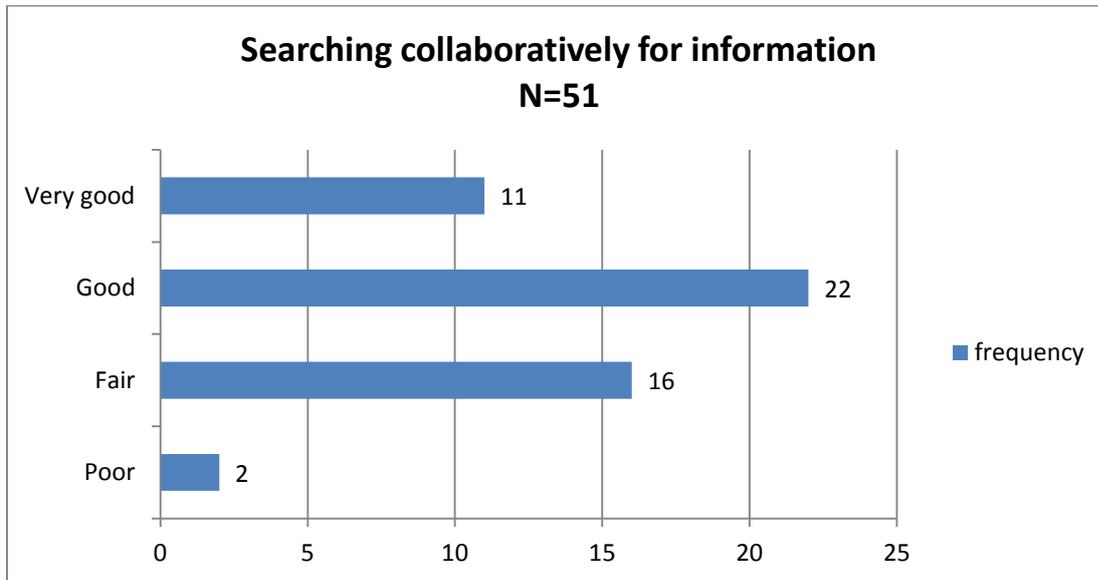


Of 51 respondents, 28/51 (54.9%) rated their skills to search for information individually as very good, followed by those who rated them as good 19/51 (37.7%) or fair 4/51 (7.8%). The combination of very good and good (47/51, 92.2%) illustrates that the majority of respondents were confident about their skills to search for information individually.

#### 5.3.4.2 Skills to search for research information through collaborating with others

Respondents were requested to rate their skills to search for research information through collaborating with others and 51/68 (75.0%) participants answered the question. N was 51. Figure 0.17 reflects the self-reported perceptions of skills in searching collaboratively for information.

**Figure 0.17 Self-reported perceptions of skills in searching collaboratively for research information**



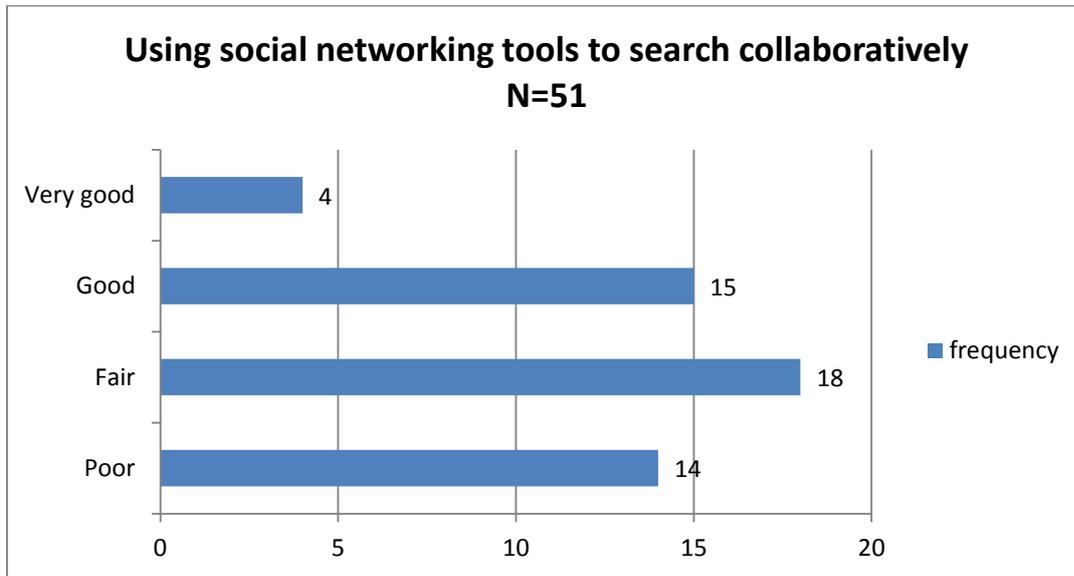
Skills to search collaboratively for research information were rated as very good by 11/51 (21.6%), followed by those rating this skill as good (22/51, 43.1%), fair (16/51, 31.4%) or poor (2/51, 3.9%). The combination of very good and good (33/51, 64.7%) illustrates that the majority of respondents felt confident about searching collaboratively for research information.

#### 5.3.4.3 Using social networking tools on the internet when searching for information

Question 14 (Addendum D) was developed to test the skills of respondents relevant to the discovery of research information, with specific reference to including other researchers. The notion of collaboration is also mentioned in the proposed ARIL definition, which highlights the importance of networking and collaboration between researchers. Question 14 therefore specifically focused on skills during collaborative searching, and respondents were requested to rate their skills in employing the following four resources: social networks, academic communities on the internet, virtual research environments and electronic mail. Results are reflected in Figure 0.18 to Figure 0.21 and discussed in sections 5.3.4.3 to 5.3.4.6.

Fifty-one of 68 (75%) participants in the study rated their skills in the use of social networking tools when including others while searching for information, while 17/68 (25%) did not answer the question. The findings for this question are thus presented in relation to the number of responses to the question, namely N=51. Results in using social networking tools when searching collaboratively for information are illustrated in Figure 0.18.

**Figure 0.18 Self-reported perceptions of skills in searching collaboratively through using social networking tools**

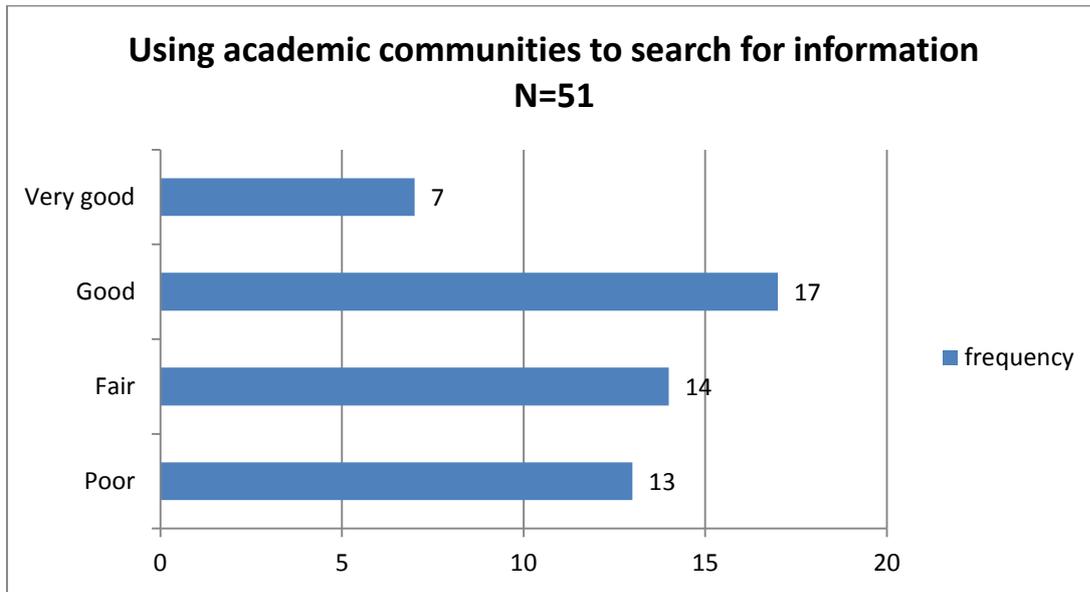


Self-reported skills to search collaboratively for information through the use of social networking tools on the internet were rated as very good by 4/51 (7.8%); 15/51 (29.4%) rated them as good, 18/51 (35.3%) as fair and 14/51 (27.5%) as poor. The combination of fair and poor (32/51, 62.2%) illustrates that the majority of respondents did not feel confident about using social networking tools to search collaboratively for information.

#### 5.3.4.4 *Employing academic communities on the internet when searching for information*

Respondents were requested to rate their skills to employ academic communities on the internet when searching for information, and 51/68 (75%) participants in the study rated their skills. N was 51. Figure 0.19 reflects the self-reported perceptions of skills in using academic communities when searching for information.

**Figure 0.19 Self-reported perceptions of skills in using academic communities to search for research information**

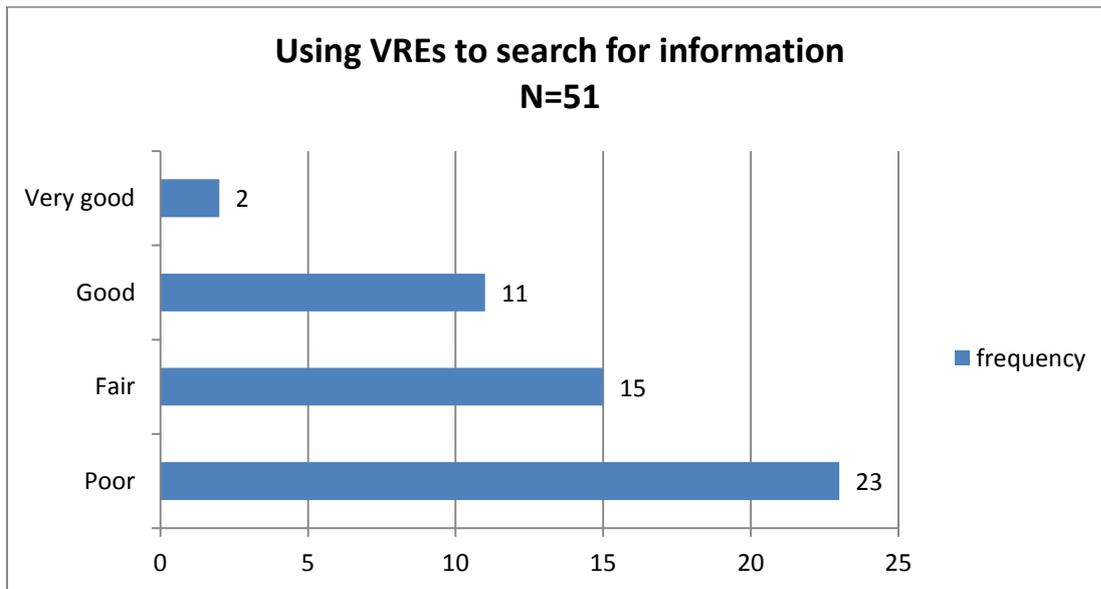


Responses differed slightly between fair 14/51 (27.5%) and poor 13/51 (25.5%) regarding skills to search collaboratively for information by using academic communities on the internet. Seven of 51 (13.7%) respondents rated this skill as very good or good 17/51 (33.3%). The combination of fair and poor (27/51, 53%) illustrates that just over half of the respondents did not feel confident about their skills to use academic communities on the internet when searching collaboratively for information.

#### 5.3.4.5 Using virtual research environments on the internet when searching for information

Fifty-one of 68 (75%) participants in the study rated their skills in using VREs when including others while searching for information, whereas 17/68 (25%) did not answer the question. The findings for this question are thus presented in relation to the number of responses to the question, namely N=51. Figure 0.20 reflects the self-reported perceptions of skills in using VREs when searching for information.

**Figure 0.20 Self-reported perceptions of skills in using VREs to search for information**

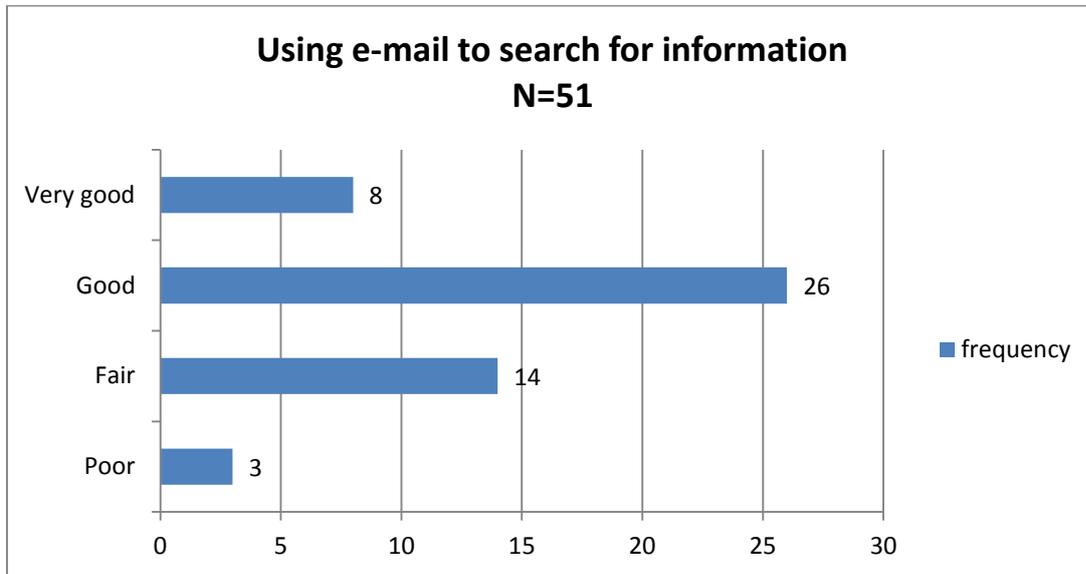


The majority of respondents rated their skills to search collaboratively through VREs as poor (23/51, 45.1%), followed by those who rated them as fair (15/51, 29.4%). The rest of the respondents marked the good (11/51, 21.6%) or very good (2/51, 3.9%) responses. The combination of fair and poor (38/51, 74.5%) illustrates that most respondents did not feel confident about using VREs to search collaboratively for research information.

#### 5.3.4.6 *Using electronic mail when searching for information*

Fifty-one of 68 (75%) participants in the study rated their skills in using electronic mail when including others to search for information. N was 51. Figure 0.21 reflects the self-reported perceptions of skills in using electronic mail to search for information.

**Figure 0.21 Self-reported perceptions of skills in searching for research information by using electronic mail**



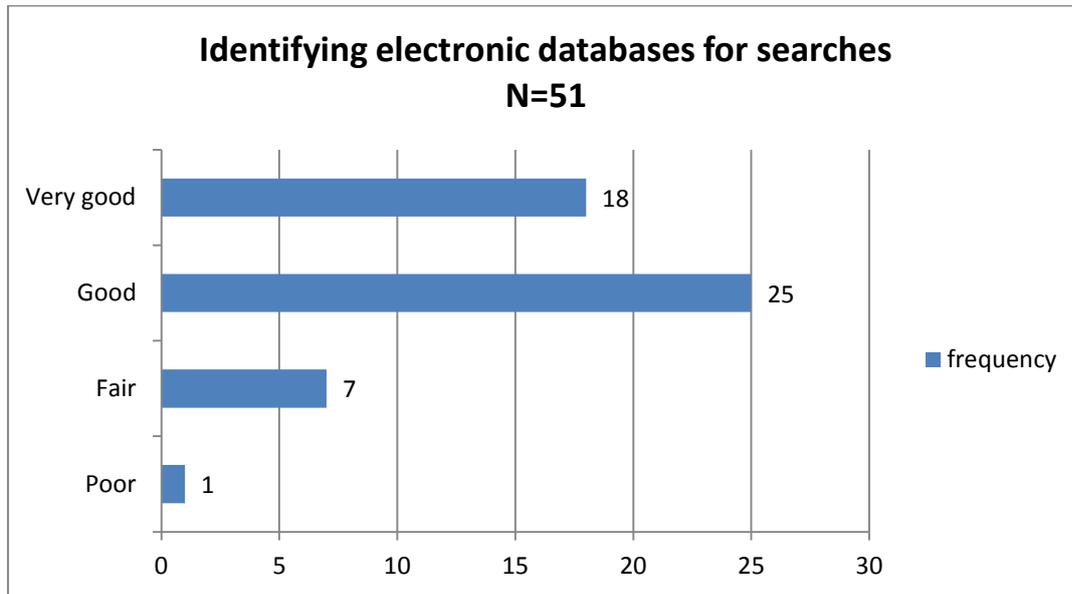
Skills to search collaboratively by using electronic mail were reported as good by 26/51 (51%), whereas 8/51 (15.7%) rated this skill as very good. The rest of the respondents rated their skills as fair 14/51 (27.5%) and 3/51 (5.9%) indicated that their skills in this regard were poor. The combination of very good and good (34/51, 66.7%) illustrates that the majority of respondents felt confident about using electronic mail when searching collaboratively for information.

#### 5.3.4.7 Identifying relevant electronic databases for searches

Question 15 (Addendum D) requested respondents to rate their skills relevant to the discovery of information with specific reference to the following six processes: identifying relevant electronic databases, searching and locating full-text engineering publications, searching and locating information in disciplines other than engineering, searching and locating technical information, searching and locating information on graphical formats, and identifying and locating people as information resources. Results obtained in question 15 are depicted in Figure 0.22 to Figure 0.27, and discussed in sections 5.3.4.7 to 5.3.4.12.

Of the 68 participants in the study, 51 (75%) rated their skills in identifying relevant electronic databases for searches. N was 51. Figure 0.22 reflects the self-reported perceptions of skills in identifying relevant electronic databases for searches.

**Figure 0.22 Self-reported perceptions of skills in identifying relevant electronic databases for searches**

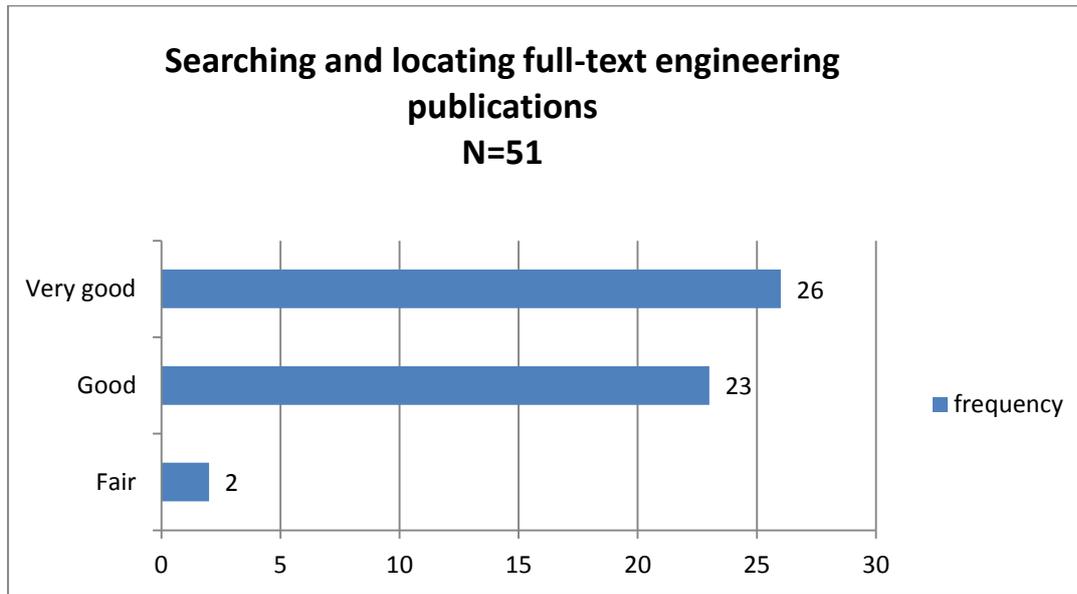


Respondents who rated their skills to identify relevant electronic databases for searches as good numbered 25/51 (49%), with a further 18/51 (35.3%) who thought they were very good. The rest of the respondents indicated their skills as fair 7/51 (13.7%) and a single respondent 1/51 (2.0%) marked the option of poor. The combination of good and very good (43/51, 84.3%) illustrates that the majority of the respondents felt confident about identifying relevant electronic databases for searches.

#### 5.3.4.8 Searching and locating full-text engineering publications

Fifty-one of 68 (75%) participants in the study rated their skills in searching and locating full-text engineering publications. N was 51. Figure 0.23 reflects the self-reported perceptions of skills in searching and locating full-text engineering publications.

**Figure 0.23 Self-reported perceptions of skills in searching and locating full-text engineering publications**

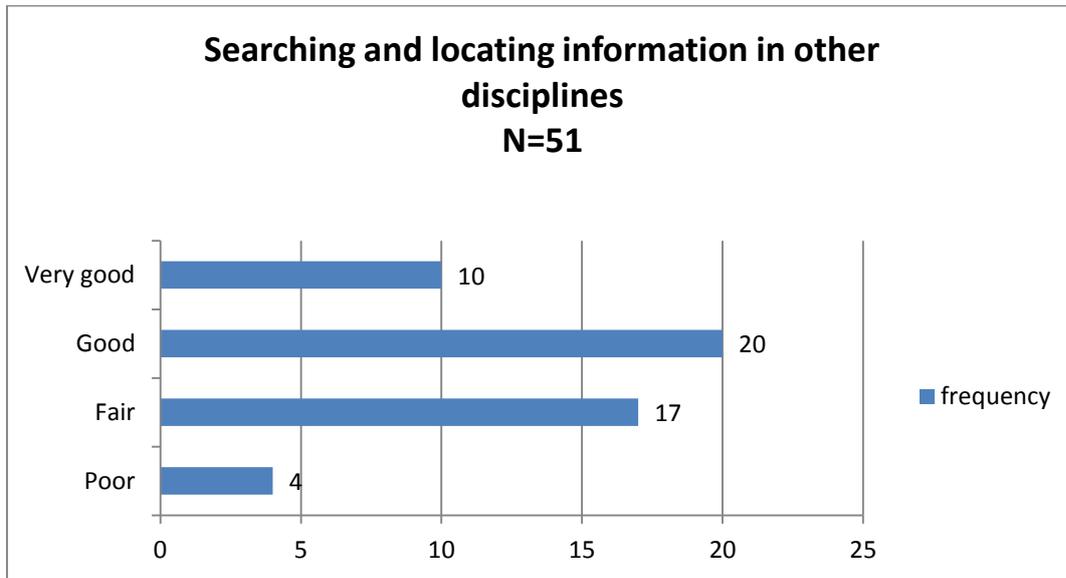


Respondents who rated their skills to search and locate full-text engineering publications as very good numbered 26/51 (51%), followed by those rating them as good (23/51, 45.1%), and fair (2/51, 3.9%). The combination of very good and good (49/51, 96.1%) illustrates that the majority of respondents felt confident about their skills to search for and locate full-text engineering publications.

#### 5.3.4.9 Searching and locating information in disciplines other than engineering

Fifty-one of 68 (75%) participants in the study rated their skills in searching and locating information in disciplines other than engineering. N was 51. Figure 0.24 reflects the self-reported perceptions of skills in searching and locating information in other disciplines.

**Figure 0.24 Self-reported perceptions of skills in searching and locating information in other disciplines**

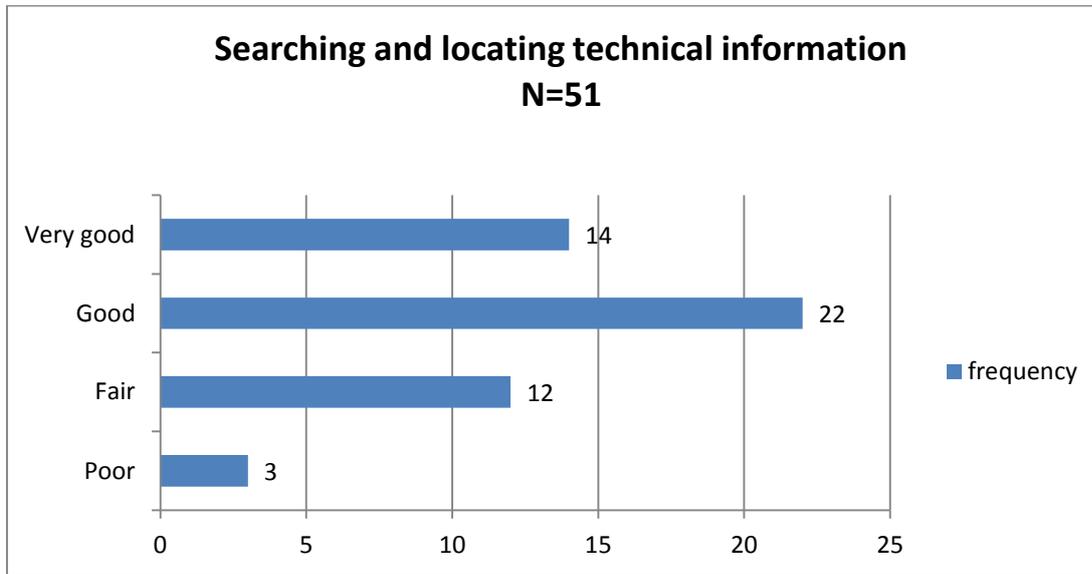


Of 51 respondents, 20 (39.2%) rated their skills to search and locate information in other disciplines as good, followed by who rated them as fair (17/51, 33.3%), very good (10/51, 19.6%) or poor (4/51, 7.8%). The combination of very good and good (30/51, 58.8%) illustrates that just over half of the respondents felt confident about their skills to search and locate information in other disciplines.

#### 5.3.4.10 Searching and locating technical information (e.g. patents, standards, technical reports)

Fifty-one of 68 (75%) participants in the study rated their skills in searching and locating technical information. N was 51. Figure 0.25 reflects the self-reported perceptions of skills in searching and locating technical information.

**Figure 0.25 Self-reported perceptions of skills in searching and locating technical information**

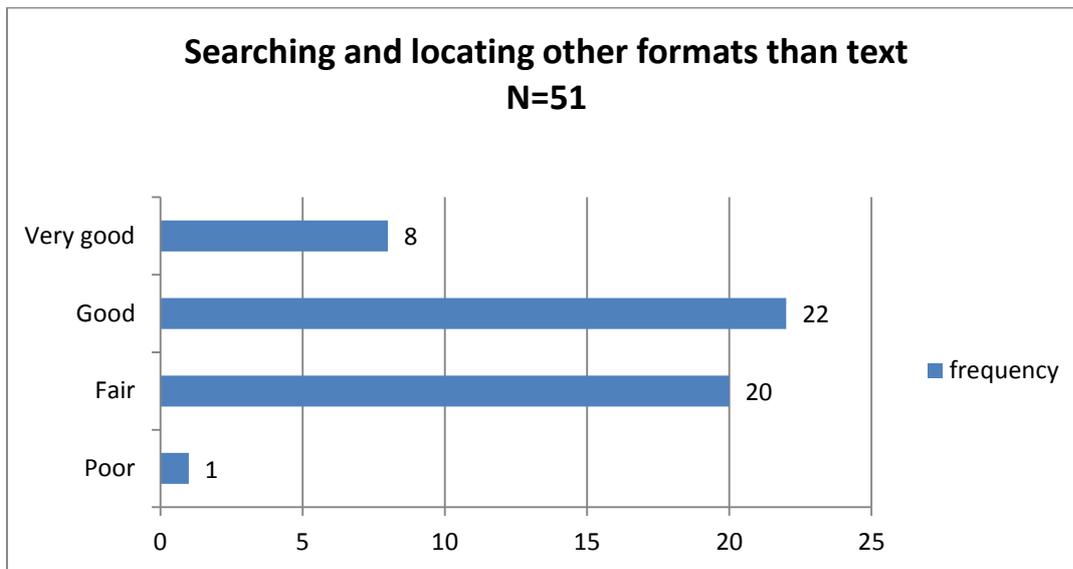


Skills to search and locate technical information as good were reported by 22/51 (43.2%) of respondents, followed by those who indicated their ability as very good 14/51 (27.5%), fair 12/51 (23.5%), or poor 3/51 (5.9%). The combination of very good and good (36/51, 70.6%) illustrates that the majority of respondents felt confident about searching and locating technical information.

#### 5.3.4.11 Searching and locating information in other formats than text (e.g. maps, graphs, images)

Fifty-one of 68 (75%) participants in the study rated their skills in searching and locating information in other formats. N was 51. Figure 0.26 reflects the self-reported perceptions of skills in searching and locating other formats than text.

**Figure 0.26 Self-reported perceptions of skills in searching and locating information in other formats than text**

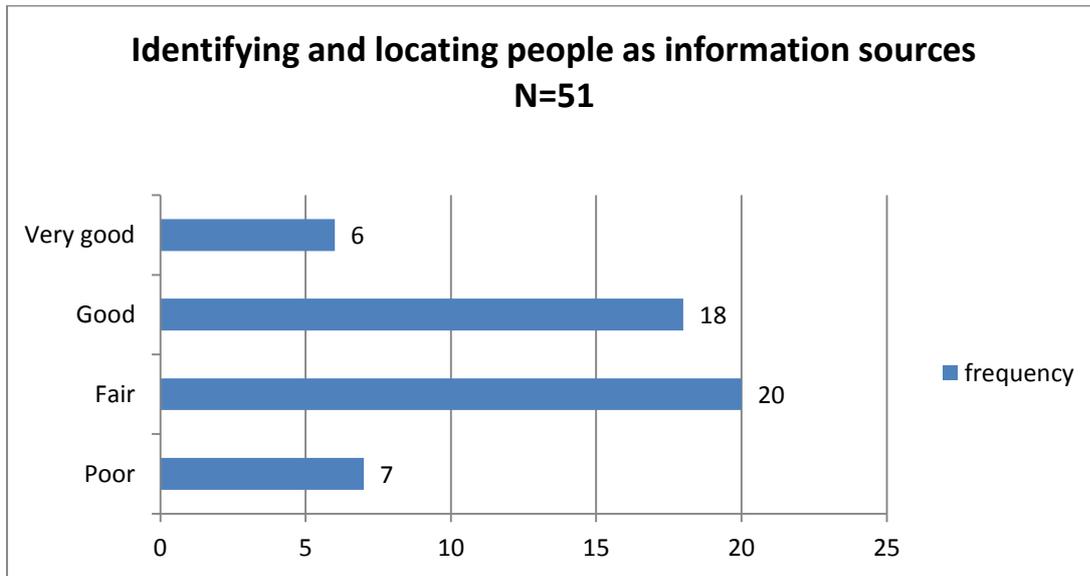


Almost half of the respondents rated their skills to search and locate information in non-text formats as good (22/51, 43.1%), followed by those who indicated their skill in this regard as fair (20/51, 39.2%), while 8/51 (15.7%) thought they were very good and 1/51 (2%) thought s/he was poor. The combination of very good and good (30/51, 58.8%) illustrates that just over half of respondents felt confident about searching and locating information in non-text formats.

#### 5.3.4.12 Identifying and locating people as information resources

Of the 68 participants in the study, 51 (75%) rated their skills to identify and locate people as information sources. N was 51. Figure 0.27 reflects the self-reported perceptions of skills in identifying and locating people as information sources.

**Figure 0.27 Self-reported perceptions of skills in identifying and locating people as information sources**



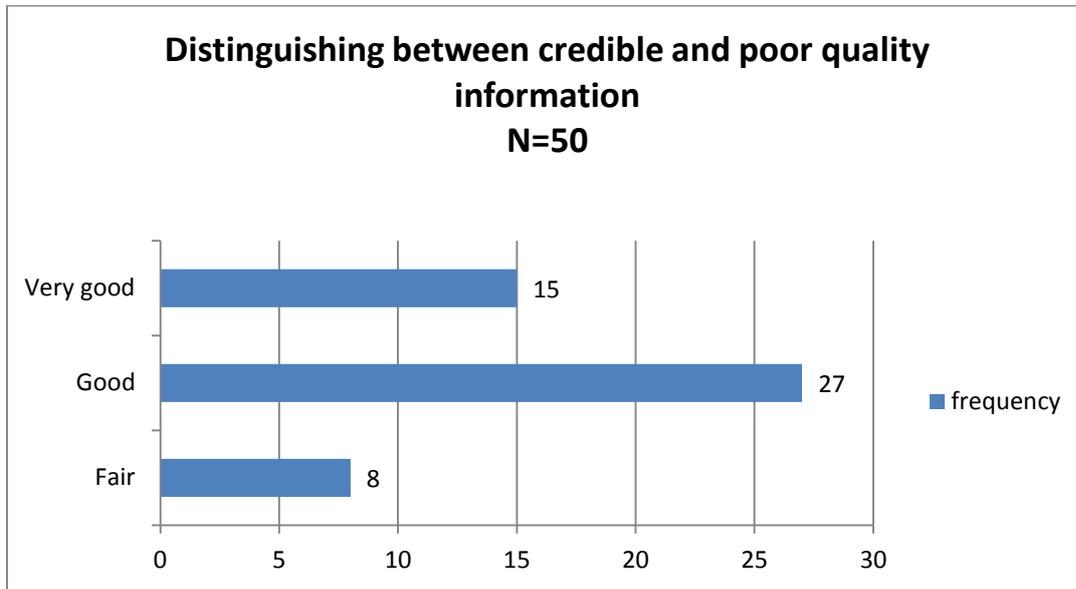
A small majority of respondents rated their skills to identify and locate people as information sources as fair (20/51, 39.2%), followed by those who rated them as good (18/51, 35.3%). There was a slight difference between the number of respondents rating themselves as poor (7/52, 13.7%) and those rating themselves as very good (6/51, 11.8%). The combination of very good and good (24/51, 47.1%) illustrates that less than half of the respondents felt confident about their skills to identify and locate people as information sources.

#### 5.3.4.13 Distinguishing between credible and poor quality information

Question 16 (Addendum D) requested respondents to rate their skills in distinguishing between credible and poor quality information. Results obtained are illustrated in Figure 0.28

A total of 50/68 (73.5%) participants in the study rated their skills in distinguishing between credible and poor quality information. N was 50. Figure 0.28 reflects the self-reported perceptions of skills in distinguishing between credible and poor quality information.

**Figure 0.28 Self-reported perceptions of skills in distinguishing between credible and poor quality information**



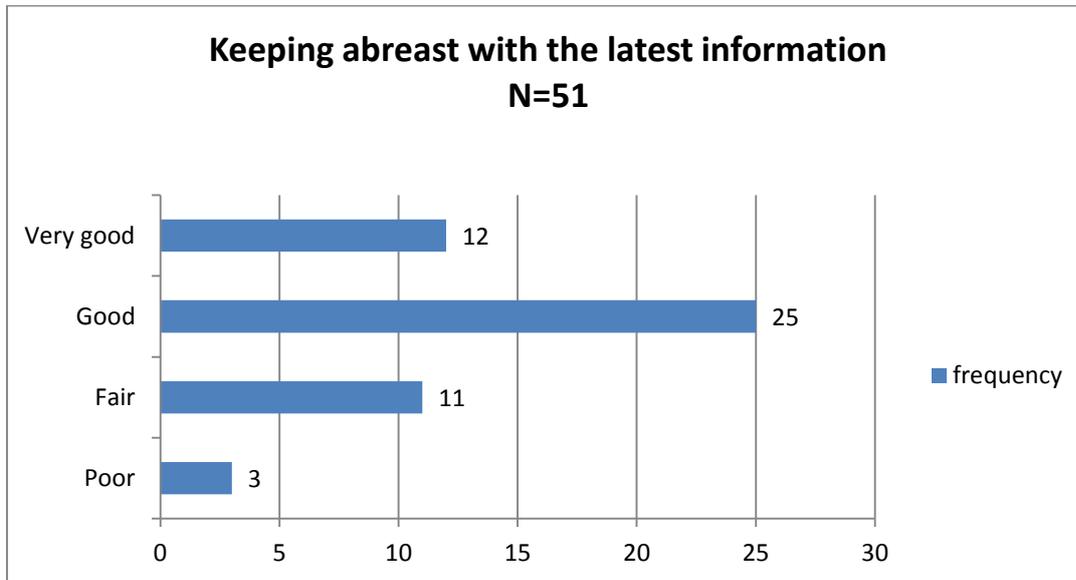
The majority of respondents rated their skills in distinguishing between credible and poor quality information as either good (27/50, 54%) or very good (15/50, 30%), whereas 8/50 (16%) rated their skills in this regard as fair 8/50 (16%). The combination of good and very good (42/50, 84%) illustrates that most respondents felt confident about distinguishing between poor and credible information sources.

#### 5.3.4.14 Keeping abreast with the latest relevant research information

Question 17 (Addendum D) was the fifth and final question developed for this research phase, and focused on skills to keep abreast with the latest information relevant to a specific research field. Results are illustrated in Figure 0.29.

Fifty-one of 68 (75%) participants in the study rated their skills in keeping abreast with the latest research information. N was 51. Figure 0.29 reflects the self-reported perceptions of skills in keeping abreast with the latest research information.

**Figure 0.29 Self-reported perceptions of skills in keeping abreast with the latest research information**



Twenty-five of 51 (49%) respondents indicated that their skills to keep abreast with the latest research information were good, and 12/51 (23.5%) said they were very good. A lower proportion 11/51 (21.6%) rated this skill as fair, and 3/51 (5.9%) rated it as poor. The combination of very good and good (37/51, 72.5%) illustrates that the majority of respondents felt confident about keeping abreast with the latest research information.

The next section of this chapter will cover another research phase, namely data collection and analysis.

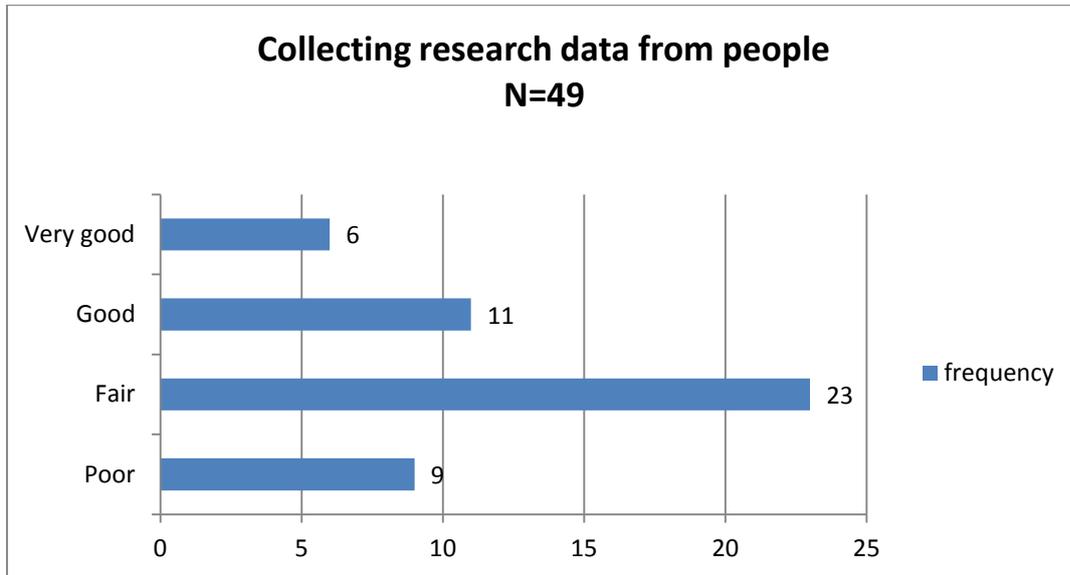
### 5.3.5 Data collection and analysis

Data collection and analysis comprised the fourth research phase tested in the questionnaire; the intention was to portray the self-reported skills of respondents with regard to data collection and the subsequent analysis thereof. The proposed ARIL definition highlights the importance of researchers being skilled in synthesising secondary as well as primary resources (i.e. empirical data), and questions 18 and 19 (Addendum D) were formulated to test the skills of respondents in this regard. Both questions provided a four-point Likert scale to respondents with the following scales: poor, fair, good and very good. Question 18 focused on skills to collect research data from three sources, namely people, electronic instruments and existing documents. The results are depicted in Figure 0.30, Figure 0.31 and Figure 0.32 and discussed in sections 5.3.5.1 to 5.3.5.3.

### 5.3.5.1 Collecting research data from people

Forty-nine of 68 (72.1%) participants in the study rated their skills in collecting research data from people. N was 49. Figure 0.30 reflects the self-reported perceptions of skills in collecting research data from people.

**Figure 0.30 Self-reported perceptions of skills in collecting research data from people**

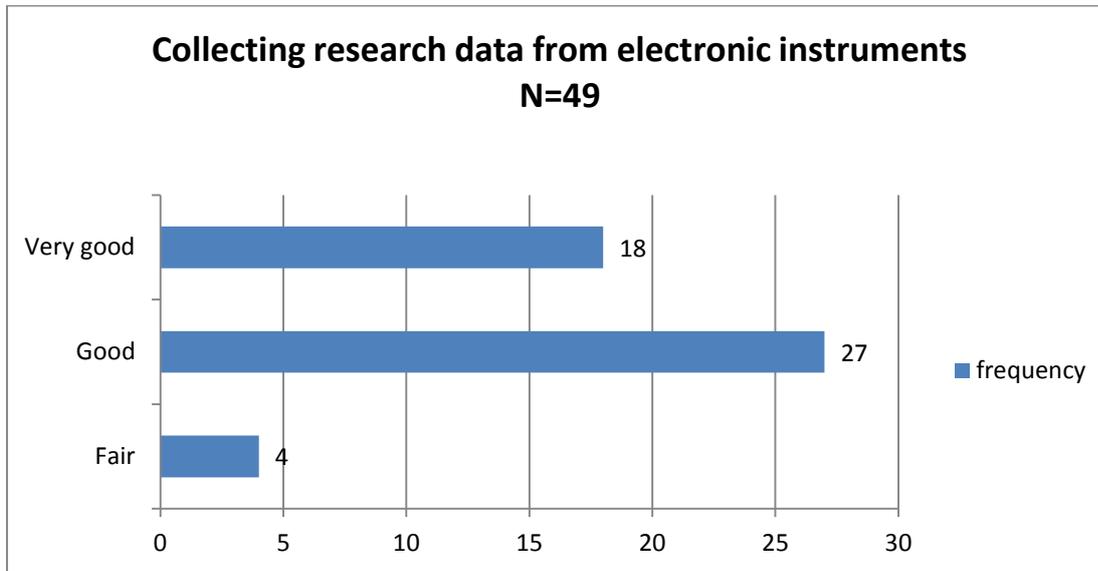


The majority of respondents indicated that their skills to collect research data from people were fair (23/49, 46.9%). The rest of the respondents rated this skill as good (11/49, 22.4%), poor (9/49, 18.4%) or very good (6/49, 12.2%).

### 5.3.5.2 Collecting research data from electronic instruments

Forty-nine of 68 (72.1%) participants in the study rated their skills in collecting research data from electronic instruments. N was 49. Figure 0.31 reflects the self-reported perceptions of skills in collecting research data from electronic instruments.

**Figure 0.31 Self-reported perceptions of skills in collecting research data from electronic instruments**

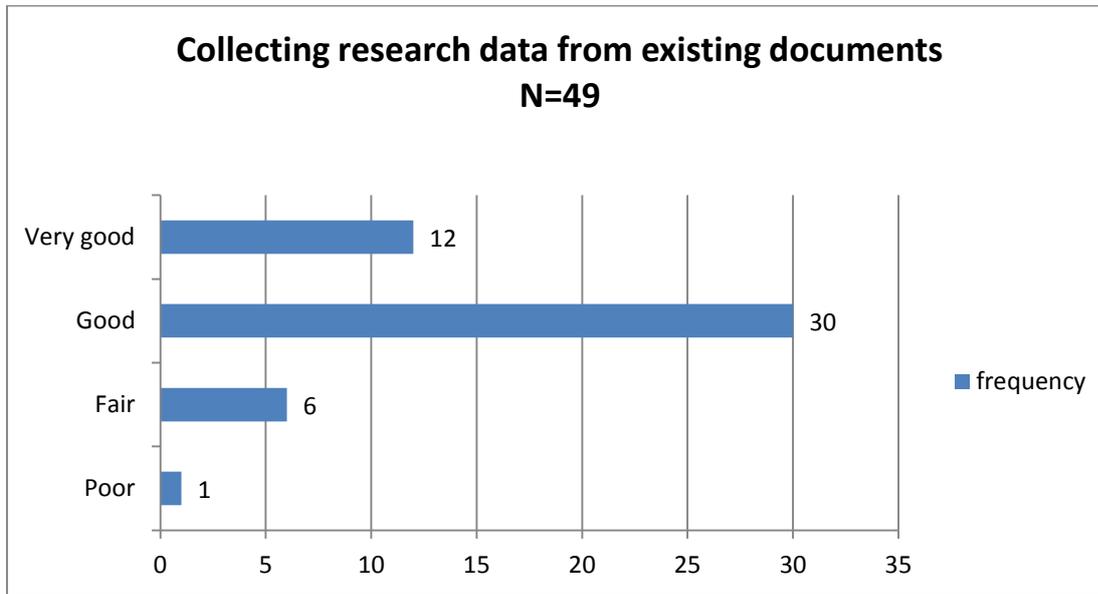


Just over half of the respondents (27/49, 55.1%) indicated that their skills to collect research data from electronic instruments were good. The remaining respondents rated this skill as very good (18/49, 36.7%) and fair (4/49, 8.2%). The combination of good and very good (45/49, 91.8%) illustrates that the majority of respondents felt confident about their skills to collect research data from electronic instruments.

#### 5.3.5.3 *Collecting research data from existing documents (e.g. content analysis)*

Forty-nine of 68 (72.1%) participants in the study rated their skills in collecting data from existing research documents. N was 49. Figure 0.32 reflects the self-reported perceptions of skills in collecting research data from existing documents.

**Figure 0.32 Self-reported perceptions in collecting research data from existing documents**



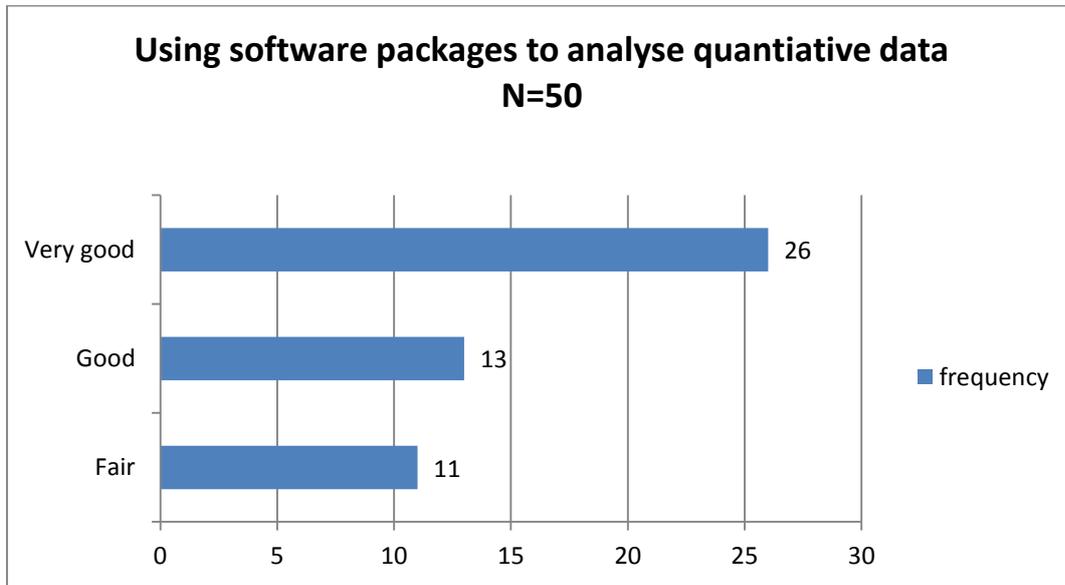
The majority of respondents indicated that their skills to collect research data from existing documents were good (30/49, 44.1%). A lower number rated their skill in collecting research data as very good (12/49, 17.6%) or fair (6/49, 8.8%). A single respondent marked the option of poor (1/49, 1.5%). The combination of very good and good (42/49, 85.7%) illustrates that most respondents felt confident about their skills to collect research data from existing documents.

#### 5.3.5.4 *Employing software packages to analyse quantitative data*

Question 19 (Addendum D) focused on data analysis skills specifically, and respondents were requested to rate their skills regarding the following four processes: the use of software packages to analyse quantitative data, using software packages to analyse qualitative data, mining of data and visualising data. Results obtained from respondents are reflected in Figure 0.33, Figure 0.34, Figure 0.35 and Figure 0.36 and discussed in sections 5.3.5.4 to 5.3.5.7.

A total of 50/68 (73.5%) participants in the study rated their skills in the use of software packages to analyse quantitative data. N was 50. Figure 0.33 reflects the self-reported perceptions of skills in using software packages to analyse quantitative data.

**Figure 0.33 Self-reported perceptions of employing software packages to analyse quantitative data**

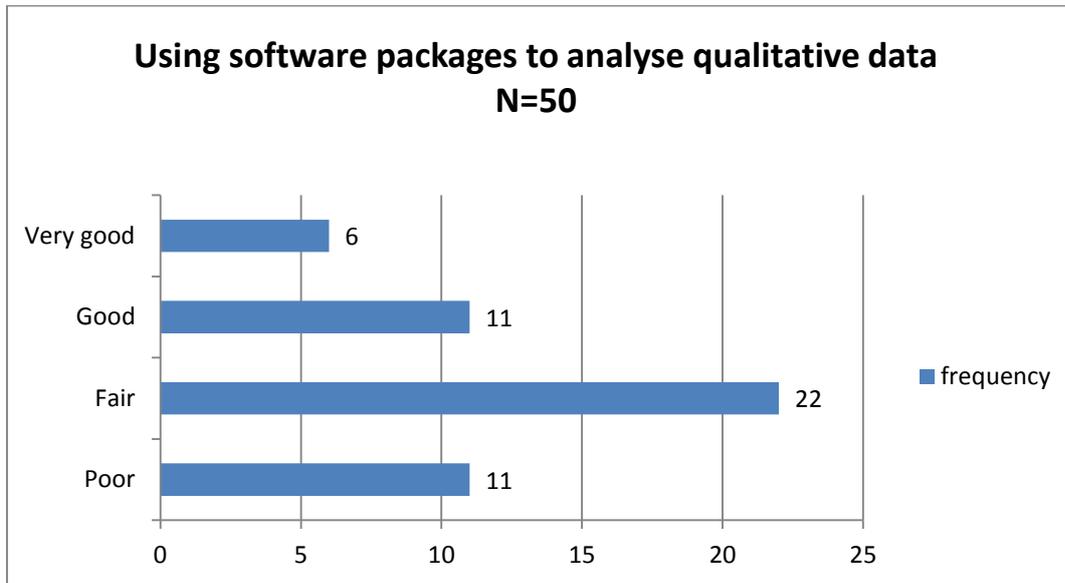


A high percentage of respondents rated their skills to employ software packages to analyse quantitative data as very good (26/50, 52%), followed by those indicating they were good (13/50, 26%) or fair (11/50, 22%) at this activity. The combination of very good and good (39/50, 78%) illustrates that the majority of respondents felt confident about using software packages to analyse quantitative data.

#### 5.3.5.5 *Employing software packages to analyse qualitative data*

Fifty of 68 (73.5%) participants in the study rated their skills in the use of software packages to analyse qualitative data. N was 50. Figure 0.34 reflects the self-reported perceptions of skills in employing software packages to analyse qualitative data.

**Figure 0.34 Self-reported skills in employing software packages to analyse qualitative data**

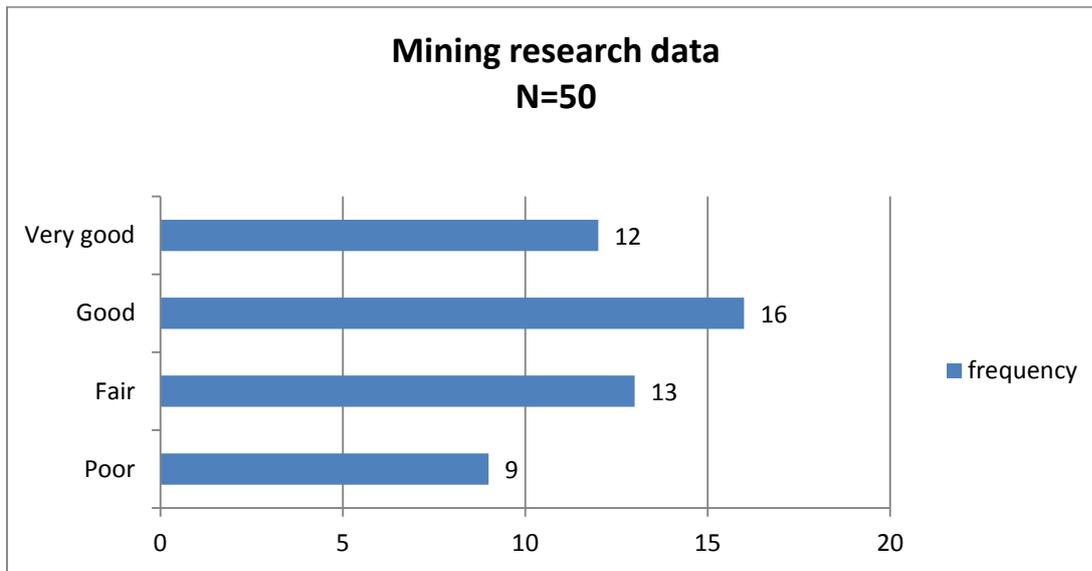


The majority of respondents (22/50, 44%) rated their skills to employ software packages to analyse qualitative data as fair. An equal number of respondents indicated they were good (11/50, 22%) or poor (11/50, 22%) at this activity, whereas (6/50, 12%) of the respondents suggested that they were very good at employing software packages to analyse qualitative data.

#### 5.3.5.6 Mining of research data (analysing large datasets to identify relationships and patterns)

Fifty of 68 (73.5%) participants in the study rated their skills in mining data. N was 50. Figure 0.35 reflects the self-reported perceptions of skills in mining research data.

**Figure 0.35 Self-reported skills in mining of research data**

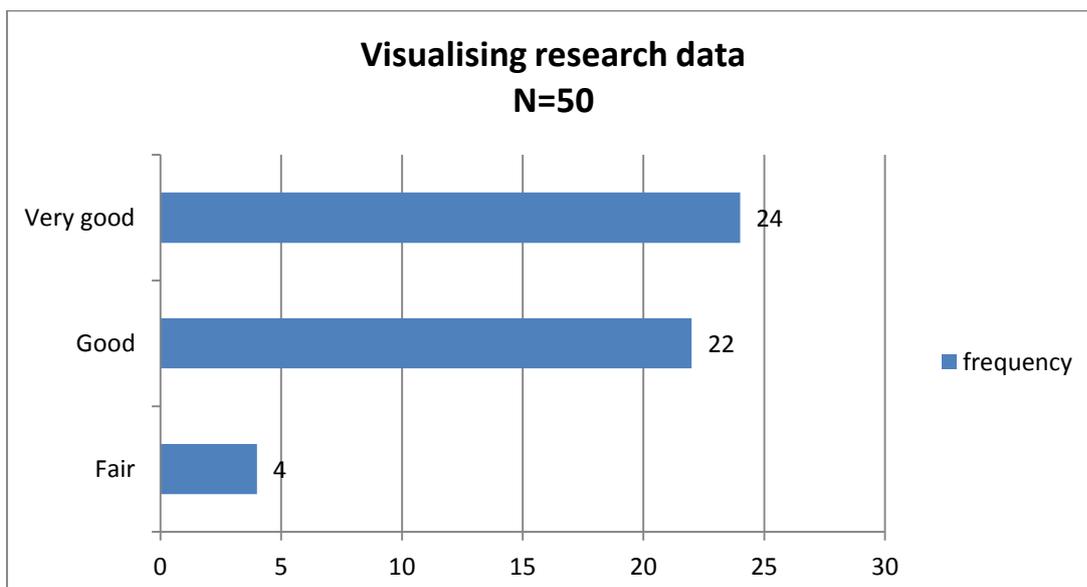


Approximately one third (16/50, 32%) of respondents rated their skills to mine research data as good, followed by those who indicated they were fair (13/50, 26%), very good (12/50, 24%) or poor (9/50, 18%) at it. The combination of very good and good (28/50, 56%) illustrates that just over half of the respondents felt confident about their skills to mine research data.

*5.3.5.7 Visualising research data (e.g. charts, graphs)*

Fifty of 68 (73.5%) participants in the study rated their skills to visualise data. N was 50. Figure 0.36 reflects the self-reported perceptions of skills in visualising research data.

**Figure 0.36 Self-reported perceptions of skills in visualising research data**



Their ability to visualise research data was thought to be very good by 24/50 (48%) of respondents. This rating was closely followed by those marking the option of good (22/50, 44%). The rest of the respondents (4/50, 8%) rated this skill as fair. The combination of very good and good (46/50, 92%) illustrates that the majority of respondents felt confident about visualising research data.

The following section of this chapter will focus on the management and organisation of research information as a research phase.

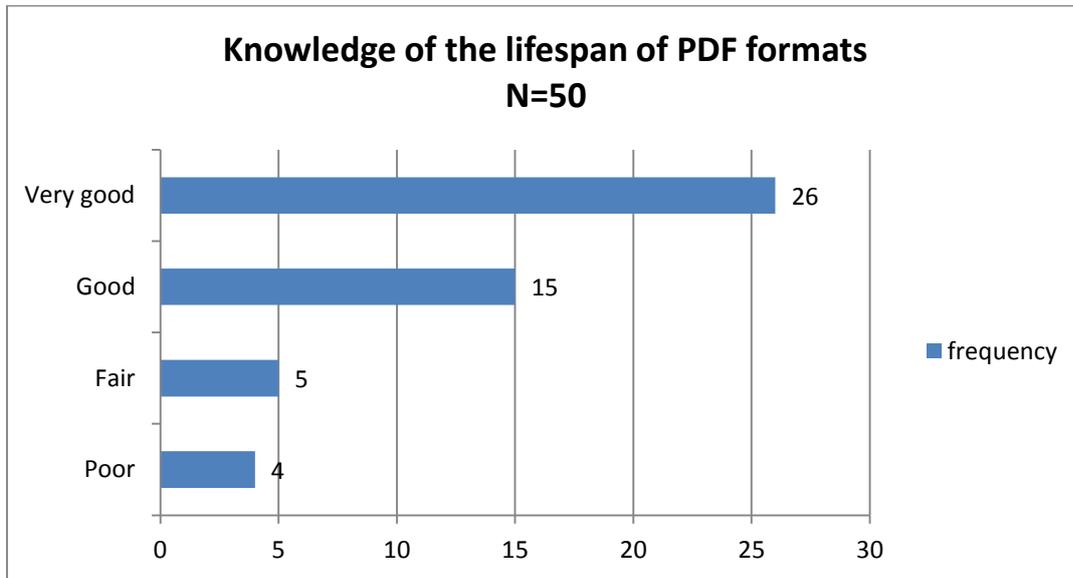
### **5.3.6 Managing and organising research information**

The management and organisation of research information was the fifth research phase tested in the questionnaire, and three questions were formulated to test the skills of researchers in this regard. All the questions provided the same four-point Likert scale to respondents with the options poor, fair, good and very good. Question 20 (Addendum D) requested respondents to rate their knowledge of the lifespan of three common digital formats in order to ensure access in future, namely PDF, MS Office (e.g. Excel, Word, PowerPoint) and HTML/XML. Results obtained from respondents are depicted in Figure 0.37, Figure 0.38 and Figure 0.39 and discussed in sections 5.3.6.1 to 5.3.6.3.

#### *5.3.6.1 Knowledge of the lifespan of research documents in PDF formats*

Fifty of 68 (73.5%) participants in the study rated their knowledge of the lifespan of information in PDF format. N was 50. Figure 0.37 reflects the self-perceptions of knowledge regarding the lifespan of documents in PDF formats.

**Figure 0.37 Self-reported perception of knowledge of the lifespan of research documents in PDF formats**

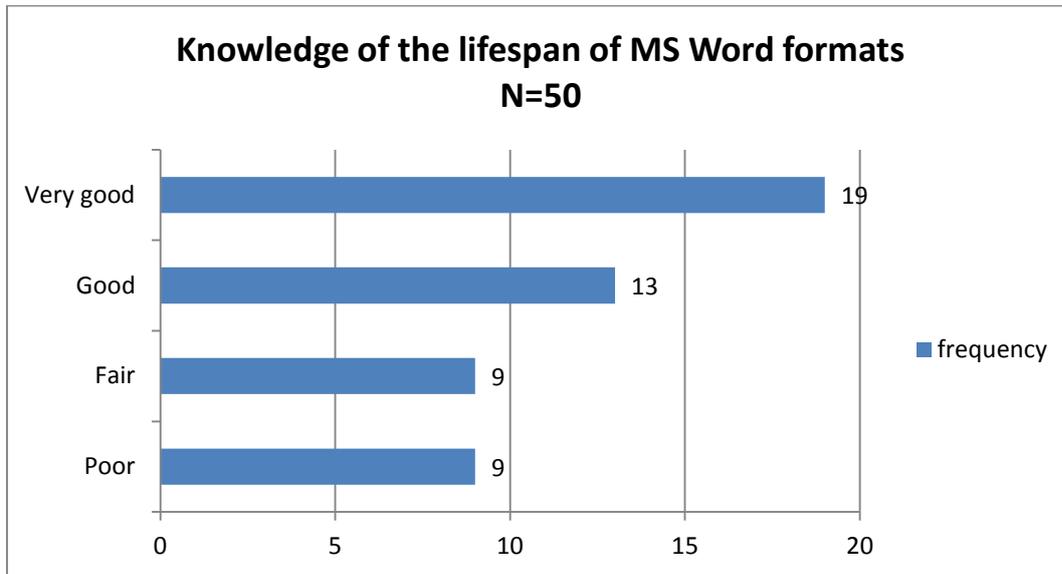


Just over half (26/50, 52%) of the respondents rated their knowledge of the lifespan of PDF formats as very good, followed by 15/50 (30%) who thought their knowledge was good; 5/50 (10%) who regarded it as fair, and 4/50 (8%) who saw it as poor. The combination of very good and good (41/50, 82%) illustrates that most respondents felt confident about their knowledge of the lifespan of information in PDF format.

#### 5.3.6.2 Knowledge of the lifespan of research documents in MS Office (e.g. Excel, Word, PowerPoint) formats

A total of 50/68 (73.5%) participants in the study rated their knowledge of the lifespan of information in MS Office formats. N was 50. Figure 0.38 reflects the self-reported perceptions of knowledge of the lifespan of documents in MS office formats.

**Figure 0.38 Self-reported perceptions of knowledge of the lifespan of documents in MS Office formats**

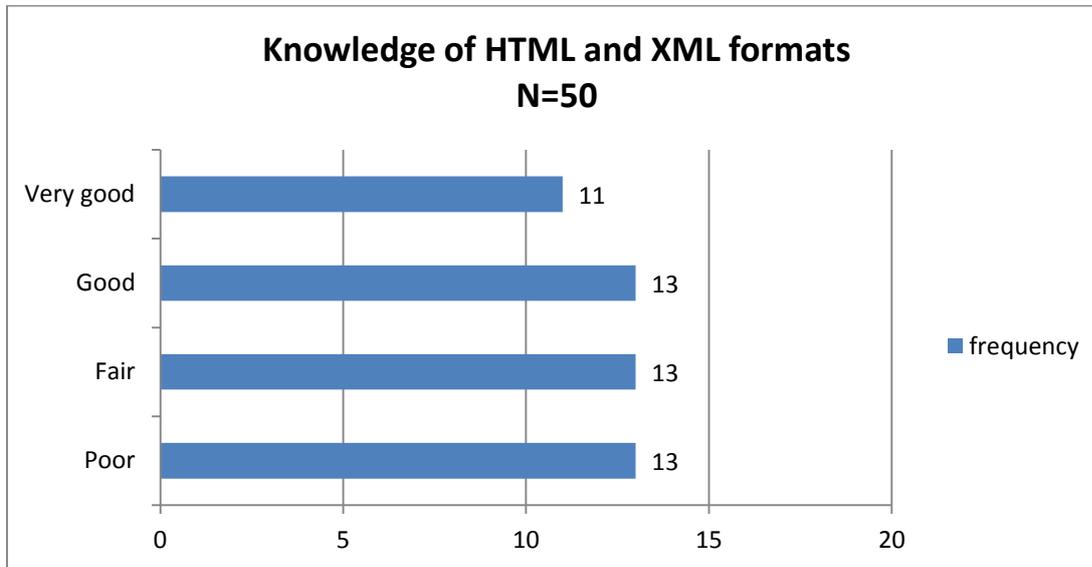


Of 50 respondents, 19 (38%) rated their knowledge of the lifespan of MS office formats as very good, followed by those who thought their knowledge was good (13/50, 26%). An equal number of respondents rated their knowledge as fair (9/50, 18%) or poor (9/50, 18%). The combination of very good and good (32/50, 64%) confirms that the majority of respondents felt confident about their knowledge of the lifespan of digital information in MS Office formats.

#### 5.3.6.3 Knowledge of the lifespan of documents in HTML and XML formats

Fifty of 68 (73.5%) participants in the study rated their knowledge of the lifespan of information in HTML and XML formats. N was 50. Figure 0.39 reflects the self-reported perceptions of knowledge of the lifespan of documents in HTML and XML formats.

**Figure 0.39 Self-reported perceptions of knowledge of the lifespan of HTML and XML formats**



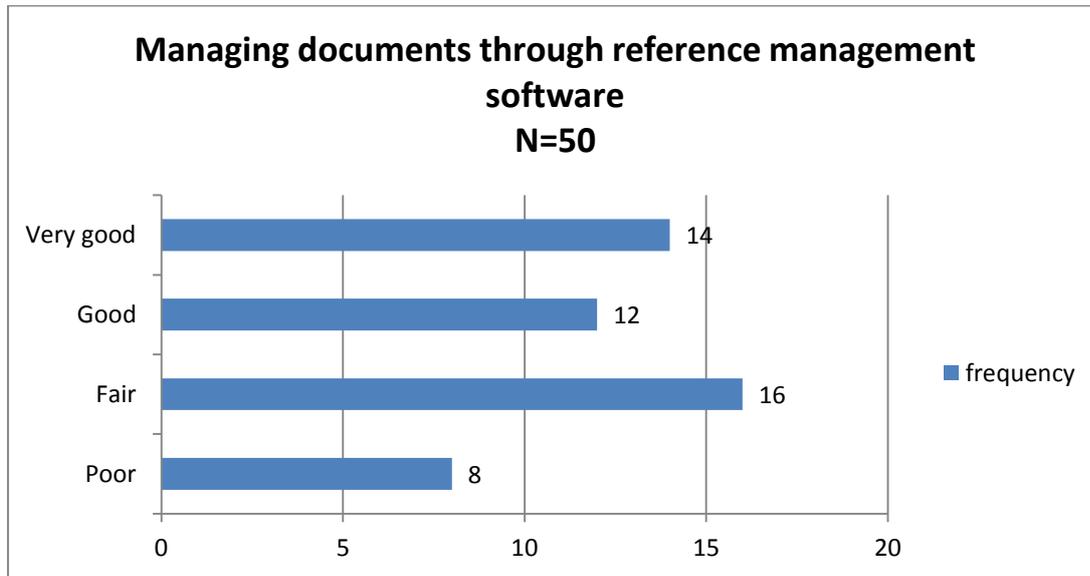
An equal number of respondents marked three different options for their knowledge of digital information in HTML and XML formats, namely good (13/50, 26%), fair (13/50, 26%) and poor (13/50, 26%). The rest of the respondents marked very good (11/50, 22%). The combination of very good and good (24/50, 48%) illustrates that less than half of the respondents felt confident about their knowledge of the lifespan of information in HTML and XML formats.

#### 5.3.6.4 *Managing and organising research documents by employing reference management software (e.g. RefWorks, EndNote, Mendeley)*

Question 21 focused on activities concerning the management and organisation of research documents, and respondents were requested to rate their skills in carrying out the following five processes: using reference management software, depositing documents into IRs, managing documents on internet sites, annotating documents, and using version control systems. Results are illustrated in Figure 0.40, Figure 0.41, Figure 0.42, Figure 0.43 and Figure 0.44 and discussed in sections 5.3.6.4 to 5.3.6.8.

Fifty of 68 (73.5%) participants in the study rated their skills to manage and organise research documents by employing reference management software. N was 50. Figure 0.40 reflects the self-reported perceptions of skills in managing and organising research documents by employing reference management software.

**Figure 0.40 Self-reported perceptions of skills in managing and organising research documents through reference management software**

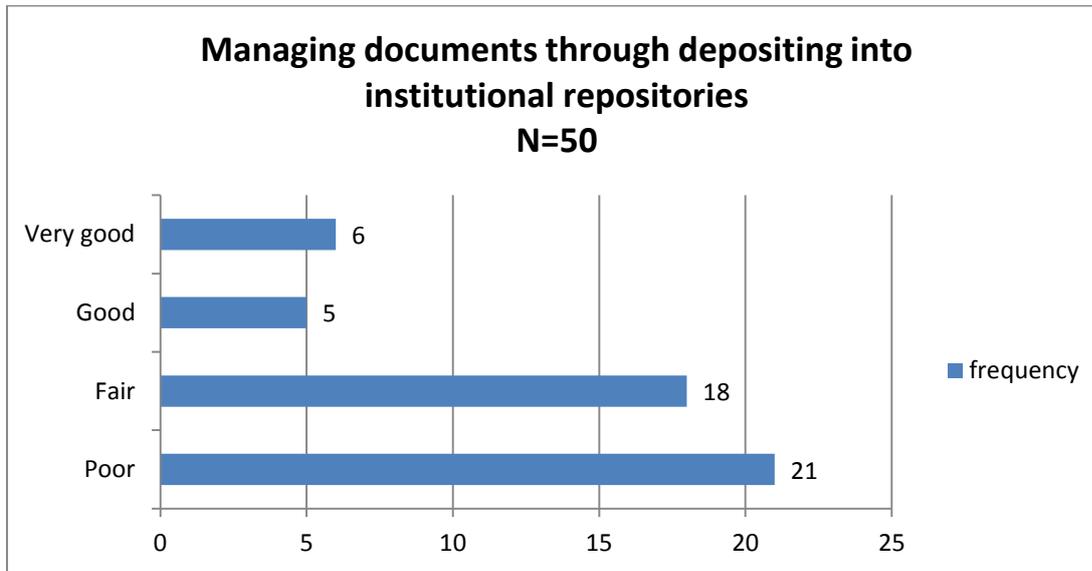


Sixteen of 50 (32%) respondents indicated that their skills to manage and organise research documents through the use of reference management software were fair, followed by those who marked the options very good (14/50, 28%), good (12/50, 24%) or poor (8/50, 16%). The combination of very good and good (26/50, 52%) illustrates that slightly over half of the respondents were confident about the use of reference management software to organise and manage research information.

#### *5.3.6.5 Managing and organising research documents through deposits into institutional repositories*

Fifty of 68 (73.5%) participants in the study rated their skills to manage and organise documents through deposits into IRs. N was 50. Figure 0.41 reflects the self-reported perceptions of skills in managing and organising research documents through deposits into IRs.

**Figure 0.41 Self-reported perceptions of skills in managing and organising research documents through institutional repositories**

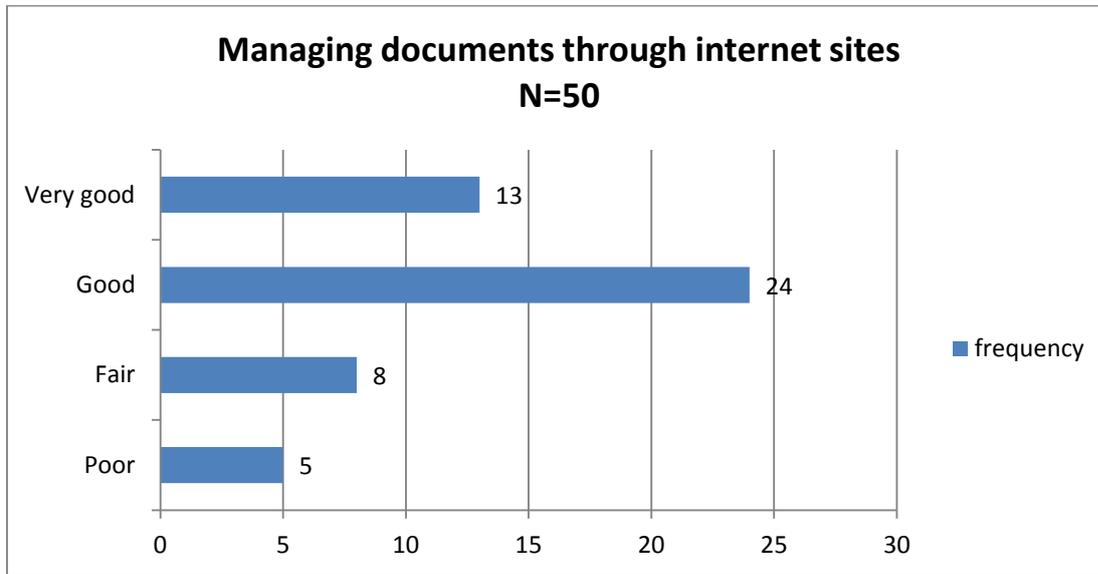


The majority of respondents rated their skills to manage and organise research documents by depositing into IRs as poor 21/50 (42%). This response was closely followed by those who thought their skills were fair (18/50, 36%), while 6/50 (12%) indicated that they were very good, and 5/50 (10%) that they were good at this activity.

#### 5.3.6.6 *Managing and organising research documents through internet sites (e.g. DropBox and Google Drive)*

Fifty of 68 (73.5%) participants in the study rated their skills to manage and organise documents by making use of internet sites. N was 50. Figure 0.42 reflects the self-reported perceptions of skills in managing and organising research documents through internet sites.

**Figure 0.42 Self-reported perceptions of skills in managing and organising research documents through internet sites**

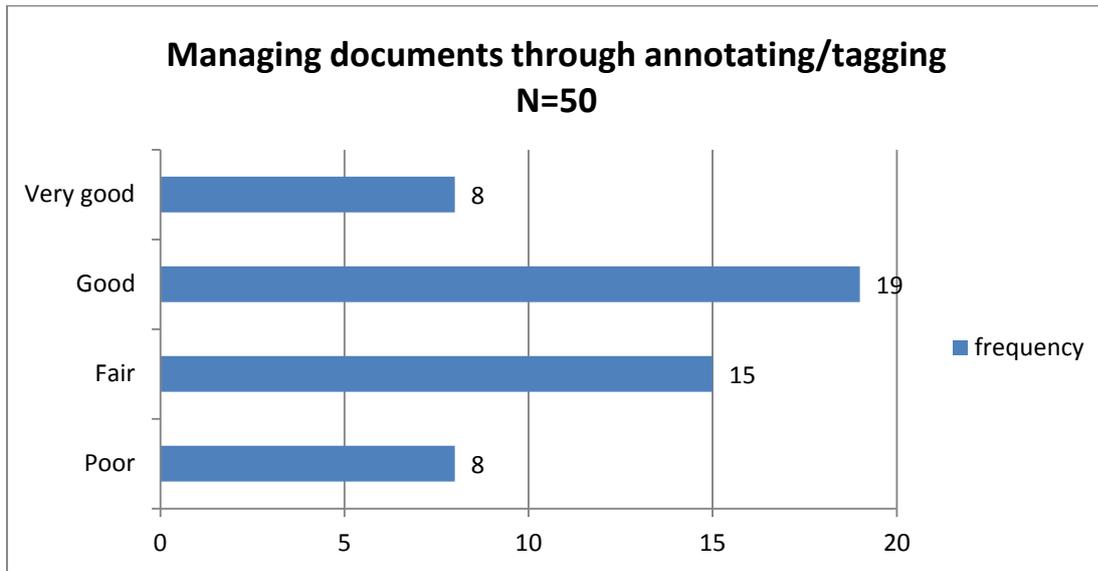


A large proportion of respondents rated their skills to manage and organise research documents on internet sites as good (24/50, 48%), followed by those who stated that they were very good (13/50, 26%), fair (8/50, 16%) or poor (5/50, 10%). The combination of good and very good (37/50, 74%) illustrates that the majority of respondents felt confident about their skills to manage and organise research documents on internet sites.

#### 5.3.6.7 *Managing and organising research documents through annotating (describing and tagging) documents*

Fifty of 68 (73.5%) participants in the study rated their skills to manage and organise information by annotating documents. N was 50. Figure 0.43 reflects the self-reported perceptions of skills in managing and organising research documents through annotations.

**Figure 0.43 Self-reported perceptions of skills in managing and organising documents through annotating/tagging**

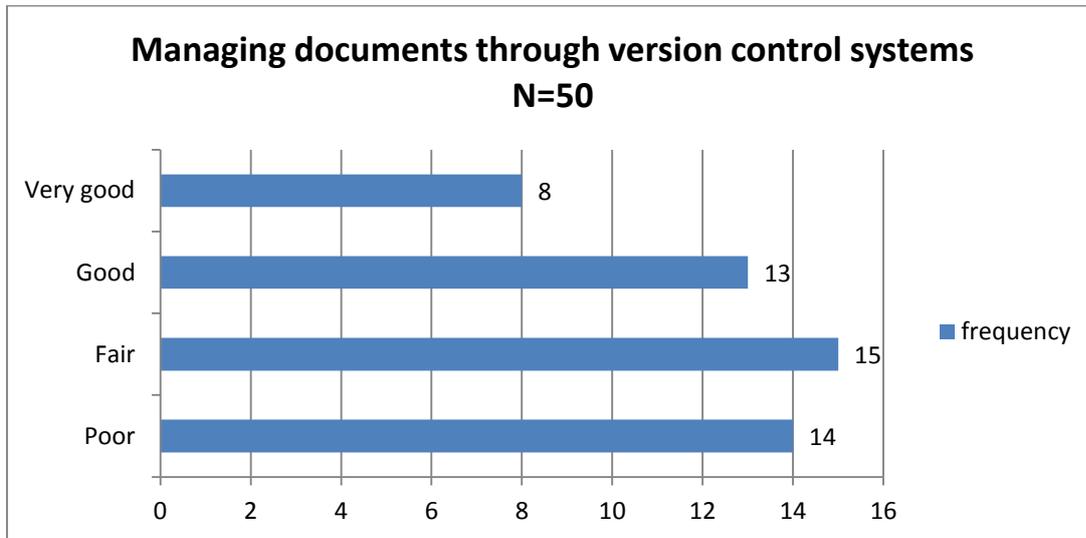


The number of respondents who rated their skills to manage and organise research documents through annotations as good was 19/50 (38%). This response was followed by those respondents indicating their skill in this regard as fair (15/50, 30%). An equal number of respondents marked the poor (8/50, 16%) and very good (8/50, 16%) options. The combination of very good and good (27/50, 54%) illustrates that just over half of the respondents felt confident about their skills to manage and organise research documents through annotating/tagging.

#### *5.3.6.8 Managing and organising research documents by employing version control systems to record changes to documents*

Fifty of 68 (73.5%) participants in the study rated their skills to manage and organise research documents through version control systems in order to keep track and record changes to documents. N was 50. Figure 0.44 reflects the self-reported perceptions of skills in employing version control systems to manage and organise research documents.

**Figure 0.44 Self-reported perceptions of skills in managing and organising research information through version control systems**



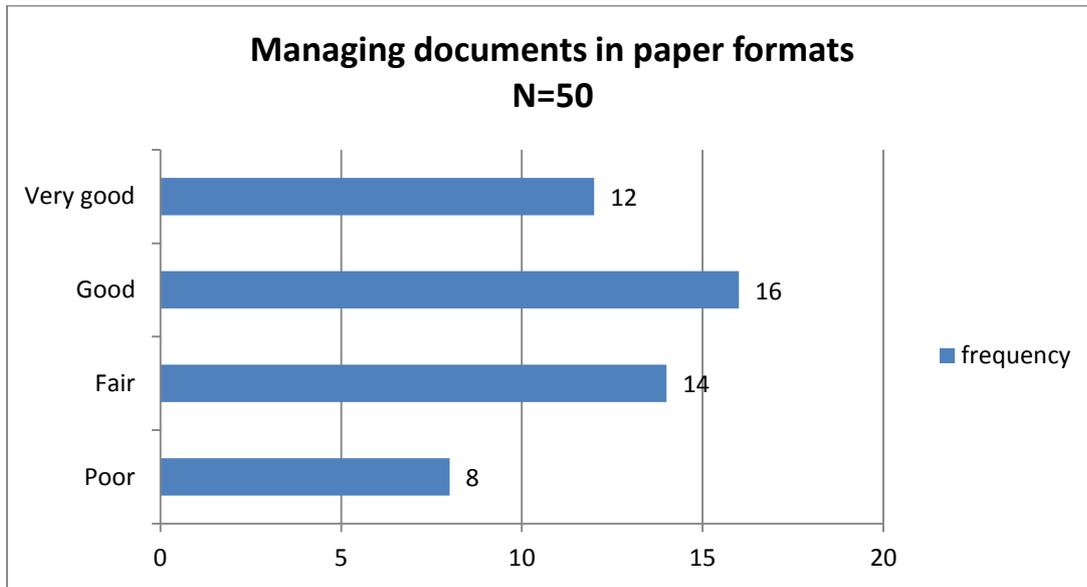
Thirty percent (15/50) of respondents rated their skills to manage and organise research documents through the use of version control systems as fair. This response was closely followed by those indicating this skill as poor (14/50, 28%) or good (13/50, 26%). Only 16% (8/50) of respondents marked the very good option. The combination of very good and good 21/50 (42%) illustrates that well below half of the respondents did not feel confident about their skills to manage and organise research documents by using version control systems.

#### 5.3.6.9 *Managing and organising paper research documents*

Question 21 (Addendum D) requested respondents to rate their skills in organising and managing five specific information formats: paper documents, multimedia, electronic information retrieved from scholarly databases, electronic information retrieved from the internet, and electronic mail communication. Figure 0.45, Figure 0.46, Figure 0.47, Figure 0.48 and Figure 0.49 reflect the results obtained from respondents regarding organising and managing these five formats and are discussed in sections 5.3.6.9 to 5.3.6.13.

Fifty of 68 (73.5%) participants in the study rated their skills in managing and organising research documents in paper format. N was 50. Figure 0.45 reflects the self-reported perceptions of skills in managing and organising paper formats.

**Figure 0.45 Self-reported perceptions of skills in managing and organising research information in paper formats**

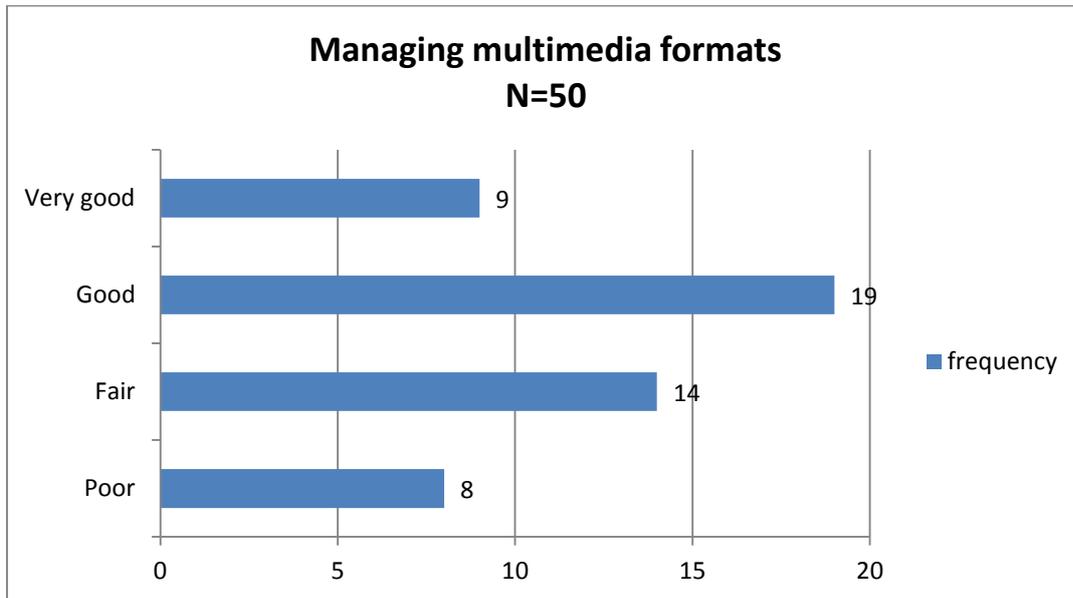


Thirty-two percent (16/50) of respondents rated their skills to manage and organise research documents in paper format as good, followed by 28% who thought their ability in this area was fair (14/50), with 24% reporting that they were very good (12/50) and 16% (8/50) stating that they were poor at this skill. The combination of very good and good (28/50, 56%) illustrates that just over half of the respondents felt confident about their skills to organise and manage information in paper format.

#### 5.3.6.10 Managing and organising multimedia (e.g. audio and video) recordings

A total of 50/68 (73.5%) participants in the study rated their skills in managing and organising multimedia recordings. N was 50. Figure 0.46 reflects the self-reported perceptions of skills in managing and organising multimedia formats.

**Figure 0.46 Self-reported perceptions of skills in managing and organising research information in multimedia formats**

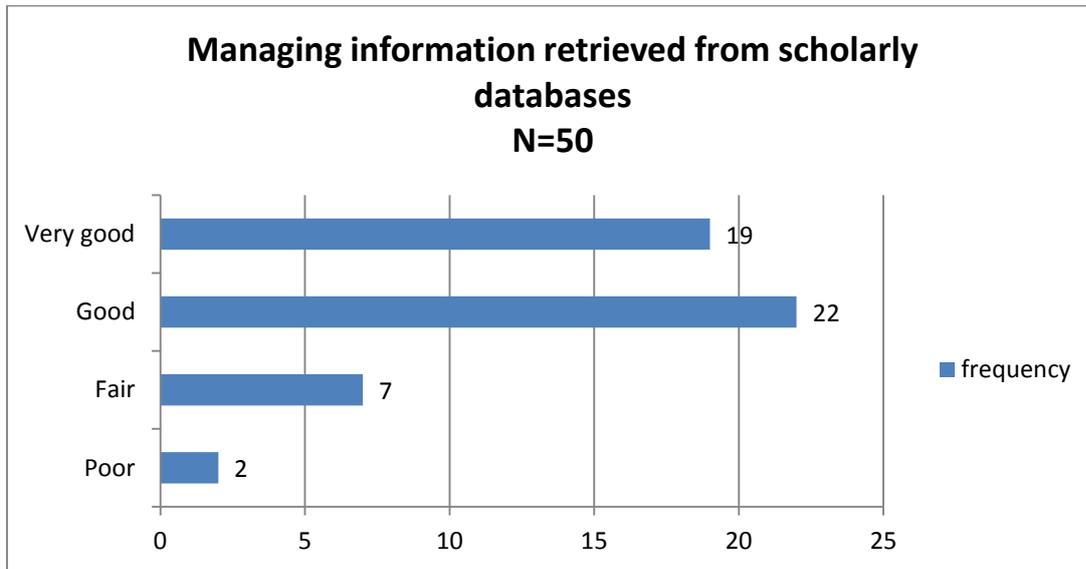


Respondents who rated their skills to manage and organise research information in multimedia formats as good numbered 19/50 (38%), followed by 14/50 respondents who indicated this ability as fair (28%). There was a slight difference between those who marked the very good 9/50 (18%) and poor 8/50 (16%) options. The combination of very good and good (28/50, 56%) illustrates that just over half of the respondents felt confident about managing and organising information in multimedia formats.

#### 5.3.6.11 Managing and organising electronic information retrieved from scholarly databases

Fifty of 68 (73.5%) participants in the study rated their skills in managing and organising information retrieved from scholarly databases. N was 50. Figure 0.47 reflects the self-reported perceptions of skills in managing and organising information retrieved from scholarly databases.

**Figure 0.47 Self-reported perceptions of skills in managing and organising electronic information from scholarly databases**

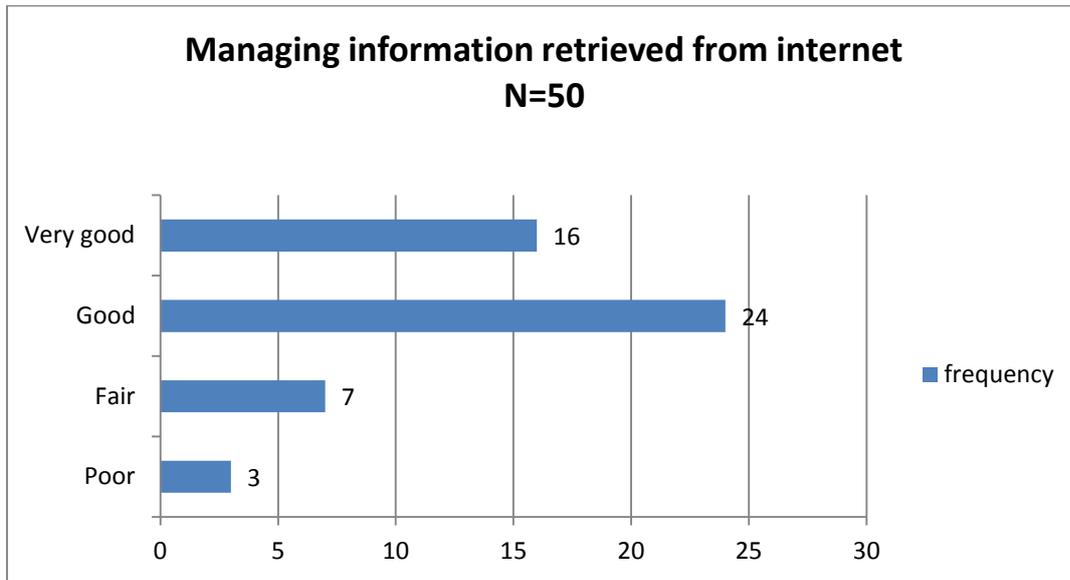


Twenty-two of 50 (44%) respondents rated their skills to manage and organise electronic information obtained from scholarly databases as good. This response was closely followed by those marking the very good option (19/50, 38%). The rest of the respondents marked the fair (7/50, 14%) or poor (2/50, 4%) options. The combination of good and very good (41/50, 82%) illustrates that the majority felt confident about their skills to organise and manage electronic information obtained from scholarly databases.

#### 5.3.6.12 *Managing and organising electronic information retrieved from the internet*

Fifty of 68 (73.5%) participants in the study rated their skills in managing and organising electronic information retrieved from the internet. N was 50. Figure 0.48 reflects the self-reported perceptions of skills in managing and organising information retrieved from the internet.

**Figure 0.48 Self-reported perceptions of skills in managing and organising electronic information from the internet**

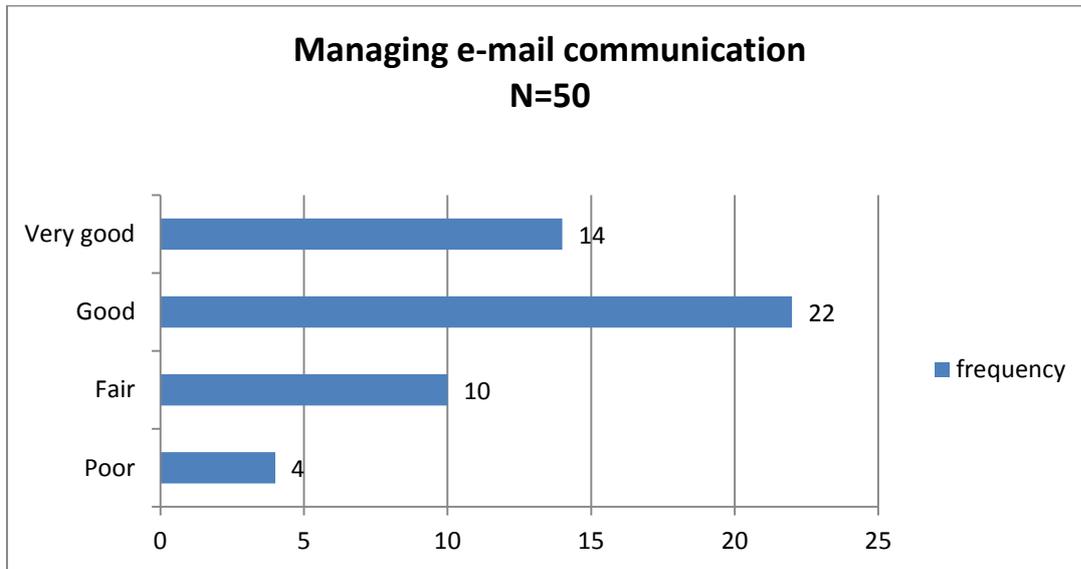


The skill to manage and organise electronic information obtained from the internet was reported as good by 24/50 (48%) respondents, and as very good by 16/50 (32%). The rest of the respondents marked the fair (7/50, 14%) or poor (3/50, 6%) options. The combination of good and very good (40/50, 80%) illustrates that most respondents felt confident about their skills to manage and organise electronic information obtained from the internet.

#### *5.3.6.13 Managing and organising electronic mail communication*

Fifty of 68 (73.5%) participants in the study rated their skills to manage and organise communication on electronic mail systems. N was 50. Figure 0.49 reflects the self-reported perceptions of skills in managing and organising electronic mail communication.

**Figure 0.49 Self-reported perceptions of skills in managing and organising electronic mail communication**



A large proportion (22/50, 44%) of respondents rated their skills to manage and organise electronic mail communication as good (22/50, 44%). The rest of the responses varied between very good (14/50, 28%), fair (10/50, 20%) and poor (4/50, 8%). The combination of good and very good (36/50, 72%) illustrates that most respondents felt confident about their skills to manage and organise information originating from electronic mail communication.

The following section of this chapter will focus on the curation of research data as a research phase.

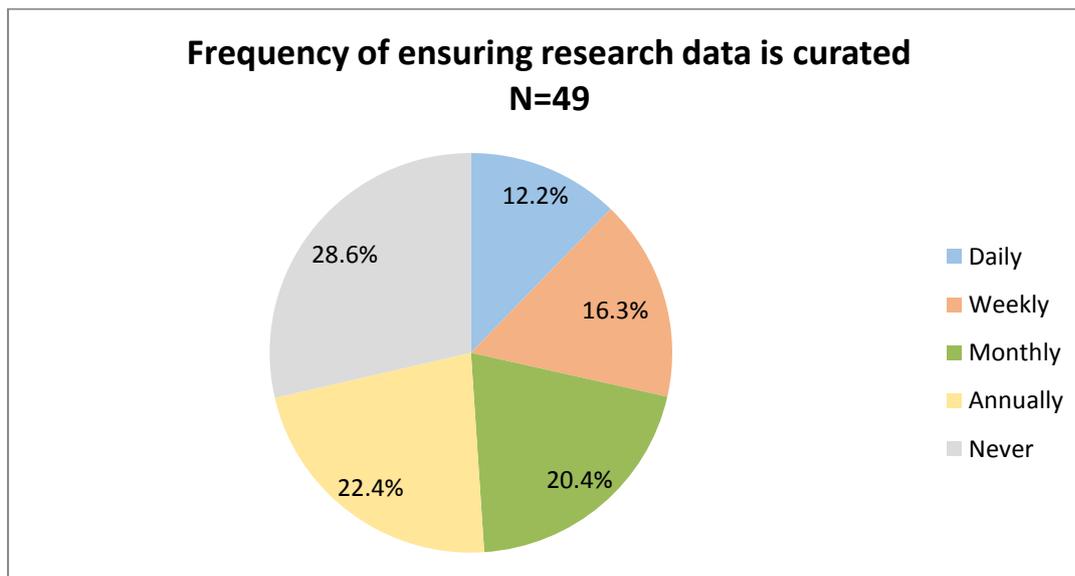
### 5.3.7 Research data curation

The curation of research data was the sixth research phase tested in the questionnaire, and two questions were formulated to determine engineering researchers' skills in this regard. Question 23 (Addendum D) requested respondents to indicate how often they took action to ensure that research data was available for an extended period (i.e. curated). The following options were provided for them to answer the question: daily, weekly, monthly, annually or never. Results based on the responses are illustrated Chart 0.1.

#### 5.3.7.1 Frequency of ensuring that research data is available for an extended period (i.e. curated)

Forty-nine of 68 (72.1%) participants in the study indicated how often they ensured that their research data was available for an extended period (i.e. curated). N was 49. Chart 0.1 reflects the frequency of ensuring that research data is curated.

**Chart 0.1 Self-reported frequency of ensuring research data is curated**



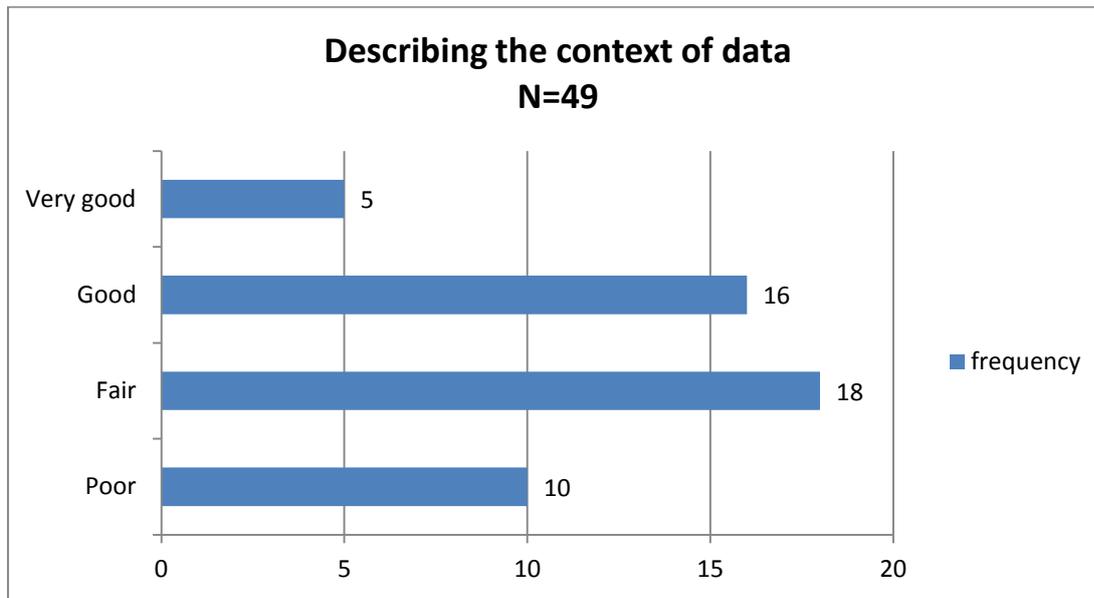
Respondents who indicated that they never ensured that their research data was curated numbered 14/49 (28.6%), while others differed in this activity, indicating annually (11/49, 22.4%) or monthly (10/49, 20.4%). A smaller proportion (8/49, 16.3%) indicated that they performed this task on a weekly basis, and 6/49 (12.2%) ensured that their research data was curated on a daily basis.

#### 5.3.7.2 *Ensuring research data is curated by describing the context of data (e.g. adding metadata, annotations)*

Question 24 (Addendum D) tested specific skills relevant to ensuring that research data is available long after a project has been completed. A four-point Likert scale was provided to respondents, which included the following options: poor, fair, good or very good. They were requested to rate their skills regarding the following five processes: describing the context of data (e.g. adding metadata), designing a data management plan, using persistent links on the internet (e.g. DOI), submitting research data to dataset repositories, and regularly migrating data files to current media. Results are depicted in Figure 0.50, Figure 0.51, Figure 0.52, Figure 0.53 and Figure 0.54 and discussed in sections 5.3.7.2 to 5.3.7.6.

Forty-nine of 68 (72.1%) participants in the study rated their skills to describe the context of research data by adding metadata or annotations. N was 49. Figure 0.50 reflects the self-reported perceptions of skills to describe the context of data.

**Figure 0.50 Self-reported perceptions of skills in describing the context of research data**

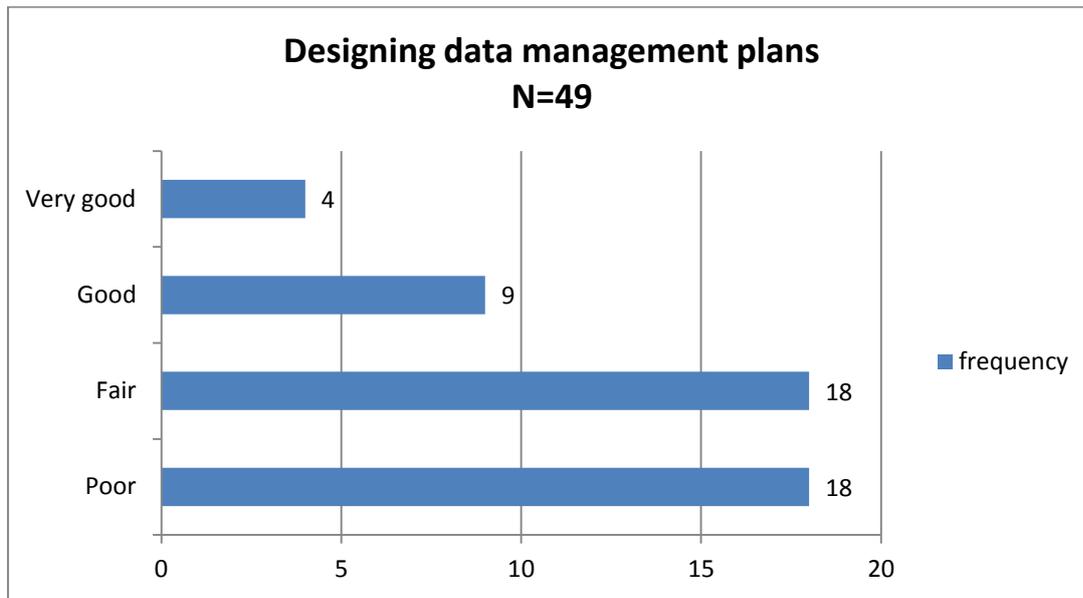


Eighteen of 49 (36.7%) respondents rated their skills to describe the context of research data through metadata or annotations as fair. These were closely followed by responses regarding such skills as good (16/49, 32.7%), poor (10/49, 20.4%) or very good (5/49, 10.2%). The combination of good and very good (21/49, 42.9%) illustrates that well below half of the respondents felt confident about describing the context of research data.

### 5.3.7.3 Ensuring research data is curated by designing a data management plan

Forty-nine of 68 (72.1%) participants in the study rated their skills to design data management plans. N was 49. Figure 0.51 reflects the self-reported perceptions of skills to design data management plans.

**Figure 0.51 Self-reported perceptions of skills in designing data management plans**

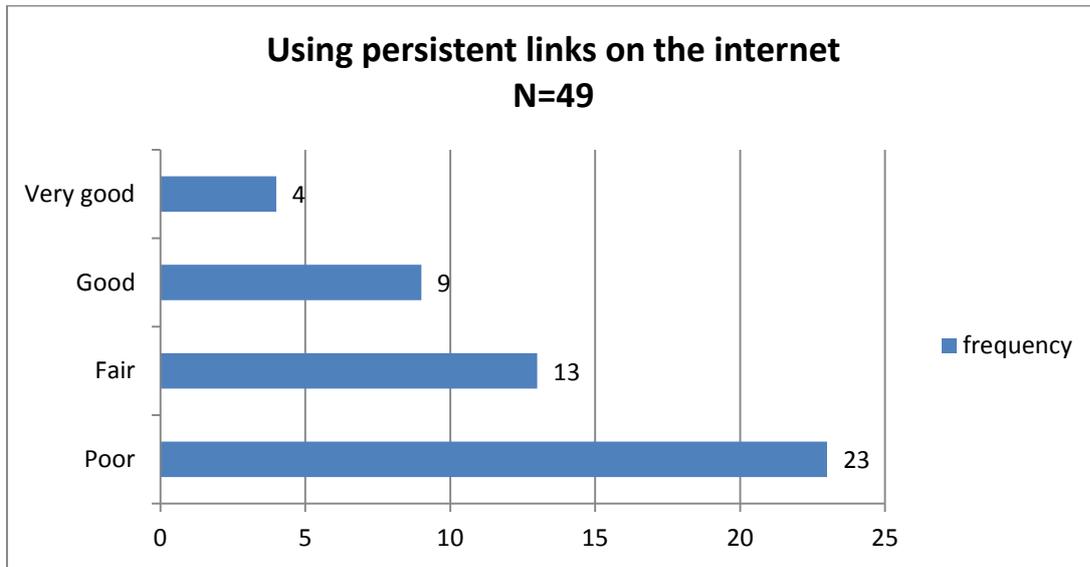


An equal number of respondents rated their skills to design a data management plan as fair or poor (18/49, 36.7%). A lower number of respondents rated this skill as good (9/49, 18.4%) or very good (4/49, 8.2%). The combination of fair and poor (36/49, 73.4%) illustrates that the majority of respondents did not feel confident about their skills to design data management plans.

#### 5.3.7.4 *Ensuring research data is curated by using persistent links on the internet (e.g. digital object identifiers)*

Forty-nine of 68 (72.1%) participants in the study rated their skills to use persistent links on the internet to ensure research data is curated. N was 49. Figure 0.52 reflects the self-reported perceptions of skills to use persistent links on the internet.

**Figure 0.52 Self-reported perceptions of skills in curating research data through persistent links on the internet**

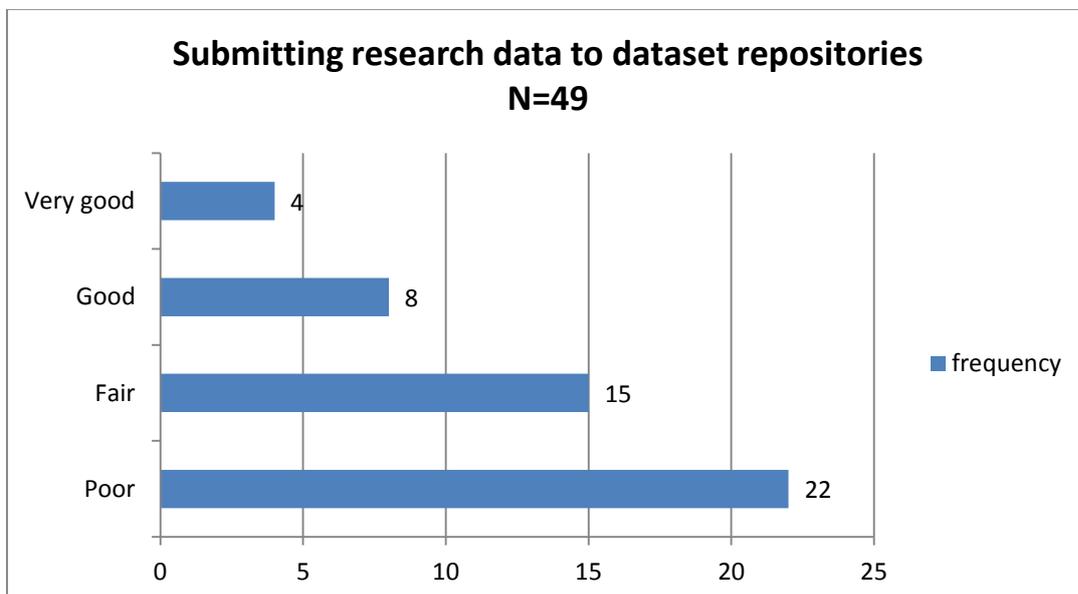


The majority of respondents rated their skills in using persistent links on the internet to curate research data as poor (23/49, 46.9%). The remainder of the responses ranged from fair (13/49, 26.5%) and good (9/49, 18.4%) to very good (4/49, 9.8%).

#### 5.3.7.5 Ensuring research data is curated by submitting data to dataset repositories

A total of 49/68 (72.1%) participants in the study rated their skills to curate research data by submitting data to dataset repositories. N was 49. Figure 0.53 reflects the self-reported perceptions of skills to submit research data to dataset repositories.

**Figure 0.53 Self-reported perceptions of skills in submitting research data to dataset repositories**

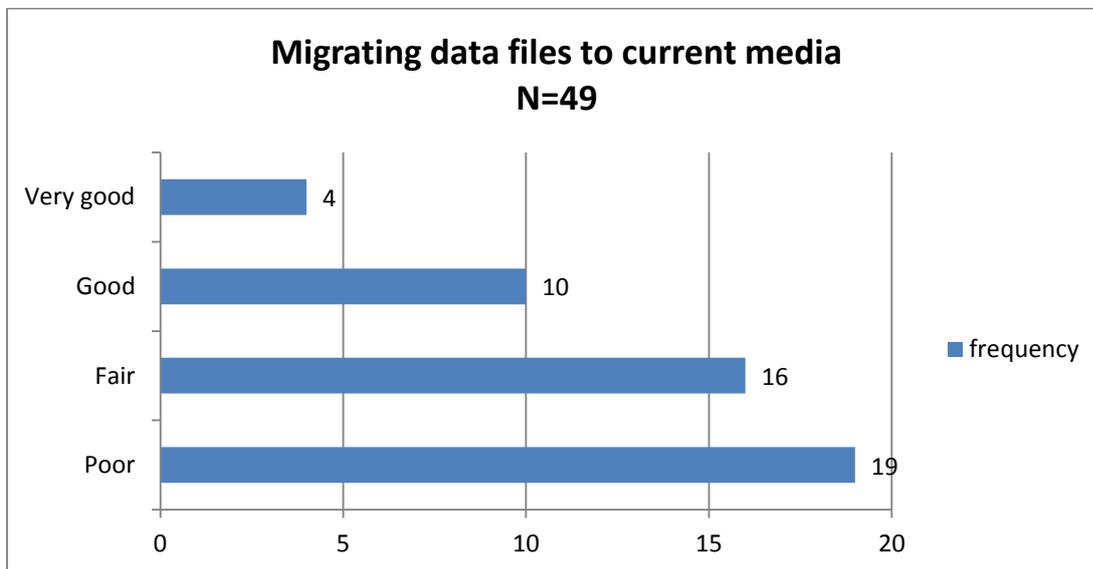


The majority of respondents rated their skills to submit research data to dataset repositories as poor (22/49, 44.9%), followed by those respondents who marked the fair (15/49, 30.6%), good (8/49, 16.3%) or very good (4/49, 8.2%) options.

### 5.3.7.6 *Ensuring research data is curated by regular migration of data files to current media*

Forty-nine of 68 (72.1%) participants in the study rated their skills to migrate research data files to current formats. N was 49. Figure 0.54 reflects the self-reported perceptions of skills to migrate data files to current media

**Figure 0.54 Self-reported perceptions of skills in the regular migration of data files to current media**



The majority of respondents rated their skills regarding the regular migrating of data files to current media as poor (19/49, 38.8%), followed by those indicating fair (16/49, 32.7%), and a lower proportion who thought their skill in this regard was good (10/49, 20.4%) or very good (4/49, 8.2%).

The following section of this chapter will focus on the creation of research documents as a next research phase.

### 5.3.8 **Creating research documents**

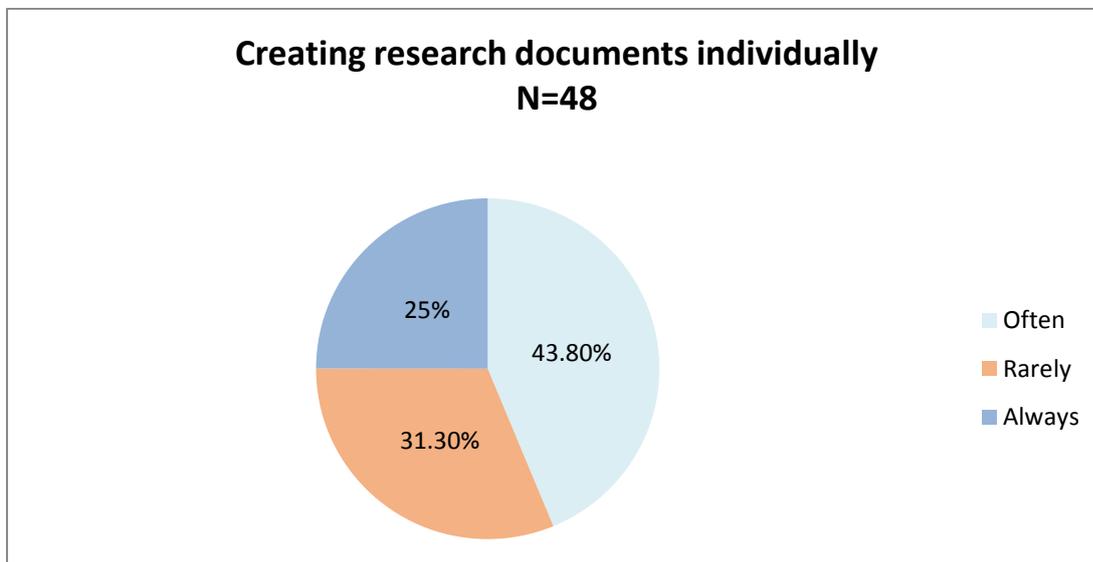
The creation of research documents was the seventh research phase tested in the questionnaire. This research phase is also highlighted in the proposed ARIL definition, where skills to synthesise information in order to generate new knowledge were highlighted. A group of four questions were developed to determine the skills of researchers during this

phase, with question 25 (Addendum D) requesting respondents to indicate respectively how often they created research documents individually and in collaboration with other researchers. A four-point Likert scale was provided, which contained the following scales: never, rarely, often and always. Results are depicted in Chart 0.2 and Chart 0.3 and discussed in sections 5.3.8.1 and 5.3.8.2.

### 5.3.8.1 *Creating research documents individually*

Forty-eight of 68 (70.6%) participants indicated how often they created research documents individually. N was 48. Chart 0.2 reflects the frequency of creating research documents individually.

**Chart 0.2 Frequency of creating research documents individually**

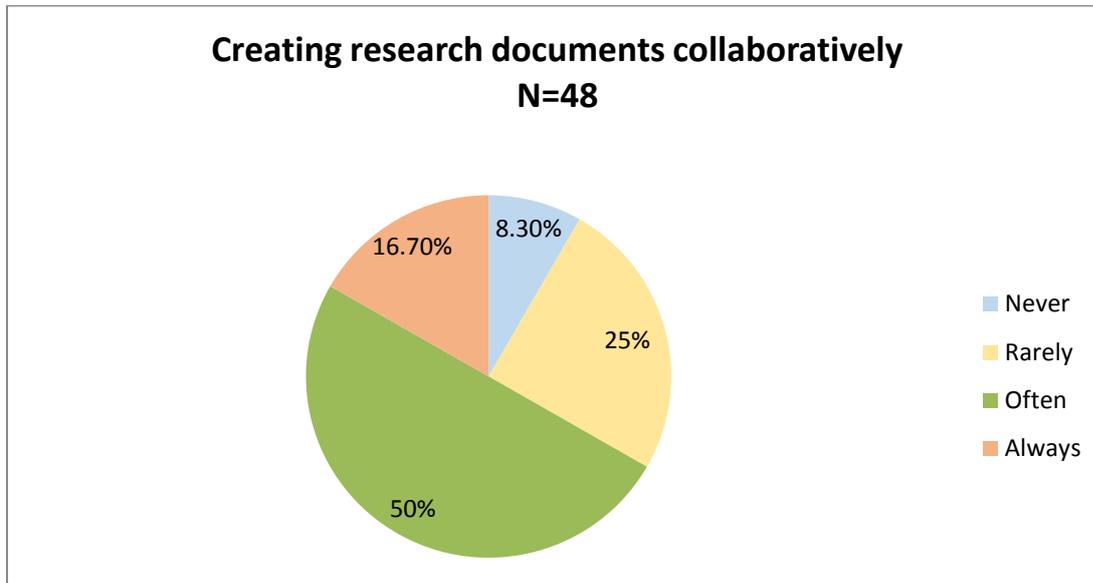


The majority of respondents (21/48, 43.8%) indicated that they often created research documents individually. A total of 15/48 (31.3%) respondents rarely created research documents individually, and 12/48 (25%) always created research documents individually. The combination of often and always (33/48, 68.8%) illustrates that the majority of respondents often created research documents individually.

### 5.3.8.2 *Creating research documents by writing in collaboration with other researchers*

Forty-eight of 68 (70.6%) participants indicated how often they created research documents by writing in collaboration with other researchers. N was 48. Chart 0.3 reflects the frequency of writing in collaboration with others.

**Chart 0.3 Frequency of creating research documents in collaboration with other researchers**



One-half of respondents (24/48, 50%) indicated that they often created research documents in collaboration with other researchers. A further 12/48 (25%) indicated that they rarely undertook this, 8/48 (16.7%) always did, and 4/48 (8.3%) indicated that they never created research documents in collaboration with other researchers. The combination of often and always (32/48, 66.7%) illustrates that the majority of respondents often created documents in collaboration with other researchers.

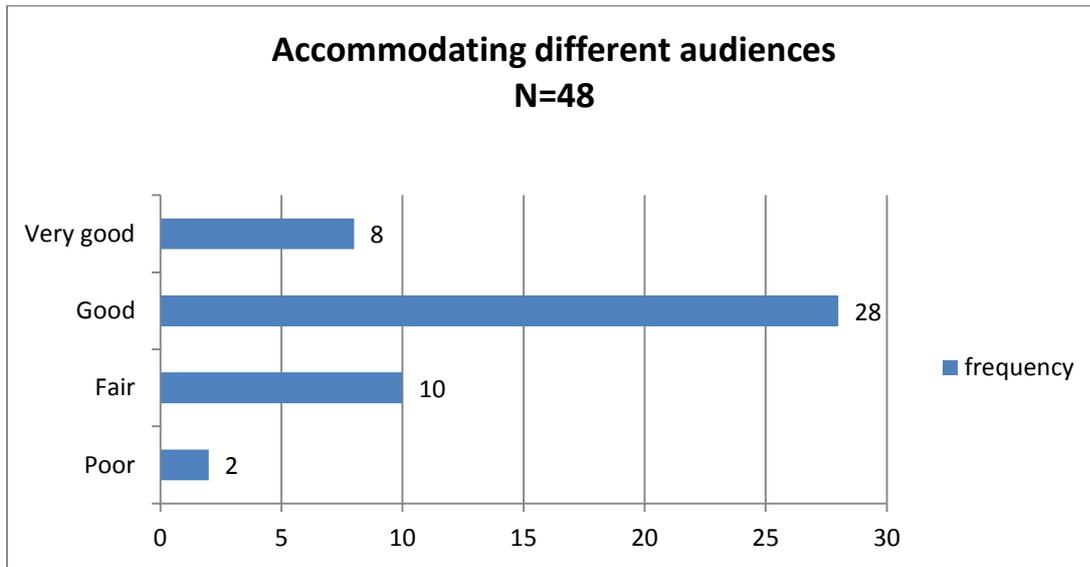
Question 26 (Addendum D) focused on skills when creating research documents.

Respondents were requested to rate themselves regarding the following four processes: adapting a piece of work to accommodate different audiences, correct citing of others' work, avoiding plagiarism and critiquing research papers. The relevant option had to be marked on a four-point Likert scale with the options: poor, fair, good and very good. Results are depicted in Figure 0.55, Figure 0.56, Figure 0.57 and Figure 0.58 and discussed in sections 5.3.8.3 to 5.3.8.6.

#### *5.3.8.3 Adapting a piece of work to accommodate different audiences*

Forty-eight of 68 (70.6%) participants in the study rated their skills to adapt a piece of work to accommodate different audiences. N was 48. Figure 0.55 reflects the self-reported perceptions of skills in adapting work to accommodate different audiences.

**Figure 0.55 Self-reported perceptions of skills in adapting a piece of work to accommodate different audiences**

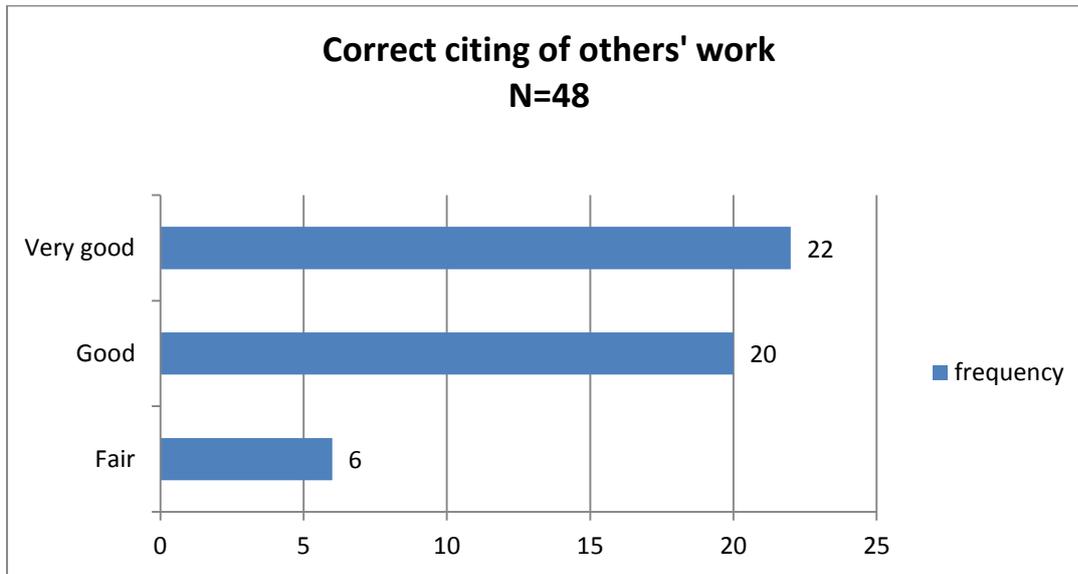


Skills to adapt a piece of work to accommodate different audiences were reported as good by 28/48 (58.3%) respondents. Others indicated their skill to be fair (10/48, 20.8%), very good (8/48, 16.7%) or poor (2/48, 4.2%). The combination of very good and good (36/48, 75%) illustrates that the majority of respondents felt confident about their skills to adapt research work to accommodate different audiences.

#### 5.3.8.4 *Correct citing of other people's work*

Forty-eight of 68 (70.6%) participants cite others' work. N was 48. Figure 0.56 reflects the self-reported perceptions of skills in the correct citing of others' work.

**Figure 0.56 Self-reported perceptions of skills in the correct citing of other people's work**

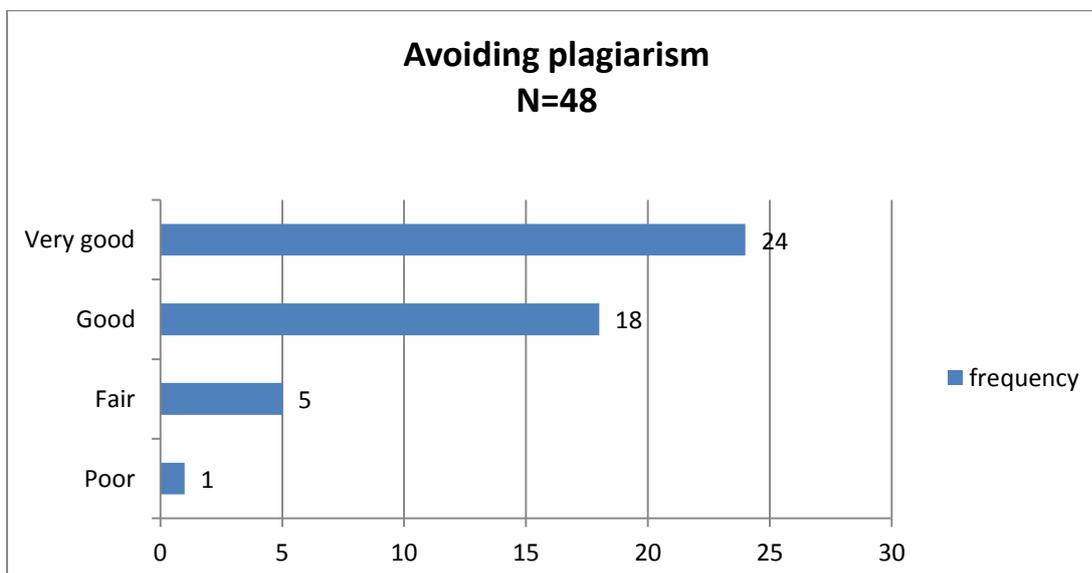


A similar proportion of respondents rated their skill as very good 22/48 (45%) and good 20/48 (41.7%) with regard to the correct citing of others' work. Others indicated this ability as fair 6/48 (12.5%). The combination of very good and good (42/48, 87.5%) illustrates that the majority of respondents felt confident about their skills to cite correctly.

#### 5.3.8.5 Avoiding plagiarism when creating research documents

Forty-eight of 68 (70.6%) participants rated their skills in avoiding plagiarism when creating research documents. N was 48. Figure 0.57 reflects the self-reported perceptions of skills in avoiding plagiarism.

**Figure 0.57 Self-reported perceptions of skills in avoiding plagiarism**

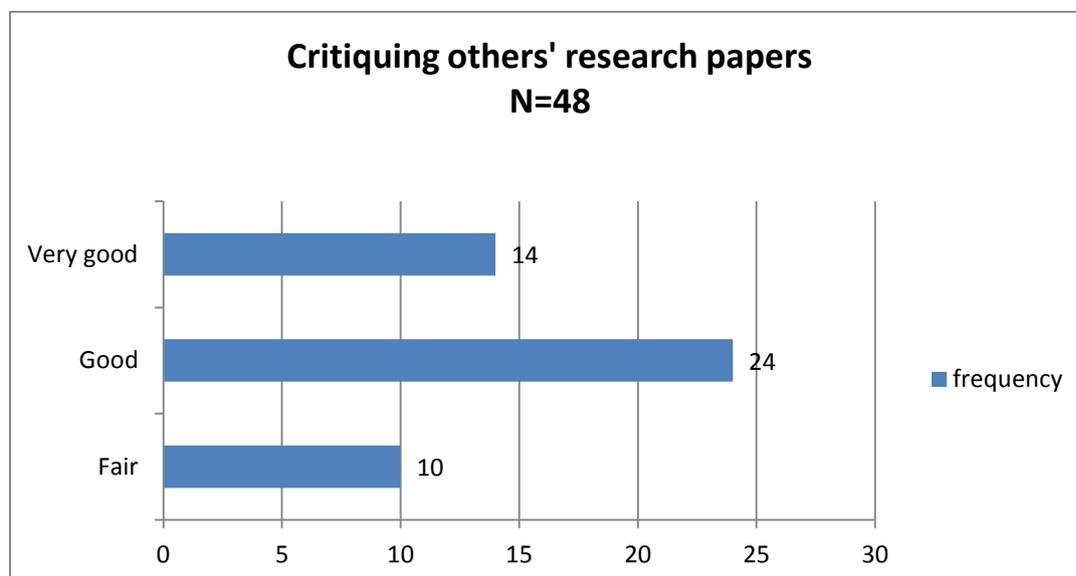


Half of the respondents (24/48, 50%) rated their skills to avoid plagiarism as very good. The remainder rated this skill as good (18/48, 37.5%), fair (5/48, 10.4%), or poor (1/48, 2.1%). The combination of good and very good (42/48, 68%) illustrates that the majority of respondents felt confident about their skills to avoid plagiarism when creating research documents.

#### 5.3.8.6 Critiquing/critical reading of others' research papers

Forty-eight of 68 (70.6%) participants rated their skills to critique other researcher's papers. N was 48. Figure 0.58 reflects the self-reported perceptions of skills in critiquing others' research papers.

**Figure 0.58 Self-reported perceptions of skills in critiquing others' research papers**



Half of the respondents (24/48, 50%) rated their skills to critique other researchers' papers as good. The rest of the responses indicated very good (14/48, 29.2%) or fair (10/48, 20.8%) skills. The combination of very good and good (38/48, 79.2%) illustrates that the majority of respondents felt confident about their skills to critique the research papers of others.

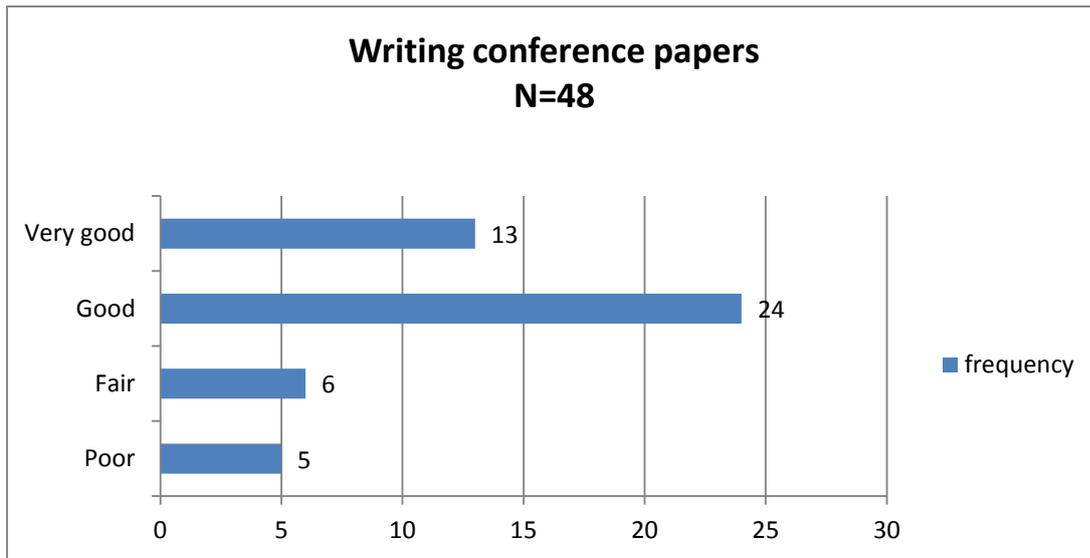
Question 27 (Addendum D) focused on the creation of specific formats and respondents had to rate their skills in creating each of the following eleven formats: conference papers, conference abstracts, conference presentations, theses, dissertations, journal articles, contributions on social media platforms, technical reports, books, chapters in books and multimedia (e.g. audio and video recordings). Respondents had to rate their skills according to a four-point Likert scale offering the following options: poor, fair, good and very good. Results are depicted in Figure 0.59, Figure 0.60, Figure 0.61, Figure 0.62, Figure 0.63, Figure

0.64, Figure 0.65, Figure 0.66, Figure 0.67, Figure 0.68 and Figure 0.69 and discussed in sections 5.3.8.7 to 5.3.8.18.

### 5.3.8.7 Writing of conference papers

Forty-eight of 68 (70.6%) participants rated their skills in writing conference papers. N was 48. Figure 0.59 reflects the self-reported perceptions of skills in writing conference papers.

**Figure 0.59 Self-reported perceptions about writing conference papers**

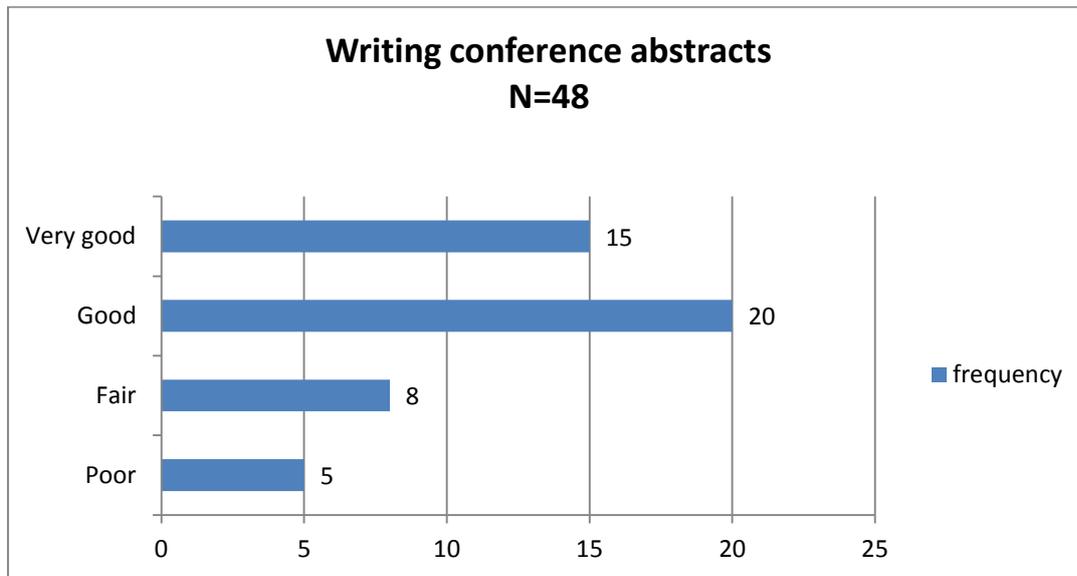


Half of the respondents (24/48, 50%) rated their skills to write conference papers as good, 13/48 (27.1%) indicated that they were very good, and the rest of the respondents indicated that they were either fairly skilled (6/48, 12.5%) or poor (5/48, 10.4%). The combination of good and very good (37/48, 77.1%) illustrates that the majority of respondents felt confident about their skills to write conference papers.

### 5.3.8.8 Writing of conference abstracts

Forty-eight of 68 (70.6%) participant rated their skills to write conference papers. N was 48. Figure 0.60 reflects the self-reported perceptions of skills in writing conference abstracts.

**Figure 0.60 Self-reported perceptions about writing conference abstracts**

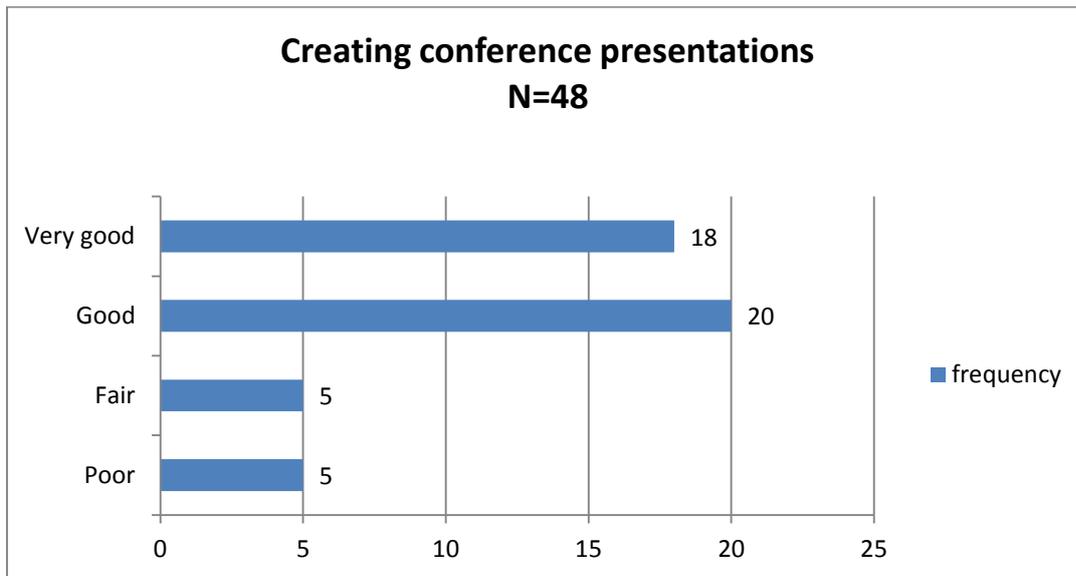


The writing of conference abstracts was thought to be good by 20/48 (41.7%), followed by those respondents who rated this skill as very good (15/48, 31.3%). Other respondents indicated their skill to be fair (8/48, 16.7%) or poor (5/48, 10.4%). The combination of good and very good (35/48, 73%) illustrates that the majority of respondents felt confident about their skills to write conference abstracts.

#### 5.3.8.9 *Creating conference presentations (e.g. PowerPoint)*

Forty-eight of 68 (70.6%) participants rated their skills regarding the creation of conference presentations. N was 48. Figure 0.61 reflects the self-reported perceptions of skills in creating conference papers.

**Figure 0.61 Self-reported perceptions about creating conference presentations**

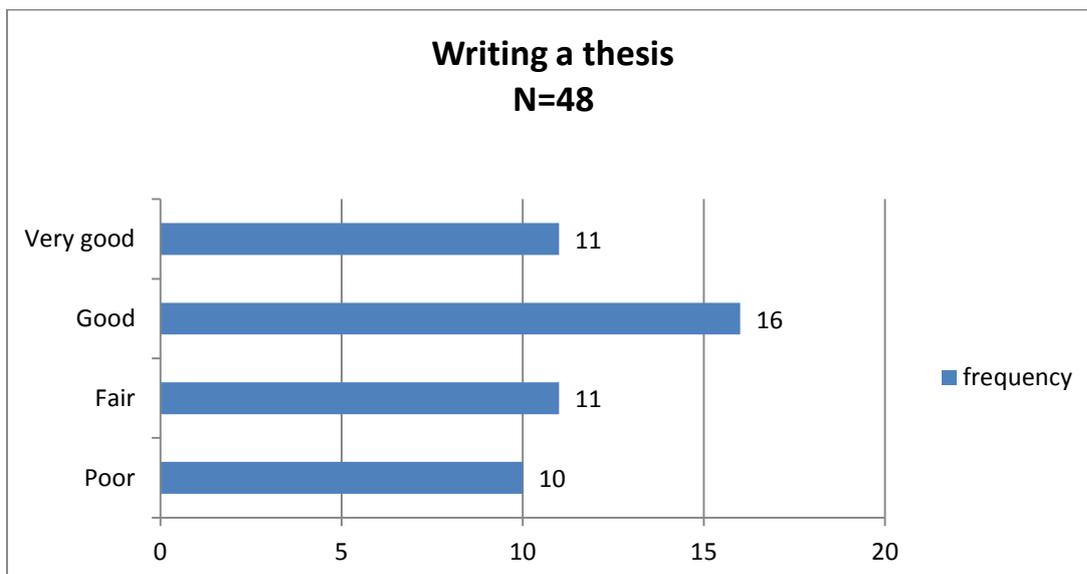


A large proportion of respondents rated their skills to create conference presentations as good (20/48, 41.7%), followed by those who thought they were very good (18/48, 37.5%). An equal number of respondents rated this skill as fair and poor (5/48, 10.4%). The combination of good and very good (38/48, 79.2%) illustrates that the majority of respondents felt confident about their skills to create conference presentations.

#### 5.3.8.10 Writing of a thesis (doctoral)

Forty-eight of 68 (70.6%) participants rated their skills to write a thesis. N was 48. Figure 0.62 reflects the self-reported perceptions of skills in writing a thesis.

**Figure 0.62 Self-reported perceptions about writing of a thesis**

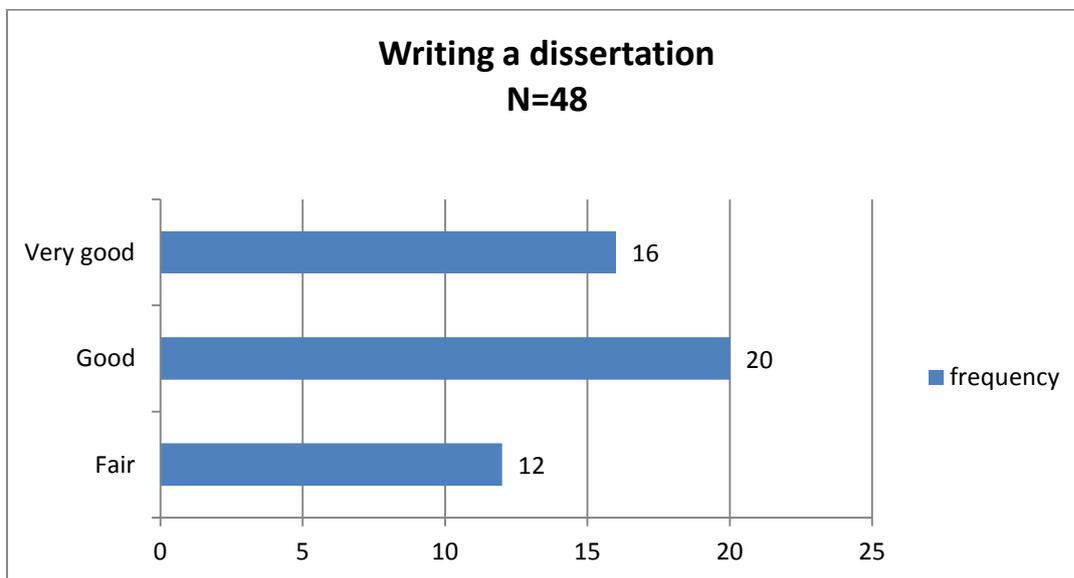


Respondents who indicated their thesis-writing skills as good numbered 16/48 (33.3%), with an equal number (11 each) who thought their skill was very good or fair (11/48, 22.9%) while 10/48 (20.8%) thought they were poor at this. The combination of good and very good (27/48, 56.2%) illustrates that just over half of the respondents felt confident about their skills to write a thesis.

#### 5.3.8.11 Writing of a dissertation (master's)

Forty-eight of 68 (70.6%) participants rated their skills to write a dissertation. N was 48. Figure 0.63 reflects the self-reported perceptions of skills in writing a dissertation.

**Figure 0.63 Self-reported perceptions about writing a dissertation**

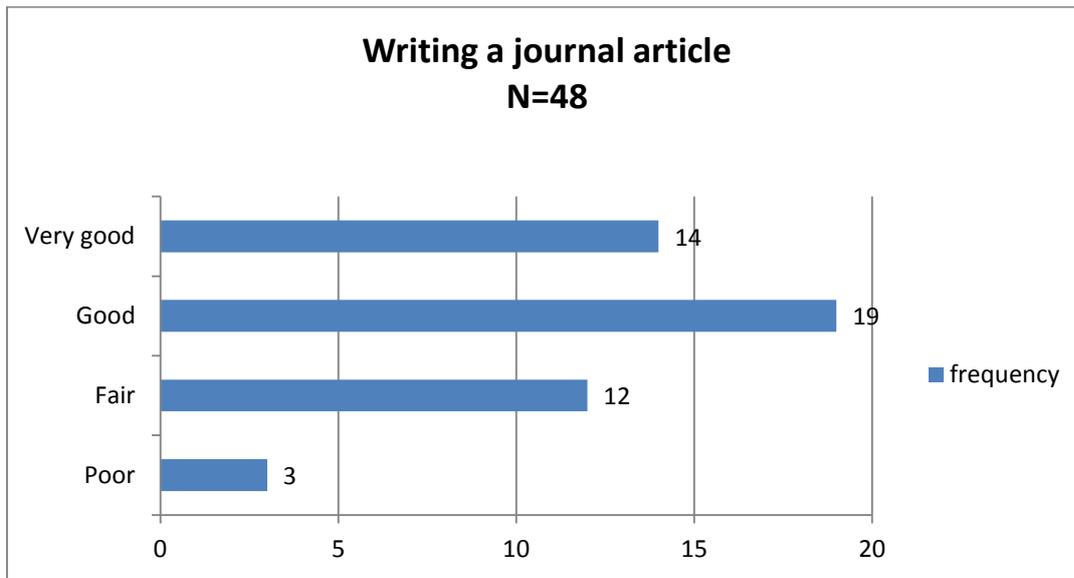


The skill of writing a dissertation was reported as good by 20/48 (41.7%) and very good by 16/48 (33.3%). The rest of the respondents rated this skill as fair (12/48, 25%). The combination of good and very good (36/48, 75%) illustrates that the majority of respondents felt confident about their skills to write dissertations.

#### 5.3.8.12 Writing of a journal article

Forty-eight of 68 (70.6%) participants rated their skills to write journal articles. N was 48. Figure 0.64 reflects the self-reported perceptions of skills in writing a journal article.

**Figure 0.64 Self-reported perceptions of skills in writing a journal article**

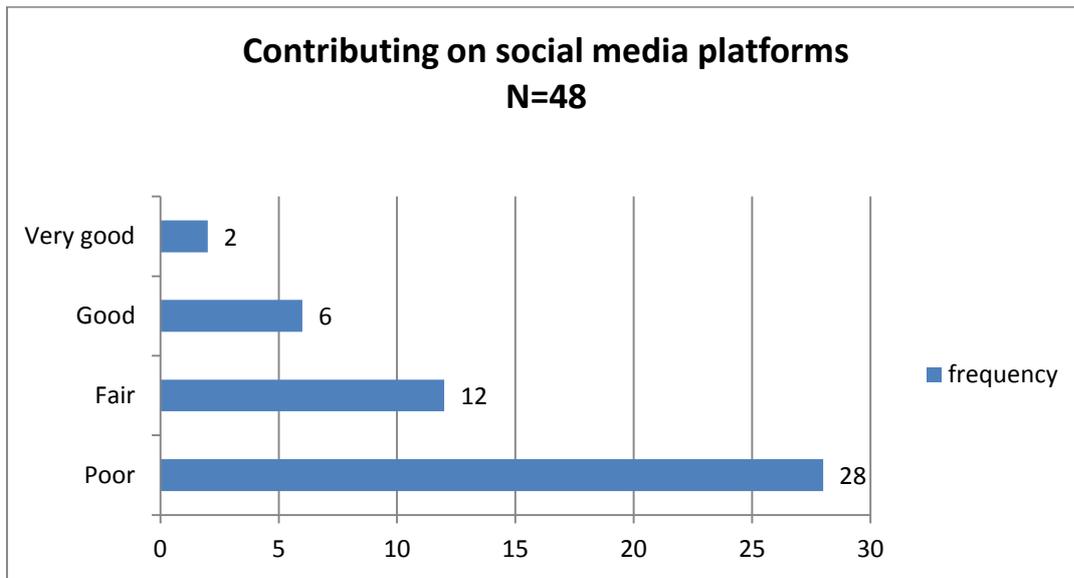


Skills to write journal articles were reported to be good by 19/48 (39.6%) and very good by 14/48 (29.2%) of respondents. The rest of the respondents indicated that they were fair (12/48, 25%) or poor (3/48, 6.3%). The combination of good and very good (33/48, 68.8%) illustrates that the majority of respondents felt confident about their skills to write a journal article.

#### *5.3.8.13 Contributing on social media platforms (e.g. blogs and wikis)*

Forty-eight of 68 (70.6%) participants rated their skills to contribute on social media platforms. N was 48. Figure 0.65 reflects the self-reported perceptions of skills in contributing on social media platforms.

**Figure 0.65 Self-reported perceptions of skills in contributing on social media platforms**

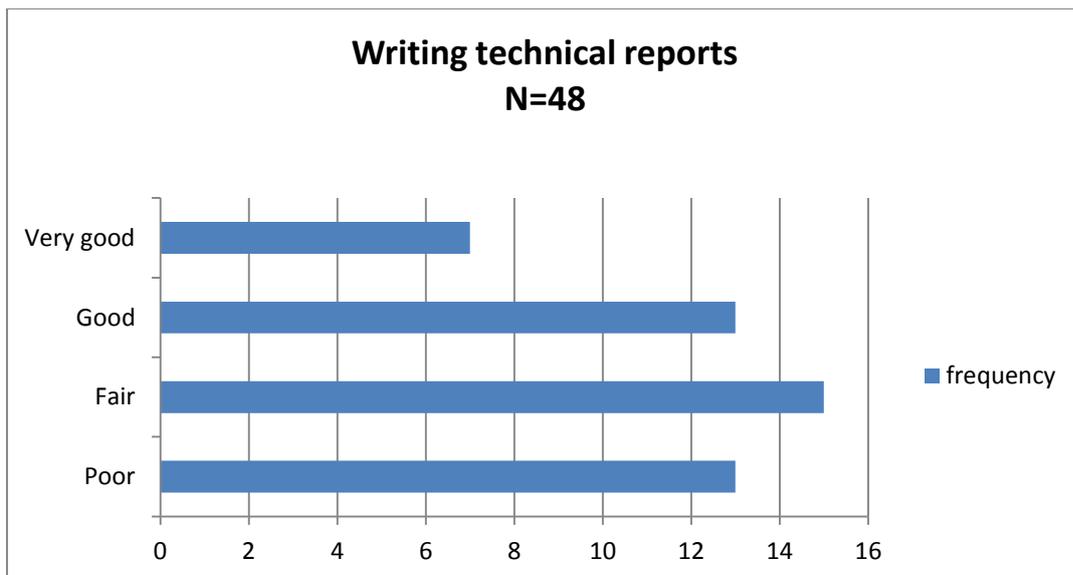


The majority of respondents (28/48, 58.3%) rated their skills to contribute to social media as poor, with other respondents rating their skill as fair (12/48, 25%), good (6/48, 12.5%) or very good (2/48, 4.2%).

#### 5.3.8.14 Writing of technical reports (e.g. patents and standards)

Forty-eight of 68 (70.6%) participants rated their skills to write technical reports. N was 48. Figure 0.66 reflects the self-reported perceptions of skills in writing technical papers.

**Figure 0.66 Self-reported perceptions of skills in writing technical reports**

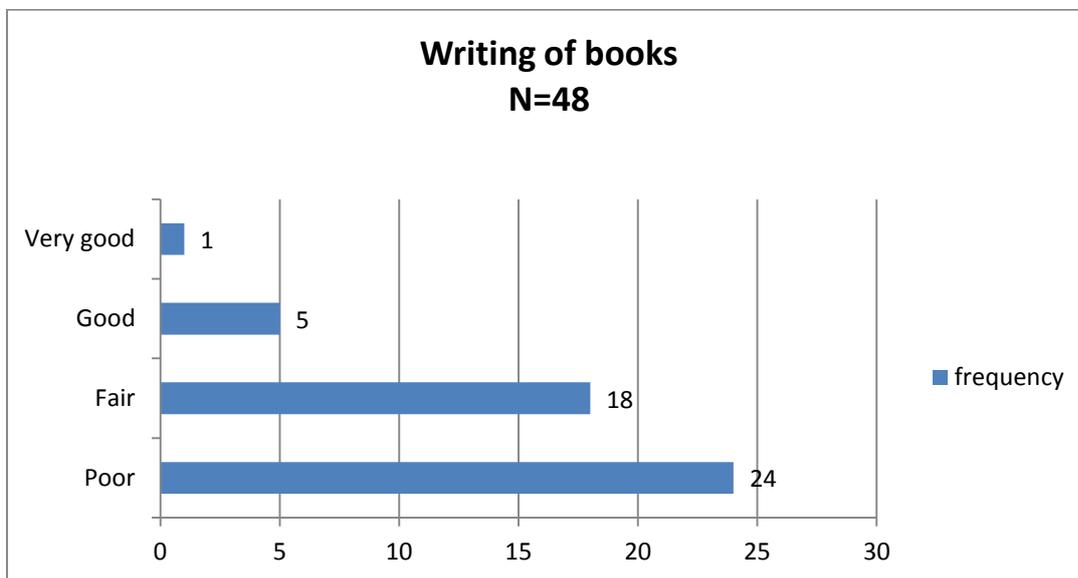


The proportion of responses rating the skill to write technical reports ranged from fair (15/48, 31.3%) and good (13/48, 27.1%) to poor (13/48, 27.1%). Only 7/48 (14.6%) indicated that their skills were very good in this regard. The combination of fair and poor (28/48, 58.4%) illustrates that just over half of the respondents did not feel confident about their skills to write technical reports.

#### 5.3.8.15 Writing of books

Forty-eight of 68 (70.6%) participants rated their skills to write books. N was 48. Figure 0.67 reflects the self-reported perceptions of skills in writing books.

**Figure 0.67 Self-reported perceptions of skills to write books**

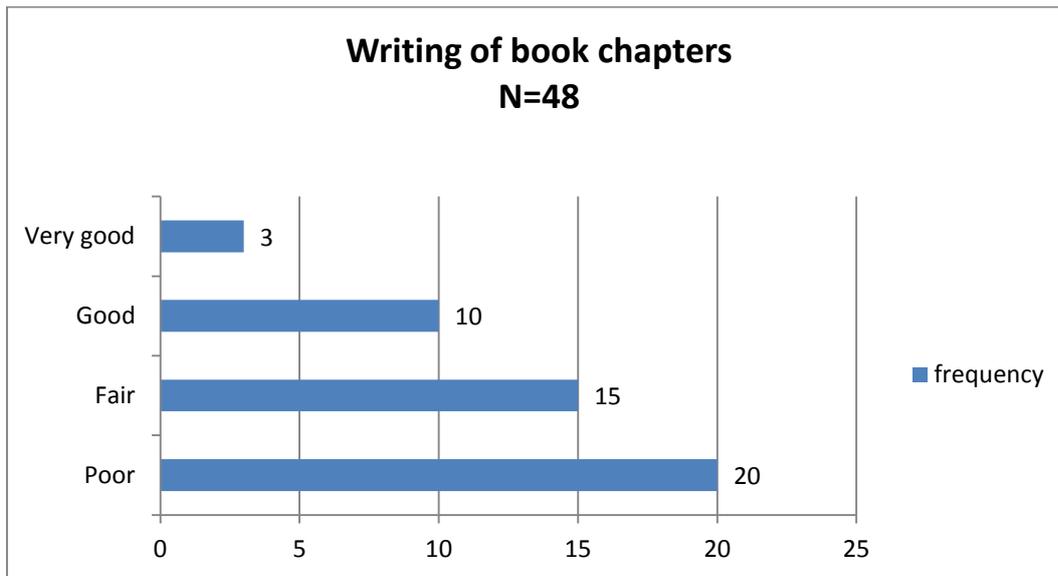


Half of the respondents rated their skills to write books as poor (24/48, 50%). The rest of the responses were divided between fair (18/48, 37.5%), good (5/48, 10.4%) and very good (1/48, 2.1%). The combination of fair and poor (42/48, 87.5%) illustrates that the majority of respondents did not feel confident to write books.

#### 5.3.8.16 Writing of chapters in books

Forty-eight of 68 (70.6%) participants rated their skills in writing chapters in books. N was 48. Figure 0.68 reflects the self-reported perceptions of skills in writing book chapters.

**Figure 0.68 Self-reported perceptions of skills in writing chapters in books**

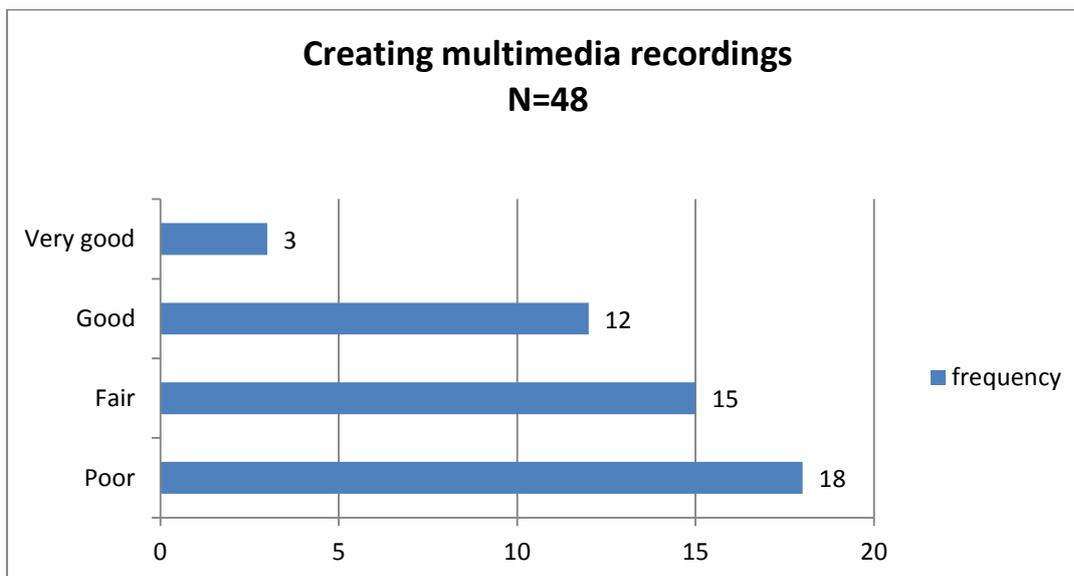


The majority of respondents rated their skills to write chapters in books as poor (20/48, 41.7%), followed by fair (15/48, 31.3%), good (10/48, 20.8%) or very good (3/48, 6.3%). The combination of fair and poor (35/48, 73%) illustrates that the majority of respondents did not feel confident about writing chapters in books.

#### 5.3.8.17 Creating multimedia recordings (e.g. audio and video)

Forty-eight of 68 (70.6%) participants rated their skills to create multimedia recordings, while 20/68 (29.4%) did not answer the question. N was 48. Figure 0.69 reflects the self-reported perceptions of skills in creating multimedia recordings.

**Figure 0.69 Self-reported perceptions of skills in creating multimedia recordings**



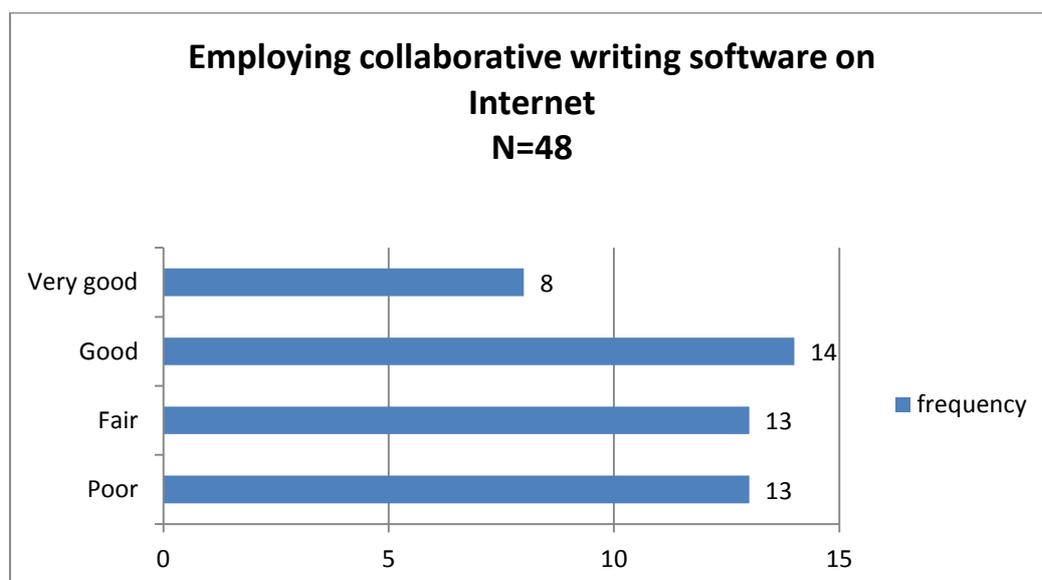
The majority of respondents rated their skills to create multimedia recordings as poor (18/48, 37.5%) or fair (15/48, 31.3%). A smaller proportion of 12/48 (25%) marked the good and very good (3/48, 6.3%) options. The combination of fair and poor (33/48, 68.8%) illustrates that the majority of respondents did not feel confident about their skills to create multimedia recordings.

Question 28 (Addendum D) focused on specifically collaborative writing. The proposed ARIL definition highlights the notion of networking and collaboration among researchers in order to enhance scholarship. A four-point Likert scale was provided to respondents on which they could rate their skills in the use of the following six collaborative writing tools: collaborative writing software from the internet, word processor packages, VREs, social media platforms, citation software and electronic mail. The options on the Likert scale were poor, fair good and very good. Responses are illustrated in Figure 0.70, Figure 0.71, Figure 0.72, Figure 0.73, Figure 0.74 and Figure 0.75 and discussed in sections 5.3.8.18 to 5.3.8.23.

*5.3.8.18 Employing collaborative writing software on the internet when creating research documents collaboratively*

Forty-eight of 68 (70.6%) participants rated their skills in employing collaborative writing software on the internet when preparing research documents. N was 48. Figure 0.70 reflects the self-reported perceptions of skills in employing collaborative software on the internet.

**Figure 0.70 Self-reported perceptions of skills in employing collaborative software on the internet**

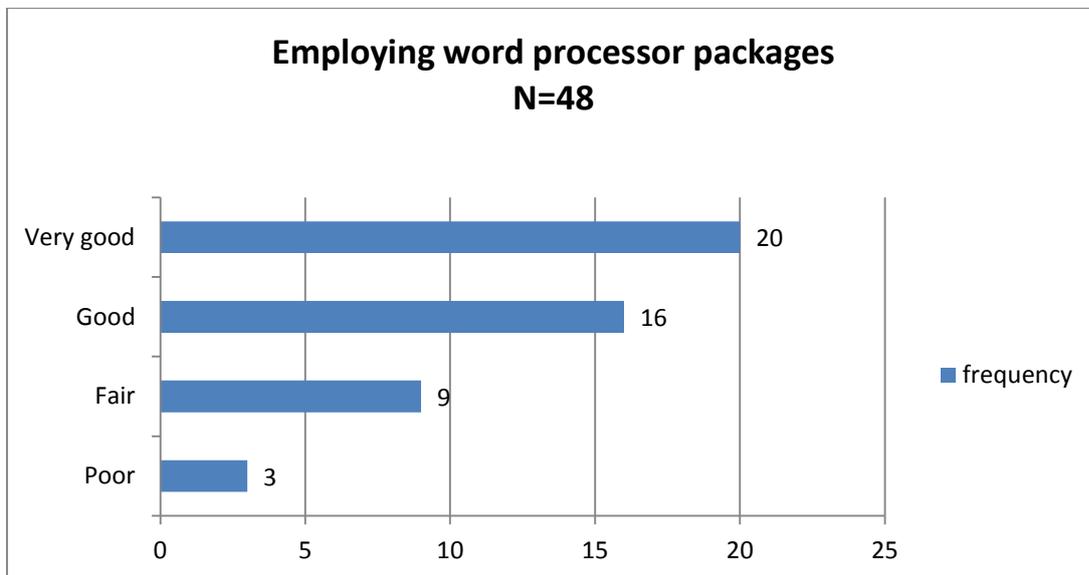


Of 48 respondents, 14 (29.2%) rated their skills to employ collaborative writing software on the internet as good. Others indicated their skill as fair or poor (13/48, 27.1% each). A further 8/48 (16.7%) rated their skills as very good. The combination of fair and poor (26/48, 54.2%) illustrates that just over half of the respondents were not confident about their skills to employ collaborative writing software tools on the internet.

*5.3.8.19 Employing word processor packages (e.g. MS office) when creating research documents collaboratively*

Forty-eight of 68 (70.6%) participants rated their skills in employing Word Processor packages when preparing research documents collaboratively. N was 48. Figure 0.71 reflects the self-reported perceptions of skills in employing Word Processor packages.

**Figure 0.71 Self-reported perceptions of skills in employing word processor packages**

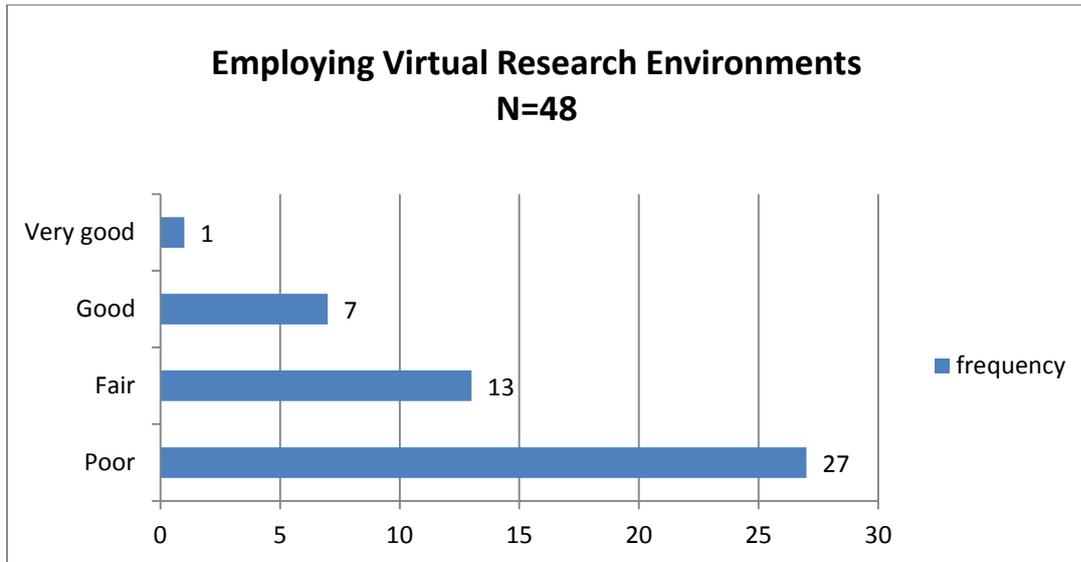


Of the 48 respondents, 20 (41.7%) rated their skills to employ word processor packages when writing in collaboration with other researchers as very good, followed by those who thought they were good (16/48, 33.3%), fair (9/48, 18.8%) or poor (3/48, 6.3%). The combination of good and very good (36/48, 75%) illustrates that the majority of respondents felt confident about their skills to employ word processor packages when writing in collaboration with other researchers.

### 5.3.8.20 *Employing virtual research environments on the internet when creating research documents collaboratively*

Forty-eight of 68 (70.6%) participants rated their skills in the use of VREs on the internet when preparing research documents collaboratively. N was 48. Figure 0.72 reflects the self-reported perceptions of skills in employing VREs when creating research documents.

**Figure 0.72 Self-reported perceptions of skills in employing VREs when creating research documents collaboratively**

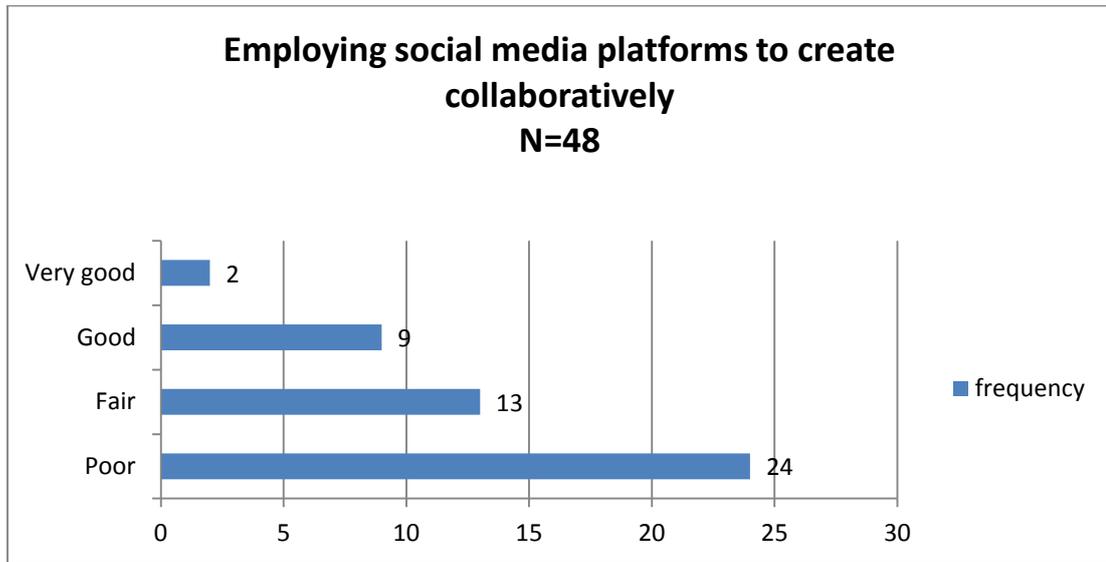


The majority of respondents rated their skills to employ VREs when creating research documents collaboratively as poor (27/48, 56.3%). The rest of respondents marked the fair (13/48, 27.1%), good (7/48, 14.6%) or very good (1/48, 2.1%) options.

### 5.3.8.21 *Employing social media platforms (e.g. wikis and blogs) when creating research documents collaboratively*

Forty-eight of 68 (70.6%) participants rated their skills to employ social media platforms when preparing research documents collaboratively. N was 48. Figure 0.73 reflects the self-reported perceptions of skills in employing social media platforms when creating research documents collaboratively.

**Figure 0.73 Self-reported perceptions of skills in employing social media platforms when creating research documents collaboratively**

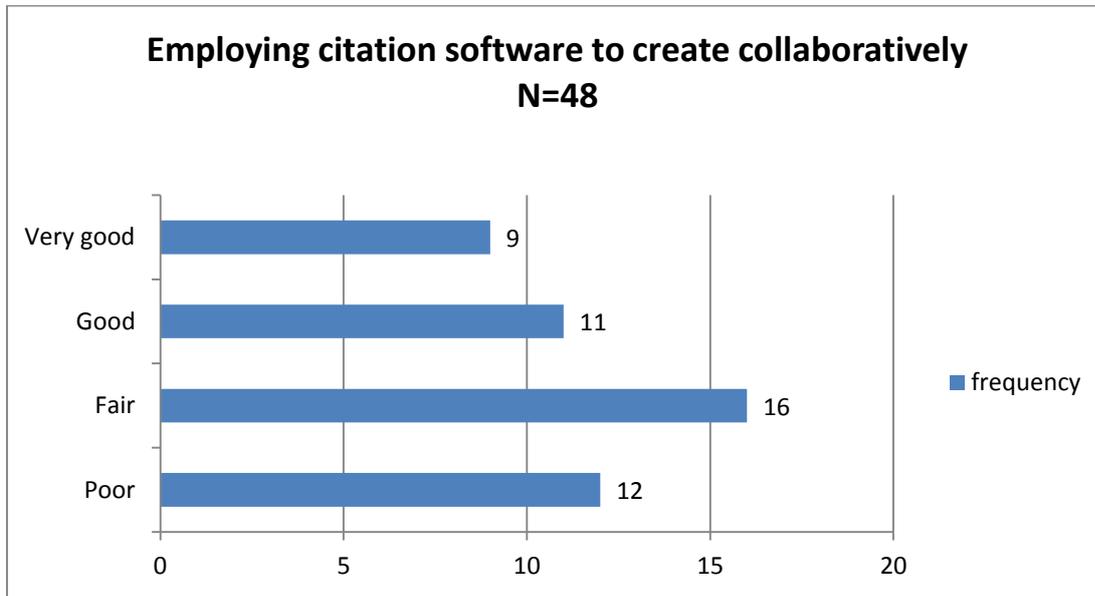


Half of the respondents rated their skills to employ social media platforms when writing in collaboration with other researchers as poor (24/48, 50%), with 13/48 (27.1%) indicating this skill as fair, 9/48 (18.8%) as good, and 2/48 (4.2%) as very good. The combination of fair and poor (37/48, 77.1%) illustrates that the majority of respondents did not feel confident about their skills to employ social media platforms when creating documents collaboratively.

#### 5.3.8.22 *Employing citation software (e.g. RefWorks, EndNote, Mendeley) when creating research documents collaboratively*

Forty-eight of 68 (70.6%) participants rated their skills in the use of citation software when preparing research documents collaboratively. N was 48. Figure 0.74 reflects the self-reported perceptions of skills in employing citation software when creating research documents collaboratively.

**Figure 0.74 Self-reported perceptions of skills in employing citation software when creating research documents collaboratively**

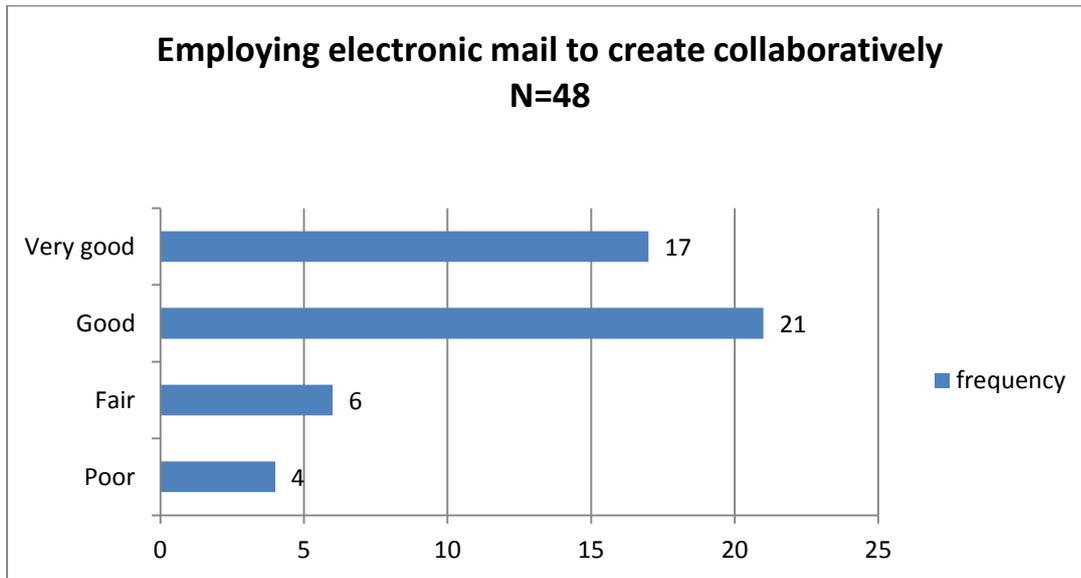


The skills to employ citation software when writing collaboratively were indicated as fair by 16/48 (33.3%), poor by 12/48 (25%) and good by 11/48 (22.9%). Only nine (18.8%) respondents indicated that they were very good. The combination of fair and poor (28/48, 58.3%) illustrates that just over half of the respondents did not feel confident about employing citation software when writing collaboratively.

#### 5.3.8.23 *Employing electronic mail when creating research documents collaboratively*

Forty-eight of 68 (70.6%) participants rated their skills in employing electronic mail when preparing research documents collaboratively. N was 48. Figure 0.75 reflects the self-reported perceptions of skills in employing electronic mail when creating research documents collaboratively.

**Figure 0.75 Self-reported perceptions of skills in employing electronic mail to create research documents collaboratively**



Of 48 respondents who rated their skills to employ electronic mail when writing collaboratively, 21 (43.8%) thought they were good, 17 (35.4%) indicated very good, 6 (12.5%) fair, and four (8.3%) poor. The combination of good and very good (38/48, 79.2%) illustrates that the majority of respondents felt confident about their skills to employ electronic mail when writing collaboratively.

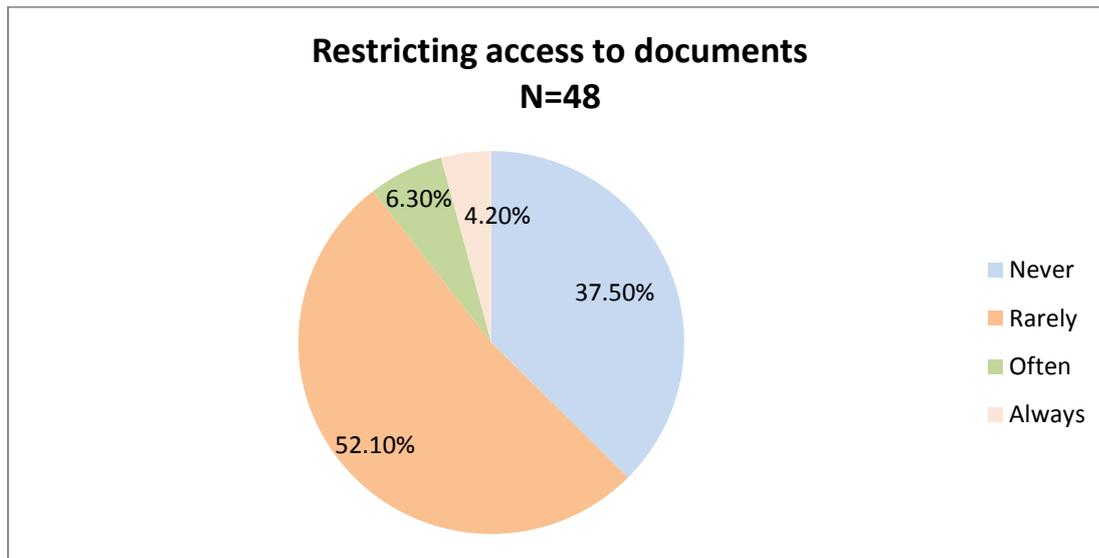
### 5.3.9 Management of IP rights to research

The management of IP rights was the eighth research phase tested in the questionnaire, with a group of five questions formulated to test the skills of researchers in this regard. Question 29 (Addendum D) requested respondents to indicate how often they needed to restrict access to research documents; the following options were provided to respondents: never, rarely, often, or always. The results obtained from respondents are depicted in Chart 0.4.

#### 5.3.9.1 Restricting access to research documents or findings

Forty-eight of 68 (70.6%) participants indicated how often they needed to restrict access to their research documents/findings. N was 48. Chart 0.4 reflects the self-reported frequency of restricting access to research documents or findings.

**Chart 0.4 Frequency of restricting access to research documents or findings**



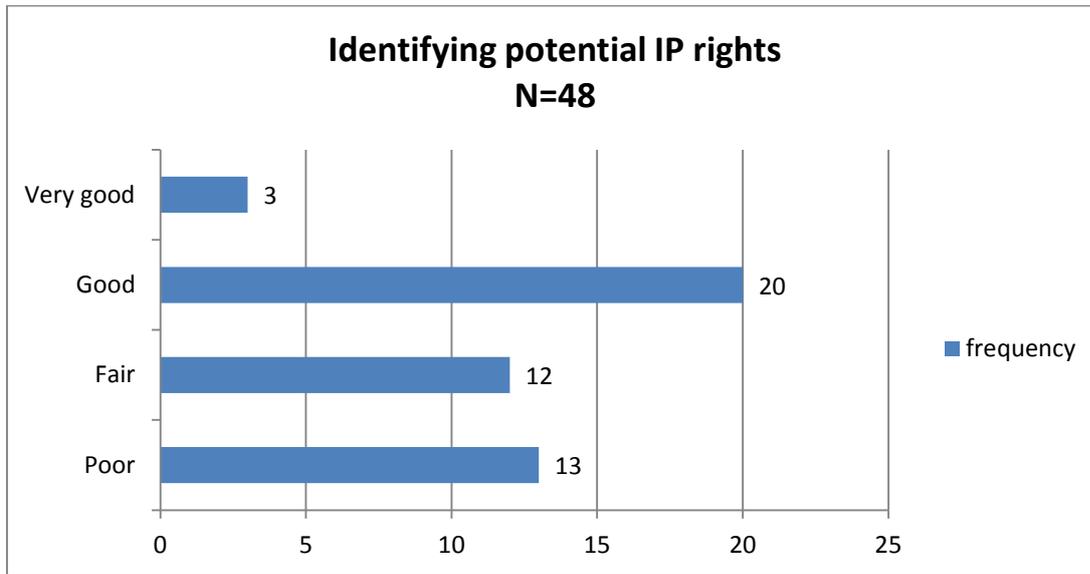
Just over half (52.1%) of the respondents indicated that they rarely needed to restrict access to research documents/findings, followed by those who never (18/48, 37.5%), often (3/48, 6.3%) or always (2/48, 4.2%) needed to follow this route. The combination of rarely and never (43/48, 89.6%) illustrates that the majority of respondents hardly ever restricted access to research documents/findings.

#### 5.3.9.2 Identifying potential intellectual property rights to research

Question 30 (Addendum D) requested respondents to rate their ability to identify potential IP rights to their research by selecting the most suitable option from the following four-point Likert scale namely: poor, fair, good or very good. Results obtained from respondents are illustrated in Figure 0.76.

Forty-eight of 68 (70.6%) participants rated their ability to identify potential IP rights to research. N was 48. Figure 0.76 reflects the self-reported perceptions of skills to identify potential IP rights to research.

**Figure 0.76 Self-reported perceptions of skills in identifying potential IP rights to research**



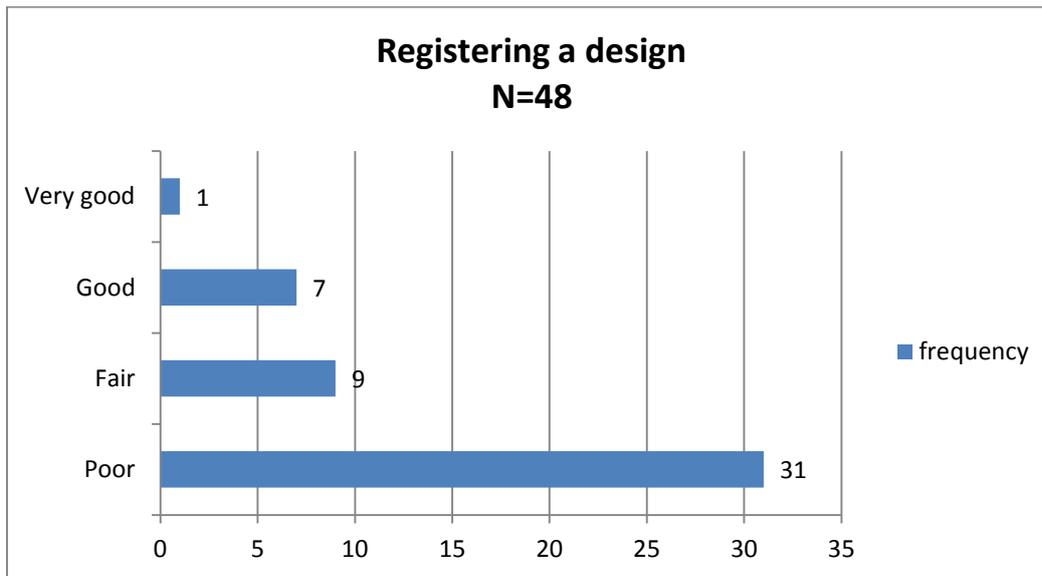
Twenty of 48 respondents rated their skills to identify potential IP rights to their work as good (20/48, 41.7%), 13/48 (27.1%) as poor, 12/48 (25%) as fair and 3/48 (6.3%) as very good. The combination of fair and poor (25/48, 52.1%) illustrates that just over half of the respondents did not feel confident about identifying potential IP rights to their research.

### 5.3.9.3 Registering a design to protect the intellectual property rights of research

Question 31 (Addendum D) requested respondents to rate their skills when using five different mechanisms to protect IP rights to their research, namely registration of a design, registration of a patent, registration of a trademark, registration of a domain name, and setting up of licenses or agreements. A four-point Likert scale was provided and contained the scales poor, fair, good and very good. Results are depicted in Figure 0.77, Figure 0.78, Figure 0.79, Figure 0.80 and Figure 0.81 and discussed in sections 5.3.9.3 to 5.3.9.7.

Forty-eight of 68 (70.6%) participants rated their skills to register a design to protect the IP rights of research. N was 48. Figure 0.77 reflects the self-reported perceptions of skills to register a design to protect IP rights.

**Figure 0.77 Self-reported perceptions of skills in registering a design**

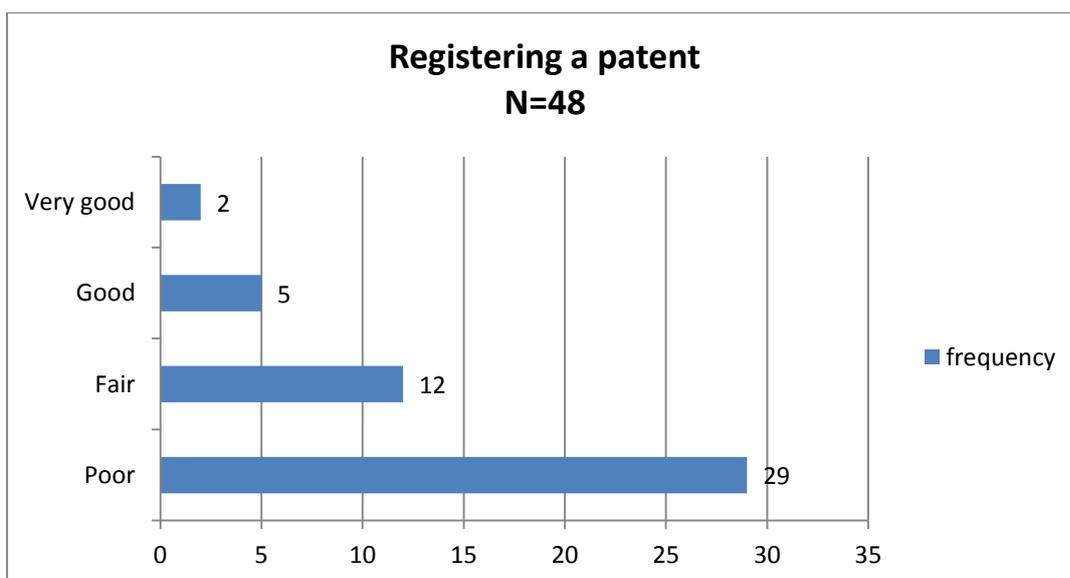


The majority of respondents (31/48, 64.6%) rated their skills to register a design as poor. Other respondents indicated their skills as fair (9/48, 18.8%) or good (7/48, 14.6%). A single respondent (2.1%) indicated this skill as very good.

#### 5.3.9.4 Registering a patent to protect the intellectual property rights of research

Forty-eight of 68 (70.6%) participants rated their skills to register a patent to protect IP rights. N was 48. Figure 0.78 reflects the self-reported perceptions of skills to register a patent to protect IP rights.

**Figure 0.78 Self-reported perceptions of skills in registering a patent**

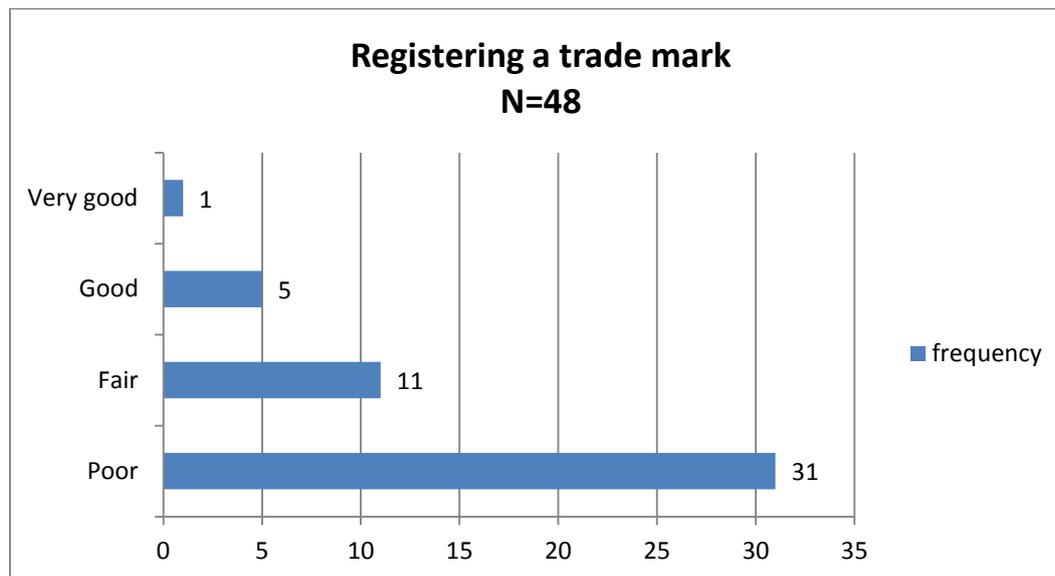


The majority respondents (29/48, 60.4%) rated their skills to register a patent as poor, with others indicating that these skills were fair (12/48, 25%), good (5/48, 10.4%) and very good (2/48, 4.2%).

#### 5.3.9.5 *Registering a trade mark to protect the intellectual property rights of research*

Forty-eight of 68 (70.6%) participants rated their skills to register trademarks to protect IP rights. N was 48. Figure 0.79 reflects the self-reported perceptions of skills to register a trademark to protect IP rights.

**Figure 0.79 Self-reported perceptions of skills in registering a trademark**

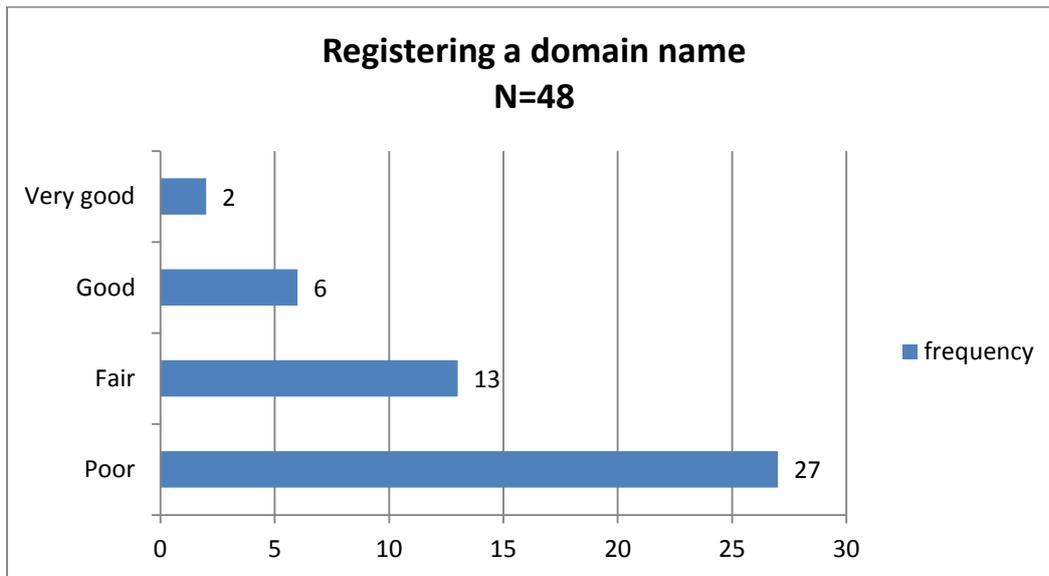


The majority of respondents rated their skills to register a trademark as poor (31/48, 64.6%). These responses were followed by fair (11/48, 22.9%) and good (5/48, 10.4%). A single respondent marked the very good (1/48, 2.1%) option.

#### 5.3.9.6 *Registering a domain name (web address) to protect the intellectual property rights of research*

Forty-eight of 68 (70.6%) participants rated their skills to register a domain name to protect IP rights. N=48. Figure 0.80 reflects the self-reported perceptions of skills to register a domain name to protect IP rights.

**Figure 0.80 Self-reported perceptions of skills in registering a domain name**

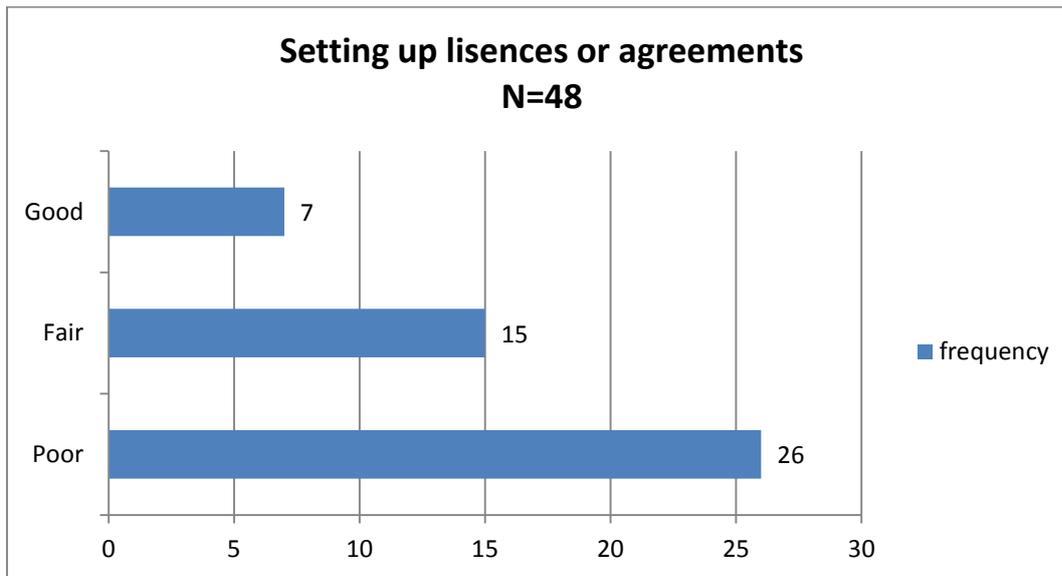


Respondents who rated their skills to register a domain name as poor numbered 27/48 (56.3%), with 13/48 indicating fair (27.1%), 6/48 (12.5%) good and only 2/48 very good (4.2%). The combination of fair and poor (40/48, 83.4%) illustrates that the majority of respondents did not feel confident about their skills to register a domain name.

#### 5.3.9.7 *Setting up a license or agreements to protect the intellectual property rights of research*

Forty-eight of 68 (70.6%) participants rated their skills to set up a licence to protect IP rights. N was 48. Figure 0.81 reflects the self-reported perceptions of skills to set up a licence or agreement to protect IP rights.

**Figure 0.81 Self-reported perceptions of skills in setting up licenses or agreements**



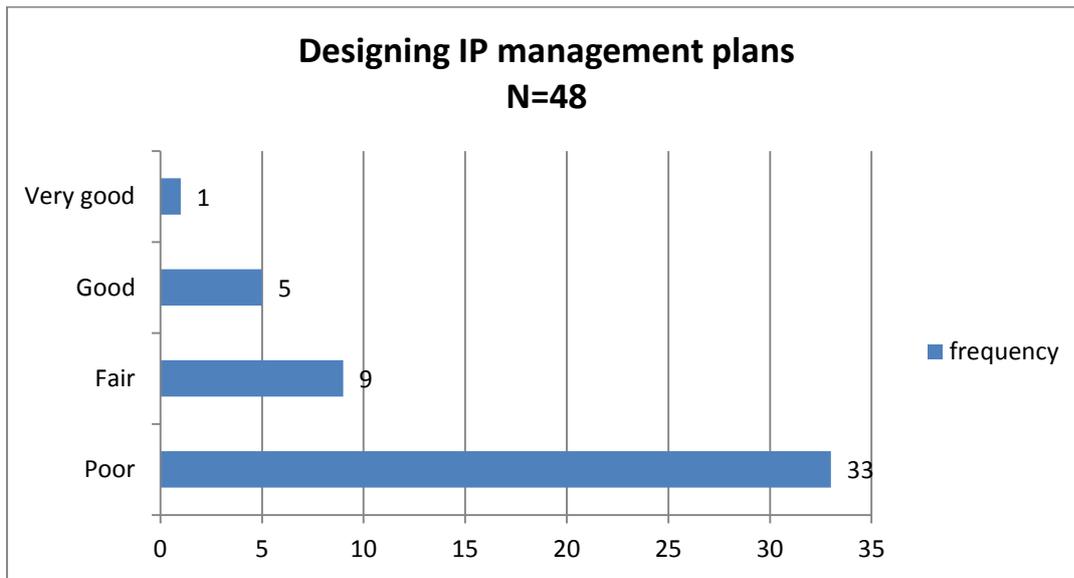
Twenty-six of 48 (54.2%) respondents rated their skills to set up licences or agreements to protect IP rights as poor, 15/48 (31.3%) as fair, and 7/48 (14.6%) as good. No respondents recognised their skill as very good in this regard. The combination of fair and poor (41/48, 85.5%) illustrates that the majority of respondents did not feel confident to set up licences or agreements to protect their research.

Question 32 (Addendum D) requested respondents to rate their skills in ensuring that research documents remain confidential. A four-point Likert scale was provided to respondents to rate their skills in using the following three mechanisms: designing IP management plans, restricting access for a certain period, and placing access conditions on documents through passwords. Results are depicted in Figure 0.82, Figure 0.83 and Figure 0.84 and discussed in sections 5.3.9.8 to 5.3.9.10.

#### 5.3.9.8 *Designing IP management plans*

Forty-eight of 68 (70.6%) participants rated their skills to design IP management plans. N was 48. Figure 0.82 reflects the self-reported perceptions of skills to design IP management plans to protect IP rights.

**Figure 0.82 Self-reported perceptions of skills in designing IP management plans**

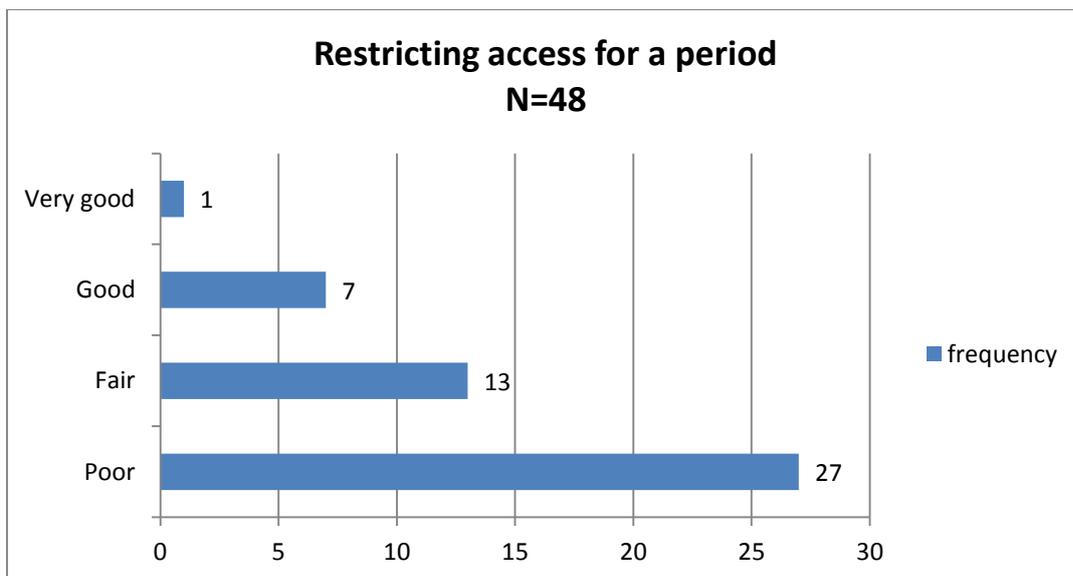


The majority of respondents rated their skills to design IP management plans as poor (33/48, 68.8%). These responses were followed by those who indicated their skills as fair (9/48, 18.8%) or good (5/48, 10.4%). A single respondent marked the very good 1/48 (2.1%) option.

#### 5.3.9.9 Restricting access to work for a certain period (embargo)

Forty-eight of 68 (70.6%) participants rated their skills to restrict access to research documents by restricting access for a certain period (embargo). N was 48. Figure 0.83 reflects the self-reported perceptions of skills to restrict access to research through embargoes.

**Figure 0.83 Self-reported perceptions of skills in restricting access to work for a certain period**

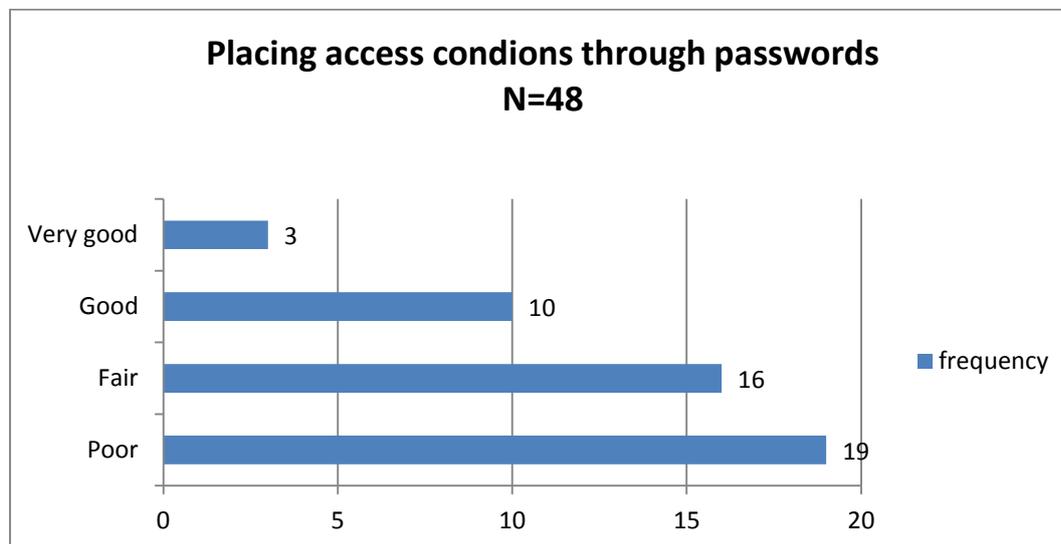


Of 48, 27 (56.3%) respondents rated their skills to restrict access to their work for a certain period (embargo) as poor. Other respondents described their skills as fair (13/48, 27.1%) or good (7/48, 14.6%). A single respondent marked the very good 1/48 (2.1%) option. The combination of poor and fair (40/48, 83.4%) illustrates that the majority of respondents did not feel confident about their skills to restrict access to their work by placing an embargo.

#### 5.3.9.10 Placing access conditions on documents through passwords

Forty-eight of 68 (70.6%) participants rated their skills to place access conditions on documents through passwords. N was 48. Figure 0.84 reflects the self-reported perceptions of skills to place access conditions on documents through passwords.

**Figure 0.84 Self-reported perceptions of skills in placing access conditions on documents through passwords**



Nineteen of 48 (39.6%) respondents rated their skills to place access conditions on their work through passwords as poor. Others rated this skill as fair (16/48, 33.3%), good (10/48, 20.8%) or very good (3/48, 6.3%). The combination of fair and poor (35/48, 72.9%) illustrates that the majority of respondents did not feel confident to place access conditions on documents through the use of passwords.

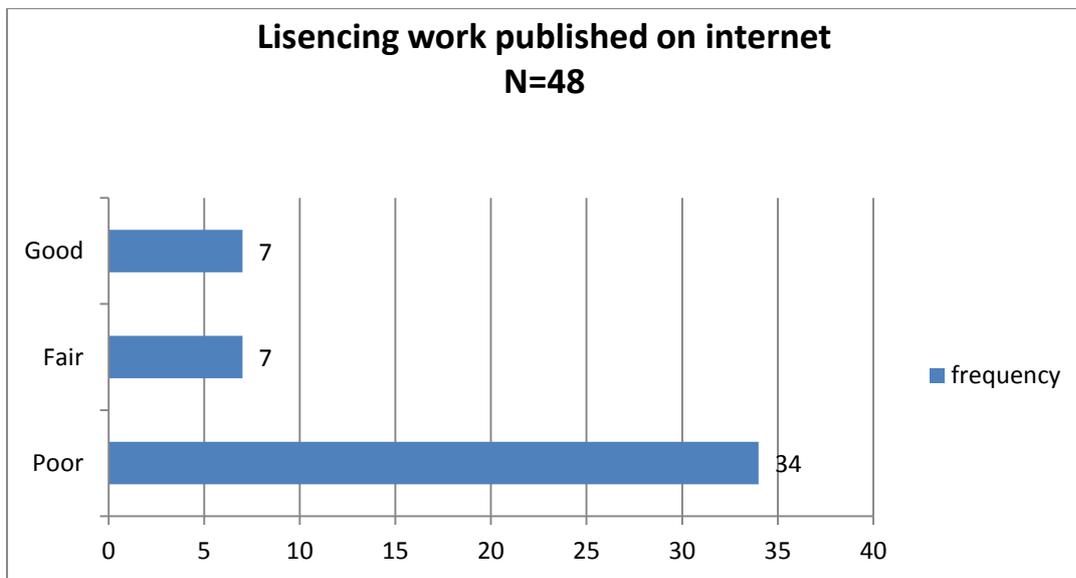
Question 33 (Addendum D) was the fifth and final question about managing IP rights. Respondents were requested to rate their skills in two ways to retain copyright to their publications, namely licensing work published on the internet (e.g. creative commons licenses), and negotiating with publishers to retain some rights (e.g. author's addenda). A four-point Likert scale was provided to respondents to rate their skills, and the results of

responses are depicted in Figure 0.85 and Figure 0.86 and discussed in sections 5.3.9.11 to 5.3.9.12.

*5.3.9.11 Licensing work published on the internet (e.g. through creative commons licenses)*

Forty-eight of 68 (70.6%) participants rated their skills to license work published on the internet (e.g. CC licences). N was 48. Figure 0.85 reflects the self-reported perceptions of skills to license work published on the internet.

**Figure 0.85 Self-reported perceptions of skills in licensing work published on the internet**

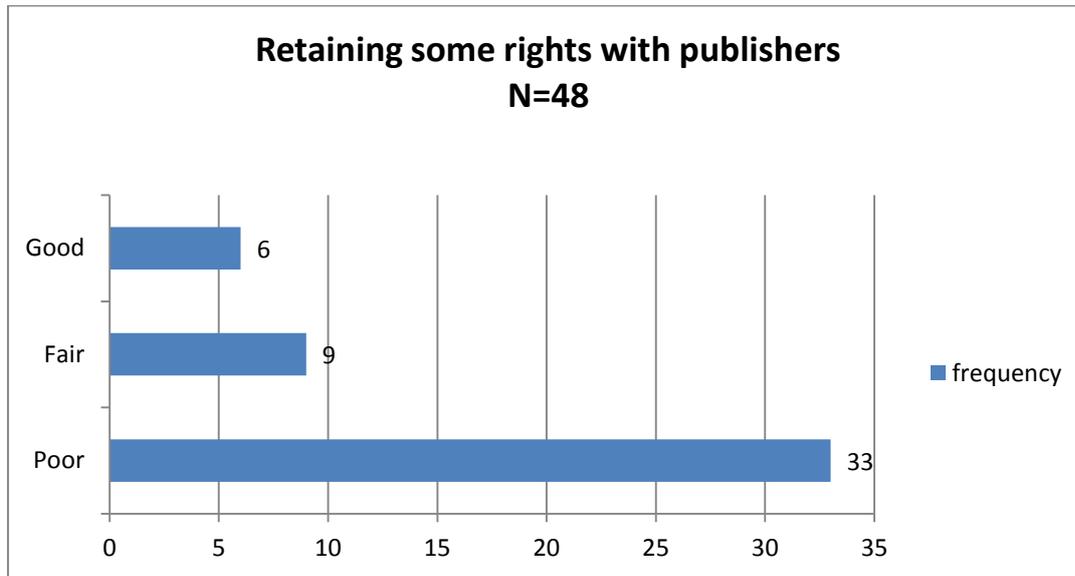


The majority of respondents rated their skills to licence work published on the internet as poor (34/48, 70.8%), whereas other respondents indicated this skill as fair (7/48, 14.6%) or good (7/48, 14.6%).

*5.3.9.12 Negotiating with publishers to retain some rights (e.g. author's addenda)*

Forty-eight of 68 (70.6%) participants rated their skills to negotiate with publishers to retain some rights. N was 48. Figure 0.86 reflects the self-reported perceptions of skills to retain some rights with publishers.

**Figure 0.86 Self-reported perceptions of skills in negotiating with publishers to retain some rights**



The majority of respondents rated their skills to negotiate with publishers to retain some rights as poor (33/48, 68.8%). Other responses marked indicated these skills as fair (9/48, 18.8%) or good (6/48, 12.5%).

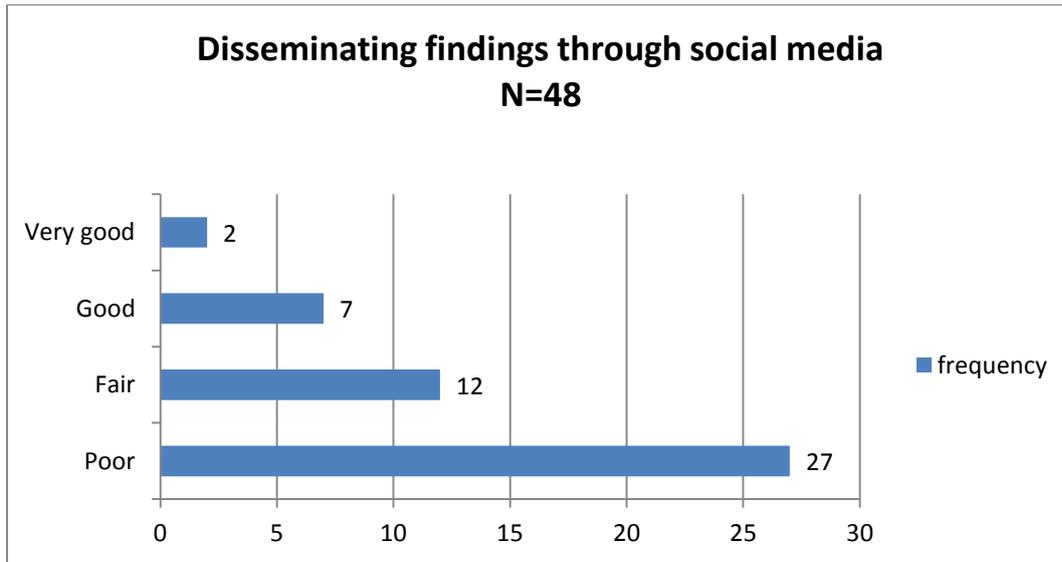
### 5.3.10 Disseminating of research findings

The dissemination of research findings was the ninth and second last research phase tested in the questionnaire. This research phase was highlighted in the proposed ARIL definition, which highlights the dissemination of research findings as well as the selection of appropriate dissemination channels. Three questions were formulated to test the skills of researchers in this regard. Question 34 (Addendum D) focused on skills when disseminating research findings by employing the following 12 possible channels: social media communication (e.g. blogs and wikis), personal webpages, IRs, discipline-specific repositories, media (e.g. newspapers and television), webinars, conference posters, conference presentations, conference proceedings, multimedia channels (e.g. audio and video recordings), journal articles, and books. Respondents had to rate each item by marking the relevant option on a four-point Likert scale with the following options: poor, fair, good and very good. Results obtained from participants are illustrated in Figure 0.87, Figure 0.88, Figure 0.89, Figure 0.90, Figure 0.91, Figure 0.92, Figure 0.93, Figure 0.94, Figure 0.95, Figure 0.96, Figure 0.97 and Figure 0.98 and discussed in sections 5.3.10.1 to 5.3.10.11.

5.3.10.1 *Disseminating research findings/information through social media communication (e.g. blogs and wikis)*

Forty-eight of 68 (70.6%) participants in the study rated their skills in using social media communication for research dissemination. N was 48. Figure 0.87 reflects the self-reported perceptions of skills in disseminating research findings through social media communication.

**Figure 0.87 Self-reported perceptions of skills in disseminating research findings/information through social media communication**

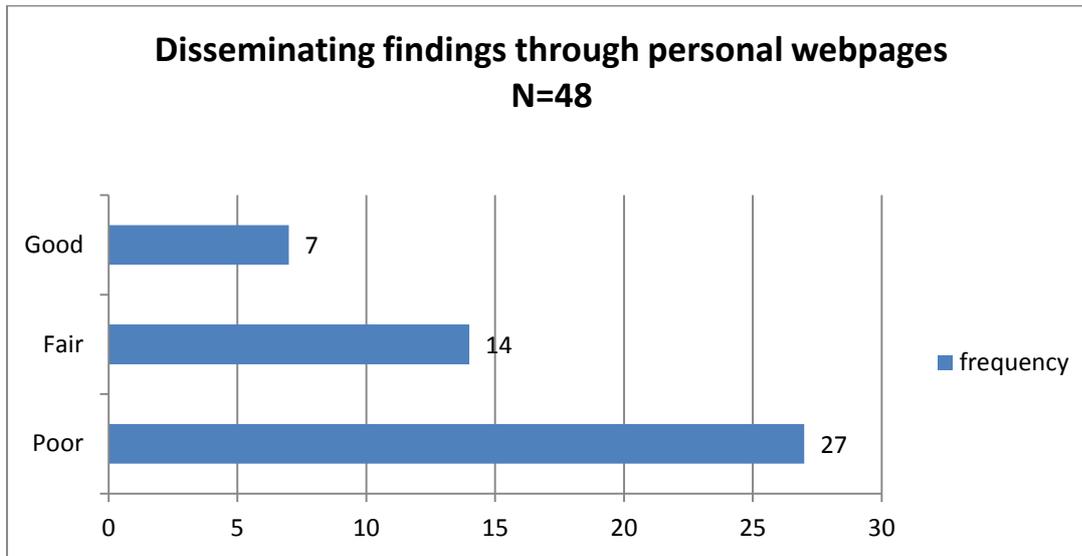


Of 48 respondents, 27 (56.3%) rated their skills to disseminate research findings through social media communication as poor. The rest of the respondents indicated this skill as fair (12/48, 25%), good (7/48, 14.6%) or very good (2/48, 4.2%). The combination of fair and poor (39/48, 81.3%) illustrates that the majority of respondents did not feel confident to disseminate research findings through social media communication.

5.3.10.2 *Disseminating research findings/information through personal webpages*

Forty-eight of 68 (70.6%) participants rated their to disseminate research findings through personal webpages. N was 48. Figure 0.88 reflects the self-reported perceptions of skills in disseminating research findings through personal webpages.

**Figure 0.88 Self-reported perceptions of skills in disseminating research findings/information through personal webpages**

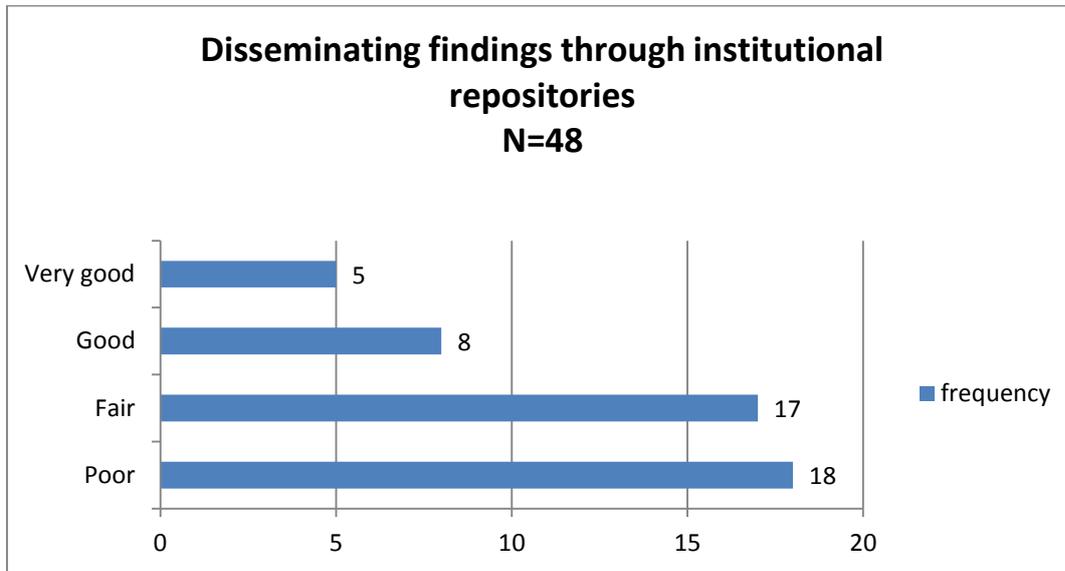


Skills to disseminate research findings through personal webpages was reported as poor by 27 (56.3%), fair by 14 (29.2%) and good by seven (14.6%) of 48 respondents. The combination of fair and poor (41/48, 85.5%) illustrates that the majority of respondents did not feel confident to disseminate research findings by using personal webpages.

#### *5.3.10.3 Disseminating research findings/information through institutional repositories*

Forty-eight of 68 (70.6%) participants rated their skills to disseminate findings through IRs. N was 48. Figure 0.89 reflects the self-reported perceptions of skills in disseminating research findings through IRs.

**Figure 0.89 Self-reported perceptions of skills in disseminating research findings/information through institutional repositories**

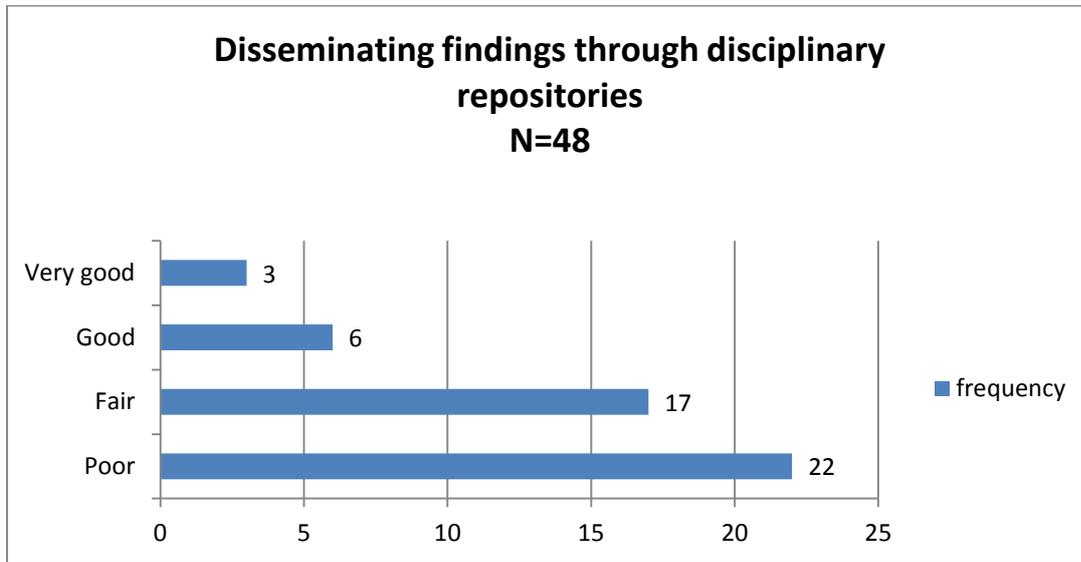


Respondents who rated their skills to disseminate research findings through IRs as poor numbered 18/48 (37.5%), with 17/48 (35.4%) rating these skills as fair, 8/48 (16.7%) as good and 5/48 (10.4%) as very good. The combination of fair and poor (35/48, 72.9%) illustrates that the majority of respondents did not feel confident about their skills to disseminate research findings through IRs.

#### *5.3.10.4 Disseminating research findings/information through disciplinary repositories*

Forty-eight of 68 (70.6%) participants rated their skills to disseminate research findings through disciplinary repositories. N was 48. Figure 0.90 reflects the self-reported perceptions of skills in disseminating research findings through disciplinary repositories.

**Figure 0.90 Self-reported perceptions of skills in disseminating research information/findings through disciplinary repositories**

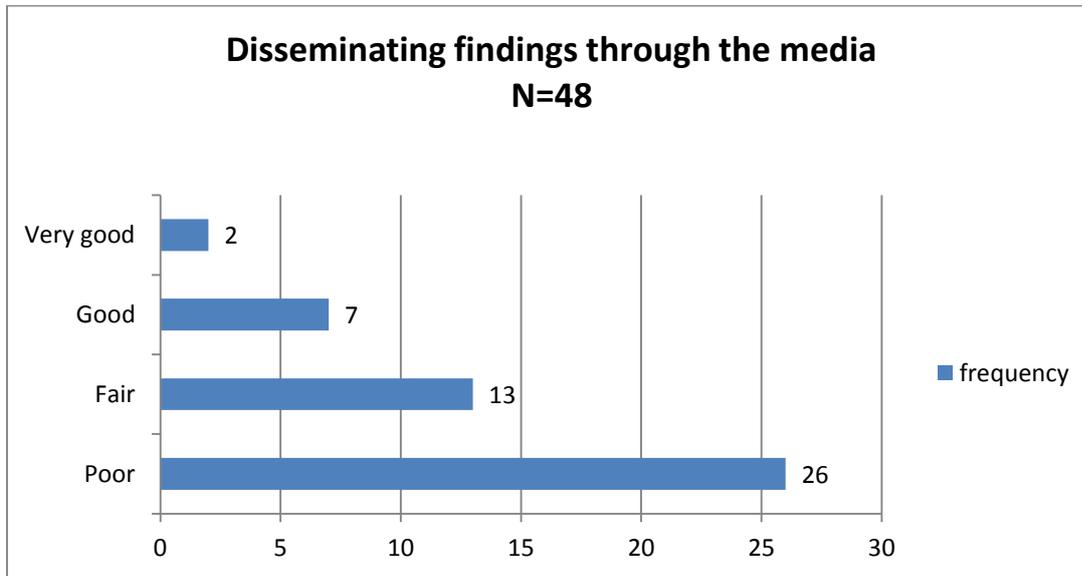


Skills to disseminate research findings through disciplinary repositories was reported as poor by 22/48 (45.8%), fair by 17/48 (35.5%), good by 6/48 (12.5%) and very good by 3/48 (6.3%) respondents. The combination of fair and poor (39/48, 81.3%) illustrates that the majority of respondents did not feel confident about their skills to disseminate research findings through disciplinary repositories.

#### *5.3.10.5 Disseminating research findings/information through the media (newspapers and television)*

Forty-eight of 68 (70.6%) participants rated their skills to disseminate research findings/information through the media N=48. Figure 0.91 reflects the self-reported perceptions of skills in disseminating research findings through the media.

**Figure 0.91 Self-reported perceptions of skills in disseminating research findings/information through the media**

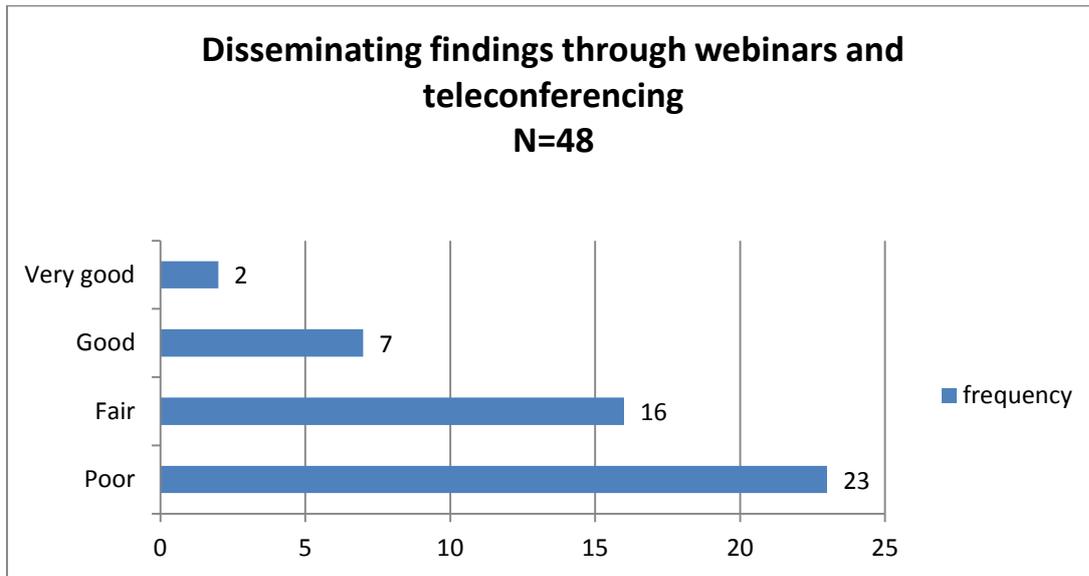


Twenty-six of 48 (54.2%) respondents rated their skills in the dissemination of research findings through the media as poor, 13/48 (27.1%) indicated their skill as fair, 7/48 (14.6%) as good, and 2/48 (4.2%) as very good. The combination of fair and poor (39/48, 81.3%) illustrates that the majority of respondents did not feel confident to disseminate research findings through the media.

#### 5.3.10.6 Disseminating research findings/information through webinars/teleconferencing

Forty-eight of 68 (70.6%) participants rated their skills to disseminate research findings/information through webinars/teleconferencing. N was 48. Figure 0.92 reflects the self-reported perceptions of skills in disseminating research findings through webinars/teleconferencing.

**Figure 0.92 Self-reported perceptions of skills in disseminating research findings/information through webinars and/or teleconferencing**

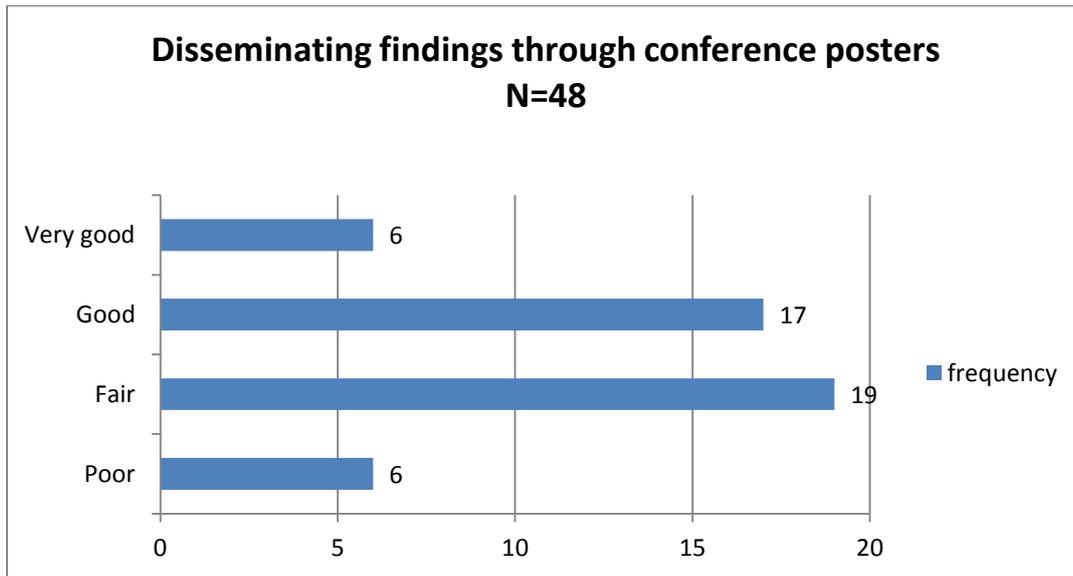


Of the 48 respondents who rated their skills to disseminate research findings through webinars/teleconferencing, 23/48 (47.9%) indicated that they were poor, 16/48 (33.3%) indicated they were fair, 7/48 (14.6%) thought they were good and 2/48 (4.2%) very good. The combination of fair and poor (39/48, 81.2%) illustrates that the majority of respondents did not feel confident to disseminate research findings through webinars and teleconferencing.

#### *5.3.10.7 Disseminating research findings/information through conference posters*

Forty-eight of 68 (70.6%) participants rated their skills to disseminate research findings/information through conference posters. N was 48. Figure 0.93 reflects the self-reported perceptions of skills in disseminating research findings through conference papers.

**Figure 0.93 Self-reported perceptions of skills in disseminating research findings/information through conference posters**

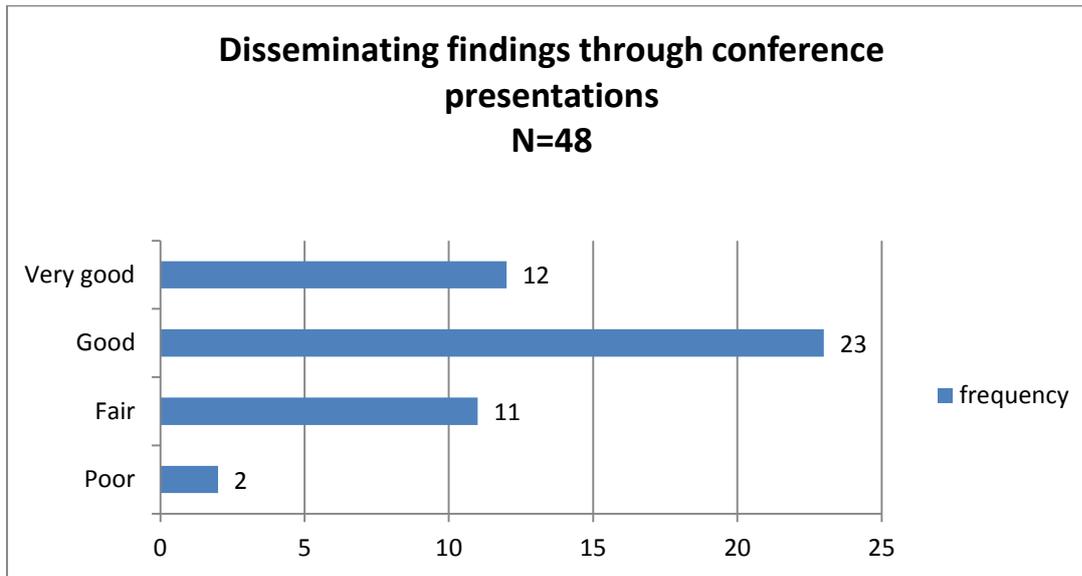


Nineteen (39.6%) of 48 respondents rated their skills to disseminate research findings through conference posters as fair, 17/48 as good (35.4%) and 6/48 thought they were either poor or very good (12.5%). The combination of fair and poor (25/48, 52.1%) illustrates that just over half of the respondents did not feel confident about the skills to disseminate research findings through conference posters.

#### *5.3.10.8 Disseminating research findings/information through conference presentations*

Forty-eight of 68 (70.6%) participants rated their skills to disseminate research findings/information through conference presentations. N was 48. Figure 0.94 reflects the self-reported perceptions of skills in disseminating research findings through conference presentations.

**Figure 0.94 Self-reported perceptions of skills in disseminating research findings/information through conference presentations**

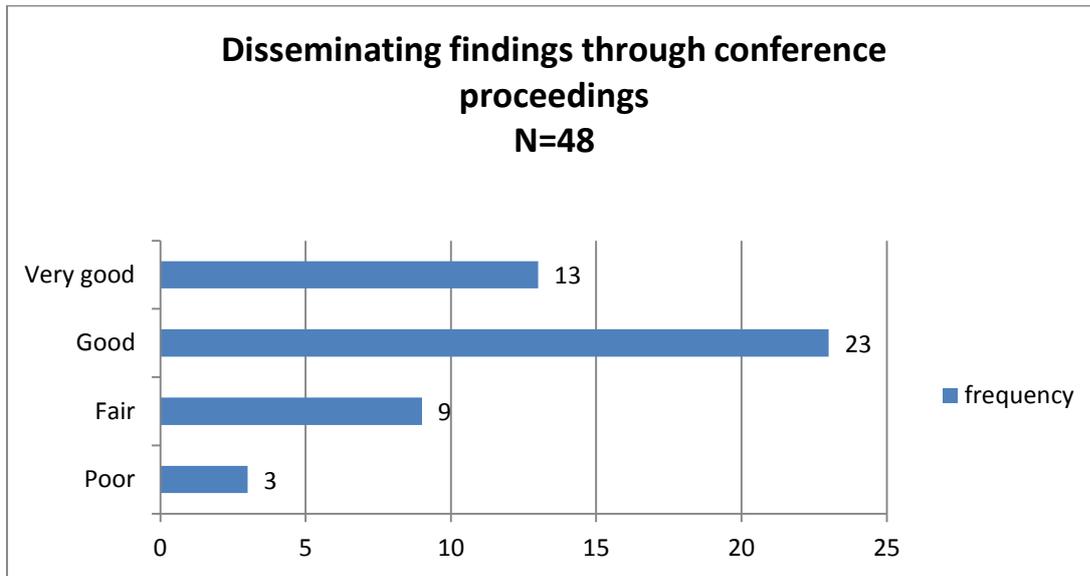


Skills to disseminate research findings through conference presentations were reported to be good by 23/48 (47.9%), very good by 12/48 (25%), fair by 11/48 (22.9%), and poor by 2/48 (4.2%). The combination of good and very good (35/48, 72.9%) illustrates that the majority of respondents felt confident about their skills to disseminate research findings through conference presentations.

#### *5.3.10.9 Disseminating research findings/information through conference proceedings*

Forty-eight of 68 (70.6%) participants rated their skills to disseminate research findings/information through conference proceedings. N was 48. Figure 0.95 reflects the self-reported perceptions of skills in disseminating research findings through conference proceedings.

**Figure 0.95 Self-reported perceptions of skills in disseminating research findings/information through conference proceedings**

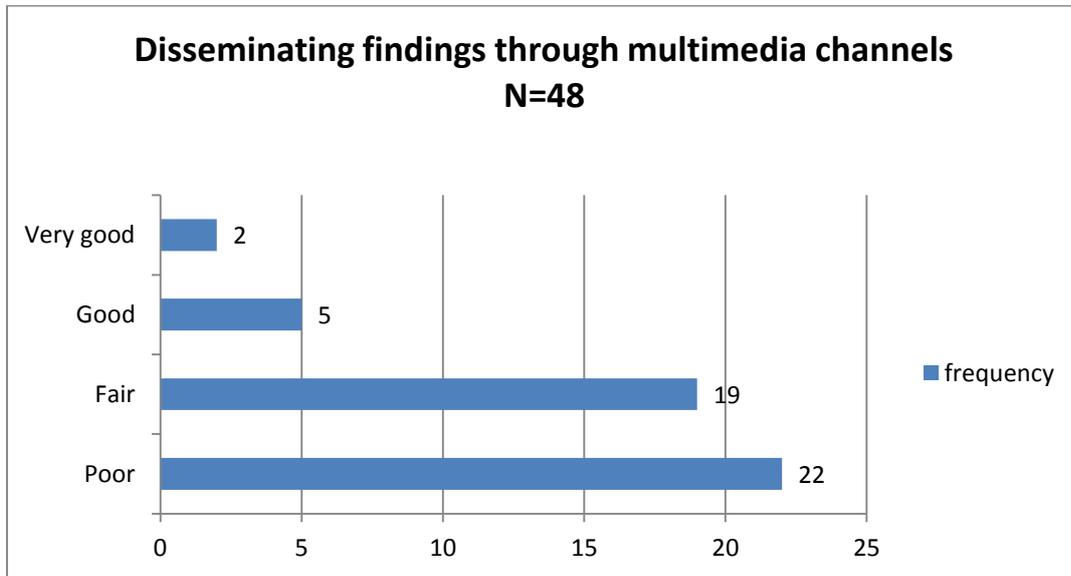


Skills to disseminate research findings through conference proceedings were reported to be good by 23/48 (47.9%), very good by 13/48 (27.1%), fair by 9/48 (18.8%) and poor by 3/48 (6.3%) respondents. The combination of good and very good (36/48, 75%) illustrates that the majority of respondents felt confident about disseminating research findings through conference proceedings.

5.3.10.10 *Disseminating research findings/information through multimedia channels (e.g. audio and video recordings)*

Forty-eight of 68 (70.6%) participants rated their skills to disseminate research findings/information through multimedia channels. N was 48. Figure 0.96 reflects the self-reported perceptions of skills in disseminating research findings through multimedia channels.

**Figure 0.96 Self-reported perceptions of skills in disseminating research findings/information through multimedia channels**

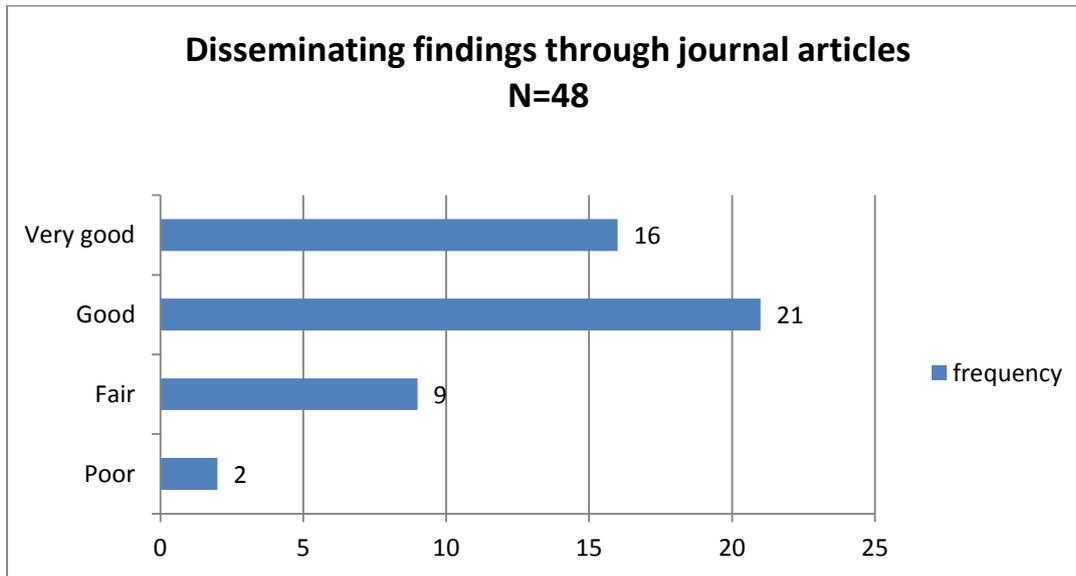


Of the 48 respondents, 22/48 (45.8%) rated their skills to disseminate research findings through multimedia channels as poor, 19/48 (39.6%) as fair, 5/48 (10.4%) as good and 2/48 (4.2%) as very good. The combination of fair and poor (41/48, 85.4%) illustrates that the majority of respondents did not feel confident about their skills to disseminate research findings through multimedia channels.

#### 5.3.10.11 *Disseminating research findings/information through journal articles*

Forty-eight of 68 (70.6%) participants rated their skills to disseminate research findings/information through journal articles. N was 48. Figure 0.97 reflects the self-reported perceptions of skills in disseminating research findings through journal articles.

**Figure 0.97 Self-reported perceptions of skills in disseminating research findings/documents through journal articles**

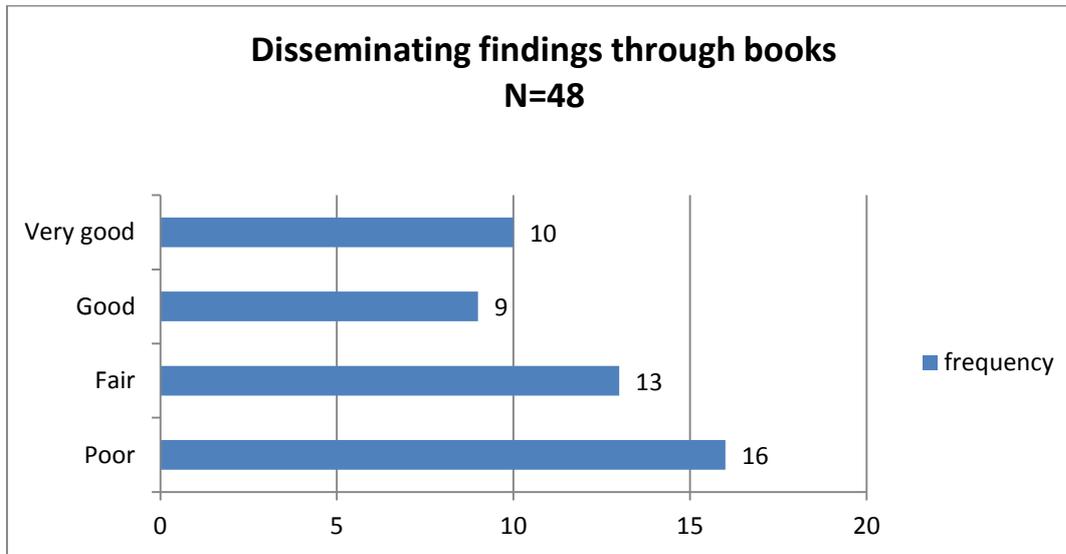


The dissemination of research findings through journal articles was rated as good by 21/48 (43.8%), very good by 16/48 (33.3%), fair by 9/48 (18.8%) and poor by 2/48 (4.2%) of respondents. The combination of good and very good (37/48, 77.1%) illustrates that the majority of respondents felt confident about their skills to disseminate research findings through journal articles.

#### 5.3.10.12 *Disseminating research findings/information through books*

Forty-eight of 68 (70.6%) participants rated their skills to disseminate research findings/information through books. N was 48. Figure 0.98 reflects the self-reported perceptions of skills in disseminating research findings through books.

**Figure 0.98 Self-reported perceptions of skills in disseminating research findings/information through books**



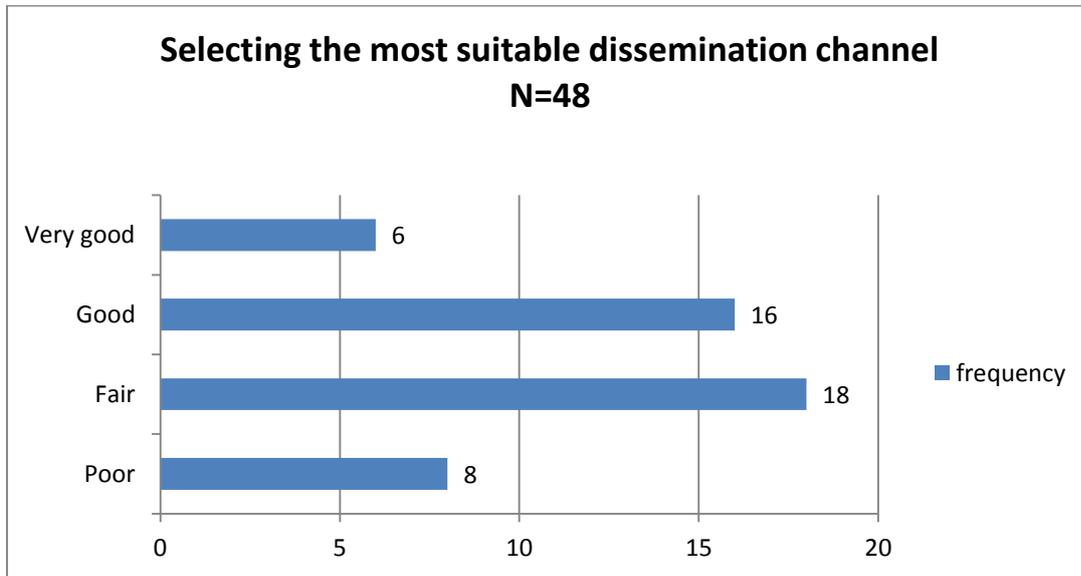
Of 48 respondents who rated their skills to disseminate research findings through books 16/48 (33.3%) indicated that they were poor, 13/48 (27.1%) stated that they were fair, 10/48 (20.8%) very good and 9/48 (18.8%) good. The combination of poor and fair (29/48, 60.4%) illustrates that the majority of respondents did not feel confident to disseminate research findings in books.

Question 35 (Addendum D) requested respondents to rate their skills in the following five processes when disseminating research findings: selecting the most suitable channel for dissemination, adapting content from one channel to another to accommodate various audiences, acquiring the technical skills necessary to employ a specific channel for dissemination, compiling a dissemination strategy to maximise visibility, and distinguishing between credible and fraudulent publishers. A four-point Likert scale was provided to respondents to rate their skills, and results are depicted in Figure 0.99, Figure 0.100, Figure 0.101, Figure 0.102 and Figure 0.103 and discussed in sections 5.3.10.13 to 5.3.10.17.

#### 5.3.10.13 *Selecting the most suitable dissemination channel for research findings/information*

Forty-eight of 68 (70.6%) participants rated their skills to select the most suitable dissemination channel. N was 48. Figure 0.99 reflects the self-reported perceptions of skills in selecting the most suitable dissemination channel.

**Figure 0.99 Self-reported perceptions of skills in selecting the most suitable dissemination channel**

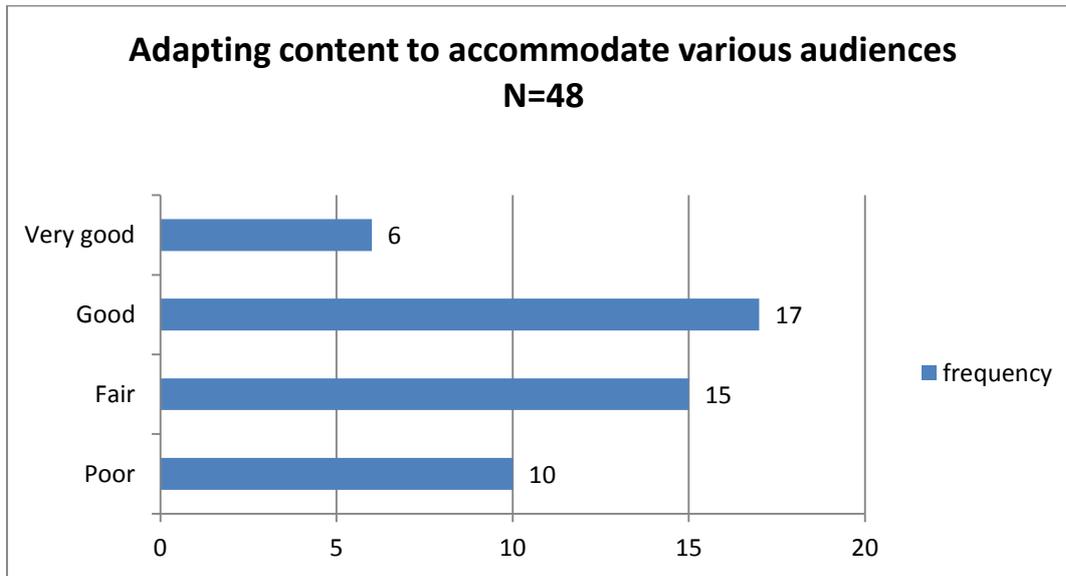


Respondents rated their skills in the selection of the most suitable dissemination channel as fair (18/48, 37.5), good (16/48, 33.3%), poor (8/48, 16.7%) and very good (6/48, 12.5%). The combination of fair and poor (26/48, 54.2%) illustrates that just over half of the respondents did not feel confident about the skill to select the most suitable dissemination channel.

*5.3.10.14 Adapting content from one channel to another to accommodate various audiences when disseminating research findings/information*

Forty-eight of 68 (70.6%) participants rated their skills to adapt content from one dissemination channel to another to accommodate various audiences. N was 48. Figure 0.100 reflects the self-reported perceptions of skills in adapting content from one channel to another to accommodate various audiences.

**Figure 0.100 Self-reported perceptions of skills in adapting content from one channel to another to accommodate various audiences when disseminating research findings**

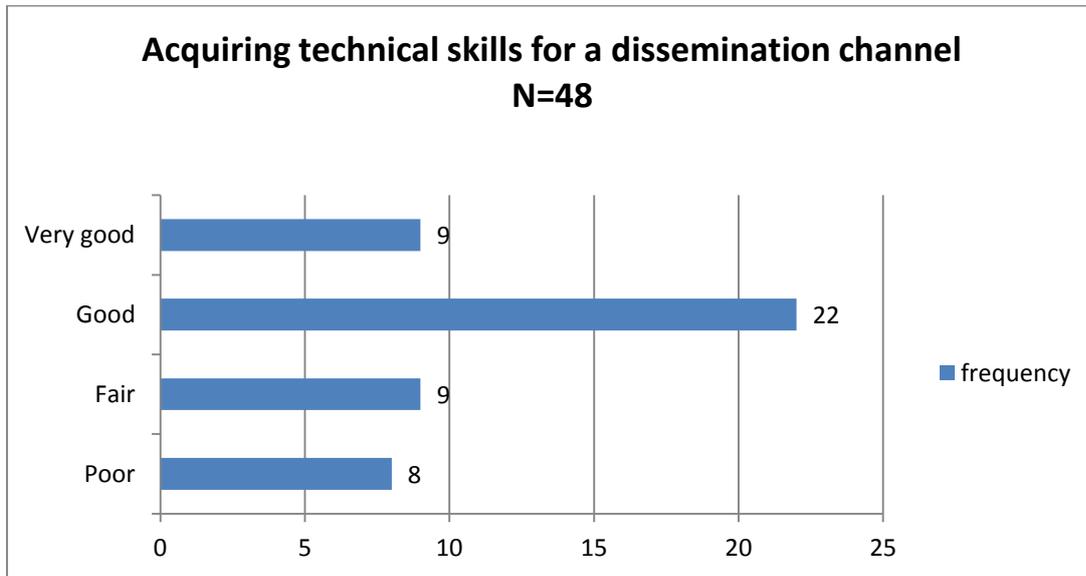


In response to the question on rating their skills to adapt content from one dissemination channel to another to accommodate different audiences, 17/48 (35.4%) indicated that these were good, 15/48 (31.3%) said they were fair, 10/48 (20.8%) poor and 6/48 (12.5%) very good. The combination of fair and poor (25/48, 52.1%) illustrates that just over half of the respondents did not feel confident about their skills to adapt content from one dissemination channel to another in order to accommodate different audiences.

*5.3.10.15 Acquiring the necessary technical skills to employ a specific channel for research findings/information*

Forty-eight of 68 (70.6%) participants rated their skills to acquire the necessary technical skills to employ a specific channel when disseminating research findings/information. N was 48. Figure 0.101 reflects the self-reported perceptions of skills in acquiring technical skills to employ a specific dissemination channel.

**Figure 0.101 Self-reported perceptions of skills in acquiring necessary technical skills to employ as specific channel when disseminating research findings/information**

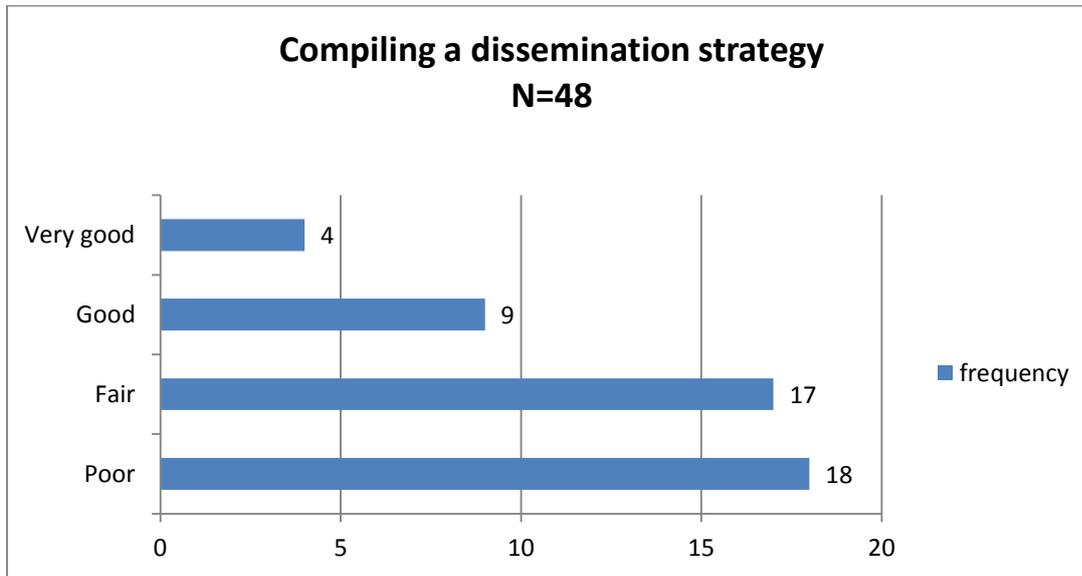


Of the 48 respondents, 22/48 (45.8%) rated their skills to acquire technical skills to employ a specific dissemination channel as good, 9/48 (18.8%) as very good, 9/48 (18.8%) as fair and 8/48 (16.7%) as poor. The combination of good and very good (31/48, 64.6%) illustrates that the majority of respondents felt confident about acquiring the necessary technical skills to employ a specific dissemination channel.

*5.3.10.16 Compiling a dissemination strategy to maximise the visibility of disseminated research findings/information*

Forty-eight of 68 (70.6%) participants rated their skills to compile a dissemination strategy to maximise visibility when disseminating research findings/information. N was 48. Figure 0.102 reflects the self-reported perceptions of skills in compiling a dissemination strategy to maximise visibility of research findings.

**Figure 0.102 Self-reported perceptions of skills in compiling a dissemination strategy to maximise visibility**

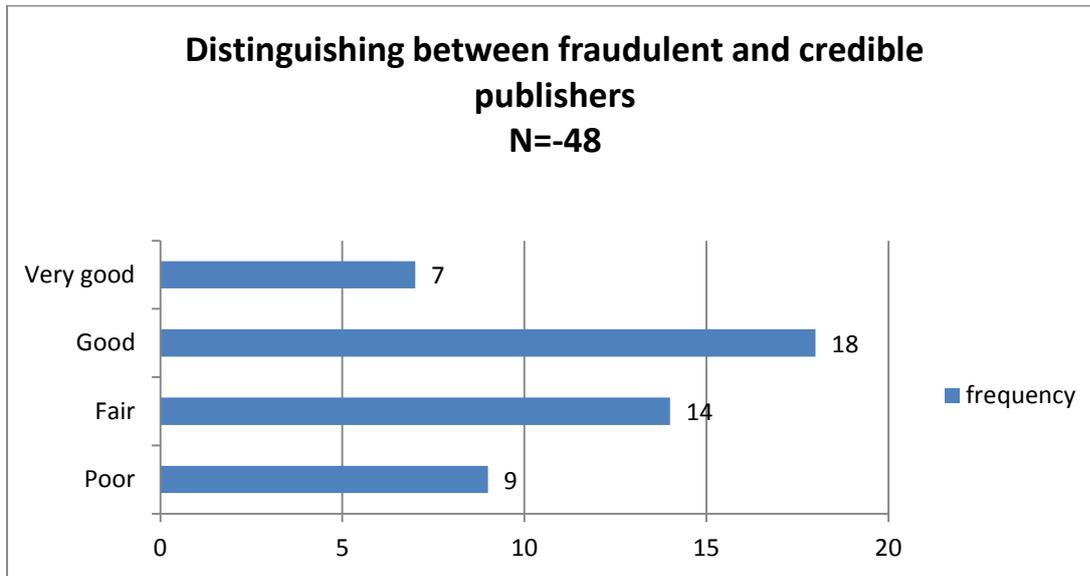


Their skills to compile a strategy to maximise visibility when disseminating research findings/information were thought to be poor by 18/48 (37.5%), fair by 17/48 (35.4%), good by 9/48 (18.8%) or very good by 4/48 (8.3%) of the respondents. The combination of fair and poor (35/48, 72.9%) illustrates that the majority of respondents did not feel confident about their skills to maximise visibility when disseminating research documents/findings.

5.3.10.17 *Distinguishing between credible and fraudulent publishers when disseminating research findings/information*

Forty-eight of 68 (70.6%) participants rated their skills to distinguish between credible and fraudulent publishers when disseminating research information/findings. N was 48. Figure 0.103 reflects the self-reported perceptions of skills in distinguishing between credible and fraudulent publishers.

**Figure 0.103 Self-reported perceptions of skills in distinguishing between credible and fraudulent publishers**



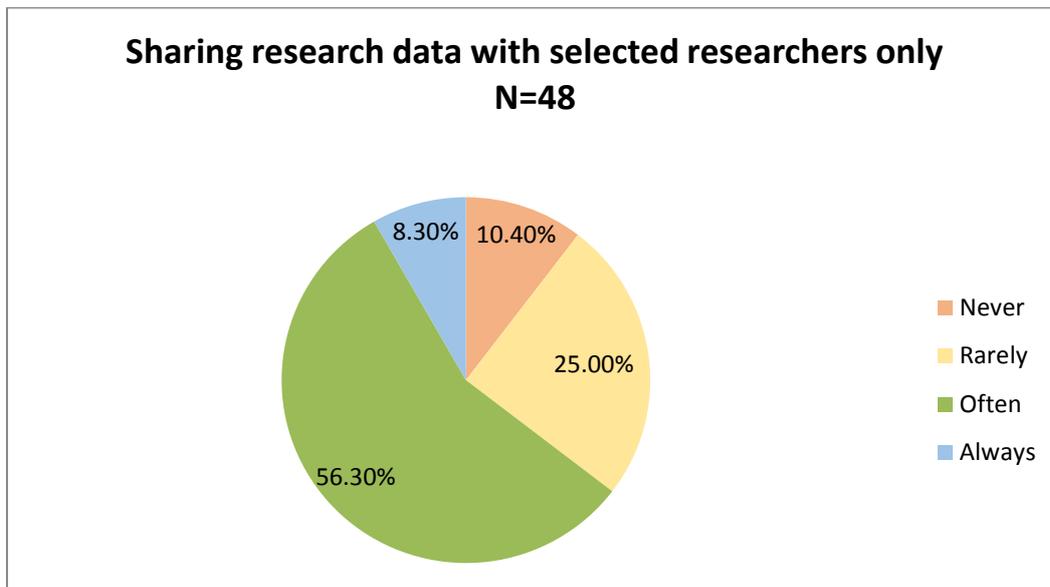
Eighteen of 48 (37.5%) respondents rated their skills to distinguish between credible and fraudulent publishers as good, 14/48 (29.2%) as fair, 9/48 (18.8%) as poor and 7/48 (14.6%) thought they were very good. The combination of good and very good (25/48, 57.5%) illustrates that just over half of the respondents felt confident about distinguishing between credible and fraudulent publishers.

Question 36 (Addendum D) was the third and last question on the dissemination of research information, and focused specifically on data. A four-point Likert scale was employed, and respondents had to rate how often they performed the following three activities: sharing data with selected researchers only, depositing data in openly available archives or repositories, and providing research data as a supplement to an article published in a subscription-based journal. The results of responses are illustrated in Chart 0.5, Chart 0.6 and Chart 0.7 and discussed in sections 5.3.10.18 to 5.3.10.20.

#### *5.3.10.18 Sharing research data with selected researchers only*

Forty-eight of 68 (70.6%) participants indicated how often they shared research data with selected researchers only. N was 48. Chart 0.5 reflects the frequency with which research data is shared with selected researchers only.

**Chart 0.5 Self-reported perceptions of skills in sharing research data with selected researchers only**

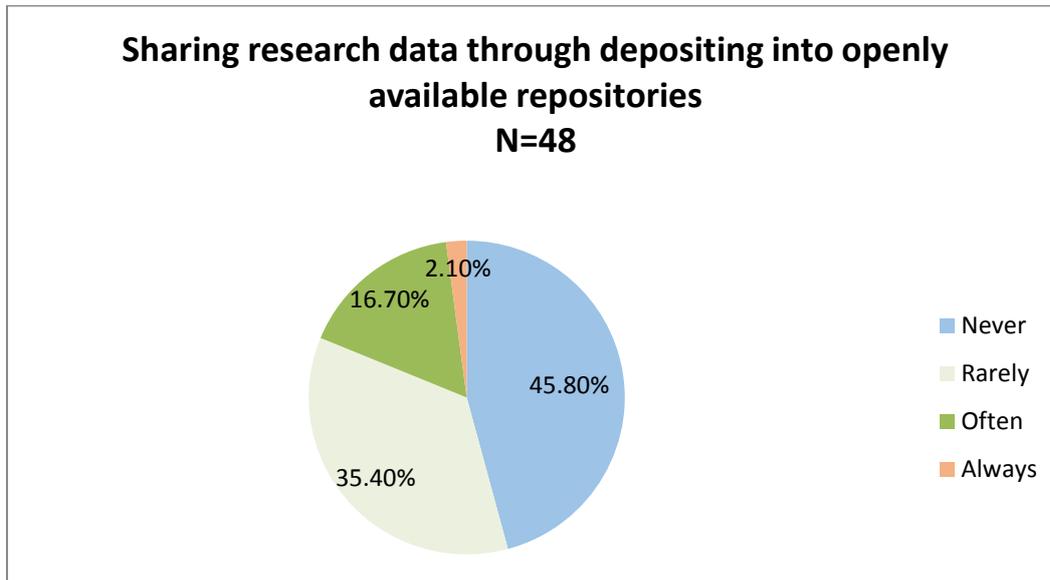


Just over half (27/48, 56.3%) of the respondents indicated that they often shared research data with selected researchers only. Others (12/48, 25%) indicated that they rarely shared research data with a selected group, 5/48 (10.4%) indicated that they never shared research data with a selected group, and 4/48 (8.3%) always did so.

*5.3.10.19 Sharing research data through depositing it into openly available archives/repositories*

Forty-eight of 68 (70.6%) participants indicated how often they shared research data by depositing it into openly available archives/repositories. N was 48. Chart 0.6 reflects the frequency with which research data is shared by depositing it into openly available archives.

**Chart 0.6 Self-reported perceptions of skills in sharing research data by depositing it into openly available archives/repositories**

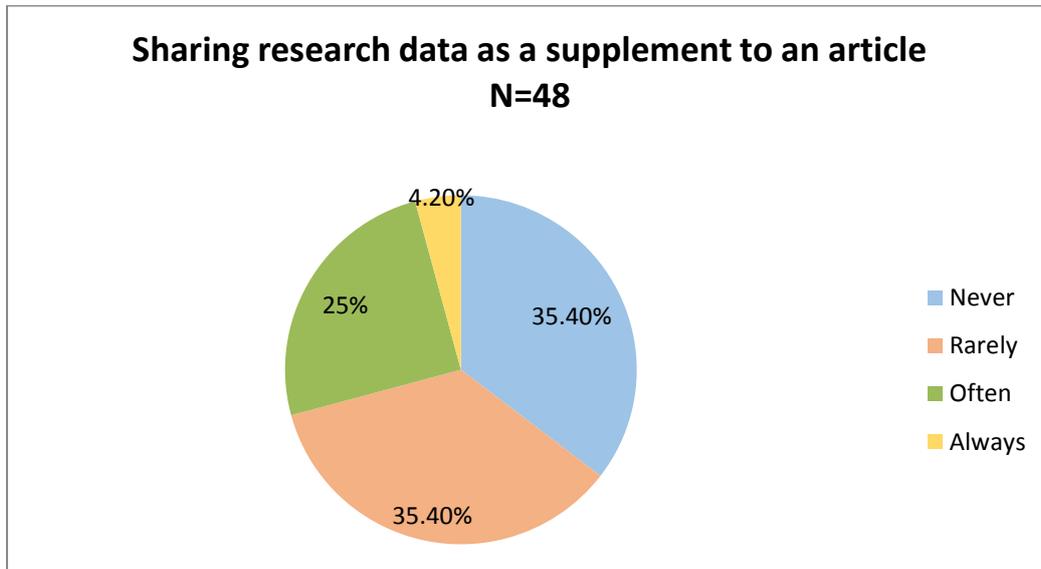


Twenty-two of the 48 (45.8%) respondents reported that they never shared research data through openly available archives/repositories. This was described as rarely happening by 17/48 (35.4%), often by 8/48 (16.7%) and always by 1/48 (2.1%) of respondents. The combination of rarely and never (39/48, 81.2%) illustrates that the majority of respondents hardly ever share research data through openly available archives or repositories.

#### *5.3.10.20 Sharing research data as a supplement to an article published in a subscription-based journal*

Forty-eight of 68 (70.6%) participants indicated how often they shared research data as a supplement to an article published in a subscription-based journal. N was 48. Chart 0.7 depicts the frequency with which research data is shared as a supplement to an article published in a subscription-based journal.

**Chart 0.7 Self-reported perceptions of skills in sharing research data as a supplement to an article published in a subscription-based journal**



Responses to this question ranged from 17/48 (35.4%) choosing each of the options never and rarely, 12/48 (25%) indicating often and 2/48 (4.2%) always. The combination of never and rarely (34/48, 70.8%) illustrates that the majority of respondents hardly ever shared research data as a supplement to an article of a subscription-based journal.

The following section of this chapter focuses on the final research phase, namely the measuring of the impact of the research, where after a summary of the responses to all the questions posed in the questionnaire will be provided.

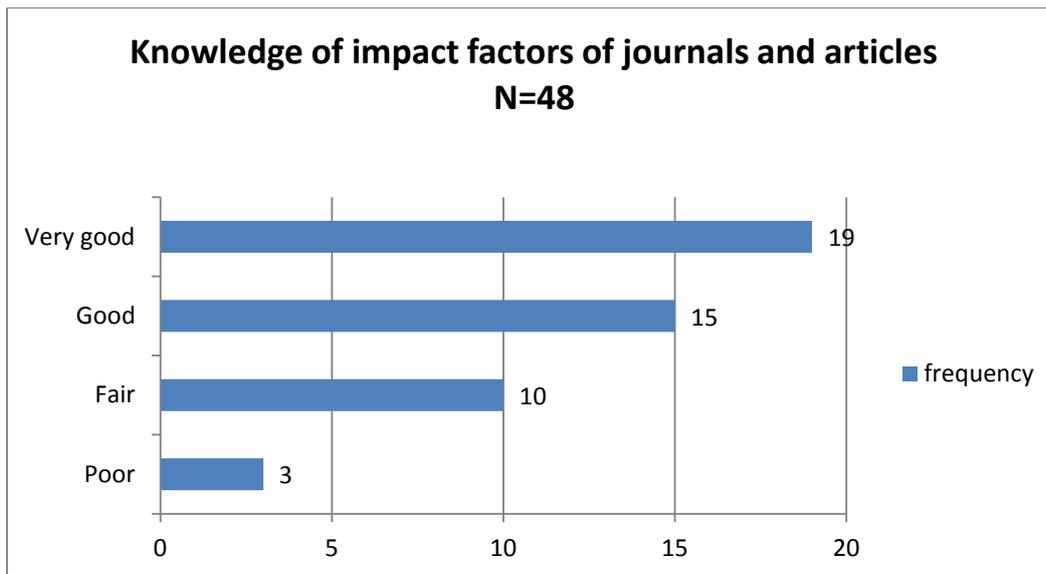
### 5.3.11 Measurement of impact

The measuring of impact was the tenth and final research phase tested in the questionnaire. Three questions were developed to test the skills of respondents during different processes associated with the measuring of impact in a specific field of study. All three questions used a four-point Likert scale, with the following scales: poor, fair, good and very good. Question 37 (Addendum D) requested respondents to rate their knowledge of five common indicators of impact/influence: impact factors of journals and articles, impact factors of researchers (e.g. H-Index), impact statistics of research published on social media, the peer review process and the ranking statistics of departments or institutions. Results are reflected in Figure 0.104, Figure 0.105, Figure 0.106, Figure 0.107 and Figure 0.108 and discussed in sections 5.3.11.1 to 5.3.11.5.

### 5.3.11.1 Knowledge of impact factors of journals and articles as indicators of impact/influence

Forty-eight of 68 (69.1%) participants in the study rated their knowledge of impact factors of journal articles as indicators of influence. N was 48. Figure 0.104 reflects the respondents' knowledge of impact factors of journals and articles as indicators of impact.

**Figure 0.104 Self-reported knowledge regarding impact factors of journals and articles as indicators of impact/influence**

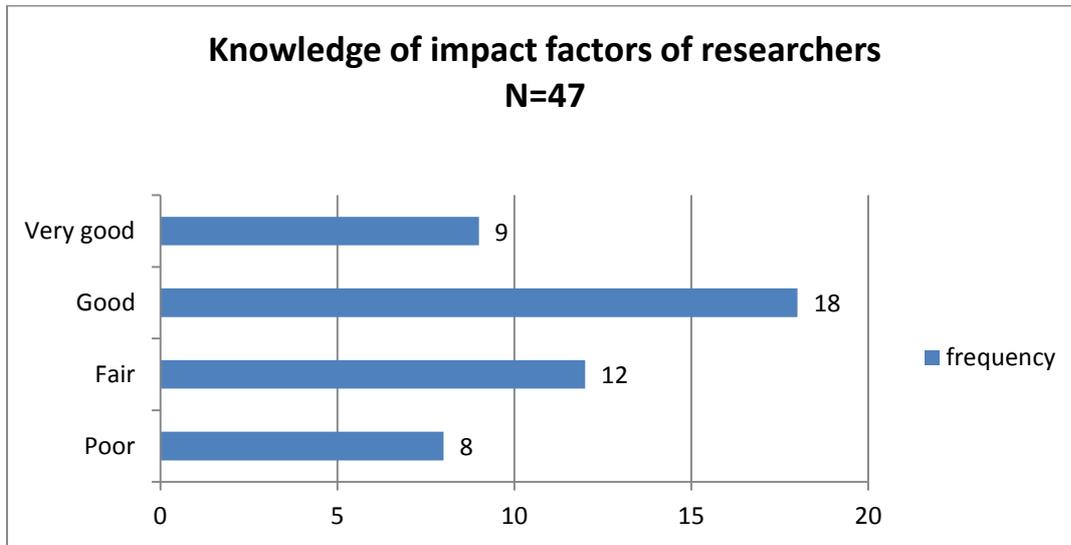


Nineteen of 48 (40.4%) respondents rated their knowledge of impact factors of journals and articles as very good, followed by those respondents who thought their knowledge was good (15/48, 31.9%) or fair (10/48, 21.3%). A small number of respondents (3/48, 6.4%) indicated their knowledge as poor. The combination of good and very good (34/47, 72.3%) illustrates that the majority of respondents felt confident about their knowledge of impact factors of journals and articles.

### 5.3.11.2 Knowledge of impact factors of researchers (e.g. H-Index) as indicators of impact/influence

Forty-seven of 68 (69.1%) participants rated their knowledge of the impact factors of researchers as indicators of influence in a field of study. N was 47. Figure 0.105 reflects the respondents' knowledge of impact factors of researchers as indicators of impact.

**Figure 0.105 Self-reported knowledge of impact factors of researchers as indicators of impact/influence**

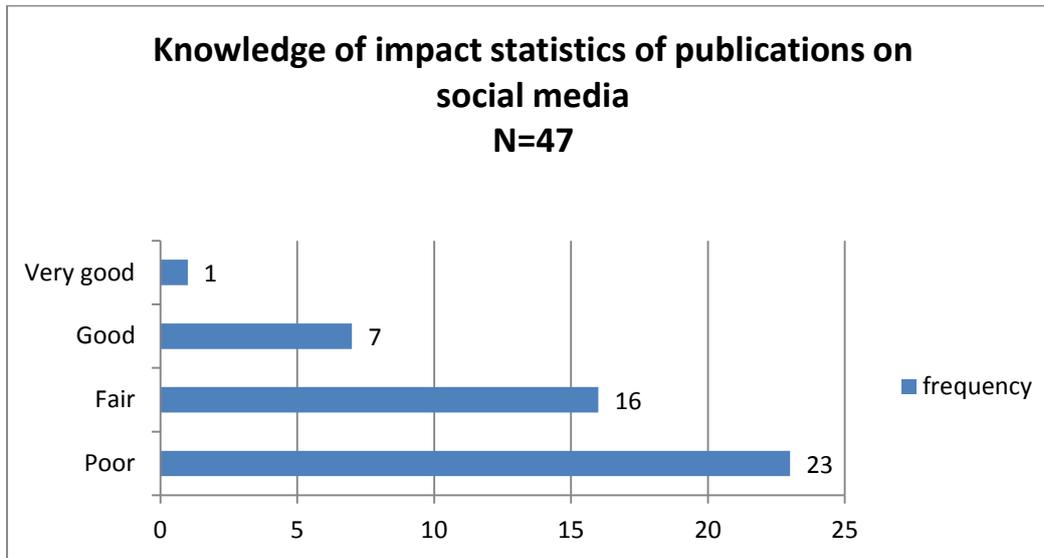


Respondents who rated their knowledge of impact factors of researchers as good, numbered 18/47 (38.3%); followed by those who indicated their knowledge to be fair (12/47, 25.5%), very good (9/47, 19.1%) or poor (8/47, 17%). The combination of good and very good (27/47, 57.4%) illustrates that just over half of the respondents felt confident about their knowledge of researchers' impact factors.

### *5.3.11.3 Knowledge of impact statistics of research published on social media as indicators of impact/influence*

Forty-seven of 68 (69.1%) participants rated their knowledge of impact statistics of research published on social media. N was 47. Figure 0.106 reflects the knowledge of participants of impact statistics of research published on social media platforms.

**Figure 0.106 Self-reported knowledge of impact statistics of research published on social media as indicators of impact/influence**

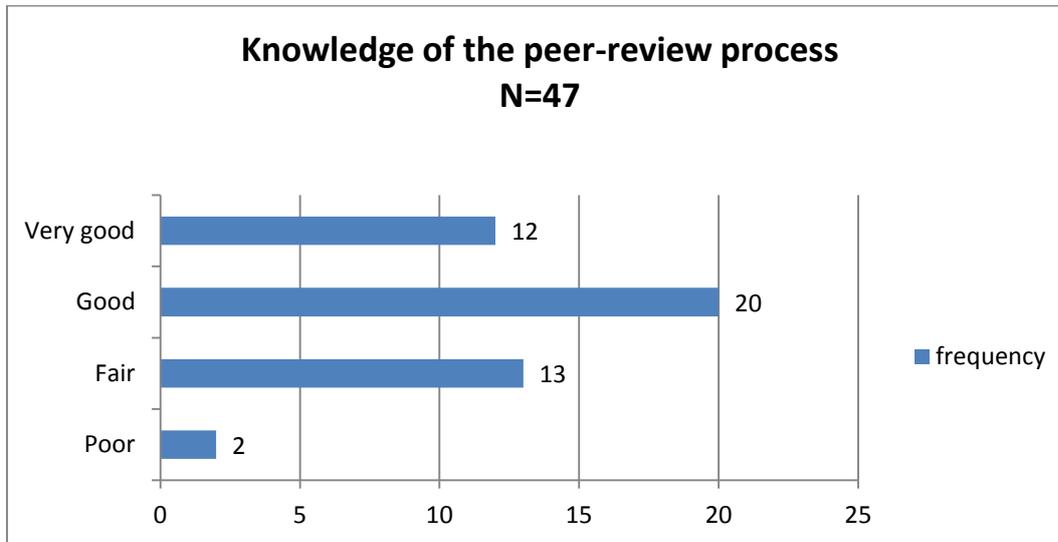


A high percentage (23/47, 48.9%) of respondents rated their knowledge of impact statistics of research published on social media as poor. The remainder of the respondents marked the fair (16/47, 34%) and good (7/47, 14.9%) options, with a single respondent (1/47, 2.1%) marking very good. The combination of fair and poor (39/47, 82.9%) illustrates that the majority of respondents did not feel confident about their knowledge of impact statistics of research published on social media.

#### *5.3.11.4 Knowledge of peer-review processes as indicators of impact/influence*

Forty-seven of 68 (69.1%) participants rated their knowledge of peer-review processes. N was 47. Figure 0.107 reflects the knowledge of participants of the peer-review process.

**Figure 0.107 Self-reported knowledge of peer-review processes as indicators of impact/influence**

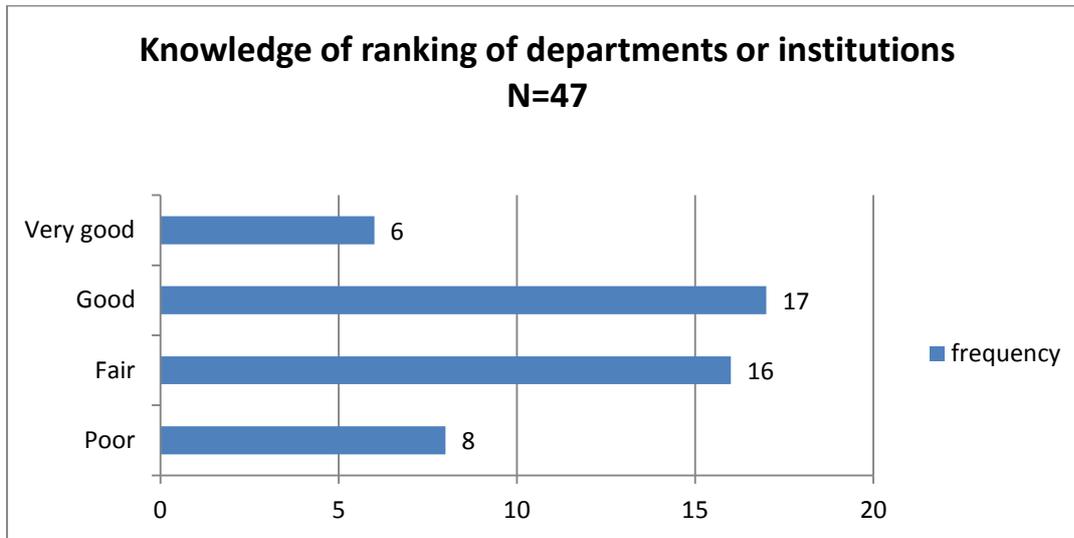


Knowledge of peer-review processes was reported as good by 20/47 (42.6%) of respondents, with others indicating their knowledge in this regard as fair (13/47, 27.7%), very good (12/47, 25.5%) or poor (2/47, 4.3%). The combination of good and very good (32/47, 68.1%) illustrates that the majority of respondents felt confident about their knowledge of peer-review processes.

*5.3.11.5 Knowledge of ranking statistics of departments or institutions nationally/internationally as indicators of impact/influence*

Forty-seven of 68 (69.1%) participants rated their knowledge of national/international ranking statistics of departments or institutions. N was 47. Figure 0.108 reflects the knowledge of respondents of ranking statistics of departments or institutions as indicators of impact.

**Figure 0.108 Self-reported knowledge of ranking statistics of departments or institutions nationally/internationally as indicators of impact/influence**



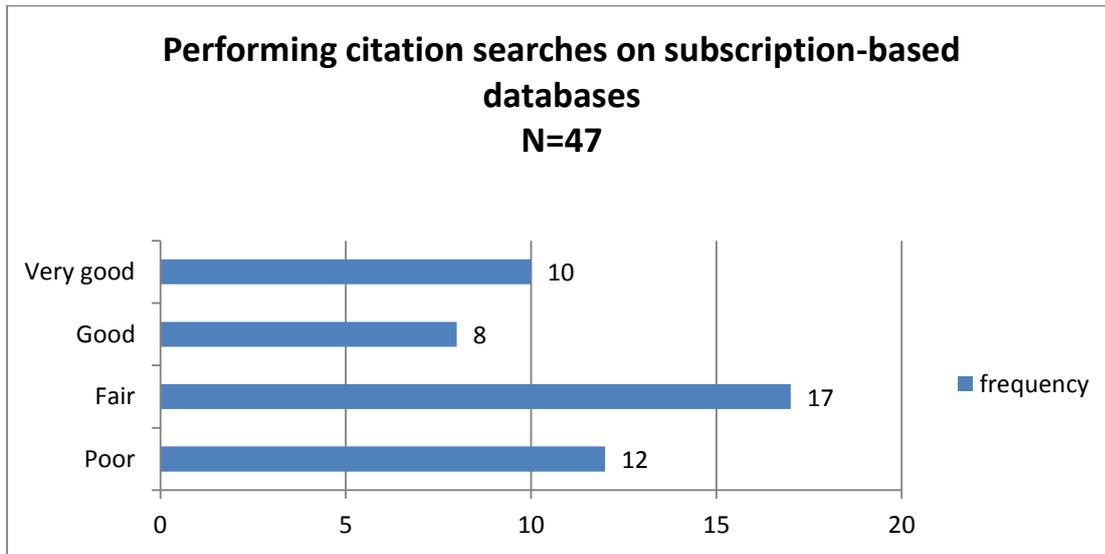
There was a slight difference in the numbers of respondents who rated their knowledge of national/international ranking statistics of departments or institutions as good 17/47 (36.2%) and fair 16/47 (34%). The rest of the respondents marked the poor (8/47, 17%) and very good (6/47, 12.8%) options. The combination of fair and poor (24/47, 51%) illustrates that just over half of the respondents did not feel confident about their knowledge of ranking statistics.

Question 38 (Addendum D) asked respondents to rate their skills when performing citation searches on subscription-based databases, as well as on freely available websites. Results are depicted in Figure 0.109 and Figure 0.110 and discussed in sections 5.3.11.6 and 5.3.11.7.

#### *5.3.11.6 Performing citation searches to analyse the impact of an article on subscription-based databases (e.g. ISI, Scopus)*

Forty-seven of 68 (69.1%) participants rated their skills to perform citation searches on subscription-based databases. N was 47. Figure 0.109 reflects the self-reported perceptions of skills in performing citation searches on subscription-based databases.

**Figure 0.109 Self-reported perceptions of skills in performing citation searches to analyse the impact of an article on subscription-based databases**

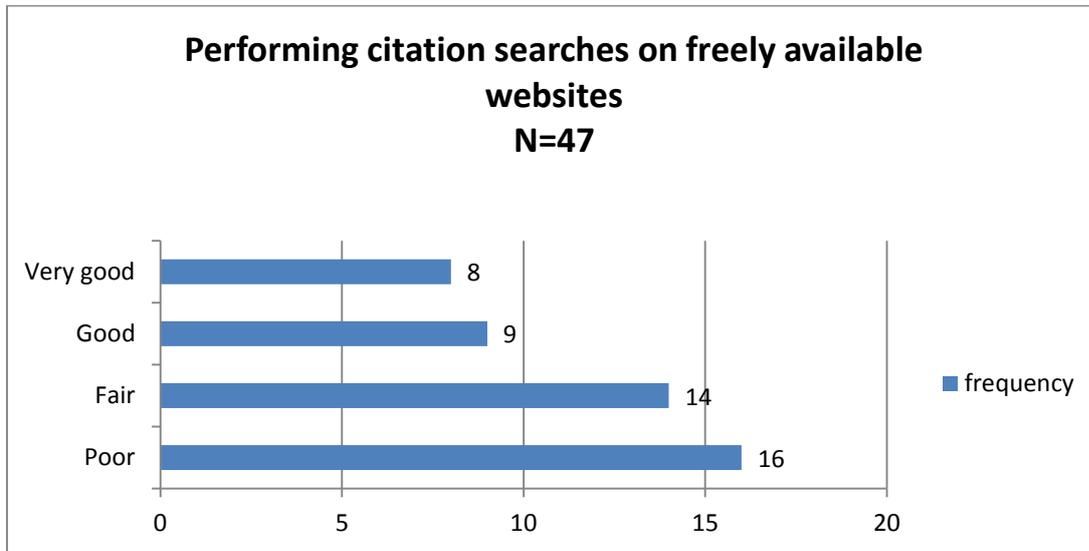


Their ability to undertake citation searches on subscription-based databases was regarded as fair by 17/47 (36.2%) of respondents. The rest of the respondents marked the poor (12/47, 25.5%), very good (10/47, 21.3%) and good (8/47, 17%) options. The combination of fair and poor (29/47, 61.7%) illustrates that the majority of respondents did not feel confident about performing citation searches on subscription-based databases.

#### *5.3.11.7 Performing citation searches to analyse the impact of an article on freely available websites (e.g. Google Scholar)*

Forty-seven of 68 (69.1%) participants rated their skills to conduct citation searches on freely available websites. N was 47. Figure 0.110 reflects the self-reported perceptions of skills in performing citation searches on freely available websites.

**Figure 0.110 Self-reported perceptions of skills in performing citation searches to analyse the impact of an article on freely available websites**



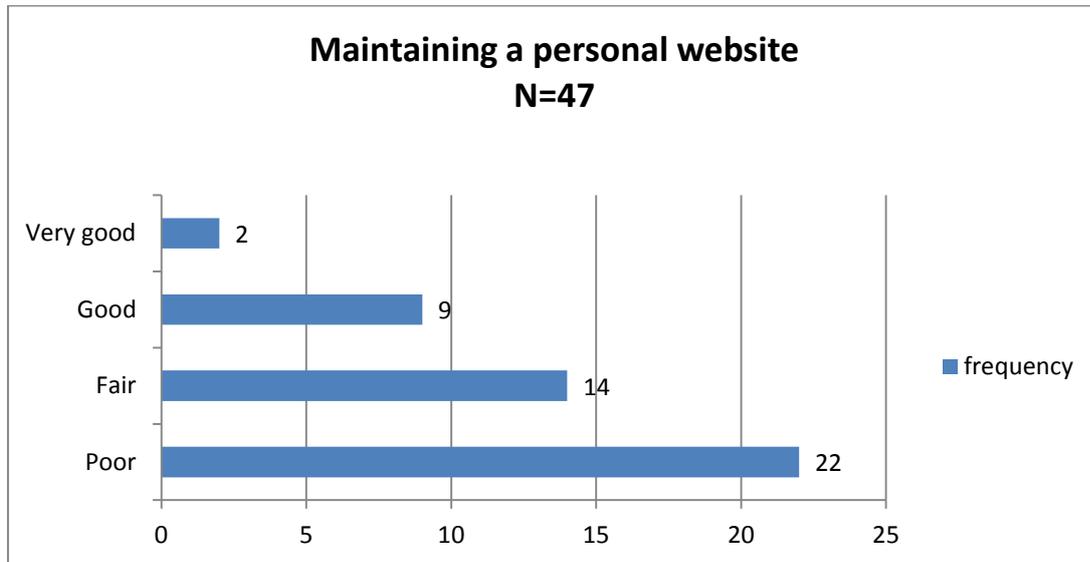
Thirty-four percent (16/47) of the respondents rated their skills to perform citation searches on freely available websites as poor. The rest of the respondents marked fair (14/47, 29.8%), good (9/47, 19.1%) or very good (8/47, 17%). The combination of fair and poor (30/47, 63.8%) illustrates that the majority of respondents did not feel confident about their skills to perform citation searches on freely available websites.

Question 39 (Addendum D) was the final question developed for this research phase, as well as of the entire questionnaire. It asked respondents to rate their skills relevant to setting up and maintaining personal online profiles. Five relevant processes were tested: maintaining and updating a personal website, creating profiles on social networks for academics (e.g. Academia, ResearchGate), creating profiles on Google Scholar Citations, utilising e-mail discussion forums and utilising software that provides unique identifiers (e.g. ResearcherID, ORCID). The results of responses are illustrated in Figure 0.111, Figure 0.112, Figure 0.113, Figure 0.114 and Figure 0.115 and discussed in sections 5.3.11.8 to 5.3.11.12.

#### *5.3.11.8 Establishing a personal online profile by maintaining and updating a personal website*

Forty-seven of 68 (69.1%) participants rated their skills to establish a personal online profile through a personal website. N was 47. Figure 0.111 reflects the self-reported perceptions of skills in establishing an online profile through a personal website.

**Figure 0.111 Self-reported perceptions of skills in establishing a personal online profile by maintaining and updating a personal website**

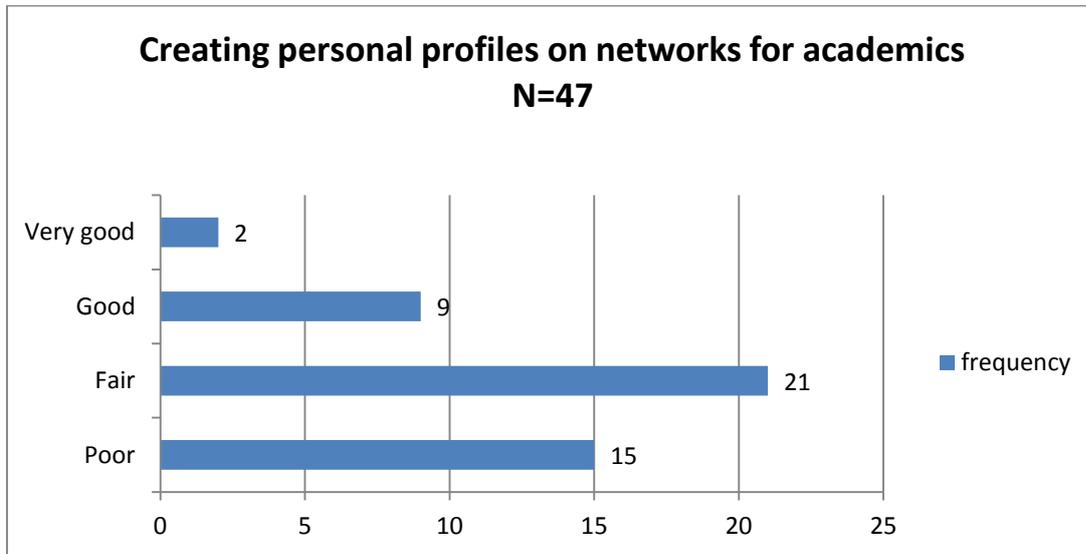


Of the respondents, 22/47 (46.8%) rated their skills to maintain and update a personal website to establish a personal online profile as poor, followed by those marking the fair (14/47, 29.8%), good (9/47, 19.1%) or very good (2/47, 4.3%) options. The combination of fair and poor (36/47, 76.6%) illustrates that the majority of respondents did not feel confident to maintain and update a personal website in order to establish a personal online profile.

*5.3.11.9 Establishing a personal online profile by creating profiles on social networks for academics (e.g. Academia, ResearchGate)*

Forty-seven of 68 (69.1%) participants rated their skills to establish a personal online profile by creating profiles on social networks for academics. N was 47. Figure 0.112 reflects the self-reported perceptions of skills in establishing a personal online profile by creating profiles on social networks for academics.

**Figure 0.112 Self-reported perceptions of skills in establishing a personal online profile through creating profiles on social networks for academics**

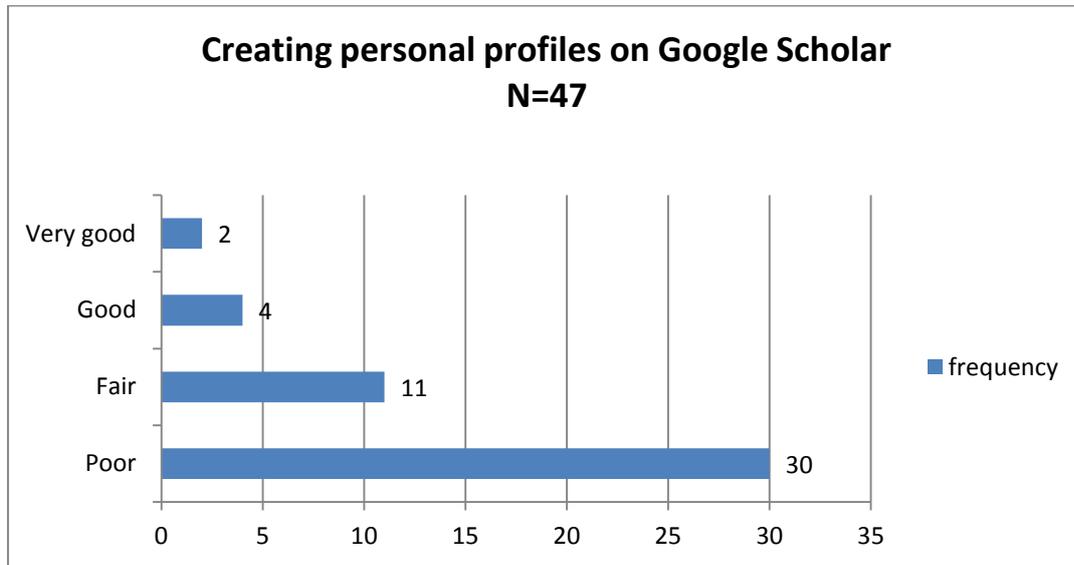


A large proportion of respondents rated their skills to create profiles on social networks for academics in order to establish a personal online profile as fair (21/47, 44.7%) or poor (15/47, 31.9%). A smaller proportion indicated these skills as good (9/47, 19.1%) or very good (2/47, 4.3%). The combination of fair and poor (36/47, 76.6%) illustrates that the majority of respondents did not feel confident about their skills to create profiles on social networks for academics in order to establish a personal online profile.

#### 5.3.11.10 *Establishing a personal online profile by creating profiles on Google Scholar Citations*

Forty-seven of 68 (69.1%) participants rated their skills to establish a personal online profile on Google Scholar Citations. N was 47. Figure 0.113 reflects the self-reported perceptions of skills in establishing a personal online profile on Google Scholar.

**Figure 0.113 Self-reported perceptions of skills in establishing a personal online profile by creating profiles on Google Scholar Citations**

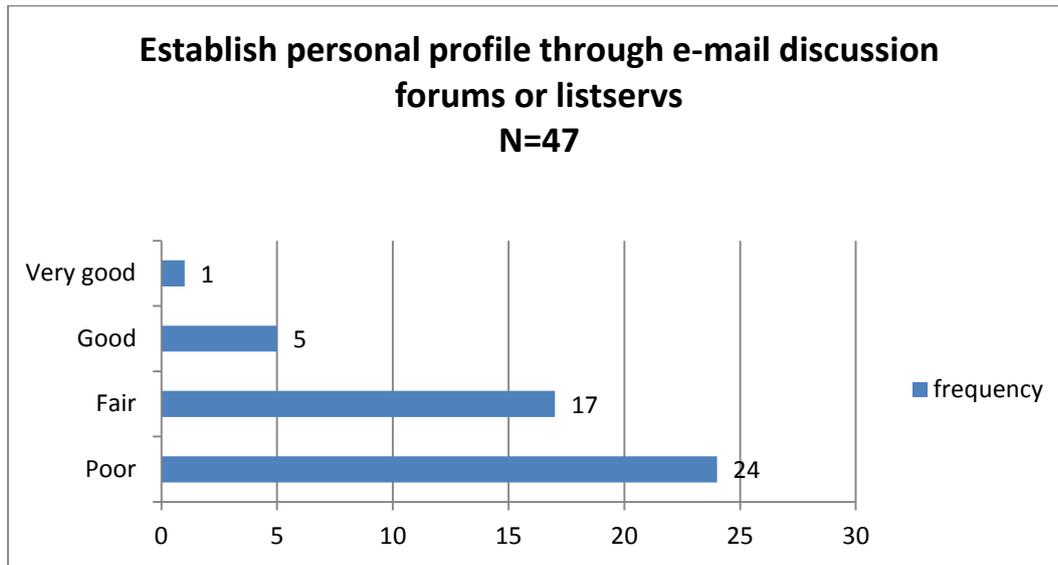


The majority of respondents rated their skills to establish a personal online profile on Google Scholar Citations as poor (30/47, 63.8%). This response was followed by those marking fair (11/47, 23.4%), good (4/47, 8.5%) or very good (2/47, 4.3%).

#### 5.3.11.11 *Establishing a personal online profile through utilising electronic mail discussion forums/listservs*

Forty-seven of 68 (69.1%) participants rated their skills to establish a personal online profile by utilising electronic mail discussion forums/listservs. N was 47. Figure 0.114 reflects the self-reported perceptions of skills in establishing a personal profile through e-mail discussion forums or listservs.

**Figure 0.114 Self-reported perceptions of skills in establishing a personal online profile through utilising electronic mail discussion forums/listservs**

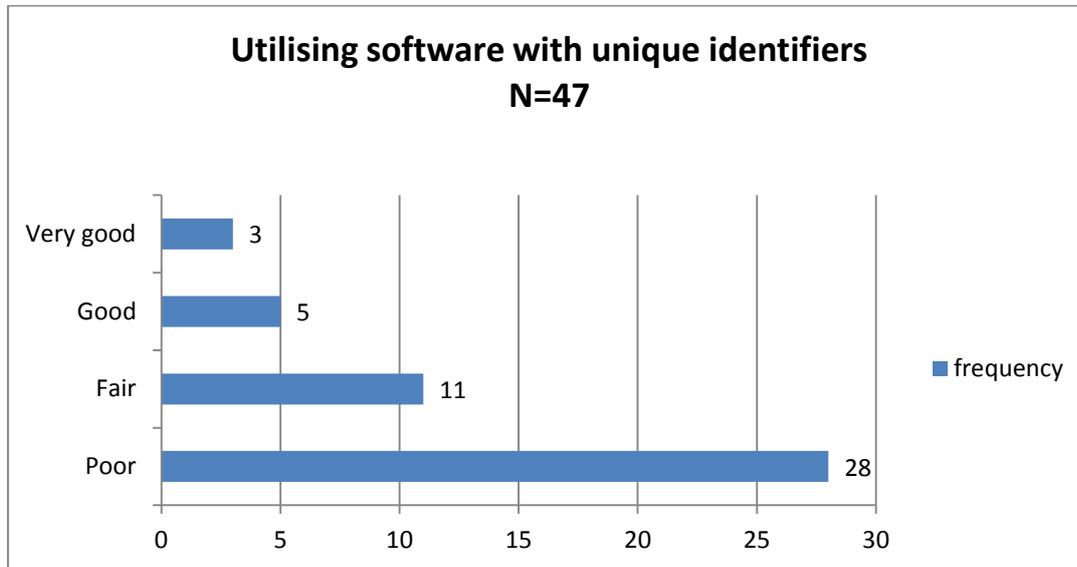


Just over half of the respondents rated their skills to utilise electronic mail discussion forums to establish a personal profile as poor (24/47, 51.1%). A further 17/47 (36.2%) marked the fair option, and 5/47 (10.6%) marked good. A single respondent 1/47 (2.1%) claimed that his/her skill in this regard was very good. The combination of fair and poor (41/47, 87.6%) illustrates that the majority of respondents did not feel confident to utilise electronic mail discussion forums to establish a personal profile.

*5.3.11.12 Establishing a personal online profile through utilising software that provides unique identifiers (e.g. ResearcherID, ORCID)*

Forty-seven of 68 (69.1%) participants rated their skills to establish a personal online profile through software providing unique identifiers. N was 47. Figure 0.115 reflects the self-reported perceptions of skills in establishing a personal online profile through software which provides unique identifiers.

**Figure 0.115 Self-reported perceptions of skills in establishing a personal online profile through utilising software that provides unique identifiers**



Their skills in using software that provides unique identifiers was rated as poor by 28/47 (59.6%) respondents. The rest of the responses ranged between those who marked the fair (11/47, 23.4%), good (5/47, 10.6%) or very good (3/47, 6.4%) options. The combination of fair and poor (39/47, 83%) illustrates that the majority of the respondents did not feel confident to use software that provides unique identifiers to establish a personal online profile.

The last section of this chapter provides a summary of responses obtained in the questionnaire on the self-reported ARIL skills of respondents. These responses are tabled according to areas where respondents felt confident about their ARIL skills, and where they did not feel confident about certain skills.

#### **5.4 SUMMARY OF RESPONDENTS' SELF-RATED ARIL SKILLS AND KNOWLEDGE**

A summary of the self-rated perceptions of skills of respondents is provided in the following section in order to group all the responses obtained from the questionnaire in a logical manner. The following categories were used in separate tables to summarise responses relevant to ARIL skills and knowledge, namely a category listing responses relevant to skills about which respondents indicated that they felt confident (e.g. where skills or knowledge were rated good and very good), and tables listing skills where respondents felt they could be lacking certain skills associated with ARIL (e.g. where skills or knowledge were rated fair or

poor). Skills will be categorised in broad percentage groups, with Table 0.8 summarising the perceptions of ARIL skills about which respondents felt confident.

**Table 0.8 Self-rated perceptions of ARIL skills and knowledge (good and very good)**

Percentage	Self-Rated Perceptions of ARIL Skills and Knowledge (Good and Very Good)
80-100%	Formulating a research problem Exploring engineering literature Searching for information individually Identifying a relevant electronic database for searches Searching and locating full-text engineering publications Distinguishing between credible and poor quality publishers Collecting research data from electronic instruments Collecting research data from existing documents Visualising research data Understanding the lifespan of information in PDF formats Managing and organising electronic information obtained from scholarly databases Managing and organising electronic information obtained from the internet Correctly citing others' work
60-79%	Identifying a research gap from existing literature Determining if somebody else is working on a specific topic Refining a research topic to be researchable Formulating a hypothesis Using electronic databases to identify a research topic Visualising relationships between concepts Identifying experts in a field of study Searching collaboratively for research information Using e-mail when searching collaboratively for information Searching and locating technical information Keeping abreast with the latest research information Using software packages to analyse quantitative data Knowledge of the lifespan of digital information in MS Office formats Managing and organising research documents on internet sites Managing and organising electronic mail information Adapting work to accommodate different audiences Avoiding plagiarism Critiquing research papers of others Writing conference papers Writing conference abstracts Creating conference presentations Writing dissertations Writing journal articles Employing word processing packages to write collaboratively Employing e-mail to write collaboratively Disseminating findings through conference presentations Disseminating findings through conference proceedings

Percentage	Self-Rated Perceptions of ARIL Skills and Knowledge (Good and Very Good)
	Disseminating findings through journal articles Acquiring technical skills to employ a specific dissemination channel Understanding the impact factors of journals and articles Understanding the peer-review process
51-59%	Searching and locating information in other disciplines Searching and locating information in non-text formats Mining research data Using reference management software to manage and organise research information Managing and organising information by annotating/ tagging documents Managing and organising information in paper format Managing and organising multimedia formats Writing a thesis Distinguishing between credible and fraudulent publishers Understanding the impact factor of researchers
Below 50%	Exploring literature in disciplines other than engineering Identifying and locating people as information sources Understanding the lifespan of digital information in HTML/XML format Managing and organising research documents through version control systems Describing the context of data (metadata/annotations)

Table 0.9 will summarise the self-rated perceptions of ARIL skills in which respondents indicated they were fair.

**Table 0.9 Self-rated ARIL skills and knowledge (fair)**

Percentage	Self-Rated Perceptions of ARIL Skills and Knowledge (Fair)
60-79%	Searching databases to identify funding opportunities Disseminating research findings in books Performing citation searches on a subscription-based database Creating a profile on social media for academics
51-59%	Using academic communities on the internet when searching for information Employing citation software to write collaboratively Disseminating research findings through conference posters Selecting the most suitable dissemination channel Adapting content to accommodate different audiences Understanding ranking statistics of departments or institutions
Below 50%	Exploring literature in disciplines other than engineering Collecting research data from people Using software packages to analyse qualitative data

Table 0.10 will summarise the self-rated perceptions of ARIL skills in which respondents indicated they were poor, or just below fair.

**Table 0.10 Self-rated ARIL skills and knowledge (poor)**

Percentage	Self-Rated Perceptions of ARIL Skills and Knowledge (Poor)
60-70%	Licensing work published on the internet Designing IP management plans Negotiating with publishers to retain some rights Registering a design to protect IP rights Registering a trade mark Establishing a personal online profile in Google Scholar Citations Registering a patent
40-59%	Using software providing unique identifiers to establish a profile Setting up electronic alerts to receive updates of funding information Contributing on social media Employing VREs to create research documents collaboratively Registering a domain name Restricting access to documents (embargoes) Disseminating research findings through social media platforms Disseminating research findings through personal webpages Disseminating research findings through the media (newspapers) Setting up licenses/agreements to protect IP rights to research Utilising e-mail discussion forums to establish a personal profile Employing social media platforms to create research documents collaboratively Understanding the impact statistics of research published on social media platforms Disseminating research findings through webinars/teleconferences Maintaining and updating a personal website to establish an online profile Using persistent links on internet to curate research data Using VREs to search collaboratively for research information Disseminating research findings through disciplinary repositories Disseminating research findings through multimedia channels Submitting research data to dataset repositories Managing and organising documents by depositing into IRs Writing chapters in books
20-39%	Placing access conditions on documents through passwords Searching electronic databases to discover funding opportunities Designing data management plans Disseminating research findings through IRs Regularly migrating data files to current formats to prevent obsolescence of data Designing a disseminating strategy to maximise visibility Creating multimedia recordings Performing citation searches on freely available websites Disseminating research findings in books Identifying possible funding opportunities

	<p>Compiling funding proposals Managing and organising documents through version control systems Ensuring research data is curated Using social networking tools to search collaboratively for information Writing technical reports Employing collaborative writing software tools on the internet Identifying potential IP rights to research</p>
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## 5.5 CONCLUSION

According to demographic data obtained from the survey, most respondents who completed the self-administered web-based questionnaire were either on master's or doctoral levels. Their responses were discussed in Chapter 5 in the same sequence as the questions appeared in the questionnaire (Addendum D). A summary of all responses was provided in table format at the end of the chapter in order to group responses broadly for future reference. The following chapter will focus on results obtained from participants during the qualitative phase of the study, by reporting on responses obtained from participants during focus group interviews as well as individual interviews.

## CHAPTER 6: RESULTS OF QUALITATIVE DATA

### 6.1 INTRODUCTION

The previous chapter reported on the results obtained during the first data collection phase of this case study, where quantitative data was gathered by means of a self-administered questionnaire. The data collection process followed a specific sequence in this study, as already mentioned in previous chapters, with this chapter being a continuation of reporting on empirical results with specific reference to qualitative data. Qualitative data was obtained in various ways in this mixed method case study, namely data in text format provided as part of the questionnaire survey, and from conducting focus group and individual interviews by means of a semi-structured interview schedule (Addendum E).

The aim of this exploratory study was to establish how an advanced research information literacy framework can inform the development of programmes supporting the scholarly research process of engineers in a South African higher education environment. As mentioned in previous chapters, this chapter attempted to contribute to the answering of the above question, as well as to address the following sub-question: *“How do information literacy skills, knowledge, and practices of engineers differ between master’s, doctoral, post-doctoral, established and expert researcher levels?”*

The discussion of the data collection process in Chapter 6 consists of four sections, with the first reporting on the execution of the qualitative data collection process, the second on demographic information obtained from participants, the third on data collected while conducting focus group and individual interviews, as well as from comments added in text format by respondents who answered the ARIL questionnaire, and the fourth on themes that emerged from the data. These four sections are followed by a short summary of findings in this chapter

Section 6.2 reports on aspects associated with procedures relevant to the collection and analysis of qualitative data in this study, namely selection of participants, data collection and analysis processes and ensuring validity and reliability.

## **6.2 EXECUTION OF THE QUALITATIVE PHASE**

The overall purpose of conducting focus group and individual interviews in this case study was to collect data that could assist with the development of an ARIL framework for postgraduate engineering researchers. More specifically, the purpose was to obtain supplementary data to the semi-structured self-administered questionnaire and to gain deeper insight in participants' views and experiences as expressed in their own words. The various data collection methods used in this study created an opportunity for the researcher to triangulate data, which is believed to strengthen the methodology selected for this case study.

### **6.2.1 Selection of participants for the individual and focus group interviews**

As already alluded to in previous chapters, qualitative research designs are associated with sampling techniques that ensure that "information-rich" participants are selected (Teddlie & Yu, 2008:209; Struwig & Stead, 2001:121), based on the existing knowledge a researcher has of a population (Uys & Puttergill, 2003:107). Small sample sizes are therefore often selected by employing purposive techniques, which are based on specific criteria or purposes associated with a research study's objectives (Teddlie & Yu, 2008:200; Kemper, Stringfield & Teddlie, 2003:273). Although the initial invitation for participation gave everybody the opportunity to indicate that they wanted to participate in a focus group or individual interview, the researcher also focused on involving participants from each career level, namely master's, doctoral, post-doctoral, established and expert level researchers across engineering departments, as well as between students and staff members in the engineering faculty. This was done by issuing personal invitations. Unfortunately there was only one expert level researcher (NRF A rated) in the faculty at the time, who was not available because of international travel commitments. The objective was achieved, with the exception of including participants in the expert level group,

Focus group and individual interviews were conducted between September and December 2016. Thirty-one participants were interviewed, with 19 participants taking part in focus group interviews and 11 taking part in individual interviews respectively. All the participants who took part in the focus group interviews were postgraduate students in the process of completing a master's or doctoral study, and participants who took part in individual interviews were staff members either in the process of completing a doctoral study or already holding a doctoral degree.

### 6.2.2 Data collection and analysis

Interview sessions were scheduled according to participants' preferences in a venue convenient to the participants, such as the participants' offices, study research areas or boardrooms at times convenient to them. Both individual and focus group interviews lasted on average between 45 and 90 minutes. The transcription of interviews, accompanied by signed written informed consent forms by participants in which they authorised the researcher to audio-record the interview, was done by a trusted transcribing company in Cape Town and commenced early in November 2015. All transcriptions were typed verbatim and delivered in Word documents to the researcher early in December 2015.

A semi-structured interview guide (Addendum E) was used as data collection instrument for the qualitative phase of this case study, and open-ended questions were developed to encourage free and open responses. Probing questions were also developed to follow up on comments made by participants in order to encourage elaboration where necessary. Demographic information of each participant was collected by means of a short questionnaire (Addendum H) before each interview commenced and focused on the following areas: relevant engineering field, highest qualification, time of holding the highest qualification, current research stage, NRF rating, position in academic department, current involvement with supervision and current collaboration with other research categories. A final question asked participants whether they had completed the ARIL questionnaire or not. This applied to both the individual and focus group interviews.

The interview schedule consisted of five sections, namely:

- Identification of the ARIL skills considered most critical to postgraduate research.
- Identification of barriers and challenges experienced during postgraduate research.
- Identification of auxiliary skills associated with information literacy and/or research processes such as time management, project management and note-taking.
- Follow-up on findings obtained from the data generated from the questionnaire survey.
- Other issues relevant to the research topic (“a framework for an advanced research information literacy (ARIL) programme for postgraduate researchers in engineering”).

The researcher explained the nature and purpose of the study to all participants before each interview session commenced and reminded participants of their right to withdraw from the study at any stage. Participants were ensured that their identities would be protected in the discussion as well as in subsequent publications arising from the case study. Each participant was requested to complete and sign an informed consent form (Addendum G) before the interviews commenced. Participants also had to indicate whether they gave permission for the researcher to audio-record interviews in order to ensure accurate transcriptions. All participants gave informed consent in writing for participating, and of the 31 participants interviewed, only seven requested the researcher not to record their comments on audio-tape; the researcher made extensive notes of their input instead.

A Phillips digital voice recorder was used to record all interviews. The recorder had the ability to store each interview in a different index to ease the tracking and transcription of interviews afterwards. In addition to the audio recordings, the researcher took extensive handwritten notes during each interview to enable her to track key points for later return.

Participants were given the following labels in order to maintain anonymity when reporting on findings: I1-I12 for individual interviews, and FG1-FG19 for participants who took part in focus group interviews. These numbers were used to refer to participants in the discussion section of this chapter. Since the interviews were conducted in both English and Afrikaans, comments were freely translated from Afrikaans to English with minimal editing for the purposes of data analysis and discussion.

The collection of data ultimately “culminates in the analysis and interpretation” of data, which involves the breaking up of data into manageable “themes, patterns, trends and relationships” (Mouton, 2001:108). Data analysis procedures are therefore often performed to convert raw data “into meaningful or interpretable data” (Struwig & Stead, 2001:150), which may involve editing, categorising and coding processes. Leedy and Ormrod (2010:153) identified four phases during the qualitative data analysis process, namely breaking up large units into smaller ones (organisation), getting an overall sense of the data (perusal), grouping data into categories or themes to find meaning (classification) and using tables, diagrams and graphs to explain findings (synthesis).

In the analysis phase the researcher therefore commenced by organising all transcriptions and then perusing them to form a clear and holistic understanding of the information at hand. Thereafter, the coding process commenced, during which data was broken down, named,

categorised and conceptualised. The researcher employed a thematic analysis strategy, which entailed a cyclic process where data is constantly synthesised to look for a deeper meaning. This strategy allowed for findings to emerge from the data (Douglas, Van Epps, Mihalec-Adkins, Fosmire & Purzer, 2015:133; Guest, 2012; Miles, Huberman & Saldana, 2014). The strategy followed for the analysis of qualitative data assisted the researcher to identify patterns in the data, and to identify what lay beyond the surface of the data. Themes were developed by separating portions of data from their original context, after which they were renamed, reorganised and merged in a search for alternative interpretations. The relationship among categories was constantly monitored, as well as the boundaries between themes. The relevance of each theme was considered against the backdrop of the central research question in this study, namely: *“How can an advanced research information literacy framework inform the development of programmes supporting the scholarly research process of engineers in a South African higher education environment?”*

### **6.2.3 Reliability and validity**

Specific action was taken to ensure reliability and validity in the qualitative phase of the study, as already discussed in Chapter 4. Reliability, which is considered a synonym for consistency (Struwig & Stead, 2001:133), was ensured through the extensive documenting of each interview by means of audio recordings and notes made by the researcher, as well as documenting comments made by participants shortly after each interview session while comments were still fresh in the researcher’s mind. A more detailed explanation of the data collection and analysis methods is provided in chapter 4. A consensus interview with an independent coder took place in February 2016 and the main findings and themes identified by the researcher were confirmed and discussed as part of quality control measurement and to increase the reliability of this study.

Validity in qualitative research refers to checking the accuracy of findings by employing certain procedures (Leedy & Ormrod, 2010:100). The researcher implemented multiple strategies by employing thick descriptions to convey findings, reporting all negative information (i.e. where participants gave vastly different opinions about issues), and continuing with data collection until data saturation was reached (Leedy & Ormrod, 2010:100; Babbie & Mouton, 2001:275). The researcher also kept track of data by recording the main discussions and events throughout the interview sessions where participants gave permission. For the seven participants who requested that interviews not be recorded, extensive handwritten notes were made. The credibility of data was ensured through the

accurate identification and description of events (Babbie & Mouton, 2001:277). Validation strategies also included the triangulation of data in this case study from both quantitative and qualitative data, as well as from the subject literature. Transferability was achieved by providing thick, detailed and precise descriptions of data (Babbie & Mouton, 2001:277).

The researcher played an active role in the collection and interpretation of others' words and contributions, based on what they were willing to share at the time of the interviews. She is therefore critically aware of her own possible bias and subjectivity, which may include influences relevant to context, culture, history, world views and experience with analytical processes, as well as the fact that the participants might not have shared all possible useful information. She therefore acknowledges that she is merely a human instrument, and may have limitations regarding her views throughout the data collection and analysis processes, and the consequent interpretation and reporting thereof. Since rich descriptions of qualitative data, supplemented with quantitative data and reports from the subject literature were considered, the analysis and findings of the study are considered valid and reliable.

The following paragraphs provide a summary of the demographic data collected from the participants who were interviewed during the individual and focus group interviews.

### **6.3 DEMOGRAPHIC DATA OF PARTICIPANTS**

The results obtained from the nine demographic questions posed to the 31 participants before the focus group and individual interviews commenced are illustrated in the following paragraphs (see Addendum H for the profile questionnaire and Addendum E for the interview schedule). Participants had to indicate the engineering field in which they were conducting research in the first question (Table 0.1), their highest qualification in the second question (Table 0.2), the time they had been holding their highest qualification in question three (Table 0.3), the research stage closest to where they found themselves in question 4 (Table 0.4), their NRF rating in the fifth question (Table 0.5), their current position in their academic department in question 6 (Table 0.6), their current involvement with post-graduate supervision of engineering researchers in question 7 (Table 0.7), the nature of collaboration with other researchers in question 8 (Table 0.8), and whether they had completed the ARIL questionnaire in question 9 (Table 0.9).

**Table 0.1 Engineering departments associated with participants**

<b>Engineering Department</b>	<b>Number of Participants (N=31)</b>
Material Science and Metallurgical Engineering	7
Mechanical and Aeronautical Engineering	7
Civil Engineering	7
Electrical, Electronic and Computer Engineering	5
Chemical Engineering	3
Industrial and Systems Engineering	1
Mining Engineering	1

An equal number of the 31 participants belonged to the Material Science and Metallurgical, Mechanical and Aeronautical and Civil Engineering departments, with seven participants from each department. Five participants belonged to the Electrical, Electronic and Computer Engineering department, while there were three participants from the Chemical Engineering department. There was only one participant in each of the Industrial and Systems Engineering and Mining Engineering departments.

**Table 0.2 Highest qualifications of participants**

<b>Highest Qualification</b>	<b>Number of Participants (N=31)</b>
Honours degree	12
Master's degree	9
Doctoral degree	10

Of the 31 participants, 12 indicated that they held honours degrees, closely followed by nine participants who had already obtained master's degrees, and 10 participants who held doctoral degrees.

**Table 0.3 Number of years of holding the highest academic qualification**

<b>Years of Holding Highest Qualification</b>	<b>Number of Participants (N=31)</b>
Less than 1 year	6
1-2 years	12
3-5 years	5
6-10 years	1
11-15 years	6
16-20 years	0
More than 20 years	1

Of the 31 participants, most indicated that they had held their highest qualification for between one and two years at the time of the survey. These were followed by participants who had held their qualification for less than a year and the group who had obtained their qualifications 11-15 years previously. These groups were followed by those who indicated that they had been holding their highest qualification between three and five years. One participant held his/her highest qualification for between six and 10 years, and one for more than 20 years. None of the participants selected the category between 16 and 20 years.

**Table 0.4 Current research stages of participants (e.g. studying for a master's or doctoral degree, or working on a special research project)**

Research Stage	Number of Participants (N=22)
Idea generation and initial literature scanning	0
Proposal writing	2
Comprehensive literature analysis	1
Choice of research methods, design and developing data collection instruments	4
Data collection, analysis and interpretation of results	7
Editing and finalisation of dissertation/thesis	6
Publishing/disseminating results	1
Other	0

Most of the staff members who took part in individual interviews did not answer the question on their current research stage. All the participants in the focus group interviews (students) answered the question. Most participants were either in the process of data collection, data analysis and data interpretation, or in the process of editing and finalising a thesis or dissertation. The rest of the participants indicated that they were in the process of deciding on research methods and designs, developing data collection instruments, proposal writing, comprehensive literature analysis or the publishing of results.

**Table 0.5 NRF rating of participants**

NRF Rating	Number of Participants (N=23)
Not rated	19
Y-rated	1
P-rated	0
C-rated	1
B-rated	2
A-rated	0

The participants who held NRF ratings were all staff members, with two holding a B rating, and one each a C and a Y rating.

**Table 0.6 Position in engineering department**

<b>Position in Department</b>	<b>Number of Participants (N=31)</b>
Not a staff member	15
Research assistant	4
Junior lecturer	0
Lecturer	1
Senior lecturer	6
Associate professor	2
Full professor	3
Visiting professor	0
Post-doctoral appointee	0
Other	0

**Table 0.7 Involvement with postgraduate supervision**

<b>Involvement with Postgraduate Supervision</b>	<b>Number of Participants Responding to each option (They could respond to more than one option)</b>
Not supervising	19
Supervising master's students	11
Supervising doctoral students	10
Supervising post-doctoral students	0

Of the 31 participants, only the participants who took part in the individual interviews (staff members) indicated that they were supervising postgraduate students, with 11 participants supervising students on master's level, and 10 participants supervising students on doctoral level. All the participants who took part in the focus group interviews (students) indicated that they were not involved with supervision on postgraduate level.

**Table 0.8 Collaboration with other researchers**

<b>Collaboration with other Researchers</b>	<b>Number of Participants Responding to Each Option (They could respond to more than one option)</b>
No collaboration	0
Industry	16
Academic institutions	12
Government departments	3
Other	0

Most of the participants indicated that they collaborated with other researchers in industry, followed by collaboration with academic institutions. Three participants indicated that they collaborated with government departments.

**Table 0.9 Completion of the ARIL questionnaire**

Completion of the Aril Questionnaire	Number of Participants (N=31)
Yes	4
No	27

Most participants did not complete the self-administered web-based ARIL questionnaire; only four participants indicated that they did complete the questionnaire. The researcher did not require explanations from participants in this regard. While various reasons could have played a role in this case, many participants might have considered the completion of the ARIL questionnaire as too time-consuming or they might have been interrupted while completing the questionnaire.

The next part of the chapter will focus on data obtained from participants based on the questions posed to them during the semi-structured focus group and individual interviews.

#### **6.4 DATA COLLECTION AND ANALYSIS (QUALITATIVE PHASE)**

The semi-structured interview schedule consisted of five sections and participants were invited to elaborate on the following issues: what they regarded as the most critical information literacy skills they needed during postgraduate research, what they regarded as barriers or challenges during postgraduate research, and whether they regarded auxiliary skills (e.g. time management, project management, note taking) as important when conducting research on postgraduate level; they could also mention other auxiliary skills. Participants were invited to make additional comments on the ARIL questionnaire survey, and to add any other issues relevant to the research topic: “A framework for an advanced research information literacy (ARIL) programme for postgraduate researchers in engineering.”

Data obtained from the focus group and individual interviews is discussed in the same sequence as it appeared in the interview schedule in this chapter, and is supported by verbatim quotations from participants where appropriate. Most participants did not complete the ARIL questionnaire that was sent to all engineering departments for further distribution. The researcher took it upon herself to provide some context to the discussions before

interviews commenced, by sharing a diagram of the proposed adapted research lifecycle presented in Chapter 2 with participants. The reason for this decision was that only a few participants had any background knowledge of the content of the ARIL questionnaire. The research lifecycle also formed part of the proposed ARIL definition and was consequently incorporated in the ARIL questionnaire. The preliminary research lifecycle is illustrated in Figure 0.1.

**Figure 0.1 Preliminary research lifecycle shared with focus group and individual interview participants**



The following paragraphs will focus on what participants considered the most critical information literacy skills during their research on postgraduate level.

#### **6.4.1 Information literacy skills considered most critical for engineering postgraduate research**

Interview question 1 (Addendum E) asked participants to indicate information literacy skills they considered most critical to complete research at master's or doctoral level, or if they already held a doctoral degree, at post-doctoral level or as an established or expert researcher.

**The question read as follows: “What are the most critical information literacy skills that you need for your research as a researcher on master’s or doctoral level? Or if you already hold a doctoral degree, at post-doctoral level or as an established or expert researcher?”**

In their responses to this question, participants were strongly influenced by the phases in the preliminary research lifecycle (Figure 0.1). Although this might be a limitation of the study, they did have the opportunity to mention skills not reflected in the research lifecycle.

Although the research lifecycle reflects phases in research, these might also be interpreted and addressed as information literacy skills. Some participants considered all the research phases in Figure 0.1 critical information literacy skills. They stressed the interconnection between the skills and that if the phases influence one another; the related skills will also influence one another. The following selection of verbatim quotations reflect their opinions on the importance of information literacy skills. Sometimes the participants referred to phases or steps.

**FG1:** “You know for me they are so interconnected, but like I say, it is so unfortunate that we tend to focus more on the end product without recognising the importance of each and every single step.”

**FG1:** “My personal opinion, I would say all of these steps are very important because they link from one to the other.”

Some participants highlighted specific skills, such as the importance of the conceptualisation of a researchable topic or the importance of good writing skills. The skills that came up most strongly were conceptualisation of a research topic, obtaining research funding, data collection/generation and analysis, discovery and analysis of information, dissemination of findings and measurement of impact. The researcher will, as far as possible, try to indicate if comments were made by master's or doctoral researchers, post-doctoral or established researchers. A summary of the critical ARIL skills identified by participants on each level is

provided in the form of a table at the end of the discussion of all sub-sections (see Table 0.10).

#### *6.4.1.1 Conceptualisation of a research topic*

The conceptualisation of a research topic was identified as critical to postgraduate engineering research by participants on every level, namely master's, doctoral, post-doctoral and established researchers.

Most participants working on their master's study indicated that their supervisors or departments provided them with research topics, which almost always originated from a problem experienced in industry. Although topics were mostly provided by their supervisors, many master's student participants confirmed the critical importance of generating a research idea at the beginning of their research journeys. One supervisor indicated that he constantly developed documents providing outlines of possible research topics, which were provided to prospective students who required research topics. These documents covered possible research topics by indicating whether the topic was on master's or doctoral level, potential funders in future, the priority of the topic in the department, possible outputs in future, what could be gained as a result of the research, what was needed to conduct the research, and whether relevant references had already been identified. Some participants mentioned that although they were provided with broad ideas, they still had to refine those into researchable topics. One participant was of the opinion that one would not be able to do a masters' degree if one was unable to identify a suitable topic.

**FG2:** "If you don't get the idea right, you won't be able to do a master's degree."

Participants on doctoral level also confirmed that topics were often suggested by their supervisors who provided them with a broad idea, whereafter they had to refine and adapt it further into a researchable topic. Only one participant (staff member) mentioned that his/her ideas came directly from discussions with people in industry. Participants and several supervisors were of the opinion that the conceptualisation of a research topic is the most important part of a doctoral degree. Many also felt strongly that research ideas should make a contribution to the discipline, by being relevant and meaningful. The verbatim quotations below reflect the opinion of participants regarding the conceptualising of a topic on doctorate level.

**I4:** "The most difficult thing of a doctoral degree is to have a topic. If you have that, the rest is easy."

**FG1:** "The idea, is where you waste a lot of time ... to convert a problem into a researchable topic ... to add the beat to it ..."

**FG2:** "Supervisors usually have several unrefined themes ... then you choose one, and start your literature review ... and then you decide and carve out a topic for yourself."

On post-doctoral level, participants were also of the opinion that generating research ideas are crucial to postgraduate research. Some participants referred to the process of identifying a researchable idea as a creative process, where they needed to keep their "eyes open and think". Apart from ideas originating from their own doctoral degrees, they also identified research topics in the following ways: attending flagship conferences, discussions with people in industry, discussions with creative colleagues in the department, reading relevant literature, reading through funding calls, serving as a peer reviewer and focusing on NRF focus areas. Participants were of the opinion that research ideas should be original and should make a contribution to the discipline and referred especially to their relevancy to problems in South Africa. In addition, many post-doctoral participants stressed the importance of research ideas to be publishable. Although a fair number of participants felt that it is especially important for ideas to have a practical orientation and that ideas should be innovative and novel in order to be implemented in industry, others supported research topics with a purely academic orientation. The following verbatim quotations reflect some of the opinions of participants on post-doctoral level about the conceptualisation of research topics.

**I1:** "Idea generation ... it is literally the critical one ... that original idea for a piece of research".

**I9:** "I think you must be doing something that's relevant, that's going to make a difference ... the rest can be overcome I think."

**I7:** "I am continuously thinking about ideas ... day in and day out ... once the idea is sorted, the rest is relatively easy, because all your stuff is heading that way."

**I1:** "It can be disheartening if you publish a long list of articles, but nobody knows about you ... because the work which you do is not relevant to the problems in the country."

On established researcher level, a participant was of the opinion that skills to generate research topics and ideas must be taught early on in a research career and that it is crucial that researchers ‘get a feeling’ when working through the literature in order to identify a research gap. Another participant commented that ideas in his field came from intense interaction with industry, whereafter he “translates” ideas into research projects on master’s and doctoral levels. His opinion on the conceptualisation of research topics is reflected in the following verbatim quotation:

**I3:** “It is one thing if ESKOM tells you they have a problem with their turbines, and another to translate that idea to a researchable project ...”

The second set of critical skills identified on postgraduate level was obtaining research funds, which will be discussed in the following paragraphs.

#### *6.4.1.2 Obtaining research funding*

Participants on every level identified obtaining research funding as critical to postgraduate engineering research.

On master’s level, participants confirmed the importance of research funds in conducting engineering research, with some mentioning that they were always “on the lookout” for funding. Some participants alluded to the high costs of engineering research in comparison with other disciplines, by referring to expensive equipment and experiments, costs associated with carrying out certain tests, and the maintenance of equipment. Although some participants indicated that they had applied for funding from the NRF in the past, many confirmed that their supervisors often did the bulk of the funding application. However, participants seldom had to obtain funds on their own, with many indicating that they received funds from their departments or bursaries from the home university. Funding applications on master’s level were mostly once-off activities, and funding received was often enough to sustain them throughout the period of obtaining their qualification. The following verbatim quotations illustrate some of the opinions of masters’ students on obtaining research funding:

**FG2:** “If you don’t get funding, you won’t be able to do a masters’ degree or research.”

**FG3:** “The process is competitive ... and you have to focus when writing a proposal ... it takes about six months.”

On doctoral level, participants also admitted the importance of research funding and referred to expensive equipment. Although students mentioned that they were often encouraged by their supervisors to apply for NRF funding, many indicated that they received funds from their departments or the university's research and development fund. Participants who had more experience in funding applications mentioned the importance of being able to write for the different funding bodies and specifically stated that research ideas should be in the funder's interest. The opinions of some participants on doctoral level on obtaining research funding are reflected in the following group of verbatim quotations:

**FG2:** "The department takes care of everything. I don't know how they get the money, but they provide."

**FG1:** "I have some experience with more instrumental work, and we are in a position where we want to buy some equipment, but we don't have the necessary funds for it, so we need to go to other institutions or research facility to maybe do some experimental work."

**I8:** "Funding is not just about your degree fees, or to get a staff member to replace you ... because it is experimental work, you need to buy apparatus, you have to pay for analysis ... you need a large amount of money to pull a successful research project off."

Some participants on post-doctoral level mentioned their successes in the past in obtaining funding from the NRF and other organisations. One participant also mentioned how he obtained research funds by winning competitions in the past. Many participants highlighted the importance of a track record when applying for funding and stated that their lack of such a record made applications difficult. A participant indicated that although the NRF and some other funding bodies could assist him, these funds were often not sufficient to sustain his research group, since he occupied a "research chair" and had to generate his own salary out of research funds.

An established researcher highlighted the pressure put on them by the university to obtain external funding. He confirmed that although he had been writing many funding proposals over the years, it was still not an easy process to apply for research funding. While acknowledging the benefits of receiving funds from the NRF, specifically for rated researchers, he still needed to approach industry for research funding. Funding applications were seldom for supporting once-off events, but rather to support various people and processes over the long term, among others to pay salaries and buy equipment.

A third critical skill identified by participants focused on the creation of research documents, which will be discussed in the following paragraphs.

#### *6.4.1.3 Creating information formats*

The creation of information formats was identified as a critical skill in postgraduate engineering on all levels. Information formats can refer to various different documents, among others books, chapters in books, technical reports and standards; most participants only referred to journal articles and theses or dissertations when referring to the creation of research documents. Many participants across departments and levels indicated that they did not consider MS Word as a suitable writing tool, and that they preferred the Latex software instead. Reasons included that it was easier to do the overall formatting of mathematics, correlations and tables, and that all their information and data were kept in a source file, which they could draw from at a later stage.

Participants at a master's level were of the opinion that their supervisors were strict about their writing skills. Many referred to a template provided by their supervisors, which served as a guide to them during the writing process. Supervisors highlighted the importance of converting information to knowledge, evaluating and communicating the different opinions of authors, the evaluation of experiments and procedures discussed in a document, and the writing of a conclusion. Some participants voiced their concern about plagiarism issues while creating documents. While a few participants were aware of anti-plagiarism software, others were not aware of the existence of software that could assist them in monitoring possible plagiarism in a document. Many participants referred to the importance of logical flow in a document and used the word "storyline" to explain the concept. The importance of the reader understanding what they were trying to communicate was highlighted by many. The remarks of students on master's level, specifically regarding the compilation of research documents, are reflected in the following selection of verbatim quotations:

**FG1:** "The whole story that you are trying to communicate must be logical and it must flow. You have to integrate all the technical knowledge and balance it out so that it flows, so that the other person can understand what you're trying to communicate."

**FG2:** "To take the reader logically from one point through the process ... with a comfortable writing style instead of a very technical writing style ... with simple words, and a plain layout."

**FG1:** “So then we have a structure (template) with an idea of which headings we could perhaps use, and then you kind of fill it up and edit.”

On doctoral level, participants were of the opinion that one needs to plan the outline of an article or document in advance. The scope of a document was also considered important by some participants, as well as a researcher’s judgement regarding what needs to be included in a document and what needs to be excluded. Plagiarism did not seem to be an issue to most participants, and many students referred to specific skills to avoid plagiarism, which included referencing of articles used and summarising information obtained in their own words before using it in a final document. The verbatim quotations below from a supervisor of doctoral students summarises his/her opinion on writing on postgraduate level:

**I1:** “The storyline is important. This is where students need a lot of assistance. They have done the work, they are technically efficient, they know what they have done, but they do not understand how to present the work at all. They struggle to put the problem in context and to produce an interesting storyline.”

**I1:** “... postgraduate training is almost an apprenticeship. It is a one-to-one relationship between the supervisor and the student ... and the final step in this process is not only to teach the student to think and to do, but also to document the work in a good way.”

On post-doctoral level, participants also referred to the importance of a logical flow (storyline) of research documents in order to accommodate the reader. One participant confirmed the effectiveness of templates to assist him with the creation of research documents. In addition to journal articles as important information formats to create, some referred to writing keynote speeches for conferences. One participant referred to the effectiveness of an article-writing course offered at the university in the past, which covered aspects concerning the development of a convincing argument and the overall structure of a document. The use of good English language was also identified as very important among post-doctoral participants, and many referred to the importance of language editors to assist in this regard. A group of verbatim quotations below reflects the opinions of some post-doctoral participants on the importance of logical flow when compiling research documents.

**I9:** “It is important to have a logical thought sequence that I can take the reader through. To make him understand what the question is, why it is relevant, what I have discovered, what difference it made, and what kind of conclusion I got. So to me it is important that it is logical and that it makes sense.”

**I10:** “For many of us English is not a first language, so it is important to me that when you publish something, it is language appropriate as good as possible, but I am not a language expert. So I am sensitive for it, I do a lot of effort with it, but in the end, one needs to send it to a language editor.”

**I7:** “What I do as well, for both articles and dissertations, is I have it professionally edited - only for grammar.”

#### *6.4.1.4 Data collection and analysis/data generation*

The ability to collect, analyse or generate research data was identified as crucial to postgraduate engineering research on all levels. Some participants referred to their data being the heart of their projects, which was mostly obtained through conducting experiments, or by means of simulations, where models were built on computer software in the form of computer codes.

On master’s level, participants were of the opinion that lack of research data will result in inability to complete the qualification and that one will not be able to produce publications without data. The following verbatim quotations summarises the opinions of a few students on master’s level regarding the importance of obtaining research data:

**FG1:** “If you don’t have data, you are done.”

**FG1:** “You cannot publish if you don’t have data.”

Participants on doctoral level were of the opinion that they were “stuck without data”. Some participants mentioned that they were working with ‘Big Data’, referring to massive amounts of data generated by electronic instruments. Participants on doctoral level specifically mentioned the ability to have insight into research data obtained. They were of the opinion that a researcher’s knowledge of the specific field in which he/she works goes hand in hand with the interpretation of data. Doctoral researchers considered it important to perform quality evaluations on their research data, and stressed the importance of being elective. The

verbatim quotations of participants on doctoral level below reflect their opinions on the importance of research data:

**FG2:** “Especially in engineering, most of the real work and labour goes into your data and analysis and your graphs.”

**FG2:** “The way in which you generate data rests upon your knowledge of the field, and if you don’t have knowledge of the field, you cannot generate data, you can’t analyse data, you can’t evaluate the quality of data ... it all depends on your ability to show insight in what is going on. If you cannot do that, I would say that you should probably not do a PhD.”

On post-doctoral level, participants also confirmed the importance of the quality data generated. They were also of the opinion that research data must be meaningful and interesting. The verbatim quotation of a participant on post-doctoral level regarding research data below summarises his/her opinion:

**I6:** “In my opinion, this is what the paper is written about ... the quality of data generated is of cardinal importance.”

The following paragraphs cover an additional critical skill for postgraduate research, namely discovering and evaluating information.

#### *6.4.1.5 Discovering and evaluating information*

The discovery and evaluation of information were identified as critical during postgraduate engineering research; this was confirmed by participants on master’s, doctoral and post-doctoral levels. From their inputs it was clear that they mainly regarded two information sources as important, namely electronic databases and people, which often included peers and/or colleagues in the department. Most participants indicated that they used Scopus, Science Direct and Google Scholar on a regular basis, and did not have any systems in place to stay abreast with the latest information published in their field of interest. Generally, most participants preferred two ways of discovering information, namely using keywords relevant to a specific topic and following references of a specific paper. Many participants indicated that the discovery of relevant information was often a situation of “hit and run”, after which information of value was filtered for use.

On master's level, participants often indicated that they received collections of articles from their supervisors during the early stages of their research, and were required to update those collections throughout the duration of their studies. Some commented on the effectiveness of such a system, and how it assisted them in feeling less overwhelmed by all the information available on a topic at a given time. Most participants on master's level were of the opinion that although the gathering of background information on their research topics was very important, their literature review skills were still inadequate. Some supervisors agreed with this, and verbatim quotations relevant to information discovery by their students on masters' level are provided below:

**I1:** "The students do not have background because they are new. The student is raw. The student cannot trust his own instinct, because he/she has not read anything, does not work a decade or more in the field, and must as a matter of importance first read."

**I10:** "I don't think students are necessarily taught a method on how to perform a structured literature review ... it is easy to trawl in Scopus in and retrieve 300 articles."

On doctoral level, participants also indicated that they sometimes felt overwhelmed by the amount of information available on a specific topic. They often specifically mentioned the value of discovering information from other researchers. A verbatim quotation of a doctoral student regarding the discovery of information is provided below:

**FG2:** "We send articles to each other, and to our professor, so there is an internal flow of information."

On post-doctoral level, most participants confirmed the importance of obtaining research information from others. The following sources were added in text format by respondents who completed the ARIL questionnaire: obtaining information from master's students who performed literature searches, telephone calls, personal meetings, conferences, online communities over the internet, serving as journal editors and serving as peer reviewers. There was a preference on post-doctoral level for a quick overall picture of what literature is available in a specific field in the form of a bubble chart opposed to merely a long list of articles. One participant was also of the opinion that the ability to filter information was more important than the discovery of information.

Although some participants on post-doctoral level indicated that they lacked skills to discover information, it did not seem to be a concern for others, with some being of the opinion that the discovery of information is not a central function during postgraduate research. One participant referred to the saying, “you don’t know what you don’t know”, while others elaborated by stating that they knew their fields very well, and combined with many contacts in academic institutions and in industry, they often consulted literature at a very late stage of their research. Another participant indicated that he/she mainly performed literature surveys to support a specific opinion. The following group of verbatim quotations highlight some of the post-doctoral participants’ views on the discovery of information:

**I1:** “I may perhaps struggle a bit to find information sources, but that is all. After identifying a research idea, I primarily perform a literature analysis to ensure I am not wasting my time, and merely need to get other researchers’ opinions, or to establish whether research in that field has been done previously or not. It is during that stage where I spend a week or so where I thoroughly ensure the research was not done before, because if so, you will waste time and will not be able to publish.”

**I1:** “So as a staff member and supervisor, it is not necessarily crucial to start reading the literature.”

**I2:** “Information always need[s] to be functional. I usually first try to solve a problem on my own before consulting the literature ... and if I get stuck, I consult somebody to assist.”

**I6:** “The most important thing, which takes a lot of time, is to perform the literature survey. So again, you have to search for things which you don’t necessarily have, but which will support your opinion or work. So then you start from scratch again to search for things in the field which has been done before.”

Although judging the quality of information obtained was considered important by many participants, they gave mixed responses to the methods they used to judge the quality of information retrieved. On master’s and doctoral levels, they referred to this process as an “independent task” where researchers must make decisions on their own regarding the applicability or relevance of a specific source. Many participants were of the opinion that they were able to decide by themselves whether information was of high quality or not, by reading a document or an abstract of a document. In addition, recommendations of supervisors or other researchers played an important role when judging the quality of an

information source. Articles obtained from electronic databases available from the library website were considered quality information. Some participants mentioned that they applied specific criteria when judging the quality of information, namely the way in which experiments were described and in which equipment was used, whether there were references listed at the end of an article, and the impact factor of the article or journal.

On post-doctoral level, although participants acknowledged the importance of evaluating information, some admitted that their evaluation skills were inadequate. Many were of the opinion that the decision depended mainly on their own knowledge about the subject. Some mentioned that knowledge about the author of a specific article assisted them with the decision. Others said they only knew if it was a quality article, once they had repeated some of the tests discussed in a research paper. A group of verbatim quotations below summarises the opinions of participants on post-doctoral level on judging the quality of information:

**I10:** “Sometimes you have to bump your head and use poor quality information to later realise it was not good information ... you try to judge as good as you can.”

**I11:** “It depends on a gut feeling ... then I decide what is usable for that specific problem on that given time.”

**I10:** “You learn to get a feeling of who works in a field, and there are certain authors you can trust. I know that, but the student is going to struggle to do that, and therefore I interact with them and say: I know this author, I have been working with him, or, he has done good work before.”

Established researchers confirmed that the quality of a research document that was discovered is a very important consideration. Knowledge of the author of an article played an important role in their decision about the quality of information, as well as their subject knowledge obtained over the years. One participant mentioned that he expected his students to evaluate the quality of research information they used in their studies.

#### *6.4.1.6 Dissemination of research findings*

Participants on master’s, doctoral and post-doctoral levels identified the dissemination of research findings as crucial to postgraduate engineering research. Most participants preferred to publish in international journals listed on ISI, preferably in journals with a high impact factor. Reasons given for this decision included that those journals were peer-reviewed, the financial benefit in the form of a subsidy from the university after successful publication, and

the performance appraisal system at the university, which rewards researchers for publishing in international journals. One respondent who completed the ARIL questionnaire confirmed a preference for high-impact journals and specifically mentioned journals published by Elsevier. Participants had different opinions about local journals, with significantly fewer participants willing to publish in local journals. Reasons given included that local journals did not have high impact factors. One participant, however, was adamant that research results should be shared with immediate collaborators in South Africa as soon as possible. Many participants across levels and departments were unsure about the meaning of open access. Some participants on post-doctoral level were willing to share research data, while others had conditions, namely they would share with close collaborators, only share raw data without any interpretations, and only after results had been published.

On master's level, most participants mentioned that they had not had much experience regarding the dissemination of their research, and many were not familiar with publication processes. Most participants did not know how to identify suitable journals in which to publish. The importance of presenting research findings and other relevant information orally, however, was identified as important, and participants often highlighted the importance of accommodating the audience when presenting work at conferences or even in their own engineering departments. The following verbatim quotation illustrates the opinion of one participant on master's level on presenting research results orally:

**FG1:** “To pitch to that audience ... the hardest part is figuring out your audience ... to know who they are, what they know and what they want.”

On doctoral level, participants highlighted the important role advice from their supervisors played during the dissemination of research findings. Good presentation skills were also identified as important when disseminating research findings. Participants were aware of expectations to publish articles after graduation and many alluded to the “publish or perish” notion in the academic environment.

On post-doctoral level, only one participant mentioned the importance of disseminating research results on television, and through workshops targeting the general public, rather than only an academic audience. Participants considered the building of a track record and their reputations as researchers especially important during the dissemination of research findings. Some were of the opinion that the acceptance rate of journals was a very important aspect influencing the choice of a journal. The group of verbatim quotations below gathered from

participants on post-doctoral level summarises their opinions on the dissemination of research results:

**I7:** “Publications, publications, publications. This is the only thing driving me ... my target at this stage is an NRF rating.”

**I2:** “If you have a really good idea, but you have not made a name in your field, it is almost impossible to get those ideas published.”

#### *6.4.1.7 Measurement of impact*

The measurement of impact in a specific research field was identified as crucial to participants on doctoral, post-doctoral and established researcher levels. Different viewpoints regarding the measurement of impact were raised by participants, with only a few referring to and supporting citations of publications as an indicator of impact. Most participants considered the postgraduate students they deliver to industry as an indicator of impact in their specific field of study. Although some participants indicated that they had created personal profiles on ResearchGate, LinkedIN, Academia or Google Scholar to increase their visibility, most participants were of the opinion that it was not a priority. A few participants admitted that although personal online profiles were important to them, they either did not have the time to create and update such profiles regularly, or referred to the additional administrative load of uploading and maintaining online profiles. One participant was of the opinion that his publication records were available on the various electronic databases to which the university subscribed anyway, and another mentioned that he used a webpage to do some marketing of their research in the department. One reason for their opinions was that the work produced as a researcher should rather serve as “advertising”, in contrast to an online profile. Some participants were of the opinion that they were not comfortable to label themselves as researchers, and indicated that they wished to avoid another administrative, time-consuming activity. The verbatim quotations below summarise the opinions of a few participants on marketing their research:

**I10:** “We have a webpage for the research group which serves a basic exposure. But we do not have a big drive to market ourselves ... Your work must talk for you, I think. If people come to you and ask to collaborate, then it is a good sign.”

**I7:** “I am a really bad administrator, so if I get something published, I forget about it. I don’t put it on my CV.”

On doctoral level, some participants were of the opinion that the fields in which they worked were small, and in some instances very specialised, and that most researchers therefore already knew one another, which made further marketing of oneself on social media pointless. Participants on doctoral level indicated that they valued acknowledgements at conferences or seminars, by experts in the field, peers or researchers from local industry more as evidence of impact in a specific field. A few verbatim quotations below summarise the opinions of participants on doctoral level on the measuring of impact in a specific field of study:

**I9:** “I would want to be acknowledged ... where people who are dealing with what I am researching can say yes, that is important research, so definitely on a local level, and then hopefully on an international level. I don’t know, to me, to be acknowledged at a conference or something like that, or asked to be a keynote speaker at a conference, that to me would be an indication that my research is relevant.”

**FG2:** “I don’t use social media at all. I am not even aware of any doctoral student who used social media to market himself ... I do have a LinkedIn profile but it is limited. I don’t know, it is almost like Facebook – you have it, but you don’t really use it.”

On post-doctoral level, most participants also stated that they considered the master’s and doctoral students delivered to industry as important indicators of their impact. Only a few participants referred to the importance of citations of their work as an indication of impact. One participant felt strong about the applicability and usability of his research in local industry. Some of the comments made by participants on post-doctoral level regarding the measurement of impact in a specific field are provided below:

**I11:** “Many researchers boast that they have published 40 articles during a year. Then you read through that thrash, and it belongs in one place – the dustbin, or it gathers so much dust. An what did they get from it? He got a rating and became a professor ... but the work he did was useless. I have 15 publications, and all of them are used in industry – that is the difference.”

**I1:** “I get a much greater kick out of the master’s and doctorate students I deliver. This is what our country needs.”

**I10:** “The student can make an impact for the next 40 years in industry. A handful of people are going to read the article.”

**I2:** “So the reality is that our rankings are total nonsense which we try to chase ... what value does it add for a student which arrives at the institution? ... Except from wearing a T-shirt which says: Number 1 ... we are chasing all these things, and although it looks good on paper, it is a flash in a pan without any substance. These are things bothering me, but I cannot voice it because nobody listens to you.”

An established researcher identified the measurement of impact as critical to postgraduate research. He was of the opinion that whether a funding application was successful or not was an important indicator of measuring impact, as well as the delivery of quality engineering graduates to South African industries.

A summary of the critical skills identified during the focus group and individual interviews by participants on master’s, doctoral and post-doctoral levels, as well as by established researchers, is provided in below.

Table 0.10 Critical ARIL skills

Qualification Level	Self-Reported Perceptions of Critical ARIL Skills
Master's	<ol style="list-style-type: none"> <li>1. Conceptualising of a research topic <ul style="list-style-type: none"> <li>• Identification of a suitable topic</li> <li>• Generation of a research idea</li> <li>• Refining of a research topic</li> </ul> </li> <li>2. Obtaining research funding <ul style="list-style-type: none"> <li>• Compiling funding applications</li> </ul> </li> <li>3. Creating information formats <ul style="list-style-type: none"> <li>• Logical flow of article/storyline</li> <li>• Conversion of information to knowledge</li> <li>• Creating journal articles</li> <li>• Accommodating the reader</li> <li>• Critiquing different opinions of authors</li> <li>• Avoiding plagiarism</li> </ul> </li> <li>4. Data collection and analysis <ul style="list-style-type: none"> <li>• Collecting/analysing/generating research data</li> <li>• Evaluating experiments and procedures</li> </ul> </li> <li>5. Discovering and evaluating information <ul style="list-style-type: none"> <li>• Discovering information from relevant people (peers, supervisor)</li> <li>• Expanding on existing literature collections suggested by supervisor</li> <li>• Gathering background information on topic</li> <li>• Conducting structured literature reviews</li> </ul> </li> <li>6. Disseminating research findings <ul style="list-style-type: none"> <li>• Sharing research findings orally</li> <li>• Accommodating the audience</li> </ul> </li> </ol>

Doctoral	<ol style="list-style-type: none"><li>1. Conceptualisation of a research topic<ul style="list-style-type: none"><li>• Generating an original, relevant and meaningful research topic</li><li>• Refining a research idea</li></ul></li><li>2. Obtaining research funding<ul style="list-style-type: none"><li>• Compiling funding applications</li></ul></li><li>3. Creating information formats<ul style="list-style-type: none"><li>• Creating journal articles</li><li>• Ensuring a logical flow/storyline</li><li>• Accommodating the audience</li><li>• Judging which sources to include/exclude</li></ul></li><li>4. Collecting and analysing data<ul style="list-style-type: none"><li>• Collecting, analysing/generating research data</li><li>• Interpreting data</li><li>• Managing 'Big Data'</li></ul></li><li>5. Discovering and evaluating information<ul style="list-style-type: none"><li>• Discovering information from people (peers, supervisors, conferences)</li><li>• Conducting structured literature reviews to obtain background information</li></ul></li><li>6. Disseminating research results<ul style="list-style-type: none"><li>• Sharing information orally and presentation skills</li></ul></li><li>7. Measuring impact<ul style="list-style-type: none"><li>• Receiving acknowledgement by peers/experts or industry</li></ul></li></ol>
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<p>Post-doctoral</p>	<ol style="list-style-type: none"> <li>1. Conceptualising a research topic <ul style="list-style-type: none"> <li>• Generating an original research topic</li> <li>• Generating practical research ideas</li> <li>• Generating publishable research ideas</li> </ul> </li> <li>2. Obtaining research funding <ul style="list-style-type: none"> <li>• Identifying possible funding sources</li> <li>• Compiling funding applications</li> <li>• Managing research funds for a research group</li> </ul> </li> <li>3. Collecting and analysing data <ul style="list-style-type: none"> <li>• Generating quality data</li> <li>• Generating meaningful and interesting data</li> </ul> </li> <li>4. Creating information formats <ul style="list-style-type: none"> <li>• Creating journal articles/keynote speeches</li> <li>• Establishing a logical flow of article/storyline</li> <li>• Accommodating the audience</li> <li>• Writing a convincing argument</li> <li>• Using good English</li> </ul> </li> <li>5. Discovering and evaluating information <ul style="list-style-type: none"> <li>• Discovering from people (postgraduate students, peers, conferences, journal editor/peer reviewer)</li> <li>• Filtering information (visually)</li> <li>• Conducting literature reviews to support a specific argument</li> </ul> </li> <li>6. Disseminating research results <ul style="list-style-type: none"> <li>• Disseminating to the public</li> <li>• Sharing research information orally</li> </ul> </li> <li>7. Measuring impact <ul style="list-style-type: none"> <li>• Delivering quality postgraduate students to industry</li> <li>• Usability of research findings in industry</li> </ul> </li> </ol>
<p>Established researcher level</p>	<ol style="list-style-type: none"> <li>1. Conceptualising a research topic <ul style="list-style-type: none"> <li>• Translating research ideas into possible topics/projects</li> </ul> </li> <li>2. Obtaining research funding <ul style="list-style-type: none"> <li>• Compiling funding applications</li> <li>• Obtaining funding to sustain research groups</li> <li>• Ensuring a stream of funds over a long period</li> </ul> </li> <li>3. Discovering information <ul style="list-style-type: none"> <li>• Judging the quality of information obtained</li> </ul> </li> <li>4. Measuring impact <ul style="list-style-type: none"> <li>• Measuring impact against success of funding applications submitted</li> <li>• Delivering competent postgraduate students to industry</li> </ul> </li> </ol>

## 6.4.2 Challenging information literacy skills associated with engineering postgraduate research

Interview question 2 (Addendum E) asked participants to identify the most challenging information literacy skills they associate with postgraduate engineering research on master's and doctoral levels, or if they already held a doctoral degree, at post-doctoral level or as an established or expert researcher.

**The question read as follows: “Which barriers or challenges are you currently encountering as a researcher on masters or doctoral level? Or if you already hold a doctoral degree, at post-doctoral level or as an established or expert researcher?”**

Many of the information literacy skills identified as critical for ARIL also proved to be the key challenges for postgraduate researchers. The following paragraphs thus discuss these skills in terms of the challenge identified by engineering researchers on postgraduate level, according to importance. These include skills relevant to obtaining research funding, creating information formats, discovering and evaluating information, managing and organising information, conceptualising a research topic, disseminating research findings, and data collection and analysis. Comments made by participants will as far as possible be distinguished into master's, doctoral, post-doctoral and established researcher levels in the following section, and a summary of the challenging skills identified by participants will be provided in the form of a table at the end of the discussion.

### 6.4.2.1 *Obtaining research funding as a challenge*

Challenges with obtaining research funding were mentioned by participants on all levels. From their inputs it was clear that participants across all levels perceived obtaining research funding as a difficult task. Participants also often referred to the burden of large amounts of documentation involved in the process, as well as to the time funding applications take to compile. Some highlighted the competitive way in which research funding was distributed.

On master's level, a supervisor indicated that students were struggling to organise funding and that challenges went “hand in hand” with their writing skills. The accurate stating of an argument to the funding body was considered important, and some students were of the opinion that it was challenging to link a research funding application with unclear objectives.

Participants on post-doctoral level specifically complained about the time it takes to apply for funding. Some participants on post-doctoral level stated that they preferred not to apply for research funding at all, and the reasons for this included the tedious process, resistance to “begging” for money, and a preference for open source software, which is free of charge to avoid the need for research funding. Another participant explained that the right collaboration is also important when applying for research funding. The following verbatim quotations summarise the opinions of some participants on post-doctoral level on obtaining research funding:

**I6:** “So if you know people ... this women from Spain, she is a world leader in which we work, so if you have her name on an application, it will go well, that sort of thing.”

**I1:** “I hate the idea of writing a funding proposal. I think it is absurd that talented academics need to spend time on activities which does not realise directly in research output.”

**I6:**” It is a huge issue, it takes a lot of time. You don’t have a choice. Otherwise there is no money ... I found that there is a lot of money available.”

Established researchers also highlighted the tremendous amount of time funding applications take. Some were of the opinion that if they had more funds, they could have attracted more students, and specifically referred to international students, which could have increased the research output in their research groups. Established researchers referred to the importance of their reputations when applying for research funding. They referred to the pressure on them to sustain large research groups, and how the effective management of funds received determined the receiving of funds in the future.

#### *6.4.2.2 Creation of information formats as a challenging skill*

The creation of research documents was identified as challenging by participants on master’s, doctoral and post-doctoral levels. Good writing skills on postgraduate level, however, were referred to as a skill that was not popular among most engineers. The following verbatim quotations summarise a supervisor’s opinion on writing on postgraduate level:

**I1:** “I am an engineer, I do not like language.”

**I1:** “I don’t think we have an engineer who likes to write. Consequently, you find that the process in which students are not good with, gets postponed till very late ...”

On master's and doctoral levels, some students indicated that they found it challenging to ensure a logical flow when compiling a research document. Many supervisors also referred to challenges experienced by postgraduate students to ensure a logical sequence in documents. In addition, the poor English language skills of postgraduate students were also of concern to them, as well as skills to interpret information obtained from the literature. A group of verbatim quotations summarises some of the supervisor's opinions on the writing skills of participants on master's and doctoral levels:

**I8:** "They struggle to write. Especially with the structure and how things are put together, and which interpretations you make."

**I1:** "I especially assist master's students who have never written an article before ... it is very hands on with the first article. You have to assist them."

**I4:** "The students cannot write. They cannot express themselves. So what I do, I refer them to Purdue University's online Writing Lab."

**I1:** "With a doctoral student you still need to assist a bit, but the last articles of a doctoral student is almost entirely written on their own and I do very little editing."

On post-doctoral level, one participant specifically referred to challenges regarding English language skills, and admitted that while he liked to solve problems in his specific research field, he disliked the writing part, and was of the opinion that it was affecting his research negatively, since many papers were waiting to be written by him. His verbatim quotation is provided below:

**I2:** "If you can be a poor engineer, but a good writer, you will have a brilliant researcher. But you cannot be a good engineer, without being a good writer."

#### *6.4.2.3 Discovery and evaluation of information as a challenging skill*

Challenges regarding the discovery and evaluation of information were raised by participants on master's, doctoral and post-doctoral levels. A few supervisors specifically highlighted the importance of literature reviews, with some indicating that they assisted their students to summarise information obtained from the literature.

On master's level, some participants were of the opinion that they lacked skills to conduct literature reviews and referred specifically to the inability to search for and locate everything that is published on a topic. Some mentioned that they were afraid of missing relevant literature in the process. A few participants on master's and doctoral levels highlighted challenges experienced when searching for information in disciplines other than engineering. The verbatim quotation below summarises some challenges to participants on master's level relevant to the discovery of information:

**FG1:** "... maybe there is a paper hiding, because that's now more on the electrical field, which is not really my primary field. So I am not experienced in looking for that."

Participants on post-doctoral level often referred to the time it took to find relevant information. One participant referred to the "timeless hours" he spent on identifying a gap in existing literature in order to publish an original article. He was of the opinion that although the discovery of information was not challenging, he experienced difficulty with filtering information. He believed that a visual summary of relevant publications could assist him in this regard. The verbatim quotation below summarises his opinion on the discovery of information.

**I3:** "It is days of only sitting and click, click, click, and read, read, read, and the reality is one could have packaged those as a small bubble chart for instance."

#### *6.4.2.4 Managing and organising information as a challenging skill*

Participants on doctoral level, as well as an established researcher, identified the management and organisation of information as a challenge.

Although participants on all levels indicated that they needed to manage and organise information in both paper and electronic formats, they either had no system in place or indicated that they used various different systems. Many participants also admitted that current systems were not sophisticated, and either preferred to print a document in paper format in order to make notes on, or to save PDF files in folders on public storage facilities such as Dropbox, GoogleDrive, Mendeley, Latex or Subversion. An established researcher confirmed that he did not have sophisticated systems in place to manage and organise large amounts of information. He referred to the building and maintenance of between 80 and 100 broad subject categories over the years, which were used to "kick-start" students on a specific

topic. He admitted that they were in files on his computer, and that he was aware that this was a “failsafe” system.

These same platforms were also mentioned by participants when the curation of research *data* was discussed, in addition to memory sticks and external hard drives.

On master’s level, students reported they worked with small datasets, which did not require intricate curation strategies. Others were of the opinion that experiments on master’s level were very simple, and that codes could easily be rewritten and repeated in order to obtain the data again. Loss of research data therefore did not seem to be a problem.

On doctoral level, a few participants specifically referred to challenges with the management and organisation of ‘Big Data’. Some indicated difficulties to focus on a specific dataset out of large amounts of data, and others referred to being overwhelmed when working with ‘Big Data’. Some participants on doctoral level were uncertain of what would happen with their research data once they had finished their studies, and used phrases such as “still working on it ...” and “curation needs attention”. Most participants did not consider it a priority to keep their research data after graduation.

An established researcher mentioned that all the research data was stored either on a computer in a laboratory or on students’ computers. He mentioned that he might need to interrogate experiments further in the future, but that research findings were not always documented, with data being hidden, which would require total reproduction in future, consuming time and money. He indicated plans for loading data onto servers in future, after working with ‘Big Data’ in the laboratory.

#### *6.4.2.5 Conceptualising of a research topic as a challenging skill*

Challenges relevant to the conceptualising of a research topic were raised by participants on doctoral level.

At doctoral level, participants were of the opinion that although supervisors often provided them with problems faced in industry, they lacked skills to convert the problem into a researchable topic. Some were concerned about time being wasted as a result, with one participant stating that one needed to avoid a situation of forever “just going in circles” without conceptualising or generating an idea. Supervisors also confirmed the lack of skills to conceptualise research problems among postgraduate students, and specifically referred to the importance of generating a manageable idea on doctoral level. Some were also of the opinion

that students may be trapped in a situation where research ideas continuously keep on changing, causing the risk of not completing a doctoral study. Several participants on post-doctoral level were of the opinion that once an idea has been finalised, the rest of the research processes on postgraduate level is relatively easy.

#### *6.4.2.6 Disseminating research findings as a challenging skill*

Several participants on post-doctoral level were of the opinion that the dissemination of research findings was challenging. Although most participants felt that they were able to identify suitable journals in which to publish research results, since they were familiar with core journals available in their field, others indicated that their research topics were still broad, and that they were unsure of the most suitable journals in which to publish. One participant referred to his/her successful use in the past of software that suggests possible journals in which to publish articles after an abstract has been submitted. Although some participants stated that they had made errors in the past with regard to research publications, which affected their publication record negatively, very few confirmed that they followed a publication strategy. An established researcher was of the opinion that it was challenging to adapt to the different requirements of publishers in order to get an article published, with specific reference to requirements regarding the formats of tables and specifications regarding layout and the general format of a document.

Participants on post-doctoral level were particularly frustrated about the time it takes to build a reputation, and were of the opinion that it was difficult to get articles published as a result. Participants often also criticised the current peer-review system, with some being of the opinion that the system is flawed, referring to difficulties to progress in an academic environment unless one “plays the game” to ensure publication numbers increase. Some complained about articles that are turned down by editors even before being sent to peer reviewers. One participant shared his own solution, which was to propose reviewers he knew to the editor of a journal. One participant got frustrated with his inability to publish some of his research in traditional peer-reviewed journals, and consequently created a Wikipedia page of his publications, which resulted in many citations. He was of the opinion, however, that social media should not be used to increase impact statistics. The verbatim quotations below summarise the opinions of a few participants on post-doctoral level:

**I2:** “I think everybody at this stage is so under pressure ... there are a lot of mediocre information that gets published, and a lot of good ideas never see the light ... it feels to me we are busy with such a superficial academic inflation, that by the end of your career you have 1000 papers behind your name, and all of them are mediocre instead of finishing a career with 50 papers which were well read.”

**I3:** “What frustrates me currently is that I am at a place in my career where I need to make a call where I publish mediocre work until I start making name in the field, whereafter I can publish what I really want.”

The management of IP rights was often mentioned in discussions on the publishing of research findings, and was identified as a barrier to publish research results by participants on doctoral and post-doctoral levels, as well as on established researcher level. Throughout the interviews, participants only referred to patents specifically when referring to the management of IP rights, in contrast to other forms such as designs or trade marks.

Participants mostly had a negative sentiment towards the management of IP rights in general, and often referred to challenges relevant to time, effort and cost. The primary reason for the negative sentiment, however, was that participants were of the opinion that knowledge should rather be open and publishable in contrast to the restriction of access to information through IP rights. Many participants did not see the value of IP rights for their research, and some were of the opinion that the university favours the publishing of articles rather than patenting. Most participants were unaware of the processes involved when IP rights needed to be managed, with only a few referring to the Technology Transfer Office on campus.

Issues concerning IP copyright also surfaced in discussions on the dissemination of findings and most participants were of the opinion that they had to transfer full copyright to publishers when publishing an article. The verbatim quotations below confirm the opinion of participants on the protection of copyright when publishing research findings:

**FG3:** “... when publishing ... you just tick what you want just to get your paper published.”

**I2:** “Oh well, I need to give copyright over to the journals ... that’s the understanding ... No journal allows you to publish a thing unless you sign that form. Or I publish by transferring copyright, or I don’t publish at all.”

**I10:** “In general, you give copyright over to the publisher. I haven’t thought much about that point.”

On doctoral level though, some participants indicated that they were considering possible IP rights in future. Some highlighted the important difference between a thesis, which is more theoretically orientated, where the publishing of articles is common, in contrast to a thesis with the aim to develop a product, which would include the management of IP rights. Some participants were also of the opinion that certain funding sources often required information from researchers on IP issues before they considered funding applications. The following verbatim quotation summarises one of the participants on doctoral level's opinion of the management of IP rights:

**FG2:** “Well, the thing where one needs the most assistance is with the managing of IP rights ... it is totally something else in which engineers don't want to be interested in. So when you realise there is intellectual property rights involved in your research, you will have to get somebody to assist you.”

**I8:** “I don't know, it doesn't feel as if the patent weighs as much as a publication ... Patents involve much more people and it involves a long process.”

On post-doctoral level, participants referred to the consequent inability to publish research results as a reason for opposing IP, and the notion of “publish or perish” was referred to by many participants. In contrast to these views, other participants on post-doctoral level felt very strongly about working on research topics with IP possibilities, where research ideas should result in the manufacturing of products. Some even stated they had their own IP and patent attorneys who assisted them with patents. One participant mentioned the importance of distinguishing between engineering research of a theoretical nature, in contrast to research of a practical nature from which industries can benefit directly. Some post-doctoral participants were of the opinion that IP causes researchers to keep information to themselves, which stifles collaboration, since both parties want to keep the IP rights. The following verbatim quotations summarise the opinions of some participants on post-doctoral level on IP rights:

**I11:** “I have 15 publications, but all those 15 get used in industry, that's the difference. Because they are more practically orientated than academic, because I now have a good balance between the two.”

**I3:** “There are two types of engineers. There are those who only want to solve a problem, and then there are those who develop methods and strategies to solve problems.”

**I2:** “IP may be good for one researcher’s CV, but IP is a thing which stalls creativity ... and makes collaboration almost impossible.”

An established researcher indicated that the management of IP rights was not easy. He included the following reasons for avoiding the management of IP rights: the time-consuming nature of the process, the major effort regarding documentation that is required, and limited resources. He mentioned that he recently realised the value of a piece of research too late, after making findings available, because of the pressure on him to publish research results. He was of the opinion that he consequently lost out on the financial benefits of owning the IP rights.

#### *6.4.2.7 Data collection/generation and analysis as a challenging skill*

Participants on master’s level specifically referred to difficulties encountered during data collection and analysis. One participant used the word “overwhelming” to describe this process. Participants often specifically referred to challenges regarding the interpretation of data after collection or generation, with one mentioning “it’s where one must find a solution”. Supervisors also confirmed this challenge and highlighted the inability of master’s students to interpret findings from research data they had obtained. The verbatim quotation of a participant on master’s level regarding data collection and analysis below summarises his opinion:

**FG1:** “It is definitely data collection and analysis. You can make or break the master’s there.”

A summary of the challenges and/or barriers identified during the focus group and individual interviews by participants on master’s, doctoral and post-doctoral levels, as well as by established researchers, is provided in Table 0.11 below.

**Table 0.11 Challenges relevant to ARIL skills**

Qualification Level	Self-Reported Perceptions of Challenging ARIL Skills
Master's	<ol style="list-style-type: none"> <li>1. Creating research documents <ul style="list-style-type: none"> <li>• Ensuring logical flow</li> <li>• English language skills</li> <li>• Interpretation of information obtained</li> </ul> </li> <li>2. Obtaining research funding <ul style="list-style-type: none"> <li>• Writing funding proposals</li> <li>• Accommodating a specific audience (funder)</li> </ul> </li> <li>3. Discovering and evaluating information <ul style="list-style-type: none"> <li>• Conducting structured literature reviews</li> <li>• Searching for multidisciplinary information</li> </ul> </li> <li>4. Data collection and analysis/generation <ul style="list-style-type: none"> <li>• Interpretation of data</li> </ul> </li> </ol>
Doctoral	<ol style="list-style-type: none"> <li>1. Creating research documents <ul style="list-style-type: none"> <li>• Ensuring a logical flow</li> <li>• English language skills</li> <li>• Interpreting information obtained from the literature</li> </ul> </li> <li>2. Obtaining research funding <ul style="list-style-type: none"> <li>• Writing funding proposals</li> <li>• Accommodating a specific audience (funder)</li> </ul> </li> <li>3. Discovering and evaluating information <ul style="list-style-type: none"> <li>• Searching for multidisciplinary information</li> </ul> </li> <li>4. Managing and organising information or data <ul style="list-style-type: none"> <li>• Managing 'Big Data'</li> <li>• Managing data after completion of studies</li> </ul> </li> <li>4. Conceptualising a research topic <ul style="list-style-type: none"> <li>• Converting a problem into a researchable topic</li> </ul> </li> </ol>
Post-doctoral	<ol style="list-style-type: none"> <li>1. Creating research documents <ul style="list-style-type: none"> <li>• English language skills</li> </ul> </li> <li>2. Obtaining research funding <ul style="list-style-type: none"> <li>• Sourcing suitable collaborators</li> </ul> </li> <li>3. Discovering and evaluating information <ul style="list-style-type: none"> <li>• Filtering of information</li> </ul> </li> <li>4. Disseminating research findings <ul style="list-style-type: none"> <li>• Peer-review system</li> <li>• Patents limiting publications</li> <li>• Building a reputation as researcher</li> <li>• Identifying suitable journals</li> <li>• Developing a publication strategy</li> </ul> </li> </ol>

Established researcher level	<ol style="list-style-type: none"> <li>1. Obtaining research funding           <ul style="list-style-type: none"> <li>• Maintaining a reputation as researcher</li> <li>• Ensuring funding streams</li> <li>• Managing research funds</li> </ul> </li> <li>2. Managing and organising documents           <ul style="list-style-type: none"> <li>• Managing and organising ‘Big Data’</li> </ul> </li> <li>3. Disseminating research findings           <ul style="list-style-type: none"> <li>• Adapting to different specifications of publishers</li> <li>• Patents limiting publications</li> </ul> </li> </ol>
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### 6.4.3 Auxiliary skills associated with postgraduate engineering research

Interview question 3 (Addendum E) asked participants to indicate auxiliary skills they considered important in relation to information literacy skills on master’s or doctoral level, or if they already held a doctoral degree, at post-doctoral level or as an established or expert researcher. The question was formulated as follows:

**“The literature also notes various other auxiliary skills associated with information literacy and/or research processes such as time management, project management, note-taking and budgeting. Do you regard such skills as important in successfully conducting engineering research? Are there other auxiliary skills that need to be addressed in an advanced research information literacy (ARIL) programme?”**

Participants on all levels confirmed the importance of auxiliary skills in addition to the ARIL skills discussed during the interviews. Some were of the opinion, however, that although the lack of certain auxiliary skills would not be detrimental, it could be a hindrance during postgraduate research. The importance of project management and time management skills was acknowledged by most, and considered by some to go “hand in hand”.

On master’s level, students often complained about their workload, and the consequent emphasis on project and time management skills mostly centred on completing their personal postgraduate studies. Participants mentioned how their supervisors often guided them to plan their projects ahead, by requiring them to submit Gantt charts to illustrate their planned progress. Although some participants on master’s level indicated that project management courses were offered on undergraduate level, others were of the opinion that their skills in this regard were inadequate. Many participants on master’s level also identified other important auxiliary skills during postgraduate research. The importance of people skills, with

specific reference to interpersonal communication with supervisors, sponsors, people needed for assistance with experiments, consultants, and experts in industry, was often highlighted. Some also mentioned skills to document conversations with other researchers informally or during meetings.

On doctoral level, project and time management skills seemed especially important to participants, and students also confirmed the importance of interpersonal communication skills. Staff members often complained about their workload and how they struggled to balance teaching and research activities. In addition to these, some staff members mentioned skills relevant to the documentation of daily activities, almost like a personal diary where an accurate record is kept of what one did. Skills to manage research teams were also identified as an auxiliary skill on doctoral level.

On post-doctoral level, participants were of the opinion that time and project management skills were important not only for their personal research endeavours, but also to manage postgraduate students. Some participants mentioned that they were constantly evaluating their personal management styles. Other auxiliary skills that were mentioned by this group of participants included supervision skills and the role as teacher and educator. In addition, problem-solving skills were mentioned by supervisors who alluded to students lacking skills in this regard, with some being of the opinion that it could stall a research project if students were unable to generate solutions to problems.

Established researchers, as well as those on post-doctoral level, also referred to their workload and the consequent importance of specifically time management. Some mentioned how they needed to “juggle” teaching and research functions on a daily basis. Established researchers, as well as post-doctoral researchers, referred to the importance of managing research groups to be productive, with special reference to the importance of knowledge and skills about group dynamics and management techniques and principles in a fast moving environment. Time management was therefore a balancing act, since it was considered important for them to function personally on a daily basis, but also important in the context of a research group, where they needed to be managed to be productive researchers all the time. The verbatim quotation of an established researcher below regarding the management of time in order to get research groups functioning summarises his opinion:

**I3:** “In other words where you get maximum outset with minimum effort, and minimum overhead costs.”

A summary of auxiliary skills identified by participants from the respective groups (master's, doctoral and post-doctoral levels, as well as established researchers) is provided in Table 0.12 below.

**Table 0.12 Auxiliary skills relevant to postgraduate research**

<b>Qualification Level</b>	<b>Self-Rated Perceptions of Important Auxiliary Skills</b>
Master's	Project management Time management Interpersonal communication skills Documentation of conversations Problem-solving skills
Doctoral	Project management Time management Interpersonal communication skills Problem-solving skills Documentation of daily activities/diary Management of postgraduate student groups to be productive
Post-doctoral	Project management Time management Supervision skills Management of postgraduate students in groups to be productive
Established	Project management Time management Management of several postgraduate groups to be productive

#### **6.4.4 Following up on responses to questions posed in the ARIL questionnaire**

Interview question 4 (Addendum E) asked participants to add additional comments or information to the ARIL questionnaire, which was distributed before focus groups and individual interviews commenced at master's or doctoral level, or if they already held a doctoral degree, at post-doctoral level or as an established or expert researcher.

Question 4 (Addendum E) was designed to give those participants who had completed the ARIL questionnaire the opportunity to make additional comments about the questionnaire. The question was formulated as follows:

**“Are there any other issues relevant to the research topic of this study (A framework for an advanced research information literacy (ARIL) programme for postgraduate researchers in engineering) that you would like to bring to the attention of the researcher?”**

Since most of the participants did not complete the ARIL questionnaire, only three additional comments were made by participants about the questionnaire.

The first comment was raised by a participant on post-doctoral level, who explained that he was unable to complete the ARIL questionnaire. The reason he gave was that “the questionnaire made assumptions about what postgraduate engineering research do[es], and then asks questions as if those statements are true.” He explained that he stopped completing the survey after reading the first few questions, which centred on skills to conceptualise research ideas, obtaining funding and discovering information. He was of the opinion that he was an expert in a specific field of study, and that he did not use the methods listed as options in the questionnaire. He specifically referred to the searching of databases in order to identify a research gap, and stated that he only searched electronic databases *after* he had already identified an idea. He also explained that such searches were mainly to establish that the research had not been done before. He did not consider literature reviews as crucial on his level as researcher either, since he was of the opinion that he had access to the latest information through his postgraduate students, attendance of conferences, and by serving as a peer reviewer for certain journals. He also stated that he did not require research funding because he preferred to use open source computer software over the internet. Although he did not complete the questionnaire, his input during a personal interview was most valuable to this study.

The second set of comments focused on staying abreast with new information. Most participants indicated that they did not have any system in place to stay informed about new publications in their fields of study, and others indicated that they lacked skills in this regard. Researchers on post-doctoral level, however, highlighted the value of attending international conferences, evaluating articles for a journal as a peer reviewer, reading daily newsletters, and reading the literature reviews of their postgraduate students to stay abreast with new literature in their field. An established researcher admitted that although he had no system in place to keep up with new findings, he also did not want more e-mail, since he was already struggling to keep up with daily e-mail messages on his computer. Participants’ opinions

about staying abreast with new information are reflected in the group of verbatim quotations below:

**I1:** “So the students bring the literature, and they go through the exercise to evaluate it, to read it, to see which articles cover the same thing ... so I only get a condensed version, which is hopefully the best of the work identified by them.”

**I10:** “I will try to do a decent search in Scopus, whereafter the student will perform a search, and that way, you hope to catch the available literature. But I don’t have a mechanism to constantly stay up to date, I don’t do it at all.”

The last comments were raised by a number of participants who complimented the researcher on a good and comprehensive questionnaire, which covered all the major aspects relevant to postgraduate research.

**6.4.5 Question 5 (Addendum E) asked participants to add any other issues relevant to the research topic. The question was formulated as follows:**

**“Are there any other issues relevant to the research topic of this study (“A framework for an advanced research information literacy (ARIL) programme for postgraduate researchers in engineering”) that you would like to bring to the attention of the researcher?”**

No comments were received from participants regarding any other issues relevant to the research topic of this study.

During the analysis of discussions with participants certain themes emerged from the data, which could not be ignored. Section 6.5 will focus on three core themes identified during the analysis of qualitative data obtained from focus group and individual interviews.

## **6.5 THEMES EMERGING FROM THE QUALITATIVE DATA**

The discussion in section 4 of the chapter focused on the opinions of participants of ARIL skills relevant to conducting postgraduate research.

The following paragraphs will provide a short discussion of themes that emerged after all the interviews had been analysed, by using a thematic analysis approach.

Three core themes emerged from the analysis of the qualitative data:

1. The importance of ensuring a “culture of quality” in conducting postgraduate engineering research
2. A visible progression from a dependent to an independent researcher
3. The importance of preparing for impact in a specific field of study.

Each theme will be discussed briefly in the following paragraphs.

### **6.5.1 A culture of producing quality postgraduate research**

Quality assurance plays an important role in performing research and can be seen in several processes associated with a research lifecycle. According to a RIN report (2010:4): “quality underpin[s] trust in the world of the research community.” Literature also confirms that successful researchers are passionate and motivated (Browning, Thompson & Dawson, 2014:125).

The notion and importance of conducting quality research among postgraduate engineering researchers in this case study became apparent during focus group and individual interviews. Comments made by many participants indicated that merely performing research for the sake of doing it was not an option for anybody. It was almost as if it was an unwritten rule in each engineering department to deliver quality publications, where scholarship is ultimately enhanced. Supervisors considered their students as quality products, with many considering the student delivered to industry as a true reflection of their impact in the field of engineering. It was evident in many discussions that students were proud of their supervisors and vice versa. Supervisors were considered important knowledgeable information sources, were held in high regard by their students and appeared to be responsive to student’s needs.

The desire among postgraduate researchers to produce high-quality research was evident from comments made by participants during the early stages of research, namely when they needed to identify a topic, which was identified as a critical part of postgraduate research in engineering. Participants were adamant that their research ideas needed to be meaningful and relevant to current problems in engineering. Many also highlighted that research on postgraduate level should have an impact on the specific discipline, industry or even on South Africa as a whole. The importance of quality was also highlighted during the collection/generation of research data. It plays a primary role during postgraduate research, with many considering quality data as very important. The interpretations made in order to provide research that has an impact on the discipline are also very important.

Regarding the creation of documents, many participants acknowledged that writing research documents was essential, and indicated that they wanted to improve this specific skill continually. Participants often highlighted the importance of accommodating a specific audience and the importance of writing interesting articles with logical layouts, while using good English. Quality principles were also evident during the dissemination of research results; most participants were adamant that they needed to publish in accredited journals with a high impact factor, in order to get global visibility. It was not an option for anybody merely to publish articles for the sake of it, or to gain citations of a specific document.

The notion of networking between participants was evident in the discussions during many interviews, and communication with other researchers seemed to be very important to all participants. Participants indicated that networking with other researchers gained momentum as they progressed from master's and doctoral levels upwards. Some participants on master's level seemed to function in a very small community, which mostly included their immediate research groups and their supervisor/s or other staff members in their departments. Many participants on master's level mentioned the value of monthly meetings or feedback sessions in departments and participants on both master's and doctoral levels mentioned that their supervisors were co-authors of their articles. Researchers beyond master's and doctoral levels tended to refer to longer-term relationships with other researchers. The selection of people in their networks seemed more strategic in nature, with specific reference to building a track record, and the importance of collaborating with influential researchers. Postdoctoral participants mentioned the importance of attending conferences they had not attended before occasionally in order to slot in with communities with new mindsets. Participants on postdoctoral level were of the opinion that one needs to know the right people when one plans to publish research results.

It became clear that research on postgraduate level is increasingly considered teamwork, even though it sometimes only applies to people in the same engineering department. Established researchers often mentioned that they collaborated outside the university borders and even outside the country. On post-doctoral level, the importance of attending conferences and being connected with other "like-minded" people cannot be over-estimated.

A group of verbatim quotations below reflect the opinions of participants on post-doctoral level on collaboration and networking with other researchers:

**I6:** "It is not what you know, it is who you know."

**I11:** “Research is teamwork. If you think you are going to solve something on your own, think again ... the challenge is sometimes bigger than yourself, and one has to admit, you need help.”

### **6.5.2 Progression from a dependent to an independent researcher**

Progression from a dependent to an independent researcher during the postgraduate trajectory was evident during the interviews. The process of personal growth of participants during their research trajectories was evident. Supervisors appeared to want to prepare their students optimally for the challenge of postgraduate research, where novice researchers were prepared for the whole research process ahead and what to expect during the period of obtaining a postgraduate degree on a specific level. One supervisor was passionate about offering research methodology courses to students on master’s level in one of the engineering departments, and was proud of their achievements and progress during each module. Some established researchers referred to the importance of motivating students during postgraduate research in order to be successful. Their opinions are summarised in the verbatim quotations below:

**I4:** “Motivation. It is the only thing ... he must get there, and he must want it himself.”

**I10** “Look, if they are motivated, there will not be a problem. If they know what they are doing is important in the bigger picture of the group, that there is a plan, that they don’t do individual projects.”

It became clear that participants on master’s and doctoral levels were in an “apprenticeship”, where they were gently guided towards independence by their supervisors. Most participants indicated that they were often uncertain of certain processes relevant to conducting postgraduate research, and acknowledged the importance of the support and guidance provided by their supervisors, with specific reference to conceptualising a research topic, obtaining research funding, creating information formats, managing IP rights, and disseminating research results. Supervisors confirmed the important task of teaching postgraduate students during their postgraduate trajectory. It was evident that as postgraduate researchers progressed, they became more skilled, up to a point where they were confident about their skills and found a way in which they do things.

A progression was evident from skills that can be taught, which include administrative or technical tasks during the performance of postgraduate research, namely discovering information, managing and organising information, curating data, disseminating research results on various platforms, and the creation of a personal profile, towards skills that require some creativity. Skills requiring creativity included the ability to generate and carve out a researchable idea with impact in a specific field of study, the ability to formulate funding proposals in order to obtain necessary research funds, the ability to collect or generate research data and to make good interpretations, the ability to write an interesting article or publication, which accommodates different audiences, and to filter information that has been discovered. One participant on post-graduate level summarised different skills:

**I3:** “There are places which require manual time, and then places which requires thinking time and thinking time requires hours, and I don’t have a problem to do that. It is what I enjoy.”

### **6.5.3 Preparing for impact in a specific research field**

Although many participants beyond doctoral level referred to the quality of students they delivered to industry as one of the most important indicators of their impact in a specific discipline, other factors were also identified, which supported the importance of impact among postgraduate engineering researchers.

This case study highlighted the importance participants on postgraduate level attached to conceptualising a research topic. Most participants highlighted the importance that ideas should make an impact in a specific field, and must address a real problem in industry to solve it. The conceptualisation and identification of a suitable research topic on postgraduate level can be regarded as a strategic process, which is mostly performed by participants beyond master’s level, where problems in industry are “translated” into possible research topics.

Apart from the importance of identifying a research topic making an impact in a specific field, participants also regarded the publication channel of their findings as important in an attempt to increase their impact. Although researchers on master’s level mainly function in small groups, which often only involve supervisors and peers, this study showed that the groups in which researchers operate expand as they progress with their qualifications. Initially, publications on master’s level are few and opportunities to discuss the impact of their research often occur inside the specific department by means of presentations among

themselves. Most participants beyond master's level, however, indicated that they mainly published journal articles in internationally accredited journals with a high impact. Apart from sharing findings with academia, which most considered their first priority, many participants beyond doctoral level also considered close connections with local industries important. Some participants even mentioned that they ensured that results of their research findings reached relevant people in industry and academic audiences simultaneously. The important role industry plays during research on postgraduate level was often highlighted during interviews.

Engineering researchers beyond master's and doctoral levels therefore seemed to brand themselves nationally and internationally. Virtually all researchers confirmed discussing their work with colleagues to obtain comments and suggestions to enhance a project, both formally and informally. Good quality conferences were considered crucial to assess and assure the quality of their research before final results were presented. Many participants highlighted the importance of acknowledgement by other researchers working in the same field as an indicator of impact, in contrast to mere citations of a publication. The role of being a peer reviewer or an editor seemed beneficial to some researchers from post-doctoral level onwards, and confirmed the new communities of people to which they were exposed as a result, in addition to the impact they would make in their discipline. In addition to sharing findings with other academics and industry, one participant was of the opinion that it was also important to share findings with the public, and referred to workshops to teach communities outside academic institutions in order to increase the impact of his research.

## **6.6 CONCLUSION**

Chapter 6 gave a reflection of the comments and opinions raised during focus group and individual interviews as part of the qualitative phase of this case study. The comments and discussions relevant to the four questions asked in the semi-structured interview schedule were analysed, and a short summary of perceptions on critical ARIL skills, challenging ARIL skills, as well as auxiliary skills was provided at the end of the chapter. This was followed by a short discussion of three themes that emerged from the qualitative data, namely a desire to conduct quality research, progressing from a dependent to an independent researcher, and collaborating as a postgraduate researcher.

The next chapter will provide interpretations of findings, and recommendations for an ARIL framework. Data obtained in Chapters 5 and 6 will be triangulated, and will also address the final research question: “Which guidelines and interventions are required to support the implementation of a comprehensive research information literacy framework for engineers?”

## CHAPTER 7: DISCUSSION OF FINDINGS AND PROPOSAL OF AN ADVANCED RESEARCH INFORMATION LITERACY FRAMEWORK

### 7.1 INTRODUCTION

The previous two chapters (Chapters 5 and 6) reported on data obtained during the two data collection phases in this case study, namely the quantitative phase by means of a self-administered web-based questionnaire, and the qualitative phase by means of a semi-structured interview schedule. The aim of this study was to explore information literacy in a postgraduate context, with specific reference to engineering researchers. This research study was carried out in an attempt to increase the understanding of information literacy in a postgraduate research context, and to suggest an ARIL framework that could serve as a guide to all possible stakeholders involved with the development and empowerment of postgraduate researchers. The entire research lifecycle was taken into consideration in this study to move away from the often too narrow scope of information literacy training on offer to postgraduate researchers.

In the first part of this chapter, data obtained from this case study will be briefly triangulated, by comparing findings from data from both the quantitative and qualitative collection phases as well as findings reported in the subject literature. In the second part of the chapter key findings relevant to this study will be briefly summarised. An ARIL framework for postgraduate engineering researchers will be proposed in the third part of the chapter, followed by explanations of each part of the framework. In the fourth part the chapter will close with a short conclusion.

The empirical study was guided by an ARIL definition proposed in Chapter 3. This definition will also guide the framework that will be proposed in this chapter. The ARIL definition states:

*Advanced research information literacy includes all the traditional information literacy skills and expands on these by including the ability to identify research gaps in the spectrum of international and interdisciplinary literature that can meet with the needs of society, access and consult literature across disciplines (multi-, inter- and trans-disciplinary) to support various facets of the research process, analyse and synthesise information from secondary as well as primary resources (i.e. empirical data), generate new knowledge, and disseminate findings and new knowledge through appropriate channels, while networking and collaborating with other researchers across different collaborative research platforms,*

*focused on enhancing scholarship. Advanced research information literacy skills are therefore evident in all the typical research phases, namely identifying a researchable topic, obtaining research funding, discovering information, managing and organising information, collecting and analysing data, storing and curating data, writing up findings, managing intellectual property, publishing results through various channels and advocating the research results (e.g. through social media), as well as measuring impact through different metrics, where each phase is associated with various processes aimed at achieving specific goals relevant to that phase.*

Before presenting the proposed ARIL framework, data as presented in earlier chapters will be triangulated to consider findings related to the main research question:

*“How can an ARIL framework inform the development of programmes supporting the scholarly research process of engineers in a South African higher education environment?”*

## **7.2 TRIANGULATION OF QUANTITATIVE AND QUALITATIVE DATA, AS WELL AS FINDINGS FROM THE LITERATURE**

The triangulation of data in this case study will include data obtained from the self-administered web-based questionnaire, data obtained during focus group and individual interviews, as well as from findings in previously documented studies. Triangulation refers to a “multimethod approach to data collection and data analysis. The basic idea underpinning the concept of triangulation is that the phenomena under study can be understood best when approached with a variety or a combination of research methods” (Rothbauer, 2008:892).

Data obtained from the focus group and individual interviews centred on researchers’ opinions of what they considered critical ARIL skills during postgraduate research, challenging ARIL skills experienced during postgraduate research, and important auxiliary skills associated with postgraduate research. The qualitative data obtained from the focus group and individual interviews confirmed many aspects relevant to the ten research phases, associated processes and self-perceptions of skills tested in the ARIL questionnaire, but also provided more in-depth data about other aspects related to conducting engineering research at postgraduate level. The following sections will highlight findings in this study, which were either supported or disputed by the literature. The ten research phases identified in Chapter 3 will be used to discuss the triangulation of data.

### **7.2.1 Conceptualisation of a research topic**

Skills to conceptualise a research topic were identified as critical to postgraduate engineering research by participants on every level during the focus group and individual interviews. The conceptualisation of a research topic is often based on identifying a gap in existing knowledge and the consequent contribution to new knowledge, which is also considered important among engineering researchers (Yearworth, Edwards, Davis, Burger & Terry, 2013; Panas & Pantouvakis, 2010). Engineering researchers in this study also confirmed findings from earlier studies that research problems should be relevant to practices, procedures and policies at the time of the study (Leedy & Ormrod, 2010).

Skills to conceptualise a research topic seemed especially important on doctoral level according to students and supervisors in this study, which is consistent with earlier findings confirming that researchers on doctoral level need to make a unique and original contribution to knowledge (Exner, 2014; Johnson, 2011; Fleming-May & Yuro, 2009; Bent, Gannon-Leary & Webb, 2008).

### **7.2.2 Obtaining research funding**

Engineering researchers on master's, doctoral, and post-doctoral levels described obtaining research funding as critical to postgraduate engineering research. These findings are consistent with findings from earlier studies, which confirm the ability to secure research funding as a key element in performing successful scientific research (Exner, 2014; Koppelman & Holloway, 2012; Jowkar, Didegah & Gazni, 2011; Szelenyi & Goldberg, 2011; Arnett, 2009; Berg, Gill, Brown, Zerzan, Elmore & Wilson, 2007). Previous studies also support findings obtained in this study that the relevant departments or research teams (Johnson, 2011) often obtain research funds for master's and doctoral level researchers. Findings from a recent study also confirmed the importance of generating and managing research funds on specifically post-doctoral level (Debasrita & Boeren, 2016; Browning, Thompson & Dawson, 2014). This would then be an important skill for supervisors in particular. The lack of a track record when applying for research funding was identified as a problem by many researchers in this case study and is echoed in earlier findings (Browning, Thompson & Dawson, 2014; Johnson, 2011).

Although obtaining funding was considered critical to engineering research, many engineers who completed the ARIL questionnaire, as well as those who took part in focus group and individual interviews, indicated that they did not feel confident to compile a funding proposal, which is also confirmed in the literature (Orlando & Gard, 2014; Gannon-Leary & Webb, 2008). Engineers often referred to the competitive and time-consuming process of applying for funding, which is confirmed in earlier studies as well (Belluz, Plumer & Resnick, 2016; Johnson, 2011). Expensive equipment and experiments associated with engineering research (Johnson, 2011; Geard & Noble, 2010) are also recorded in the literature. Established researchers highlighted the importance of successfully obtaining research funding, which is consistent with an earlier study confirming that they regard obtaining research funding as an important factor to employ good quality researchers (Bent, Gannon-Leary & Webb, 2008).

### **7.2.3 Discovery and evaluation of information**

The discovery of information was identified as critical to postgraduate engineers on master's, doctoral and post-doctoral levels. Engineering researchers indicated that they regarded scholarly journals as the most important information sources, which is echoed in earlier studies (Okafor & Ukwoma, 2011; Hiller, 2002). Most engineering researchers indicated during the focus group and individual interviews that they preferred to print articles that were obtained electronically, with only a few participants indicating that they primarily worked with electronic copies of information. This was in contrast to earlier studies, which found that engineering researchers preferred mainly electronic copies rather than print formats (Engel *et al.*, 2011; Robbins *et al.*, 2011; Tucci, 2011; HEFCE, 2002).

Most researchers rated their skills to discover information as good in the ARIL questionnaire, although insufficient skills in this regard were identified during the interviews. This phenomenon is confirmed in recent literature, which found that postgraduate students were over-confident about their searching skills when answering questionnaires, but identified challenges during follow-up interview sessions (Adams *et al.*, 2016; Madden, 2014; Mamtora, 2013; Fleming-May & Yuro, 2009; Chu & Law, 2007). Researchers on master's and doctoral levels in both data collection phases of this case study also specifically commented on the overwhelming amounts of information available on a topic at a given time, and many feared missing out on important information. This phenomenon was echoed in recent studies among postgraduate researchers (Vezzosi, 2009; Bent, Gannon-Leary & Webb, 2008), as well as in studies focusing on engineering researchers specifically (Kerins *et al.*,

2004). Some engineering researchers indicated during the interviews that they found conducting structured literature reviews challenging. Some earlier studies stressed the importance of doctoral level researchers being able to conduct comprehensive literature reviews to identify quality current literature (Madden, 2014; Fleming-May & Yuro, 2009; Vezzosi, 2009; Chu & Law, 2007; Via & Schmidle, 2007).

Most engineers who completed the ARIL questionnaire felt confident about their skills to critique other researchers' work. Interview data, however, indicated that the majority of researchers on master's and doctoral levels do not follow specific criteria in order to ensure that documents are of good quality. Although earlier literature confirms that engineering research is becoming more interdisciplinary (Chu & Law, 2008), engineering researchers in both the qualitative and quantitative phases of this study indicated that they were *not* confident about their skills to explore literature in other disciplines.

The importance of searching databases such as Scopus, Science Direct or Google Scholar was evident among researchers during focus group and individual interviews, and is also confirmed in previous studies among engineers specifically (Tucci, 2011; Bennett & Buhler, 2010; Chanson, 2009; Fleming-May & Yuro, 2009; Vezzosi, 2009; George, *et al.*, 2006). Although previous studies found that engineering researchers consider the use of correct keywords a critical factor during the discovery of information (Sampson & Comer, 2011; du Bruyn, 2004), the focus group and interview data from this study showed that most participants regarded the discovery of relevant information as a "hit and run" process. In addition, previous studies found that although engineering researchers often conduct relatively simple keyword searches (Chu & Law, 2008), they still experience difficulty in identifying suitable keywords and search terms, planning good search strategies, refining results and managing extensive volumes of information (Sampson & Comer, 2011; Patterson, 2009; Chu & Law, 2008; Hoffmann, Antwi-Nsiah, Feng & Stanley, 2008; Randall, Smith, Clark & Foster, 2008; Antwi-Nsiah, Feng, Chu & Law, 2007; Hoffmann & Stanley, 2006; Ngatai, 2006).

Following references forward and backward was also highlighted as a popular method to discover information during focus group and individual interviews, which is consistent with earlier research (Fleming-May & Yuro, 2009; Via & Schmidle, 2007; Wang *et al.*, 2007).

During focus group and individual interviews engineering researchers often confirmed the vital importance of discovering information directly from other researchers, peers or colleagues. This is confirmed in several earlier studies focusing on engineers (Engel *et al.*, 2011; Robbins *et al.*, 2011; Sampson & Comer, 2011; Bennett & Buhler, 2010; Fleming-May & Yuro, 2009; Vezzosi, 2009; Chu & Law, 2007; Wang, *et al.*, 2007; Kerins, Madden & Fulton, 2004; HEFCE, 2002; Lilja, 1997). Fewer than half of the researchers (mostly on master's and doctoral levels) participating in this case study, however, rated their skills to identify and locate people as effective.

Although engineering researchers who completed the ARIL questionnaire (mostly on master's and doctoral levels) were confident about their skills to stay abreast with the latest information relevant to their field of research, interview data indicated that many researchers felt they were lacking skills in this regard. Earlier studies confirmed that although keeping abreast with the latest developments was considered a primary role among engineering researchers (Engel *et al.*, 2011; Ellis & Haugan, 1997) many studies confirmed a lack of skills among researchers to stay abreast with the latest information in their field (Hall & Jaquet, 2016; Mamtora, 2013; Vezzosi, 2009; Bent, Gannon-Leary & Webb, 2008).

Employing social media to stay abreast with the latest developments was *not* popular among engineers participating in this case study. This confirms findings in earlier studies with engineers (Engel *et al.*, 2011; Robbins *et al.*, 2011; Bennett & Buhler, 2010; Patterson, 2009; Chu & Law, 2007; Wang *et al.*, 2007).

Over half of the engineers who completed the ARIL questionnaire (mostly master's and doctoral level researchers) indicated that they were confident about their skills to mine for research results (e.g. analysing large datasets to identify patterns in the data). Focus group and individual interview data, however, revealed a lack of these skills on post-doctoral level specifically. The need to enhance this specific skill was very clearly and explicitly articulated by several post-doctoral participants.

#### **7.2.4 Data collection/generation and analysis**

Engineering researchers on doctoral and post-doctoral levels regarded the data they collect/generate and consequently analyse and interpret as very important. Researchers on post-doctoral level highlighted the importance of generating quality data, specifically in order to publish quality articles. This finding was consistent with an earlier study, which confirmed that high-quality data is important to researchers, coupled with advanced methodological knowledge (Orlando & Gard, 2014).

Engineering researchers who completed the ARIL questionnaire rated their skills as very good in collecting data from electronic instruments during experimental studies, or generating data by means of computer simulations, and indicated that the collection and analysis of quantitative data were important to them. Earlier studies also confirmed that engineers prefer quantitative approaches to data collection and analysis (Soni & Kodali, 2012; Panas & Pantouvakis, 2010; Runeson & Host, 2009). Collecting and analysing research data from people, however, did not feature high on the agenda for most engineers participating in this case study. Strictly speaking data collection, generation and analysis could be seen as pure research skills. Traditional information literacy can, however, play an important role in identifying appropriate resources on methods and tools, and representing data, and need to be interrelated with what is traditionally considered as pure research skills – Karien – jou mening en herformulering asb.

Some researchers indicated that they were increasingly working with ‘Big Data’, which is consistent with findings noted in the literature (Mauch, Kunze & Hillenbrand, 2013).

Engineering researchers who completed the ARIL questionnaire were very confident about their skills to present research data in the form of graphs and tables, among others. Earlier studies also regard the effective computational visualisation and presentation of research data as important after collecting or generating research data (Covert-Vail & Collard, 2012; Blignaut & Els, 2010).

#### **7.2.5 Management and organisation of information**

Engineering researchers indicated during focus group and individual interviews that they used various systems to manage and organise research information, of which freely available software on the internet, such as Dropbox and Mendeley, was most popular.

Slightly over half of the engineers who completed the ARIL questionnaire, however, indicated that they were confident about using reference management software to organise and manage references. Literature confirms this (MacMillan, 2012; Petre & Rugg, 2010), specifically among engineering researchers (Randall *et al.*, 2008; Wang *et al.*, 2007). Although some previous studies therefore confirm that academic engineering researchers regard the effective use of bibliographic reference management systems as important (Zhang, 2009; Hoffmann *et al.*, 2008; Duskatch, 2007; Poirier, 2005), other studies confirm difficulties experienced by researchers to acquire skills in using reference management tools (Mamtora, 2013; Vezzosi, 2009; Hoffmann *et al.*, 2008; Harrison *et al.*, 2002).

Only a few of the engineers participating in the focus group and individual interviews considered the management and organisation of documents critical to postgraduate research. One established researcher referred to the importance of managing and organising large volumes of documents with multiple titles as critical. A few engineering researchers completing the ARIL questionnaire, however, rated the management and organisation of research documents as challenging. This is consistent with earlier studies on postgraduate researchers (Hall & Jaquet, 2016), especially on doctoral level (Madden, 2014; Bent, Gannon-Leary & Webb, 2008).

#### **7.2.6 Curation of data**

Although many engineering researchers participating in this case study regarded the collection and generation of quality research data as important, most engineers who completed the ARIL questionnaire indicated that they were not confident about skills in data curation. This confirms recent findings reported in the literature referring to the importance and necessity of data management plans and other related actions to preserve research data (Hall & Jaquet, 2016). Some researchers were also unsure about the lifespan of certain digital formats. Only a few engineers who took part in the focus group and individual interviews considered the curation of data an important process during their postgraduate trajectory.

### **7.2.7 Managing IP rights**

Engineering research projects are often referred to as “applied research” in the literature, since they mostly focus on practical issues such as products, processes or services (Speight & Foote, 2011; Pinelli & Haynie, 2010; O’Sullivan & Cochrane, 2009; Du Preez, 2008; Lindberg, Pinelli & Batterson, 2008:2). Most engineers who completed the ARIL questionnaire, however, were not familiar with the management of IP rights. This corresponds with findings from an earlier study that the education of engineers regarding IP is inadequate in institutes of learning (Speight & Foote, 2011). The majority of engineering researchers who took part in the focus group and individual interviews considered the management of IP as hampering their opportunities to publish articles because of the secrecy concerning IP and possible commercialisation. Commercial secrecy and delays with publications were also identified as some of the barriers affecting IP-related issues (Czarnitzki, Hussinger & Schneider, 2011; Johnson, 2011).

### **7.2.8 Creation of information formats**

The creation of information formats was considered critical to postgraduate engineering by researchers on master’s, doctoral, and post-doctoral level who participated in this study. The writing process, however, seemed challenging for engineers on every level, which was confirmed by supervisors in an earlier study (Bent, Gannon-Leary & Webb, 2008). Some researchers on post-doctoral level who took part in the focus group and individual interviews referred to challenges during the writing process and although some previous studies confirmed that researchers on post-doctoral level should be able to write well (Browning, Thompson & Dawson, 2014; Orlando & Gard, 2014), other studies also highlighted that these researchers require academic writing skills to assist them with the transition from writing a thesis to writing for publication (Orlando & Gard, 2014; Gannon-Leary & Webb, 2008).

### **7.2.9 Dissemination of research findings**

The dissemination of research findings was considered important by engineering researchers on master’s, doctoral and post-doctoral level who participated in this case study. The identification of the best publication channel was also considered important in an earlier study focusing on postgraduate supervisors (RIN, 2011). Engineers who took part in this study mainly referred to publishing in high-impact, accredited journals, which is echoed in earlier studies (Johnson, 2011; Okafor & Ukwoma, 2011; Speight & Foote, 2011). Most engineering researchers indicated during the interviews that they preferred to publish mainly for academic communities, rather than the public. This phenomenon is fairly common among

academics, according to a recent study (Belluz, Plumer & Resnick, 2016), which suggests that scientists should acquire skills on how to communicate with the public. Although earlier studies found that postgraduate researchers required skills to identify open access journal titles in which to publish (Mamtora, 2013), engineering researchers who participated in this study were often unaware of what the concept open access entails. Engineering researchers participating in this study did not regard social media as important dissemination channels to communicate research findings either; this is consistent with findings from an earlier study (Mamtora, 2013). Overall, engineers seemed to prefer more “traditional” dissemination channels (e.g. conference presentations, conference proceedings and journal articles) over books.

Post-doctoral level researchers identified challenges with the dissemination of research findings during interviews, with specific reference to a need to build a strong research track record. Recent literature also confirms a need among post-doctoral researchers to situate themselves and establish credentials in a specific field of study, and to create impact through publications (Debasrita & Boeren, 2016; Bent, Gannon-Leary & Webb, 2008). Many participants complained about the current peer-review system and their distrust in the system. Literature confirms that although researchers still consider peer review as fundamental to assess research quality, the system also attracts criticism (Belluz, Plumer & Resnick, 2016; RIN, 2010). During the interviews post-doctoral researchers often referred to a “publish or perish culture”. The phrase “publish or perish”, which “hangs over nearly every decision” (Belluz, Plumer & Resnick, 2016:1), adds to the pressure on especially post-doctoral researchers to publish high-quality research (Debasrita & Boeren, 2016; Bent, Gannon-Leary & Webb, 2008). Some engineering researchers participating in the interviews were of the opinion that striking a balance between the quality and quantity of publications is becoming increasingly difficult; this is confirmed by a recent study (Belluz, Plumer & Resnick, 2016).

Although an earlier study found that researchers on all levels indicated that they required skills to upload their research outputs on an institutional repository (Mamtora, 2013), engineering researchers participating in this case study did not consider institutional repositories as important dissemination channels.

Regarding the sharing of specifically research information, the majority of participants in this study indicated that they seldom restricted access to their research documents, not even for a short period (e.g. embargoes, passwords, CC, or even retaining rights with publishers). This was in contradiction to the sharing of research *data*, however, where the majority of the participants indicated that they had reservations about sharing research data with others.

#### **7.2.10 Measurement of impact**

The measurement of impact was considered an important issue among participants in this study. Only a few researchers mentioned traditional citation statistics (bibliometrics) as instruments to measure impact in a specific field of study. Although recent studies found that researchers identified courses in bibliometrics as useful (Hall & Jaquet, 2016; Madden, 2014), participants in the study did not indicate a need for additional knowledge or skills regarding citation statistics. Some earlier studies also noted personal websites as a way to market profiles and productivity as important (Johnson, 2011). Only a few participants referred to personal webpages or online personal profiles.

#### **7.2.11 Auxiliary skills**

Most researchers who took part in the survey were of the opinion that project and time management skills were very important during postgraduate research. Recent studies performed on the training needs of both doctoral and post-doctoral researchers confirmed the importance of project management skills (Debasrita & Boeren, 2016; Exner, 2014). Time management was also identified as an important skill, with researchers on all levels indicating that they did not have enough time during their postgraduate trajectory. Time management was a concern for especially researchers on post-doctoral level, who often referred to the daily “juggling between teaching and research” activities. Time management was also found to be a crucial skill on post-doctoral level in earlier studies (Orlando & Gard, 2014; Bent, Gannon-Leary & Webb, 2008).

Another important auxiliary skill often mentioned during interviews was interpersonal relationships with other researchers and/or relevant people. The literature describes engineering researchers as active collaborators (Johnson, 2011; Soorymoorthy, 2011; Lee & Bozeman, 2005), especially since research is increasingly becoming multi-, inter- and trans-disciplinary, requiring more integrated responses to research problems (Martin, 2011; Sampson & Comer, 2011; Tucci, 2011).

During the interviews researchers on especially post-doctoral level mentioned the importance of skills to work in research teams. Earlier studies also confirmed that solving problems effectively in teams was becoming crucial in engineering research (Gider, *et al.*, 2011). According to Johnson (2011), teamwork in large groups is becoming the norm in engineering.

During the interviews researchers on post-doctoral level also referred to the importance of “slotting into active communities”. They mentioned the attendance of conferences as one of the instruments to identify such communities. The importance of networks among researchers is confirmed in the literature (Hall & Jaquet, 2016; Browning, Thompson & Dawson, 2014), especially on post-doctoral level, with earlier studies confirming the importance of joining communities and active research groups to develop partnerships and international networks, and to increase their profiles (Browning, Thompson & Dawson, 2014; Orlando & Gard, 2014; Johnson, 2011).

In addition to interpersonal and networking skills, researchers on post-doctoral level identified the importance of supervision skills as an important auxiliary skill; this confirms findings reported in an earlier study (Orlando & Gard, 2014).

The following section of the chapter will briefly cover the key issues associated with the proposed ARIL framework, which will be presented in section 7.3.

### **7.3 KEY ISSUES ASSOCIATED WITH THE PROPOSED ARIL FRAMEWORK**

The case study methodology used in this study offered a detailed examination of the current self-reported information literacy skills of postgraduate engineering researchers. Although previous studies supported many of the findings in this study, certain findings in this study were unique in nature. Although the researcher does not claim that the results are comprehensive, she hopes that the essence of what engineers communicated during this study was captured.

Before arguing the case for an ARIL framework, certain key issues need to be highlighted as they emerged in this case study from both data collection phases in Chapters 5 and 6, as well as from the literature.

The three key issues that emerged from this case study are:

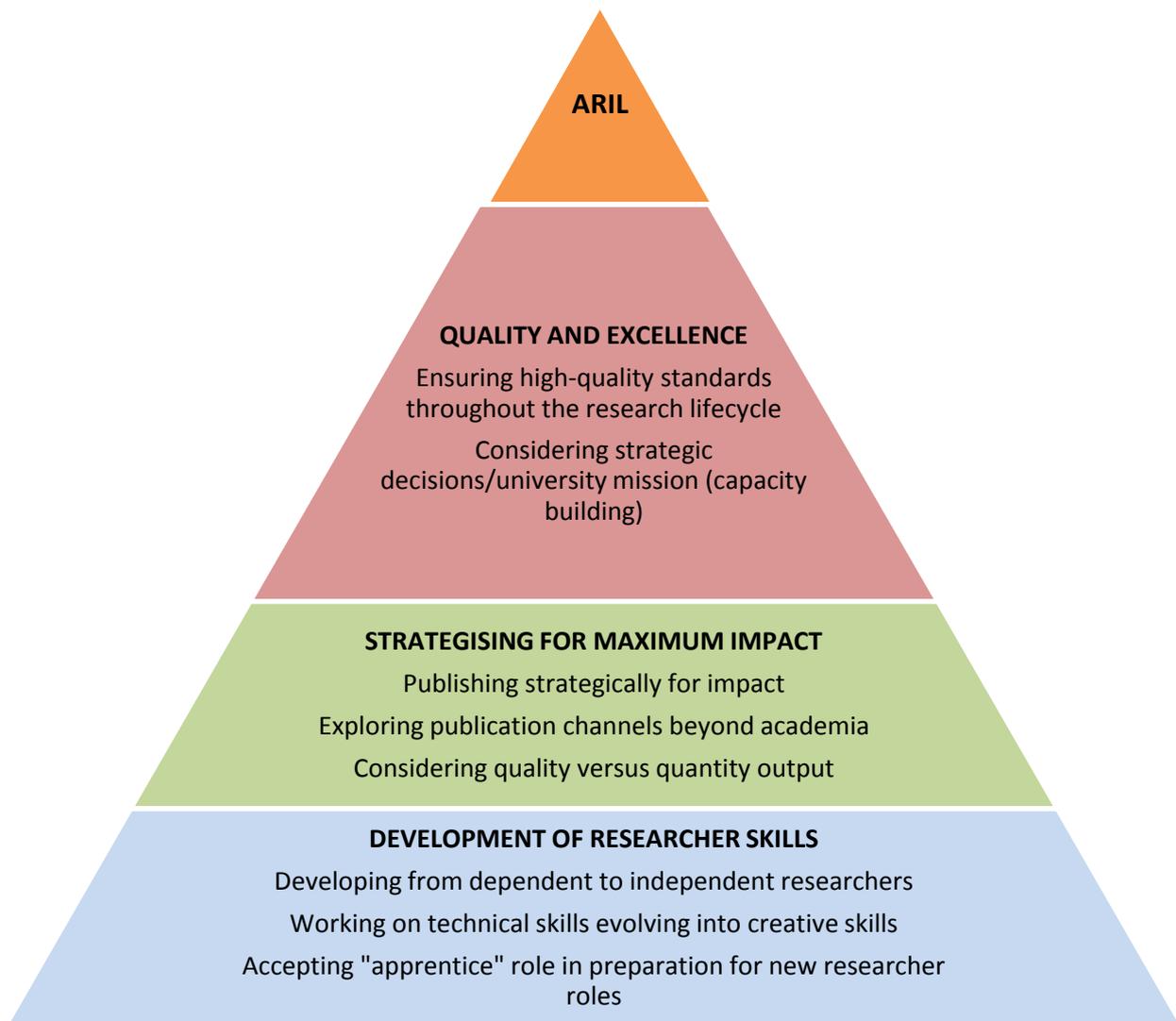
- Progression from a dependent to an independent researcher
- The importance of preparing for impact in a specific field of study
- The importance of ensuring a “culture of quality” in conducting postgraduate engineering research.

Each of these issues will be discussed in more detail as part of the discussion of the proposed ARIL framework, as illustrated below. Although these issues were discussed briefly in Chapter 5, the researcher will highlight certain unique aspects in more detail in the following paragraphs dealing with each key issue.

#### **7.4 PROPOSAL OF AN ARIL FRAMEWORK FOR POSTGRADUATE ENGINEERING RESEARCHERS**

The proposed framework is presented in Figure 0.1 and consists of three categories, which are supplemented by detailed tables in subsequent paragraphs, addressing various levels of post-graduate research with specific reference to ARIL skills required on each level (Table 0.1 – Table 0.4). In addition, Figure 0.2 and Figure 0.3 portray the issue of preparing for impact in a research field, as well as conducting quality postgraduate research. This part of the chapter will address the final research question in this case study, namely: “*Which guidelines and interventions are required to support the implementation of an ARIL framework for engineers?*” Findings from Chapters 5 and 6 will be considered in the design of the ARIL framework, with specific reference to findings gained from the analysis of questionnaire and interview data as summarised in Table 0.8, Table 0.9, Table 0.10, Table 0.10, Table 0.11 and Table 0.12.

**Figure 0.1 Proposed ARIL framework for postgraduate engineering researchers**



This framework was specifically designed in such a way that most work that needs to be done to make this framework more effective fell in the bottom row of the pyramid, namely to prepare researchers across different levels to develop the necessary skills relevant to postgraduate research. The second part of the pyramid, namely strategising for maximum impact, comes into play at a later stage (beyond master's and doctoral level studies), and ensuring quality appears right at the top of the pyramid, where there are not only postgraduate researchers, but also influential people on campuses who can play a significant role in ensuring that quality standards are upheld; this applies even though every researcher is inherently responsible for the quality of his/her own work right through the research lifecycle.

#### **7.4.1 Researchers progressing from dependent to independent postgraduate researchers**

A large part of feedback from this study centres on the progression from a dependent to an independent postgraduate researcher. Two other equally important key aspects of this study were obvious. Researchers on master's and doctorate levels seem heavily dependent on their supervisors and peers. They often have diverse information needs with respect to many processes during their postgraduate research trajectory (e.g. with regard to obtaining funding, quality of writing, assistance to identify quality journals for publication and idea generation, among others).

When analysing the data collected in this case study closely, a distinction between technical versus creative skills (technical skills that can be taught, and creative skills that often develop over time) becomes evident. A study performed by Brewerton (2012) predicted the development of important skills for postgraduate researchers, of which librarians should be aware over the next five years (i.e. five years from reporting the study in 2012). These skills included excellent knowledge of bibliographic tools, finding tools per discipline, information discovery, good citing and referencing skills, effective use of bibliographic management software and data sources available per discipline (Brewerton, 2012:106). Other similar skills could have included the curation of research data, organising and managing research documents, setting up and maintaining online profiles etc.

Most of these skills, however, are of a technical nature, which implies that they can be taught or explained to researchers, often in a short period. In contrast to these technical skills are skills such as compiling structured literature reviews, compiling funding applications, a working knowledge of different research methodologies, data collection/generation, analysis and interpretation techniques, writing of various formats of research documents, presenting academic papers and publication of research findings. These skills can be associated with more creative skills, which cannot be taught over a short period but are often learnt over time as researchers progress with their careers.

ARIL skills on master's and doctoral levels therefore tend to turn into various roles at a later stage, where researchers are regarded more as creators, leaders and gatekeepers of information, "translators of research ideas", peer reviewers, editors, administrators responsible for financially maintaining research groups, and supervisors. Technical skills could be regarded as those that are more straightforward to address and measure, in contrast

to the second set of skills, which are considered more creative in nature, develop over time and may even require extensive training and support over a longer period to teach to postgraduate researchers.

It seems that more basic research skills are propagated and considered important in the literature on master's and doctoral levels, where basic research skills are believed to be taught through an "apprenticeship" model instead of transforming researchers into independent scholars who are able to identify and conceptualise good research topics on their own, to secure research funding and not only to discover information, but also to filter huge volumes into usable chunks for purposes of publication. In addition, they need to be knowledgeable about suitable publication channels for their research findings and able to generate quality and interesting research data. These skills imply more creative processes, which are associated with higher level thinking than that required on master's and doctoral researcher levels.

The following sections will start with the lower level of the proposed ARIL framework, where important ARIL skills (technical as well as creative) for each level, namely master's, doctoral, post-doctoral and established researcher, will be illustrated as researchers progress from dependent to independent researchers, and as further explanation of the ARIL framework for the purpose of future development of ARIL programmes for postgraduate researchers. These sections will be illustrated in Table 0.1, Table 0.2, Table 0.3 and Table 0.4 provide more detail about the skills required on each postgraduate level.

#### *7.4.1.1 Research skills required at master's level of postgraduate research*

The following table will summarise skills required on master's level, according to skills of a technical nature required, as well as skills of a more creative nature.

#### **Table 0.1 ARIL skills required on master's level - technical and creative skills**

MASTERS LEVEL (TECHNICAL SKILLS)	MASTERS LEVEL (CREATIVE SKILLS)
CONCEPTUALISATION OF AN IDEA	CONCEPTUALISATION OF AN IDEA
	<b>Refine</b> a suitable/suggested research topic
OBTAINING RESEARCH FUNDING	OBTAINING RESEARCH FUNDING
	Learn the basics of a funding proposal and compile a <b>funding proposal</b> (with assistance from supervisor/s)
	DATA COLLECTION/GENERATION AND ANALYSIS
	<b>Evaluating experiments</b> and procedures followed in an article
	Collect/generate, analyse and <b>interpret</b> research data from instruments/ <b>people</b>
DISCOVERING INFORMATION	DISCOVERING INFORMATION
Include a <b>wider pool of electronic databases</b> for information searches than Scopus, Google and Science Direct	Use efficient keywords and <b>search strategies</b> to refine results
Identify and locate relevant <b>people as information sources</b>	Effectively discover <b>background information</b> on topics
Perform <b>structured</b> literature reviews	Apply criteria to <b>evaluate</b> documented research and publishers <b>critically</b>
<b>Stay abreast</b> with the latest information in field automatically (alerts, social media)	
Explore literature in other disciplines than engineering	
Follow references forward and backward	
MANAGING AND ORGANISING INFORMATION	MANAGING AND ORGANISING INFORMATION
Use good <b>version control systems</b> for document changes	
Manage <b>overload of paper and electronic</b> formats effectively	
Improve <b>use of reference management software tools</b> (e.g. Mendeley)	
CREATING RESEARCH DOCUMENTS	CREATING RESEARCH DOCUMENTS
Employ <b>anti-plagiarism software</b>	Create academic journal articles
Use good <b>English</b>	Follow a <b>logical flow of thoughts</b> when writing documents
Consider employing <b>Latex software</b> for writing documents	Convert <b>information into knowledge</b>
	<b>Accommodate the audience</b> /reader
DISSEMINATION OF FINDINGS	DISSEMINATION OF FINDINGS

	Focus on good <b>oral presentation skills</b>
	Use <b>additional publication channels</b> (e.g. open access, social media, personal webpage)
	Develop a <b>dissemination strategy</b> for future publications in high-impact accredited articles
<b>MANAGEMENT OF IP RIGHTS</b>	<b>MANAGEMENT OF IP RIGHTS</b>
Gain knowledge about the management and protection of IP rights and <b>copyright addenda</b>	
<b>MEASURING IMPACT</b>	<b>MEASURING IMPACT</b>
Create and maintain an <b>online presence</b> on social media/personal webpage/active research community	
Knowledge about <b>bibliometrics and altmetrics, citation searching</b> and software designed for illustrating impact in a field of study	
<b>AUXILIARY SKILLS</b>	<b>AUXILIARY SKILLS</b>
Project management skills	Problem-solving skills
Time management skills	
Interpersonal communication skills	
Note/minute-taking skills	

The following table will summarise skills required on doctoral level, according to skills of a technical nature required, as well as skills of a more creative nature.

**Table 0.2 ARIL skills on doctoral level - technical and creative skills**

DOCTORAL LEVEL ( <b>TECHNICAL SKILLS</b> )	DOCTORAL LEVEL ( <b>CREATIVE SKILLS</b> )
<b>CONCEPTUALISATION OF AN IDEA</b>	<b>CONCEPTUALISATION OF AN IDEA</b>
	Refine/identify <b>original research topics</b>
<b>OBTAINING RESEARCH FUNDING</b>	<b>OBTAINING RESEARCH FUNDING</b>
Searching relevant databases to identify funding opportunities	<b>Compile funding applications</b> for various funding calls (with assistance from supervisor)
	<b>Obtain research funding</b> (with assistance from supervisor)
<b>DATA COLLECTION/ GENERATION AND ANALYSIS</b>	<b>DATA COLLECTION/GENERATION AND ANALYSIS</b>
<b>Manage ‘Big Data’</b> (context/metadata)	Data collection/generation/analysis and <b>interpretation of data from instruments and people</b>

	Interpret and <b>show insight</b> in quality research data
DISCOVERING INFORMATION	DISCOVERING INFORMATION
Include a <b>wider pool of electronic databases</b> for information searches than Scopus, Google and Science Direct	Use efficient keywords and <b>search strategies</b> to refine results
Identify and locate relevant <b>people as information sources</b>	Apply criteria to <b>evaluate</b> documented research and publishers <b>critically</b>
Perform <b>comprehensive structured literature reviews</b> – also focus on review articles	
Explore literature in other disciplines than engineering	
Follow references forward and backwards	
<b>Stay abreast</b> with latest information in field automatically (alerts, social media)	
MANAGING AND ORGANISING INFORMATION	MANAGING AND ORGANISING INFORMATION
Use good <b>version control systems</b> for document changes	
Manage <b>overload of paper and electronic</b> formats effectively	
Improve use of <b>reference management software tools</b> (e.g. Mendeley)	
DATA CURATION	DATA CURATION
Curation of ‘Big Data’ for future reuse	<b>Design data management plans</b> for preservation and re-use
Curation of research data after completion of studies	
Share research data/ <b>archive in data repositories</b>	
CREATING RESEARCH DOCUMENTS	CREATING RESEARCH DOCUMENTS
	Convert <b>theses into articles</b>
Use good <b>English</b>	Follow a <b>logical flow of thoughts</b> when writing documents
Consider employing <b>Latex software</b> for writing documents	Convert/interpret <b>information into knowledge</b>
	<b>Accommodate the audience/reader</b>
DISSEMINATION OF FINDINGS	DISSEMINATION OF FINDINGS
	Develop a <b>dissemination strategy</b> for future publications in accredited high-impact academic journals
	Develop good <b>oral presentation skills</b>
	Consider <b>sharing research data</b> or archive in repositories for re-use

<b>MANAGEMENT OF IP RIGHTS</b>	<b>MANAGEMENT OF IP RIGHTS</b>
Gain knowledge about managing and protection of IP rights, copyright addenda, CC licenses and restricting access to work – even temporarily (embargoes, passwords)	
<b>MEASURING IMPACT</b>	<b>MEASURING IMPACT</b>
Create and maintain an online presence on social media/personal or academic webpages	
Knowledge about bibliometrics and altmetrics, citation searching and software designed for illustrating impact in a field of study	
<b>AUXILIARY SKILLS</b>	<b>AUXILIARY SKILLS</b>
Project management skills	Problem-solving skills
Time management skills (student)	
Interpersonal communication skills	
Note/minute-taking skills	

The following table will summarise skills required on post-doctoral level, according to skills of a technical nature required, rather than skills of a more creative nature.

**Table 0.3 ARIL skills on post-doctoral level - technical and creative skills**

<b>POST-DOCTORAL LEVEL (TECHNICAL SKILLS)</b>	<b>POST- DOCTORAL LEVEL (CREATIVE SKILLS)</b>
<b>CONCEPTUALISATION OF AN IDEA</b>	<b>CONCEPTUALISATION OF AN IDEA</b>
	<b>Generate and “translate” original</b> research topics for postgraduate students
<b>OBTAINING RESEARCH FUNDING</b>	<b>OBTAINING RESEARCH FUNDING</b>
Manage research funding for a research group	<b>Compile funding applications</b> for various funding calls
Searching relevant databases to identify funding opportunities	<b>Obtain research funding</b> for self and research group/s
<b>DATA COLLECTION/GENERATION AND ANALYSIS</b>	<b>DATA COLLECTION/GENERATION AND ANALYSIS</b>
<b>Manage ‘Big Data’</b> (context/metadata)	Collect/generate <b>quality and interesting research data in a competitive environment</b>
Share research data/ <b>archive in data repositories</b>	Collect/generate, analyse and <b>interpret</b> research data from instruments/people
Increase knowledge of advanced research methods	

DATA CURATION	DATA CURATION
Increase knowledge of data curation skills	<b>Design data management plans</b> for preservation and re-use
DISCOVERING INFORMATION	DISCOVERING INFORMATION
Include a <b>wider pool of electronic databases</b> for information searches than Scopus, Google and Science Direct	Use efficient keywords and <b>search strategies</b> to refine results
Identify and locate relevant <b>people as information sources</b>	Apply criteria to <b>evaluate</b> documented research, findings and publishers <b>critically</b>
Perform <b>structured</b> literature reviews – also focus on review articles	Information discovery mostly to <b>confirm specific findings or arguments</b>
<b>Stay abreast</b> with latest information in field automatically (alerts, social media)	<b>Information-mining skills</b> for hidden information or patterns (bubble charts)
Discover literature in <b>disciplines other than engineering</b>	
MANAGING AND ORGANISING INFORMATION	MANAGING AND ORGANISING INFORMATION
Use good <b>version control systems</b> for document changes	
Manage <b>overload of paper and electronic</b> formats effectively	
Improve use of <b>reference management software tools</b> (e.g. Mendeley)	
CREATING RESEARCH DOCUMENTS	CREATING RESEARCH DOCUMENTS
Consider employing <b>Latex software</b> for writing documents	Transition from <b>writing a thesis to writing for publication</b>
Use good <b>English</b>	Good to <b>excellent academic writing skills</b>
Explore collaborative writing software	Writing <b>convincing arguments (competitive environment)</b>
	<b>Accommodate various audiences</b>
DISSEMINATION OF FINDINGS	DISSEMINATION OF FINDINGS
Identify suitable academic journals for publication	<b>Include additional publication channels</b> (e.g. Open Access, social media, personal webpage)
	Develop a <b>dissemination strategy</b> for future publications in various formats in addition to accredited high impact factor journals to build a more elaborate track record
	Consider <b>sharing research data</b> or archiving in repositories for re-use
	Focus on reinforcing and <b>preparing for new roles such as journal editor, peer reviewer, examiner, quality controller</b>
MANAGEMENT OF IP RIGHTS	MANAGEMENT OF IP RIGHTS

Good knowledge required about principles for <b>managing and protecting IP rights, copyright addenda, CC licenses and restricting access</b> to work – even temporarily (embargoes, passwords)	
MEASURING IMPACT	MEASURING IMPACT
Create and maintain an <b>online presence</b> on social media/personal webpage/active research community	
Knowledge about <b>bibliometrics and altmetrics, citation searching</b> and software designed for illustrating impact in a field of study	
AUXILIARY SKILLS	AUXILIARY SKILLS
Project management skills	Problem-solving skills
Time management skills (student)	Managing a group of postgraduate students to be productive
Interpersonal communication skills	Supervision skills
Teamwork, join influential subject communities	

The following table will summarise skills required on established researcher level, according to skills of a technical nature required, as well as skills of a more creative nature.

**Table 0.4 ARIL skills on established researcher level - technical and creative skills**

ESTABLISHED RESEARCHERS (TECHNICAL SKILLS)	ESTABLISHED RESEARCHERS (CREATIVE SKILLS)
CONCEPTUALISATION OF AN IDEA	CONCEPTUALISATION OF AN IDEA
	<b>“Translator” of original</b> research topics
OBTAINING RESEARCH FUNDING	OBTAINING RESEARCH FUNDING
Searching relevant databases to identify funding opportunities	<b>Compile funding applications</b> for various funding calls
	<b>Maintain research funding streams for multiple projects/centres</b>
DATA COLLECTION/GENERATION AND ANALYSIS	DATA COLLECTION/GENERATION AND ANALYSIS
<b>Planning and overseeing the managing of ‘Big Data’</b> (context/metadata)	Oversee the collection/generation of quality and interesting research data in a competitive environment
	Oversee the collection/generation, analysis and <b>interpretation of</b> research data from instruments/people
DISCOVERING INFORMATION	DISCOVERING INFORMATION
Include a <b>wider pool of electronic databases</b> for information searches than Scopus, Google and Science Direct	Use efficient keywords and <b>search strategies</b> to refine results
<b>Stay abreast</b> with latest information in <b>multiple subject fields</b> automatically (alerts, social media)	Apply criteria to <b>evaluate</b> documented research, findings and publishers <b>critically</b>
Explore literature in other disciplines than engineering	
MANAGING AND ORGANISING INFORMATION	MANAGING AND ORGANISING INFORMATION
Manage <b>multiple extensive</b> collections of published information for several research groups	
Use good <b>version control systems</b> for document changes	
Manage <b>overload of vast amounts of paper and electronic</b> formats effectively	
Improve use of <b>reference management software tools</b> (e.g. Mendeley)	
DATA CURATION	DATA CURATION
Share research data/ <b>archive in data repositories</b>	Develop <b>data management plans</b> for data curation and electronic readings generated in several laboratories on campus simultaneously

<b>CREATING RESEARCH DOCUMENTS</b>	<b>CREATING RESEARCH DOCUMENTS</b>
Consider employing <b>Latex software</b> for writing documents	Create high-quality academic journal articles
	<b>Apply excellent academic writing skills</b>
<b>DISSEMINATION OF FINDINGS</b>	<b>DISSEMINATION OF FINDINGS</b>
Adapt to unique technical <b>specifications of different publishers</b>	<b>Include additional publication channels</b> (e.g. open access, social media, personal webpage)
	Develop a <b>dissemination strategy</b> for future publications in various contexts
	Consider <b>sharing research data</b>
<b>MANAGING IP RIGHTS</b>	<b>MANAGING IP RIGHTS</b>
Excellent knowledge and an advisor to other researchers about managing and protecting <b>IP rights, copyright addenda, CC licenses</b> and restricting access to work – even temporarily (embargoes, passwords)	
<b>MEASURING IMPACT</b>	<b>MEASURING IMPACT</b>
Maintaining, <i>not</i> building, a reputation	
Knowledge about <b>bibliometrics and altmetrics, citation searching</b> and software designed for illustrating impact in a field of study	
<b>AUXILIARY SKILLS</b>	<b>AUXILIARY SKILLS</b>
Project management skills	Managing several groups of postgraduate teams to be productive
Time management skills (students and other research groups)	Supervision skills

#### 7.4.2 Preparing for impact in a specific field of study

The development of an advanced information literacy skills framework on postgraduate level is multi-dimensional and does not imply merely the development and enhancement of new research-related skills aligned with traditional information literacy skills, but also includes aspects of quality research, as well as ensuring that research makes an impact where anticipated or where and how it counts. Morris, Pitt and Manathunga (2012:619) also reported that the aim of postgraduate research programmes should be to transform students into “independent researchers, future colleagues and supervisors”. This implies new roles researchers need to take on as they progress in their careers.

“Researchers are extremely interested in increasing the impact of their individual scholarly work” (Mullen, 2008:1), to see the impact of their work on others. This is important since it is also considered in the evaluation of their work and for promotion and appointment purposes. This case study highlighted the importance engineers on postgraduate level attach to the conceptualisation of good research topics, and emphasised that ideas should make an impact in a specific field, as well as the need to address and solve real problems in industry.

Apart from the importance of identifying a research topic that will make an impact in a specific field, participants considered the publication channel of their findings as important in an attempt to increase their impact globally in accredited journals with a high impact. Although researchers on master’s level mainly function in small groups, which often only involves support and advice from supervisors and peers, this study showed that the groups in which researchers operate expand as they progress with their qualifications. Apart from sharing findings with academia, which was considered the first priority for most researchers, close connections between participants and local industries during their doctoral studies and beyond were also considered important. Some participants even mentioned that they ensured that the results of their research findings reached the relevant people in industry at the same time that they reached academic audiences.

Engineering researchers beyond master’s and doctoral levels seemed to need to market themselves nationally and internationally. Virtually all researchers confirmed discussing their work with colleagues to obtain comments and suggestions to enhance a project, both formally and informally. Good quality conferences were considered crucial in order to assess and assure the quality of their research before final results are published. Many participants highlighted the importance of acknowledgement by other researchers working in the same field as an indicator of impact, in contrast to mere citations (bibliometric statistics) of a publication. The role of being a peer reviewer or an editor seemed beneficial to researchers from post-doctoral level onwards and confirmed the new communities of people to which they are exposed as a result, in addition to the impact they will make in their discipline. In addition to sharing findings with other academics and industry, one participant was of the opinion that it was also important to share findings with the public, and referred to workshops to teach communities outside academic institutions in order to increase the impact of his/her research. Although the dissemination of research findings for maximum impact seemed of the utmost importance to most engineering researchers, most participants did not follow a publication strategy.

#### *7.4.2.1 Important issues regarding preparing for impact of research findings*

The following image (Figure 0.2) summarises the key issues postgraduate researchers should consider when they need to start preparing and strategising for maximum impact of their findings in their field of study.

**Figure 0.2 Key issues in preparing for impact of research findings**

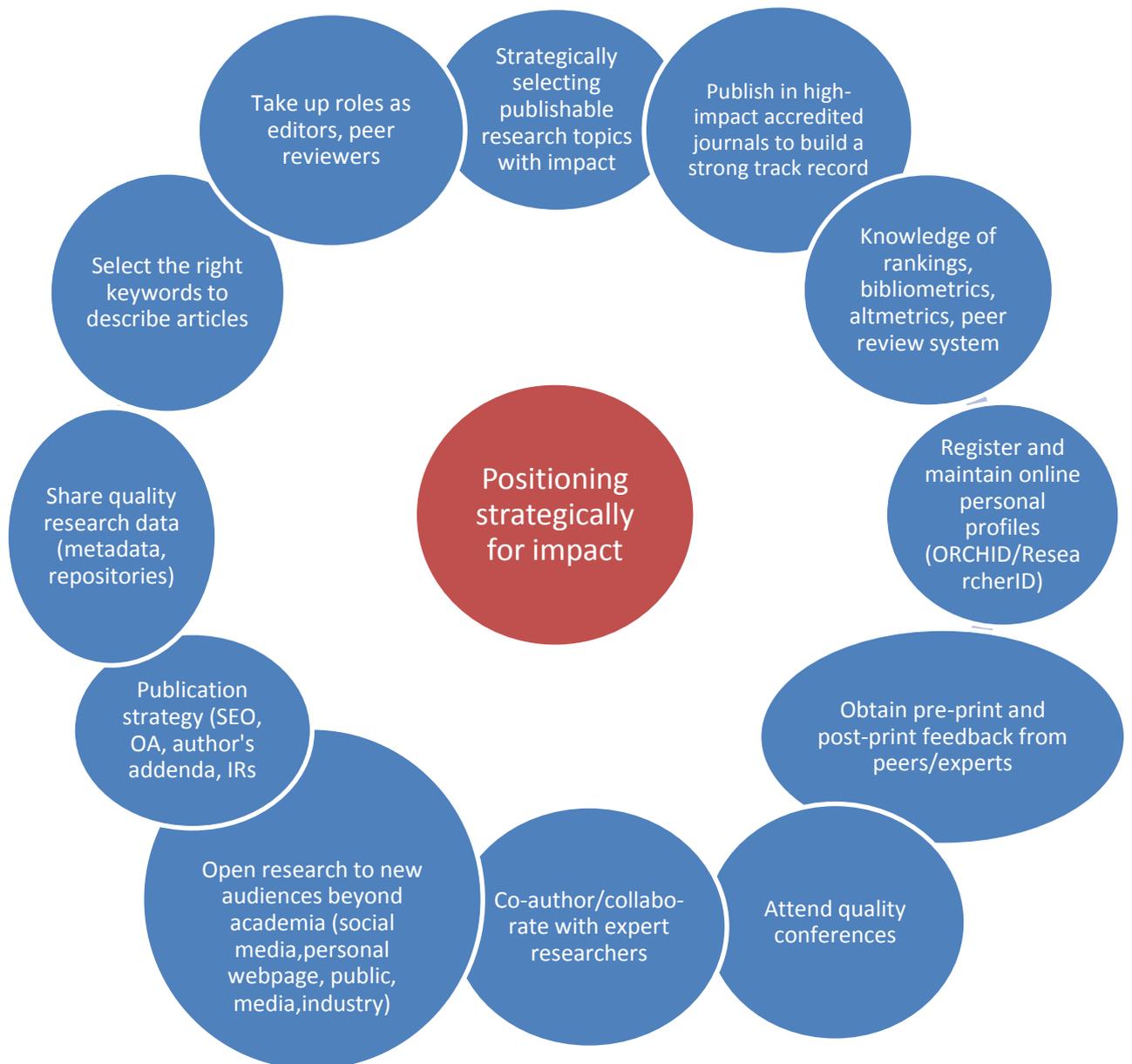


Figure 0.3 address the same issues, but is taking a strategic approach focusing on the issues portrayed in Figure 0.2.

**Figure 0.3 Strategic approach to key issues in preparing for impact**



### **7.4.3 Importance of ensuring a culture of quality in conducting postgraduate engineering research**

The notion and importance of conducting quality research among postgraduate engineering researchers in this case study became almost immediately apparent during focus group and individual interview discussions. A high regard for norms and values was evident in the interviews with both students and academic staff members. Comments made by many participants indicated that the performance of research merely for the sake of doing it was not an option for anybody. It was almost as if it was an unwritten rule in each engineering department to deliver quality publications, where scholarship would ultimately be enhanced. Supervisors considered their students as quality products and it was evident on campus how postgraduate students from the engineering faculty were provided with quiet facilities close to their supervisors' offices, fitted with computers, study cubicles, as well as group discussion facilities. Students were proud of their supervisors and vice versa. Supervisors were considered important and knowledgeable information sources, were held in high regard by their students and appeared to be responsive to students' needs.

Networking on different levels should not be under-estimated; in the researcher's opinion it contributes to quality relationships and collaboration.

### 7.4.3.1 Quality issues important when conducting postgraduate research

Figure 0.4 reflects the ARIL framework with reference to quality standards that influence postgraduate research during every research phase. The orange circles confirm that not only the researchers, but also university policies and procedures play an important role in ensuring quality during postgraduate research in universities.

**Figure 0.4 ARIL framework with reference to quality standards**



## 7.5 CONCLUSION

Becoming a successful postgraduate researcher entails far more than merely developing certain research skills; it also entails a desire to conduct research of high quality, as well as to disseminate research findings as effectively as possible to a wide audience.

This study confirmed that instruction for advanced researchers should accommodate the different levels on which they find themselves, which necessitates a distinction of using different instruction methods and content (Li, Wang, Fu & Xu, 2009; Kohl-Frey, 2007), in addition to the time spent with each researcher.

The proposed ARIL framework is intended to inform future programmes aimed at empowering postgraduate researchers in different contexts and working in different disciplines to complete their degrees successfully.

South Africa is a country with enormous pressure to progress to a knowledge society; research output needs to increase and various parties should become involved in supporting and maintaining the research culture on campuses (Hart & Kleinveldt, 2011).

## **CHAPTER 8: SUMMARY OF FINDINGS, RECOMMENDATIONS AND CONCLUSION**

### **8.1 INTRODUCTION**

The purpose of this chapter is to summarise this case study as it unfolded over eight chapters. The first part of the chapter will briefly discuss the design and purpose of the study, followed by the problem statement and objectives of the study. The next section of the chapter will focus on key findings for each of the sub-problems, followed by noting some limitations to the study. Suggestions for further research, as well as recommendations for the implementation of the ARIL framework (from both practical and theoretical perspectives) will precede the conclusion of Chapter 8.

A brief summary of the research design is presented in the next section.

### **8.2 SUMMARY OF THE RESEARCH DESIGN**

The research design is briefly sketched in Chapter 1, and discussed in more detail in Chapter 4. A summary of the research design is presented Table 0.1.

#### **Table 0.1 Summary of the case study research design**

<b>Research approach</b>	Mixed methods approach
<b>Research method</b>	Case study
<b>Target group</b>	Engineering postgraduate researchers (staff, master's and doctoral students, post-doctoral researchers) at a higher education institution in South Africa
<b>Selection of target group</b>	Convenience and purposeful sampling All engineering departments at the case study institution were invited to participate. They distributed the invitation in their department.
<b>Data collection methods</b>	Self-administered web-based questionnaire: 68 responses received (22/09/2015 - 7/12/2015)
	Focus group and individual interviews conducted: 01/10/2015 - 07/12/2015 (three focus groups with 19 participants, and 12 individual interviews).
<b>Academic levels of postgraduate engineering researchers who participated</b>	Master's level Doctoral level Post-doctoral level Established researcher level.
<b>Ethical clearance</b>	Ethical clearance was obtained from the Department of Information Science Research Committee (University of Pretoria) as the department where the study was supervised The Engineering, Built Environment and Information Technology Faculty Ethics Committee at the University of Pretoria as the institution granting the degree Dean of the faculty where the data was collected Heads of departments participating in the study.
<b>Informed consent</b>	The compulsory completion of anonymous electronic consent letters preceded every web-based questionnaire, and paper copies of consent forms were handed out and signed before every focus group and individual interview commenced. Participants gave signed consent for interviews to be recorded.
<b>Ensuring confidentiality</b>	Participants were reassured about the confidential treatment of their input. No names and personal detail were collected. Participants in individual and focus group interviews each received a code to refer to their input. The institution where the study was conducted was not mentioned by name.
<b>Reliability and validity</b>	Instruments were based on insight gained from the literature analysis. The instruments were tested through a pilot group at the researcher's institution of work to ensure the expected understanding before being issued to respondents and participants for data collection. Triangulation of data was also performed, where literature, quantitative and qualitative data were compared.

### **8.3 PURPOSE AND AIM OF THE STUDY**

The purpose of the study was to investigate what an ARIL framework should entail and how it can guide future programmes aimed at preparing and empowering engineering postgraduate researchers. This framework will be of use not only to the institution where the case study was performed, but also to other universities (nationally as well as internationally), especially newer universities, which can benefit from guidelines on how to introduce research capacity building initiatives on campus. This study may also be of relevance to disciplines other than engineering.

### **8.4 PROBLEM STATEMENT AND OBJECTIVES REVISED**

The assumption that postgraduate researchers are information literate has resulted in among others neglect of some of their information literacy requirements (Streatfield, Allen & Wilson, 2010:230), un-coordinated approaches globally, variations in the breadth and depth of information literacy training sessions on offer, an over-concentration on information-seeking activities (Streatfield, Allen & Wilson, 2010:230), as well as ignoring unique characteristics of different disciplines (Inskip, 2013:3). The problem that was investigated in this study originated from the absence of a discipline-specific framework based on an empirical investigation with regard to ARIL skills during the postgraduate research trajectory in South African higher education institutions, with specific reference to engineering researchers. The researcher has been involved with this user group for more than 20 years at an academic institution, and discovered increasingly deteriorating ARIL skills on postgraduate levels in recent years. The primary research question that guided this study was:

**“How can an advanced research information literacy framework inform the development of programmes supporting the scholarly research process of engineers in a South African higher education environment?”**

The researcher elected to follow a structured approach, where the entire research lifecycle is taken into consideration to avoid a narrow scope of ARIL training on offer to postgraduate researchers (Mamtora, 2013:355). This can also assist investigators to understand the various stages during a research career, which could imply different needs at different stages (Aucland, 2012:2).

In order to explore the primary research question fully, secondary research questions were formulated to meet the primary objective of this study, namely to provide the ARIL framework to develop programmes supporting the scholarly research process of engineers in

a South African higher education environment. These secondary questions were developed in order to establish the following issues in more detail:

- What are the characteristics of introductory and ARIL programmes as reported in subject literature as well as on the WWW?
- What are the documented information needs, information behaviour and information-related experiences of engineering researchers in academic institutions, as well as from industry?
- What are the current self-reported ARIL skills of South African postgraduate engineering researchers?
- How do information literacy skills, knowledge and practices of engineers differ between master's, doctoral, post-doctoral, established and expert researcher levels?
- How can an ARIL framework assist to determine which skills need to be developed during various levels of the engineering research process?
- Which guidelines and interventions are required to support the implementation of an ARIL framework for engineers?

Findings for each of the sub-questions are covered in Chapters 2 to 6. Table 0.2 shows how the questions were addressed and in which chapters of the thesis this was done.

The research questions relate to the objectives set for the study in Chapter 1 (section 1.4). The objectives included:

- Determining the characteristics of introductory and ARIL programmes as reported in subject literature as well as on the WWW.
- Determining the documented information needs, information behaviour and information-related experiences of engineering researchers in academic institutions, as well as from industry.
- Determining the current self-reported ARIL skills of South African postgraduate engineering researchers.
- Determining how information literacy skills, knowledge, and practices of engineers differ between master's, doctoral, post-doctoral, established and expert researcher levels.
- Determining how an ARIL framework can assist in determining which skills need to be developed at various levels of the engineering research process.

- Developing an ARIL framework for engineering researchers that can also be adapted for other disciplines.
- Determining which guidelines and interventions are required to support the implementation of an ARIL framework for engineers.

The sub-questions gave direction to the development of an ARIL framework, which can inform future programmes developed for postgraduate academic researchers to become independent researchers, conducting a high standard of work and wishing to distribute their findings to all relevant people inside and beyond academic institutions. As will be shown in sections 8.4.1 to 8.4.5, all sub-questions were answered and thus all study objectives were met.

**Table 0.2 Research questions developed for this study**

<b>Research question</b>	<b>Addressed</b>	<b>Chapter</b>
<b>Sub-question 1:</b> What are the characteristics of introductory and ARIL programmes as reported in the subject literature?	Literature analysis	2
<b>Sub-question 2:</b> What are the documented information needs, information behaviour and information-related experiences of engineering researchers in academic institutions, as well as from industry?	Literature analysis	3
<b>Sub-question 3:</b> What are the current self-reported ARIL skills of South African postgraduate engineering researchers?	Empirical data collected by means of a self-administered questionnaire	5
<b>Sub-question 4:</b> How do information literacy skills, knowledge, and practices of engineers differ between masters, doctoral, post-doctoral, established and expert researcher levels?	Empirical data collected by means of focus group and individual interviews	6
<b>Sub-question 5:</b> How can an ARIL framework assist to determine which skills need to be developed during various levels of the engineering research process?	Researcher's interpretation based on findings of sub-questions 1-4	7
<b>Sub-question 6:</b> Which guidelines and interventions are required to support the implementation of an ARIL framework for engineers?	Researcher's interpretation based on findings of sub-questions 1-5	7

#### **8.4.1 Literature analysis on characteristics of introductory and ARIL programmes**

*Research question 1: What are the characteristics of introductory and ARIL programmes as reported in the subject literature?*

The literature analysis covered reports on information literacy in different contexts with special focus on postgraduate researchers, and the characteristics of introductory and ARIL programmes. It was noted that programmes often focus only on basic information literacy skills. Information literacy programmes for postgraduate researchers were also often based on those designed for undergraduates, with a strong focus on information retrieval. The rationale for reviewing the literature on information literacy programmes was to determine a definition of information literacy that could guide the study and indicate what an ARIL framework should consider.

Among the many variations of information literacy definitions considered, the ALA definition stood out: “An information literate person is somebody who is able to recognise when information is needed, and has the ability to locate, evaluate, and use effectively the needed information” (ALA, 1989). For the purpose of the study information literacy in the context of engineering research was associated with a combination of skills, processes and phases, which is applied in a specific context (in this case engineering). Therefore, information literacy was defined by the researcher as a person’s ability to apply relevant contemporary information technology, as well as cognitive competencies during the interaction with, and responsible use of information in different formats, throughout one’s lifetime, in order to develop personally and professionally (Section 2.2.2).

In addition, a definition of ARIL was formulated (Section 3.3.11), namely: ARIL includes all traditional information literacy skills and expands on these by including the ability to identify research gaps in the spectrum of international and interdisciplinary literature that can satisfy the needs of society, access and consult literature across disciplines (multi-, inter- and trans-disciplinary) to support various facets of the research process, analyse and synthesise information from secondary as well as primary resources (i.e. empirical data), generate new knowledge, and disseminate findings and new knowledge through appropriate channels, while networking and collaborating with other researchers across different collaborative research platforms, focused on enhancing scholarship. ARIL skills are therefore evident in all the typical research phases, namely identifying a researchable topic, obtaining research funding, discovering information, managing and organising information, collecting and analysing data, storing and curating data, writing up findings, managing IP, publishing results through various channels and advocating the research results (e.g. through social media), as well as measuring impact through different metrics, where each phase is associated with various processes aimed at achieving specific goals relevant to that phase.

After conducting the empirical study (sub-questions 3 and 4), it became clear that in addition, ARIL skills require an individual to satisfy the research requirements of the discipline as well as the institution where research is conducted.

#### **8.4.2 Documented information needs, information behaviour and information-related experiences of engineering researchers**

*Research question 2: What are the documented information needs, information behaviour and information-related experiences of engineering researchers in academic institutions, as well as from industry?*

Most studies consulted about the information needs of engineering researchers were performed in international contexts, with limited information available on how academic engineering researchers in South Africa approached and managed each research phase, thus portraying information needs and behaviour. The literature analysis, however, did highlight areas where assistance and support were needed throughout the research lifecycle, e.g. creating research documents, data curation and the management of IP rights. These are discussed in more detail in chapter 3.

#### **8.4.3 Current self-reported ARIL skills of South African postgraduate engineering researchers**

*Research question 3: What are the current self-reported ARIL skills of South African postgraduate engineering researchers?*

This research question was answered during the empirical phase, where a self-administered, web-based questionnaire and a semi-structured interview guide were used. Findings are reported in Chapter 5. The triangulation of findings between the questionnaire, focus group and individual interviews indicated that while some respondents were confident about their skills when responding to the questionnaire, they nevertheless indicated challenges with exactly the same issue during interviews. Some findings in this case study also differed from findings in the literature regarding opinions of engineering researchers about postgraduate research (e.g. knowledge of and support for open access, preferences for electronic and print resources and conducting of interdisciplinary research).

#### **8.4.4 Information literacy differences between master's, doctoral, post-doctoral and established researchers**

*Research question 4: How do information literacy skills, knowledge and practices of engineers differ between master's, doctoral, post-doctoral and established researchers?*

Data obtained from the empirical phase of this study showed differences between the information needs of engineering researchers on different levels, e.g. between master's, doctoral, post-doctoral and established level researchers. Some of these differences are the conceptualisation of a research topic, obtaining of research funding and the discovery of information. These differences are discussed in more detail in section 7.4.1.1. It is important to consider these differences and to customise and develop training programmes accordingly.

#### **8.4.5 Use of an ARIL framework to identify which skills need to be developed on various postgraduate levels**

*Research question 5: How can an ARIL framework assist to determine which skills need to be developed during various levels of the engineering research process?*

The proposed ARIL framework is presented in Figure 0.1 and is discussed in more detail in Chapter 7. The framework highlights important skills associated with each level of researchers, namely master's, doctoral, post-doctoral and established researchers. These skills were based on the research lifecycle, which included the following ten research phases: conceptualisation of a research idea, obtaining of research funding, data collection/generation and analysis, discovery of information, management and organisation of information, data curation, creation of information formats, management of IP rights, dissemination of findings, and the measurement of impact in a field of study. In addition, the framework also addressed the importance of auxiliary skills (e.g. project management and time management).

#### **8.4.6 Guidelines required to support the implementation of an ARIL framework for postgraduate engineering researchers**

*Research question 6: Which guidelines and interventions are required to support the implementation of a comprehensive research information literacy framework for engineers?*

Many findings from the empirical component as well as the literature review can be incorporated into such as framework. Such findings are evident from the data triangulation discussed in section 7.2. However, three key issues emerging from the qualitative data collection phase of this case study were noteworthy. They were highlighted in section 7.3 as guidelines to support the implementation of the proposed ARIL framework, which can direct future training and support of postgraduate engineering researchers. The issues include:

##### **(a) The importance of ensuring a “culture of quality” in conducting postgraduate engineering research**

The importance of conducting quality research for postgraduate engineering researchers became almost immediately apparent during focus group and individual interview discussions. A high regard for norms and values was evident in the interviews with both students and staff. Supervisors regarded their students as quality products, and students were proud of their supervisors. Supervisors were considered important knowledgeable information sources, were held in high regard by their students, and appeared to be responsive to students’ needs. The importance of networking among engineering researchers on different levels was obvious, and this may contribute to quality relationships and collaboration with other researchers. ARIL training and support should take due cognisance of this.

##### **(b) Progression from a dependent to an independent researcher**

To a considerable extent the findings centred on the progression from a dependent to an independent postgraduate researcher. Although researchers on master’s and doctorate levels seemed heavily dependent on their supervisors, their development is actually multi-dimensional and does not just imply gradually being prepared to be researchers who are able to conduct quality research that can make an impact in a specific field of study. A distinction between technical versus creative skills (technical skills that can be taught, and creative skills that often develop over time) becomes evident. Over time the nurturing of ARIL skills on master’s and doctoral levels should prepare engineering researchers to take on roles where

they as researchers are increasingly regarded as creators, leaders and gatekeepers of information, “translators of research ideas”, peer reviewers, editors and administrators responsible for financially maintaining research groups and supervisors.

### **(c) The importance of preparing for impact in a specific field of study**

This case study highlighted the importance that engineers on postgraduate level attach to conceptualising a research topic and ensuring that research and ideas have an impact in their specific field, as well as addressing and solving a real industry-related problem. Apart from the importance of identifying a research topic with potential impact, the choice of publication channels for disseminating research findings is considered very important in ensuring high impact. The groups in which researchers operate expand as they progress with their qualifications, which also affects the impact of their research findings. Apart from sharing findings with academia, which was considered the first priority for most researchers, close connections between participants beyond doctoral level and local industries are very important.

Discussions of work with colleagues and attending high-quality conferences before final research results are published are also important to engineering researchers. Accepting work as peer reviewer, editorial work, and for a few, sharing of findings with the public, were also considered very important to improve the impact of research.

## **8.5 LIMITATIONS OF THE STUDY**

The researcher was unable to interview a researcher on expert level (A-rated according to the NRF), which would have made this study more unique, in that all postgraduate level researchers would have been profiled regarding information literacy skills, needs and preferences.

In addition, it is recognised that self-assessment has limitations, since participants’s skills were not tested in this study. It is also noted that people often tend to overrate their skills during surveys (Rosman, Mayer & Krampen, 2014). This issue is therefore identified as a limitation to this case study.

Although some academics criticise single-case studies (Case & Light, 2011:191; Rule & John, 2011:21; Leedy & Ormrod, 2010:137) and may refer to them as limitations to a study, the researcher dealt with the matter thoroughly in chapter 4 (section 4.2.1). The case study methodology proved to be very useful for capturing new layers of reality during each data

collection phase, since a multi-method approach was followed by starting with a quantitative phase, followed by a qualitative phase. Sixty-eight web-based questionnaires were filled in (although not all completely), and 31 engineering researchers across levels and departments were interviewed, either in focus groups or individually. The multiple methods employed improved the quality of the research overall, allowed for the triangulation of data, reduced bias and increased the validity of the study.

## **8.6 RECOMMENDATIONS FOR IMPLEMENTING THE PROPOSED ARIL FRAMEWORK**

In order for this proposed ARIL framework to be effectively implemented, and for it to benefit engineering postgraduate researchers and all other relevant parties, some recommendations for implementation are suggested. Four of the recommendations will be of a practical nature and five will be of a more theoretical nature.

### **8.6.1 Recommendations of a practical nature**

#### *8.6.1.1 Integration of ARIL skills into existing research methodology courses in departments and/or faculties*

The integration of the ARIL framework into existing research methodology courses in departments, faculties and existing capacity-building programmes for postgraduate researchers may result in a more holistic approach to postgraduate researcher development. This will, however, require close collaboration between libraries, academics, supervisors, IT support services, research offices, academic development offices and career services, among others. This might also require that the integration of the ARIL framework be embedded into university policies. Research methodology courses can therefore be supplemented to provide a more holistic approach to postgraduate research, and can be designed in such a way that they accommodate researchers at specific levels (e.g. master's, doctoral, post-doctoral and established researchers).

#### *8.6.1.2 Empowering supervisors with ARIL skills*

Although supervisors often tend to focus on technical issues during research methodology or similar courses (e.g. data collection/generation and analysis and hypothesis statements among others), aspects related to ARIL, such as the effective discovery and evaluation of information, preparing funding proposals, designing publication strategies, preparing for maximum impact of findings, data curation, maintenance of personal online profiles and

information management and organisation, among others, are often not covered in these sessions.

Since faculty members may lack knowledge of the benefits that the ARIL framework may have for research methodology courses, it is recommended that they also attend ARIL training programmes, and even regular refresher courses.

### *8.6.1.3 Expanding the scope of academic publications*

As already alluded to in the ARIL framework, engineering researchers who took part in this case study did not seem to support low-impact local journals, the media or popularised articles as channels for sharing their research findings. According to Albert, Laberge and McGuire (2012:11), academics consider these dissemination channels sub-standard, primarily since they are not peer-reviewed. The majority of engineering researchers who took part in this study preferred rather to publish in high-impact, ISI-accredited journals only; in doing this, they and their institutions can receive a subsidy from the South African government.

Universities should thus reconsider how academics are assessed, with specific reference to the dissemination of research findings, in order to enable the local industry and the public to note their research and to benefit from it as well, not only high-impact journals.

### *8.6.1.4 Appointment of supervisory teams, in contrast to following a 1:1 supervision model*

Supervisors are key sources of information for researchers and can influence the information literacy knowledge and skills development of students. According to Eshtiaghi, Robertson and Warren-Myers (2012:198), supervisors should conduct a needs analysis during the first meeting with postgraduate researchers to identify areas where assistance is required. An advisory committee model can then be followed, where the supervisor and supporting advisors work together to develop postgraduate researchers, which could ensure sufficient support regarding ARIL skills.

## **8.6.2 Recommendations of a theoretical nature**

### *8.6.2.1 Applying role theory to information behaviour studies on the development of various roles and ARIL skills during the trajectory of postgraduate academic research careers*

As already mentioned in the ARIL framework, researchers take on many different roles as they progress from a novice (master's level) to an experienced researcher, namely postgraduate students, supervisors, leaders of research teams, research assistants, co-

investigators, peer reviewers, editors, co-authors, teaching assistants, tutors, instructors, co-workers or fellow students (Dash, 2015:158). It is therefore recommended that these roles be studied in more detail from an information behaviour and ARIL skills and specifically longitudinal perspective. The work by Leckie, Pettigrew and Sylvain (1996) and Huvila (2008) can serve as point of departure.

#### *8.6.2.2 Applying trust theory to the publishing behaviour of post-graduate researchers and their opinion of academic peer-review systems*

This case study confirmed distrust among several engineering researchers in the current academic peer-review system. The reconsideration, clarification and examination of the current peer-review systems in academic institutions and acceptable outlets for research output can be combined with understanding on the publication behaviour of post-graduate researchers, and thus also their need for information literacy skills. Discussions on the peer-review system may lead to better understanding and more transparency among academics. Weller (2002) provides a good, although somewhat dated point of departure. Peer-review refresher courses for current peer reviewers and training for new ones can also result in greater consistency in future regarding the peer-review system (RIN, 2010:8).

#### *8.6.2.3 Informing ARIL programmes from information behaviour and information practices perspectives – identification of appropriate theories*

Several authors have noted the need to consider information and information behaviour in making decisions on information literacy and information literacy training. The same would apply for information practice. Future work can specifically approach such studies from relevant theories such as self-efficacy theory, role theory, student development theories and even sense-making theory in terms of understanding the full information research life cycle of engineering research. The work of Julien and Williamson (2011) would be a good point of departure.

#### *8.6.2.4 Impact of the contextualisation of postgraduate research on information literacy skill needs*

The contextualisation of ARIL should be interpreted by acknowledging the impact of individual academic institutions in terms of vision and mission, as well as infrastructures and research support, the requirements of the specific discipline with regard to research and practice, and country-specific requirements.

#### 8.6.2.5 *Disciplinary differences for ARIL skills*

The interpretation of ARIL and the ARIL framework suggested for information literacy skill interventions can be applied to any discipline. There would, however, be some differences in terms of disciplinary interpretations of research and requirements which would have an impact on finer nuances of the interpretation of ARIL, ARIL skills and the ARIL framework. Further research is thus required, especially between disciplines representing the broad sciences, namely natural science, social science and humanities, as well as between applied, theoretical and philosophical disciplines.

### **8.7 SUGGESTIONS FOR FURTHER RESEARCH**

This study can serve as starting point for a larger body of research on ARIL and ARIL skills, which can be extended to other disciplines, specific sub-disciplines and the workplace. Since postgraduate research in academic institutions is constantly evolving along with technological developments, there will always be opportunities for further research in this field to expand what is currently known about ARIL and the way in which it can play a role to improve the conduct of postgraduate research. The following sub-sections address suggestions for further research.

#### **8.7.1 Investigate ARIL needs at newly established academic institutions and institutions lacking a strong research culture**

Several new universities have been established in South Africa as a result of restructuring by the government after 1994, which are for the first time in the process of developing researchers for the future. Each of these institutions operates in its own unique and specific context. The needs of researchers at small universities (i.e. substantially smaller than the university where the case study was conducted) may be different from those of researchers at large, established, research-intensive universities (Mamtora, 2013:362) and this should be taken into account when consulting the ARIL framework. This may call for further research to determine if there are differences between small and large universities, and to what extent their ARIL needs correspond.

### **8.7.2 Utilisation of social media platforms**

This study showed lack of interest among engineers in the use of social media platforms for academic purposes (e.g. to find information, to comment on others' findings, to create personal online profiles or to publish findings). Further research can establish if this is a phenomenon at only the specific institution where the case study was conducted, and to determine to what extent engineering researchers are willing to adopt and include alternative ways to communicate their research findings. Comparisons might also be drawn with researchers in other disciplines.

### **8.7.3 Open access as a means for improving dissemination of research findings**

There are highly reputable academic journals available through open access platforms, and although open access publications can be explored to enhance the dissemination of findings, engineering researchers participating in this study did not consider these an important dissemination channel. Lack of knowledge regarding the benefits and principles of open access was also evident among participants. Further research to establish reasons (e.g. personal or institutional) for avoiding open access channels to disseminate findings may shed light on this matter, which may result in a better understanding of open access and even an uptake of open access among engineers in future. In addition, dual benefits of open access in providing free access to information, as well as raising awareness of individual as well as institutional research profiles, need to be investigated.

### **8.7.4 Studies exploring suggested theories with regard to ARIL and information behaviour**

Several theories hold value for the further exploration of ARIL and information behaviour for engineering researchers, as well as researchers in other disciplines. Such studies can deepen understanding and support the implementation of appropriate interventions. Theories to explore include role theory, self-efficacy theory and student development theories.

## **8.8 CONCLUSION**

This case study shed light on how postgraduate engineering researchers in a case study representative of postgraduate engineering research in South Africa approach their research. This applied to research on master's, doctoral, post-doctoral and established researcher level. Their information literacy skills relevant to research on each level differed and a progression in their research careers was evident with regard to how these skills became more creative over time.

This research is not only about research skills, but also about the quality and impact of research findings in a specific field. Research is of no value if it is not shared or published, and it is hoped that this ARIL framework will assist to address this issue in time.

Some participants with whom the researcher had interviews were of the opinion that their departments and current workflows concerning postgraduate research were sufficient, and that neither they nor their students needed additional skills. This study showed, however, that postgraduate engineering researchers, as well as their supervisors, can benefit from this ARIL framework, with the reward that South African engineering researchers may produce research of the highest quality, distributed to the widest audience possible.

Although the study focused on engineering researchers at a South African university, the interpretation of ARIL and the suggested framework could also be applied to direct studies in other disciplines and other contexts.

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## **ADDENDA**

### **ADDENDUM A: PERMISSION TO CONDUCT A CASE STUDY**

TO [Anonymous] Survey Committee

RE Permission to conduct a case study involving students and personnel for a doctoral study

FROM Ms Karien du Bruyn

DATE 10 April 2015

Dear Prof. [Anonymous]

I hereby request permission to involve students and personnel from the [anonymous] faculty of the University of [anonymous] in my doctoral study entitled: A framework for an advanced information literacy programme for postgraduate researchers in engineering. My supervisor is Prof. Ina Fourie (Department of Information Science, University of Pretoria), and I am currently in the process of applying for ethical clearance (full application attached).

I have selected a case study approach for the research study which will involve only the [anonymous] faculty from the University of [anonymous] as it has been found to have the highest global impact among South African universities with regard to research output in the field of engineering (InCites - Thomson Reuters). I am therefore interested in studying this specific institution, and the [anonymous] faculty in particular, and which serve as an example to other universities in this specific context.

I also request permission to mention the university by name in my research. However, if this is problematic I can refer to the university as “a leading academic institution in South Africa”. I am open to any other suggestions in this regard. I hope that you will consider this application favourably, and thank you for your assistance.

Yours faithfully

Ms Karien du Bruyn

kariendb@vut.ac.za;\_076 183 5892 / 016 950 9651

## ADDENDUM B: ETHICAL CLEARANCE FOR THE INSTITUTION GRANTING THE DEGREE



UNIVERSITEIT VAN PRETORIA  
UNIVERSITY OF PRETORIA  
YUNIBESITHI YA PRETORIA

Reference number: EBIT/33/2015

14 May 2015

Ms K Du Bruyn  
Box 552  
Park South  
1910

Dear Miss Du Bruyn,

### FACULTY COMMITTEE FOR RESEARCH ETHICS AND INTEGRITY

Your recent application to the EBIT Ethics Committee refers.

- 1 I hereby wish to inform you that the research project titled "A framework for an advanced research information literacy (ARIL) programme for postgraduate researchers in engineering" has been approved by the Committee.

This approval does not imply that the researcher, student or lecturer is relieved of any accountability in terms of the Codes of Research Ethics of the University of Pretoria, if action is taken beyond the approved proposal.

- 2 According to the regulations, any relevant problem arising from the study or research methodology as well as any amendments or changes, must be brought to the attention of any member of the Faculty Committee who will deal with the matter.
- 3 The Committee must be notified on completion of the project.

The Committee wishes you every success with the research project.



**Prof JJ Hanekom**

Chair: Faculty Committee for Research Ethics and Integrity  
FACULTY OF ENGINEERING, BUILT ENVIRONMENT AND INFORMATION  
TECHNOLOGY

**ADDENDUM C: PERMISSION TO INVOLVE STUDENTS AND STAFF IN  
DOCTORAL STUDY**

TO Prof [anonymous]

RE Permission to involve students and staff from [anonymous] Faculty in data collection for a doctoral study

FROM Ms Karien du Bruyn

DATE 10 April 2015

Dear Prof. [anonymous]

I hereby request your permission to involve postgraduate students and staff from the [anonymous] faculty of the University of [anonymous] in my doctoral study. My supervisor is Prof. Ina Fourie (Department of Information Science, University of Pretoria), and I am currently in the process of applying for ethical clearance from the EBIT Research Committee (full application attached).

My study focuses on the information literacy skills of postgraduate engineering researchers. The aim of my study is to identify how their advanced research information literacy (ARIL) needs can be addressed in advanced research information literacy training programmes. This study will involve only the [anonymous] faculty at the University of [anonymous] in the form of a case study, since this institution, according to the InCites database (Thomson Reuters), has the highest impact among South African universities with regard to research output in the field of engineering in South Africa. I intend to use an electronic questionnaire which will focus on the current, self-reported skills and practices of engineering researchers, followed by focus group and individual interviews with people who are willing to participate. Engineering postgraduate researchers will include engineers (both staff and students) enrolled in the masters and doctoral programmes, as well as those who already hold a doctoral degree and will include researchers appointed in a post-doctoral position in an academic department, academics without NRF rating as well as academics with NRF ratings.

Thank you for your assistance.

Yours faithfully

Ms Karien du Bruyn kariendb@vut.ac.za 076 183 5892 / 016 950 9651

## **ADDENDUM D: WEB-BASED QUESTIONNAIRE**

### **ENGINEERING RESEARCHERS: ADVANCED RESEARCH INFORMATION LITERACY (ARIL):**

#### **QUESTIONNAIRE<sup>6</sup>**

- (i) Please select the option(s) closest to the engineering field in which you are conducting research or supervising. You may select more than one option if applicable.
- Chemical Engineering
  - Civil Engineering
  - Electrical, Electronic and Computer Engineering
  - Industrial and Systems Engineering
  - Material Science and Metallurgical Engineering
  - Mechanical and Aeronautical Engineering
  - Mining Engineering
  - Other, please specify
- (ii) What is your highest academic qualification?
- Honours
  - Masters
  - Doctorate
- (iii) For how long have you had your highest qualification?
- Less than 1 year
  - 1-2 years
  - 3-5 years
  - 6-10 years
  - 11-15 years
  - 16-20 years
  - More than 20 years
- (iv) Please select the research stage that closest reflects your current progress
- Idea generation and initial literature scanning
  - Proposal writing
  - Comprehensive literature analysis
  - Choice of research methodology (e.g. research design and developing of data collection instruments)
  - Empirical phase (e.g. data collection, data analysis and interpretation of results)
  - Editing and finalisation of dissertation/thesis
  - Publishing/disseminating of results (e.g. articles, conference papers)
  - Other (please specify)

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<sup>6</sup> The questionnaire was distributed electronically, where the selected software determined the layout and overall appearance and functionality.

- (v) What is your current position in your academic department?  
Not a staff member; Research assistant; Junior lecturer  
Lecturer; Senior lecturer; Associate professor  
Full professor; Visiting professor; Post-doctoral appointee  
Other (please specify)
- (vi) What is your current involvement with post-graduate supervision of engineering researchers? (Please select all applicable options.)  
Not supervising  
Supervising honours students  
Supervising masters' students  
Supervising doctoral students  
Supervising post-doctoral students
- (vii) What is the nature of your current collaborations with other researchers? (Please select all applicable options.)  
No collaboration  
Industry specific  
Academic institutions  
Government departments  
Please specify other sources of collaboration
- (viii) Please indicate your National Research Foundation (NRF)<sup>7</sup> rating:  
Not rated  
Y-rated  
P-rated  
C-rated  
B-rated  
A-rated

## CONCEPTUALISATION OF A RESEARCH TOPIC AND INITIAL EXPLORING OF THE LITERATURE

- (1) Please rate your skills regarding the following: (1 = poor, 2 = fair, 3 = good, 4 = very good)  
Identifying a research gap from existing literature  
Verifying if somebody else is working on a specific topic  
Refining the topic to be researchable (e.g. not too broad/general, not too narrow/specific)  
Formulating a research problem  
Formulating a hypothesis  
Using electronic databases to identify a research topic

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<sup>7</sup> Ratings are according to the South African National Research Foundation (NRF) categories, namely: P/Y (young promising researcher – younger than 40), C (established researcher), B (internationally recognised researcher), and A (leading international researcher)

Visualising relationships between concepts (e.g. mind maps or concept maps)  
Identifying experts in your field of study

- (2) Please rate your skills with regard to exploring literature during the early stages of your research: (1 = poor, 2 = fair, 3 = good, 4 = very good)  
Exploring engineering literature  
Exploring literature in disciplines other than engineering

#### RESEARCH FUNDING

- (3) Please rate your skills in identifying possible funding opportunities for your research: (1 = poor, 2 = fair, 3 = good, 4 = very good)
- (4) Please rate your skills regarding the following: (1 = poor, 2 = fair, 3 = good, 4 = very good)  
Searching electronic databases to discover funding opportunities  
Setting up electronic alerts to automatically receive updates of funding information  
Compiling funding proposals  
Not applicable

#### INFORMATION DISCOVERY

- (5) Please rate your skills in searching for research information: (1 = poor, 2 = fair, 3 = good, 4 = very good)  
Searching for information by myself  
Collaborating with others to find information
- (6) Please rate your skills in using the following when including others while searching for information: (1 = poor, 2 = fair, 3 = good, 4 = very good)  
Social networking tools on the Internet (discussion lists, blogs, wikis, etc.)  
Academic communities on the Internet (e.g. ResearchGate)  
Virtual research environments (VREs) on the Internet (e.g. myExperiment)  
Electronic mail  
Specify other methods you use when including others while looking for information
- (7) Please rate your skills regarding the following: (1 = poor, 2 = fair, 3 = good, 4 = very good)  
Identifying relevant electronic databases for searches  
Searching and locating fulltext engineering publications  
Searching and locating information in disciplines *other than* engineering  
Searching and locating technical information (e.g. patents, standards, technical reports)  
Searching and locating information in other formats than text (e.g. maps, graphs, images)  
Identifying and locating people as information resources

- (8) Please rate your skills in distinguishing between credible and poor quality information: (1 = poor, 2 = fair, 3 = good, 4 = very good)
- (9) Please rate your skills in keeping abreast with the latest information relevant to your research: (1 = poor, 2 = fair, 3 = good, 4 = very good)

#### DATA COLLECTION AND ANALYSIS

- (11) Please rate your skills in collecting research data from the following: (1 = poor, 2 = fair, 3 = good, 4 = very good)  
Collecting data from people  
Collecting data from electronic instruments  
Collecting data from existing documents, e.g. through content analysis  
Specify other important sources of research data in your field of research
- (12) Please rate your skills in using the following to analyse data: (1 = poor, 2 = fair, 3 = good, 4 = very good)  
Software packages to analyse quantitative data (numbers)  
Software packages to analyse qualitative data (words)  
Data mining (analysing large datasets to identify relationships and patterns)  
Visualising data (e.g. charts, graphs)

#### MANAGING AND ORGANISING INFORMATION

- (13) Please rate your knowledge regarding the lifespan of different digital formats in order to ensure access in future: (1 = poor, 2 = fair, 3 = good, 4 = very good)  
PDF  
MS Office (e.g. Excell, Word, Powerpoint documents)  
HTML, XML
- (14) Please rate your skills in managing and organising research documents: (1 = poor, 2 = fair, 3 = good, 4 = very good)  
Using reference management software (e.g. RefWorks, EndNote, Mendeley)  
Depositing documents into institutional repositories (e.g. UPSpace)  
Managing documents on Internet sites (e.g. DropBox and GoogleDrive)  
Annotating (describing and tagging) documents  
Using version control systems to record changes to files or documents over time  
Specify any other skills you consider important when managing and organising your research documents
- (15) Please rate your skills in organising and managing the following information formats to ensure easy recovery in future: (1 = poor, 2 = fair, 3 = good, 4 = very good)  
Paper documents  
Multimedia (e.g. audio and video recordings)  
Electronic information retrieved from scholarly databases  
Electronic information retrieved from the Internet  
Electronic mail communication  
Specify any other information formats you find challenging to organise and manage

## DATA CURATION

- (16) How often do you take actions to ensure that your research data is available for an extended period (i.e. curated)?
- Daily
  - Weekly
  - Monthly
  - Annually
  - Never
- (17) Please rate your skills in terms of ensuring that your research data is available long after you have finished your project (i.e. curated): (1 = poor, 2 = fair, 3 = good, 4 = very good)
- Describing the context of data (e.g. adding metadata, annotations)
  - Designing a data management plan
  - Using persistent links on the Internet (e.g. Digital Object Identifiers)
  - Submitting research data to dataset repositories
  - Regular migration of data files to current mediums
  - Specify any other skills you consider important to ensure research data is curated

## CREATING RESEARCH DOCUMENTS

- (18) Which of the following is relevant when you create research documents? (1 = never, 2 = rarely, 3 = often, 4 = always)
- Individual writing only
  - Writing in collaboration with other researchers
- (19) Please rate your skills regarding the following when creating research documents (1 = poor, 2 = fair, 3 = good, 4 = very good):
- Adapting a piece of work to accommodate different audiences
  - Correct citing of other people's work
  - Avoiding plagiarism
  - Critiquing/critical reading of research papers
- (20) Please rate your skills regarding the writing of the following: (1 = poor, 2 = fair, 3 = good, 4 = very good)
- Conference papers
  - Conference abstracts
  - Conference presentations (e.g. PowerPoint)
  - Theses (doctoral)
  - Dissertations (masters)
  - Journal articles
  - Contributions on social media platforms (e.g. blogs and wikis)
  - Technical reports (e.g. patents and standards)
  - Books
  - Chapters in books
  - Multimedia (e.g. audio and video recordings)

- (21) Please rate your skills in using the following when preparing research documents in collaboration with others: (1 = poor, 2 = fair, 3 = good, 4 = very good)
- Collaborative writing software on the Internet (e.g. GoogleDrive)
  - Word processor packages (e.g. MS office)
  - Virtual Research Environments (VREs) on the Internet
  - Social media platforms (e.g. wikis and blogs)
  - Citation software (e.g. RefWorks, EndNote, Mendeley)
  - Electronic mail
  - Not applicable
  - Specify other collaborating tools you prefer to use

## MANAGING INTELLECTUAL RIGHTS

- (22) How often do you need to restrict access to your research documents or findings? (1 = never, 2 = rarely, 3 = often, 4 = always)
- (23) How would you rate your ability to identify potential intellectual property rights to your research? (1 = poor, 2 = fair, 3 = good, 4 = very good)
- (24) Please rate your skills in using the following mechanisms to protect the intellectual property rights of your research: (1 = poor, 2 = fair, 3 = good, 4 = very good)
- Registration of a design
  - Registration of a patent
  - Registration of a trademark
  - Registration of a domain name (web address)
  - Setting up licences or agreements
  - Not applicable
- (25) Please rate your skills in terms of the following to ensure that research documents stay confidential: (1 = poor, 2 = fair, 3 = good, 4 = very good)
- Designing intellectual property management plans
  - Restricting access to work for a certain period (embargo)
  - Placing access conditions to documents through passwords
  - Specify any other ways you use to protect confidential documents
- (26) Please rate your skills in retaining copyright to your publications with regard to the following: (1 = poor, 2 = fair, 3 = good, 4 = very good)
- Licensing of work published on the Internet (e.g. through creative commons (CC) licenses)
  - Negotiating the retaining of some rights with publishers (e.g. author's addenda)

## DISSEMINATING RESEARCH FINDINGS

- (27) Please rate your skills in disseminating research findings/information through the following channels: (1 = poor, 2 = fair, 3 = good, 4 = very good)
- Social media communication (e.g. blogs and wikis)
  - Personal webpages
  - Institutional repositories (e.g. UPSpace)
  - Disciplinary repositories
  - Media (newspapers and television)

Webinars/teleconferencing  
Conference posters  
Conference presentations  
Conference proceedings  
Multimedia channels (e.g. audio and video recordings)  
Journal articles  
Books

- (28) Please rate your skills regarding the following when disseminating research findings/information: (1 = poor, 2 = fair, 3 = good, 4 = very good)
- Selecting the most suitable channel for dissemination
  - Adapting content from one channel to another to accommodate various audiences
  - Acquiring the technical skills necessary to employ a specific channel for dissemination
  - Compiling a dissemination strategy to maximise visibility
  - Distinguishing between credible and fraudulent publishers
  - Specify any other challenges you experience when disseminating your research
- (29) Which of the following is applicable when sharing your research *data* with others? (1 = never, 2 = rarely, 3 = often, 4 = always)
- I share research data as follows:*
- By sharing it with selected researchers only
  - By depositing data in archives/repositories which are openly available to anyone
  - By providing research data as a supplement to an article published in a subscription-based journal
  - Specify any other ways in which you prefer to share research data

## MEASURING IMPACT

- (30) Please rate your knowledge with regard to the following as indicators of impact/influence: (1 = poor, 2 = fair, 3 = good, 4 = very good)
- Impact factors of journals and articles
  - Impact factors of researchers (e.g. H-index)
  - Impact statistics of research published on social media
  - Peer review processes
  - Ranking statistics of departments or institutions nationally/internationally
- (31) Please rate your skills regarding the following: (1 = poor, 2 = fair, 3 = good, 4 = very good)
- Performing citation searches to analyse the impact of an article on subscription-based databases (e.g. ISI, Scopus)
  - Performing citation searches to analyse the impact of an article on freely available websites (e.g. Google Scholar)

- (32) Please rate your skills with regard to establishing a personal online profile as a researcher: (1 = poor, 2 = fair, 3 = good, 4 = very good)
- Maintaining and updating a personal website
  - Creating profiles on social networks for academics (e.g. Academia, ResearchGate)
  - Creating profiles on Google Scholar Citations (GSC)
  - Utilising e-mail discussion forums/listservs
  - Utilising software which provides unique identifiers (e.g. ResearcherID, ORCID, ImpactStory.org)
  - Specify any other ways you prefer when establishing an online presence

THANK YOU FOR TAKING THE TIME TO COMPLETE THIS QUESTIONNAIRE.

## **ADDENDUM E: INTERVIEW SCHEDULE**

### **ENGINEERING RESEARCHERS: ADVANCED INFORMATION LITERACY (ARIL):**

#### **INTERVIEW SCHEDULE FOR FOCUS GROUP AND INDIVIDUAL INTERVIEWS**

The purpose of the focus group and individual interviews is to explore important issues which surfaced during the data analysis of the questionnaire, and to elicit responses from engineering researchers regarding the most critical information literacy skills required during their research activities from masters level onwards. In addition, participants will be asked to discuss any barriers and challenges they may be experiencing during the research process. They will also be asked to describe what they believe will become more important in the future regarding information literacy skills during the engineering research process specifically. These issues will also be explored via individual interviews in order to accommodate all researchers where necessary and to extract more detail on the subject.

The interviews will focus on typical processes during the research life cycle as identified in the literature analysis of the study, namely: identifying a researchable topic, obtaining research funding, discovering information, collecting and analysing data, organising information, managing information, curating data, creating research documents, managing intellectual rights, dissemination and sharing information, and measuring the impact of research findings in a specific field of research, as well as on the scholarly environment in which engineering researchers are conducting their research. Issues arising from the data analysis of the questionnaires will be added to the interview schedule as considered necessary.

The researcher will attempt to hold separate interviews for (1) masters and doctoral students, and (2) post-doctoral, established and expert researchers. During the focus group interviews participants will be asked to state whether they are involved with (first time) masters or doctoral studies or whether they already hold a doctoral degree.

The following questions will guide the focus group interviews:

1. What are the most *critical* information literacy skills that you need for your research...
  - a. at masters or doctoral level?

Or if you already hold a doctoral degree

b. at post-doctoral level or as an established or expert researcher?

2. Which barriers or challenges are you currently encountering as a researcher...

a. at masters or doctoral level?

Or if you already hold a doctoral degree

b. at post-doctoral level or as an established or expert researcher?

Depending on the responses, probing questions from the following list will be asked to stimulate discussion and to address issues considered important for the study (the selection of issues will depend on the time available and on the participants' responses).

**Probing questions:** Are there any specific barriers and challenges relevant to the following?

- Identifying a researchable topic
- Obtaining research funding
- Discovering information relevant to the research topic
- Collecting and analysing data
- Organising and managing information
- Curating data
- Creating research documents
- Managing intellectual rights
- Dissemination and sharing information, e.g. using open access resources (the intention is not to limit discussion to open access)
- Measuring the impact of research in a field
- Collaborating with other researchers
- Using virtual research environments (VREs)
- Planning a research career
- Conducting inter-disciplinary, multi-disciplinary and trans-disciplinary research

3. The literature also notes various other auxiliary skills associated with information literacy and/or research processes such as time management, project management, note-taking and budgeting.
  - a. Do you regard such skills as important in successfully conducting engineering research?
  - b. Are there other auxiliary skills that need to be addressed in an advanced research information literacy (ARIL) programme?
4. The next set of questions will, if necessary, follow up on findings obtained from the data generated from the questionnaire survey.
5. Are there any other issues relevant to the research topic of this study (“A framework for an advanced research information literacy (ARIL) programme for postgraduate researchers in engineering”) that you would like to bring to the attention of the researcher?

## **APPENDIX F: INVITATION TO PARTICIPATE IN A QUESTIONNAIRE SURVEY AND INFORMED CONSENT FORM**

ENGINEERING RESEARCHERS: ADVANCED RESEARCH INFORMATION  
LITERACY (ARIL):

### **INVITATION TO PARTICIPATE IN A QUESTIONNAIRE SURVEY AND INFORMED CONSENT FORM**

Dear Researcher

My name is Karien du Bruyn and I am a doctoral student in Information Science at the University of Pretoria. I would like to invite you to participate in my research study which aims to develop a framework which can serve as a guide for advanced research information literacy programmes designed specifically for engineering researchers.

If you participate you will be required to complete a questionnaire which is structured according to a typical research life cycle including the finer details of each component and information needs and information activities associated with each component.

I have obtained consent from the Faculty of [anonymous] Research Ethics Committee and heads of engineering departments to distribute this questionnaire. Your participation in this study is completely voluntary and you may withdraw at any stage. There are eight questions on demographic details and 31 questions on information-related activities. The questionnaire will take approximately 20 minutes to complete. All data provided by you will be treated as confidential, and your demographic data will not be linked to your answers.

After completion of the study, I will make an abbreviated copy of the suggested framework available to all participants on request. Please feel free to contact me if you would like more information regarding the project and the findings. If you decide to participate in this study, please complete the form below.

Thanking you in advance for your participation.



Ms Karien du Bruyn

Doctoral student: Department of Information Science  
University of Pretoria  
Email: kariendb@vut.ac.za  
Tel: (016) 950 9651  
Mobile: 076 183 5892

Supervisor Prof Ina Fourie Department of Information Science University of Pretoria Tel: (012) 420 5216 Email: ina.fourie@up.ac.za
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Please complete the following if you wish to take part in this study:

1. I .....hereby voluntarily grant my permission for participation in the project as explained to me by KARIEN DU BRUYN.
2. The nature, objective, possible safety and health implications have been explained to me and I understand them.
- 3 I understand my right to choose whether or not I want to participate in the study and that the information furnished will be handled confidentially.
4. I am aware of the fact that I can opt out of this study at any given time.
5. I am aware that the results of this investigation may be used for the purposes of publication in the form of a thesis, journal articles and conference proceedings.

**Month** (drop down menu)    **Day** (drop down menu)

Clicking here indicates that you confirm your voluntary participation and that you are aware of the abovementioned issues.

**ADDENDUM G: INFORMED CONSENT FORM FOR FOCUS GROUP AND INDIVIDUAL INTERVIEWS**

ENGINEERING RESEARCHERS: ADVANCED RESEARCH INFORMATION LITERACY (ARIL):

**INFORMED CONSENT FORM FOR FOCUS GROUP AND INDIVIDUAL INTERVIEWS**

1. I ..... hereby voluntarily grant my permission for participation in the project as explained to me by KARIEN DU BRUYN.
2. The nature, objective, possible safety and health implications have been explained to me and I understand them.
3. I understand my right to choose whether to participate in the project and that the information furnished will be handled confidentially.
4. I am aware of the fact that I can opt out of this study at any given time.
5. I am aware that results of this investigation may be used for the purposes of publication in the form of a thesis, journal articles and conference proceedings.
6. I agree to the focus group interview being audio-recorded  
Yes  No

Signed: \_\_\_\_\_ Date: \_\_\_\_\_

Witness: \_\_\_\_\_ Date: \_\_\_\_\_

Researcher: \_\_\_\_\_ Date: \_\_\_\_\_

## **ADDENDUM H: DEMOGRAPHIC INFORMATION FOR FOCUS GROUP AND INDIVIDUAL INTERVIEWS**

ENGINEERING RESEARCHERS: ADVANCED RESEARCH INFORMATION LITERACY (ARIL):

### DEMOGRAPHIC INFORMATION FOR FOCUS GROUP AND INDIVIDUAL INTERVIEWS

Please select the option(s) closest to the engineering field in which you are conducting research or supervising. You may select more than one option if applicable.

Chemical Engineering

Civil Engineering

Electrical, Electronic and Computer Engineering

Industrial and Systems Engineering

Material Science and Metallurgical Engineering

Mechanical and Aeronautical Engineering

Mining Engineering

Other, please specify

What is your highest qualification?

Honours

Masters

Doctorate

For how long have you had your highest qualification?

Less than 1 year

1-2 years

3-5 years

6-10 years

11-15 years

16-20 years

More than 20 years

If you are currently enrolled and doing a masters or doctoral study, please select the research stage closest to where you currently find yourself:

Idea generation and initial literature scanning

Proposal writing

Comprehensive literature analysis

Choice of research methods, research design and developing data collection instruments

Data collection, data analysis and interpretation of results

Editing and finalisation of dissertation/thesis

Publishing/disseminating results (e.g. articles, conference papers)

Other (please specify)

If you hold a doctoral degree, please indicate your National Research Foundation (NRF)<sup>8</sup> rating:

Not rated

Y-rated

P-rated

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<sup>8</sup> Ratings are according to the South African National Research Foundation (NRF) categories, namely: P/Y (young promising researcher – younger than 40), C (established researcher), B (internationally recognised researcher), and A (leading international researcher)

C-rated

B-rated

A-rated

What is your current position in your academic department?

Not a staff member

Research assistant

Junior lecturer

Lecturer

Senior lecturer

Associate professor

Full professor

Visiting professor

Post-doctoral appointee

Other (please specify)

What is your current involvement with post-graduate supervision of engineering researchers?  
(Please select all applicable options.)

Not supervising

Supervising masters' students

Supervising doctoral students

Supervising post-doctoral students

Are you currently collaborating with other researchers in order to produce new research findings? If yes, where are they located? (Please select all applicable options.)

No collaboration

In industry

At academic institutions

In government departments

Please specify other sources of collaboration

Did you complete the Advanced Research Information Literacy (ARIL) questionnaire?

Yes

No

## ADDENDUM I: DECLARATION OF INDEPENDENT CHECKER OF CODING

CHARLENE DOWNING

BA CUR, BA HONS, M CUR (CUM LAUDE), D CUR

16 August 2016

TO WHOM IT MAY CONCERN:

**Student Name:** Karien du Bruyn

**Student Number:** 11376351

I hereby confirm the following participation and involvement:  
in the PhD Thesis Title:

**A FRAMEWORK FOR AN ADVANCED RESEARCH INFORMATION LITERACY PROGRAMME  
(ARIL) FOR POSTGRADUATE RESEARCHERS IN ENGINEERING**

- acted as the independent coder of the original transcriptions of the individual interviews for the study; and
- attended and actively participated in a consensus discussion with the candidate re data saturation; synthesis and analysis of the sub-categories, categories and main themes of the study. The following key themes emerged from the data obtained in this study namely:
  - Ensuring a culture of quality towards postgraduate engineering research
  - Researchers progressing from dependent to independent researchers
  - Preparing for impact in a specific field of study

Name in full: Charlene Downing

Date: 16 August 2016

Signature: 