GUIDELINES FOR THE USABILITY EVALUATION OF A BI APPLICATION WITHIN A COAL MINING ORGANIZATION

by

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I hereby declare that this dissertation titled:

GUIDELINES FOR THE USABILITY EVALUATION OF A BI APPLICATION WITHIN A COAL MINING ORGANIZATION,

is my own work, and that all sources used or quoted in the study have been indicated and acknowledged by means of complete references.

Name: ____________________________ *Signature:* __________________________

Research Abstract

Business Intelligence (BI) applications are consulted by their users on a daily basis. BI information obtained assist users to make business decisions and allow for a deeper understanding of the business and its driving forces. In a mining environment companies need to derive maximum benefit from BI applications, therefore these applications need to be used optimally. Optimal use depends on various factors including the usability of the product. The documented lack of usability evaluation guidelines provides the rationale for this study. The purpose is to investigate the usability evaluation of BI applications in the context of a coal mining organization. The research is guided by the question: What guidelines should be used to evaluate the usability of BI applications. The research design included the identification of BI usability issues based on the observation of BI users at the coal mining organization. The usability criteria extracted from the usability issues were compared and then merged with general usability criteria from literature to form an initial set of BI usability evaluation criteria. These criteria were used as the basis for a heuristic evaluation of the BI application used at the coal mining organization. The same application was also evaluated using the Software Usability Measurement Inventory (SUMI) standardised questionnaire. The results from the two evaluations were triangulated to provide a refined set of criteria. The main contribution of the study is the heuristic evaluation guidelines for BI applications (based on these criteria). These guidelines are grouped in the following functional areas: visibility, flexibility, cognition, application behaviour, error control and help, affect and BI elements.

Keywords: Heuristic evaluation, usability evaluation, BI usability, Business Intelligence Systems, decision support usability, usability evaluation methods, usability evaluation guidelines, usability evaluation criteria.

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List of Abbreviations and Acronyms

Acronym	**Meaning**
BI	BI
BIS	BI Systems
BPMF	Business Performance Management Forum
BSC	Balance Scorecard
CDIB	Comprehension Degree to Implementer's Business
CEO	Chief Executive Officer
CPMS	Corporate Performance Management Systems
CR	Conformity to the Requirement
CRM	Customer Relationship Management
CSE	Computer Self Efficacy
DSS	Decision Support Systems
DW	Data Warehouse
EDP	Enterprise Development Planning
EIS	Executive Information Systems
ERP	Enterprise Resource Planning
ETL	Extract, Transform, Load
FBIS	Functions of BI System
GSS	Group Support Systems
HCI	Human-Computer Interaction
HE	Heuristic evaluation
HFRG	Human Factors Research Group
HTML	Hyper Text Mark-up Language
ID	Interaction Design
IDSS	Intelligent Decision Support Systems
IEC	International Electro-technical Commission
IEC	Implementing Experiences of Consultant

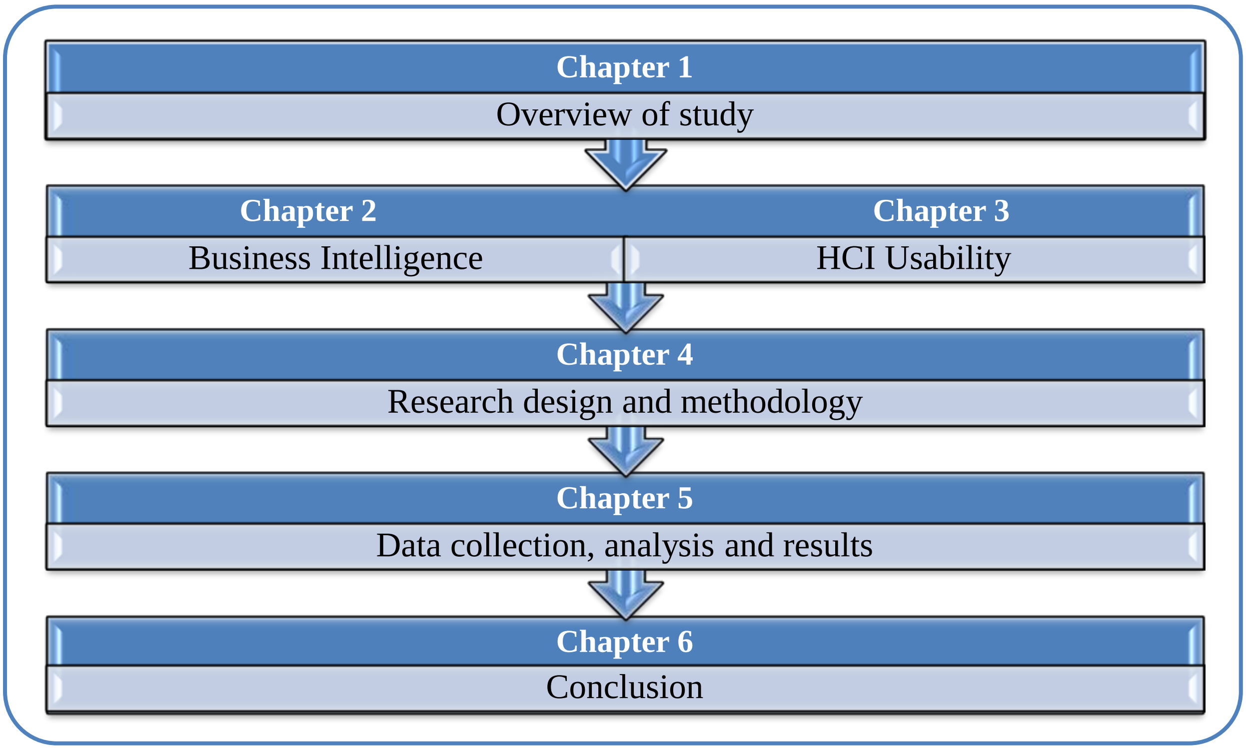
Abbreviations and Acronyms (continued)

Acronym	Meaning
IS	Information Systems
ISO	International Organization for Standardisation
IT	Information Technology
JIT	Just In Time
KMDSS	Knowledge Management-Based DSS
KPI	Key Performance Indicators
MER	Meeting Enterprise Requirements
MIS	Management Information Systems
MOLAP	Multidimensional Online Analytical Processing
MUMMS	Measuring the Usability of Multi-Media Systems
MUN	Meeting Users Needs
NSS	Negotiation Support Systems
OIA	Output Information Accuracy
OLAP	OnLine Analysis Processing
PDSS	Personal Decision Support Systems
PEOU	Perceived Ease Of Use
QUIS	Questionnaire for User Interface Satisfaction
ROLAP	Relational Online Analytical Processing
SC	Supply Chain
SCM	Supply Chain Management
SDM	Support in Decision-Making in organization
SDUH	Support Degree of Users and High management level
SIA	Service and Integration Ability
SOE	Support of Organizational Efficiency
SRT	System Response Time

Abbreviations and Acronyms (continued)

Acronym	Meaning
SS	System Security
SUMI	Software Usability Measuring Inventory
SUS	System Usability Scale
UE	Usability Engineering
UE	Usability Evaluation
UER	Usability Evaluation Reporting
UFOS	Usability Questionnaire for Online Shops
UI	User Interface
UP	Usability Problem
UPA	Usability Problem Analysis
US	User Satisfaction
WAMMI	Website Analysis and Measurement Inventory

Chapter Arrangement



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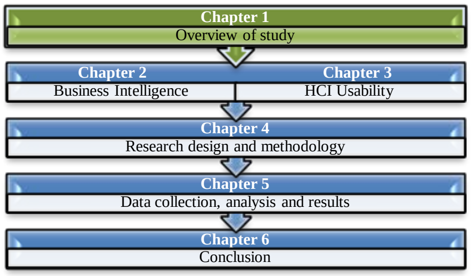


Chapter 1: OVERVIEW OF STUDY

1.1 INTRODUCTION TO THE STUDY

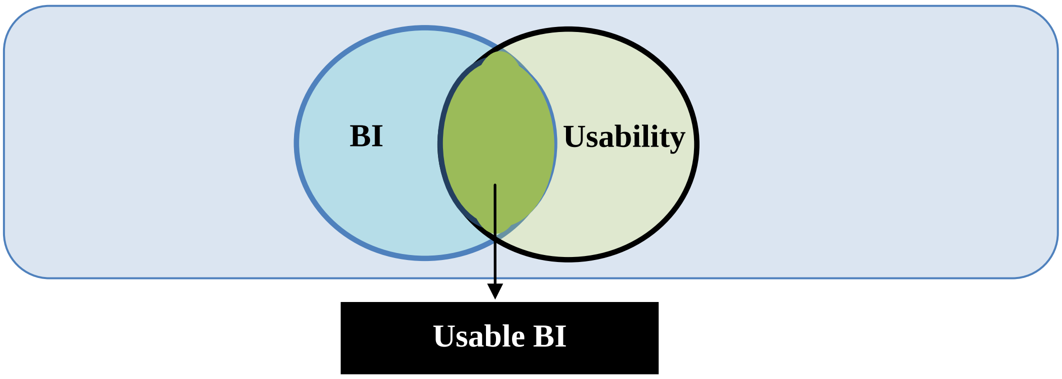
Many organizations implement BI solutions to improve their decision-making process (Isik, Jones, & Sidorova, 2011, Hou, 2012). Other benefits that can be derived from the use of BI applications include faster and easier access to information, savings in information technology (IT), greater customer satisfaction and improved competitiveness of enterprises (Hočevar & Jaklič, 2010). Usability attributes such as end-user satisfaction and application usage have been recognised by researchers as critical determinants of the success of information systems (Isik et al., 2011, Hou, 2012). However, there is still a limited amount of empirical research that explores the nature of end user satisfaction with BI applications (Hou, 2012) and other critical success factors of BI systems (Isik et al., 2011). This chapter presents the rationale behind the study and the motivation to conduct the research. Furthermore, it provides background information to contextualise the study and the problem statement together with the study aim and study objectives. The philosophical view to be assumed during the research process and the significance of the study are also discussed. The chapter will be concluded with a graphical representation of the chapter arrangement of the study.

1.2 RATIONALE

People at various levels in an organization such as Anglo American, use BI on a daily basis. (Coronel, Morris, & Rob, 2011) define BI as an effective data warehouse and a reactive component capable of monitoring the time-critical operational processes to allow tactical and operational decision-makers to tune their actions according to the company strategy.

BI applications are consulted in order to obtain information that assists business users with a multitude of tasks, including enabling effective business performance (Cupoli, Devlin, Ng , & Petschulat , 2012).

In the current era of abundant data, it is accepted as implicit that data-driven decisions are the norm (Rouhani, Ghanzanfari, & Jafari, 2012). However, a survey of corporate decision-makers, conducted by the Business Performance Management (BPM) Forum, indicated that only 26% of organizations included had a well-established, formal process for making decisions (Lamont, 2007). Only 40% of respondents had a high level of confidence in their organization's current process for making decisions, while 14% of survey respondents reported turning to a technology solution such as planning, forecasting, reporting analysis, scorecarding or dashboarding (Lamont, 2007). Therefore, for a Decision Support System to be successful, managerial decision-making is critically dependent upon the availability of integrated, high quality information organised and presented in a timely and easily understood manner (Chen, Chiang, & Storey, 2012, Ömerali, 2012, March & Hevner, 2007). Figure 1.1 presents a visual representation of the conceptualisation of the study.



Decisions based on BI information impact the choices made in the organization, therefore it could be argued that a more usable information system would assist with the ease of decision-making, and additionally enhance the quality of decisions made.

Figure 1.1 Conceptualization of the study

BI is an acknowledged element in the success of many businesses, but little research is available on *the usability of BI applications and the evaluation thereof*, in order to determine to what extent usability principles enable optimal use and therefore optimal, confident decision-making, which in turn leads to value added to the bottom line. The rationale behind this study is that the BI application should be *usable* to render optimal results. Consequently, we are confronted with the dilemma of what exactly is BI application *usability*. This focuses our attention on the human element where human-computer interaction (HCI) occurs.

1.3 BACKGROUND

Management Information Systems (MIS) and Executive Information Systems (EIS) were developed in the middle 80's (refer to Section 2.2 for definitions of these terms), as a result the approach to business management across the entire globe has changed dramatically (Matei, 2010). Firms understand the importance of enforcing achievement of the goals defined by their strategy through metrics-driven management (KPI's) (Lutsch, 2011). In the twenty-first century, organizations are evolving into new forms, based on knowledge and networks, this is in response to an environment characterised by unclear organizational boundaries and fast-paced change (Sahay & Ranjan, 2008). In short, the BI system provides high-level and low-level reconnaissance of the data landscape, for the purpose of decision making in a competitive environment.

In a supply chain environment such as found at Anglo American (where the survey and observation for the study were conducted), managers and lower level end-users rely heavily on BI to provide information for carrying out their jobs to the best of their abilities. In the current economically challenging mining industry, users need to be equipped with up to date, accurate information to be able to manage (value, supplier and operational) performance according to KPI targets. Human-computer interaction (HCI) within electronic spaces is of central importance in modern BI (Geczy, Izumi, Akaho, & Hasida, 2007); hence the need for HCI usability within the supply chain's BI.

In this study the term *supply chain management* (SCM) is considered as defined in the APICS dictionary as the design, planning, execution, control, and monitoring of supply chain activities with the objective of creating net value, building a competitive infrastructure, leveraging worldwide logistics, synchronising supply with demand and measuring performance globally.

The term *performance* is viewed as performance across the board, which is with regards to managers, users, subordinates, inventory, benefits and all other supply chain elements that are target driven. The BI application is consulted by supply chain users to determine (user, colliery or supplier) performance against key performance indicator (KPI) targets, thereby allowing management to strategize, for example: to monitor supplier spend, to identify inventory movement and inventory trends.

In the context of Anglo American Thermal Coal as a mining organization, Anglo American (AA) protects information and information systems by establishing documented control objectives (Anglo American Global Information Management, 2010). Information is provided according to the correct classification for each user within the information system. Information system users consult a BI application called Cognos Upfront (IBM, 2012) to gather information relevant to their jobs. This BI system collates transactional data from the various Enterprise Resource Planning (ERP) site instances (11 collieries) into a consolidated data repository. Cognos within Thermal Coal supply chain will be discussed in more detail in Chapter 2, where the topic of BI is explored.

1.4 PROBLEM STATEMENT

Appropriate usability criteria for BI applications could not be found from the literature review conducted. Literature searches were conducted by the researcher, as well as the university librarian, but yielded little BI usability information. Sources consulted to find relevant research concerning BI usability included: Scopus, ScienceDirect, Techno-link, ACM Digital Library, JStor, Scitopia and SpringerLink. For this reason, the evaluation of BI applications for usability purposes emerged as a gap in the literature (in other words under-theorised) and worthy of investigation. Recent research focussing on important BI criteria does not identify BI's usability as such a criteria (Rouhani et al., 2012, Chaudhuri, Dayal, & Narasayya, 2011).

Thus the need for BI application usability criteria is evident. Subsequently the focus of this research is: the identification of usability criteria for the evaluation of BI applications in a coal mining organization. These criteria can then be used as the basis for usability evaluation guidelines of BI applications in similar contexts.

Therefore, the problem statement of the study is formulated as: **There are no clear guidelines on how the usability of BI applications used for decision-making in a mining organization should be evaluated.**

1.5 AIM OF THE STUDY

The aim of this study is to propose guidelines for the usability evaluation of BI applications within a coal mining organization. This entails firstly, to investigate which formally accepted usability principles are core to usability, and secondly, which usability attributes are required by BI application users for the BI application to be regarded as *usable* by the users. This study then aims to derive the criteria for a usable BI application, and develop a set of usability guidelines (based on the identified criteria) for the purpose of the HE of BI applications.

The aim of this research is achievable by means of answering the following research questions:

- RQ1: Which usability principles form the core of usability criteria?
- RQ2: What are the user requirements regarding the usability of BI applications?
- RQ3: What are the criteria for usable BI applications?
- RQ4: What are the HE guidelines (based on the usability criteria) by which to evaluate the usability of BI applications in a (mining) organization?

These research questions provide direction as to the required objectives to achieve the overall aim of the study. These research objectives are presented in Section 1.6.

1.6 OBJECTIVES OF THE STUDY

Upon identification and formulation of the research problem, aim and respective questions, the objectives of this research are formalised as the following:

- RO1: Identify usability principles that form the core of usability criteria.
- RO2: Identify the user requirements regarding the usability of BI applications.
- RO3: Identify criteria for usable BI applications.
- RO4: Develop usability guidelines (based on the usability criteria) to evaluate the usability of BI applications in a (mining) organization.

1.7 RESEARCH DESIGN

Theoretical assumptions are useful in directing research decisions (Chinn & Kramer, 1995, Mouton & Marais, 1996). Consequently, a research study requires a philosophical view, in this study a pragmatic perspective was adopted (Plano Clark & Creswell, 2008); this is a collection of linked concepts and propositions that provide a theoretical perspective or orientation, which guide the research approach to a particular topic (Ulin, Robinson, & Tolley, 2002). A pragmatic philosophical view will be employed in order to investigate user requirements for the usability of BI applications in the context of their working environment (Creswell, 2009).

The research design will include the identification of BI usability issues based on the observation of BI users at the coal mining organization. The usability criteria extracted from the usability issues will be compared and then merged with general usability criteria from literature to form an initial set of BI usability evaluation criteria. These criteria will be used as the basis for a HE of the BI application used at the coal mining organization. The same BI application will also be evaluated using the Software Usability Measurement Inventory (SUMI) standardised questionnaire. The results from the two evaluations will be triangulated to provide a refined set of criteria. The main contribution of the study will be the usability evaluation guidelines for BI applications in a coal mining organization (based on these criteria). The research design together with the methodology followed will be the focus of Chapter 4.

1.8 RESEARCH PROCESS FLOW

The research process flow is presented in Figure 1.2. This diagram illustrates the sequence of sub-processes within the study.

- Process 1 is dedicated to the *literature review* on the subjects of BI and HCI (usability).
- Process 2 is dedicated to the *observation* of BI users within their natural working setting (while making use of the Cognos7 Upfront BI application).
- Process 3 is dedicated to the comparison, integration and synthesis of the usability principles identified from the literature in process 1. A *set of core usability principles* was extracted as output from this process.

- Process 4 is dedicated to the compilation of *synthesised usability issues* from the BI user observations in process 2 (refer to the annexure F).

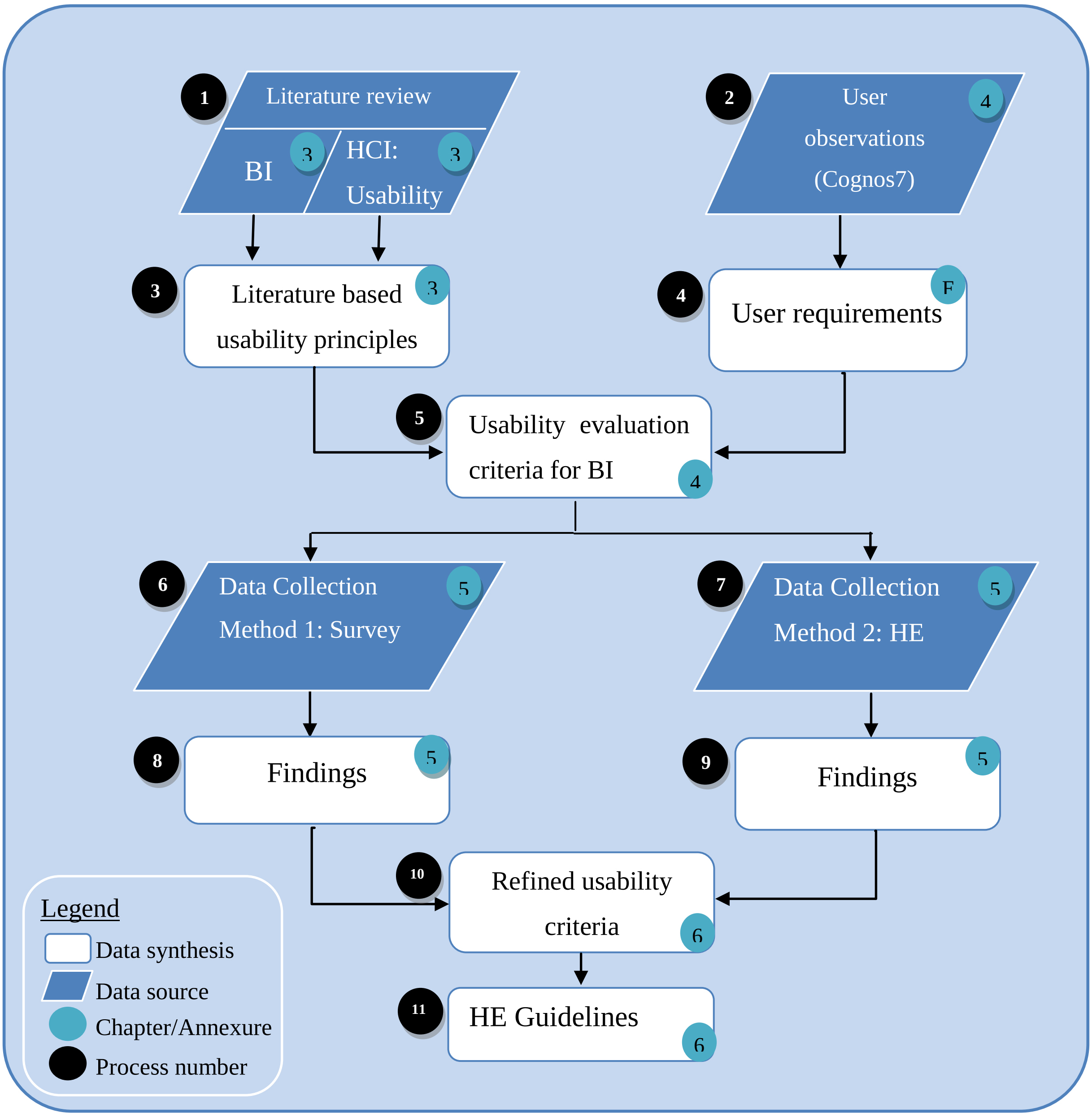


Figure 1.2 Research design process flow

- Process 5 is dedicated to the comparison and *synthesis* of the core usability criteria identified from literature (*process 3*) with the BI user usability issues (*process 4*) to form an initial set of BI usability evaluation criteria.
- Process 6 is dedicated to a *survey* to evaluate the same BI application (Cognos7 Upfront), using the Software Usability Measurement Inventory (SUMI) standardised questionnaire (data collection method 1).

- Process 7 is dedicated to the execution of a HE by usability experts on the same BI application (Cognos7 Upfront). The criteria identified by process 5 were used as the basis for a HE (data collection method 2) of the BI application used at the coal mining organization.
- Process 8 and process 9 involves the compilation of findings from the results obtained from process 6 and process 7.
- Process 10 triangulated the results from the two evaluations (process 6 and process 7) to produce a refined set of criteria.
- Process 11 concerns the main contribution of the study, which is the compilation of a set of HE usability guidelines for BI applications based on the refined set of criteria produced in process 10.

1.9 CONCEPTS, SCOPE AND LIMITATIONS

In this section assumptions made during the study will be outlined, the main concepts of the study clarified, and the scope of the study and the limitations of the study will be defined.

1.9.1 Definition of main concepts.

Based on the literature reviewed and presented in Chapter 2 and Chapter 3 the following synthesised working definitions are selected for HCI and BI for the purpose of the study.

- *Human-Computer Interaction*: Karahoca & Karahoca (2009) define *Human-Computer Interaction (HCI)* as an interdisciplinary field of science focused on the interaction of people and systems and the way they influence each other. For a more comprehensive discussion on HCI refer to Section 3.2.

- *Usability:* ‘Usability’ is the effectiveness, efficiency, and satisfaction with which users of an application are able to achieve specific goals (ISO 9241-11, 1998) Section 3.3 discusses the definitions of usability in more detail together with elaborations on this definition.

- *BI*: *BI* is a set of advanced decision support systems that allows for tactical and operational decision-makers to tune their actions according to the company strategy. (Lin, Tsai, & Shiang, 2009, Baars, Kemper, Lasi, & Siegel, 2008, Microsoft, 2009).

This study focuses specifically on the front-end user interface where interaction with end users takes place. Section 2.3 provides a synopsis of BI definitions.

- *Cognos7 Upfront*: Cognos7 Upfront is a BI application, intended for use by end users. Data is collected from distributed sources and the end product of the data presented in this environment. In this system users can view reports and multi-dimensional cubes, create customised views on the cubes, share the cubes with other users for management purposes (IBM, 2012, COGNOS (IBM), 2012).

- *Supply chain management*: Supply chain management is defined as the design, planning, execution, control, and monitoring of supply chain activities with the objective of creating net value, building a competitive infrastructure, leveraging worldwide logistics, synchronising supply with demand and measuring performance globally (APICS, 2012).

- *Context*: Context refers to an environment or region surrounding a particular place, the context or setting, structures and conditions within which an organism operates or a system which enables a person to operate (Brown, 1996). In this study the context refers to the front-end end-user usage of a BI application within a coal mining environment.

- *Usability principles:* Usability principles refer to those principles proposed and accepted in an end-user system environment. The usability principles of the leaders in the field of usability such as Nielsen, Dix and Tognazzini are used as the basis of discussions. Refer to Section 3.5.1 for more detail.

- *User requirements:* User requirements refer to the usability requirements of the end-users of the BI application, called Cognos Upfront.

- *Criteria:* Criteria refer to the plural of criterion, which in this context may be regarded as a principle or a standard by which something may be evaluated or decided.

- *Guidelines:* Guidelines refer to proposed measure of compliance, lower in authority and more general in application (Dix, Finlay, Abowd, & Beale, 2004).

- *Heuristic evaluation (HE):* HE is a popular inspection method that involves few experts inspecting the system, and evaluating the interface against a list of recognised usability principles: the heuristics (De Kock, Van Biljon, & Pretorius, 2009).

1.9.2 Scope of the study

The scope of this study is limited to the usability evaluation of Cognos7 Upfront as the selected BI application, using two concurrent usability methods of evaluation within the context defined in Section 1.9.1. Note that coal mining is the application context, not the research context and therefore any investigation into the coal mining context is beyond the scope of this study. Furthermore, the BI usability guidelines were developed for a coal mining organization but they can be used as a basis for BI guideline development in a wider context.

1.9.3 Limitations of the study

The research was conducted within the operational constraints of the organization. This means that users could not leave the work site to attend usability evaluation tests in a usability laboratory, subsequently the research design had to accommodate this constraint. The research was limited to the Thermal Coal business unit which includes 11 (eleven) collieries.

The usability guidelines of Nielsen, Dix and Tognazzini are assumed as comprehensive enough to form a basis for the BI usability guidelines after the usability elements from Dix et al. (2004), Gebus & Leivisk (2009), Tabachneck-Schijf & Geenen (2009), Gould & Lewis (1985), Nielsen (1993), and Norman (1990). Later Rogers, Sharp, & Preece (2012), Tullis & Albert (2008) and Scott & Walczak (2009) were compared with this set of usability guidelines from literature and found to have the same core concepts.

Cognos7 was selected as it is currently employed as the BI application for decision-making purposes in the researcher's organization. The fact that the study was based on only one case within a coal mining organization limits the applicability to other BI applications. However, the business unit studied was comprehensive and the study provides usability evaluation guidelines that can be used as a basis for further refinement and verification in other BI contexts.

1.10 SIGNIFICANCE OF THE STUDY

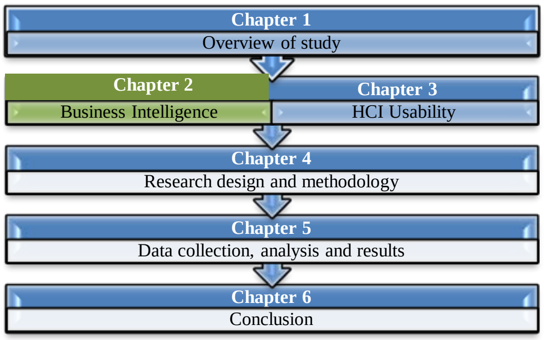
The results of this study will contribute both to the understanding of the requirements of BI usability and the improvement of BI usability. The HE instrument developed should assist in the usability evaluation specifically for BI applications and the usability evaluation guidelines developed from the study findings should assist in the overall assessment of usability within BI applications.

1.11 CHAPTER SUMMARY

This chapter introduced the study, and provided background to the research problem. The problem identified is that currently there are no clear guidelines on how the usability of BI applications should be evaluated. Research questions and associated objectives were presented to address this problem. The study's process flow was presented which illustrated the sequence of the research processes. In the Chapter 2 BI will be explored as per Figure 1.2, Process 1, since this study is concerned with the *usability* of *BI* applications.

End of Chapter 1

Document Map



Chapter 2: Business Intelligence

Figure 2.1 Composition of Chapter 2

2.1 INTRODUCTION

In the current age of globalization, emerging markets, rapid change, and increased regulation BI is employed as a tool to support business decision-making (Coronel, et al., 2011). This chapter serves the purpose of introducing BI as the first of the two focus areas of this study. Literature will be reviewed to gain an understanding of BI to compile a conceptual framework for the study. Firstly the context for BI, Decision Support Systems (DSS) is briefly discussed. BI is then defined and investigated in terms of its (BI's) purpose, components and requirements, this is followed by sections on the assessment of BI, challenges faced within BI, BI within Supply Chain; and finally, the value of BI with regards to decision-making and its future within Supply Chain.

2.2 BI WITHIN THE CONTEXT OF DECISION SUPPORT SYSTEMS

DSS a heterogeneous field, with a number of distinct sub-fields, the history of DSS revealed the evolution of a number of sub-groupings of research and practice (Arnott & Pervan, 2008).

Table 2.1 Decision Support System sub-fields (Nelson, et al., 2005)

DSS Sub-field	Definition
Personal Decision Support Systems (PDSS)	Usually small-scale systems developed for one manager, or a small number of independent managers, to support a decision task.
Group Support Systems (GSS)	A combination of communication and DSS technologies used to facilitate the effective working of groups.
Negotiation Support Systems (NSS)	A DSS where the primary focus of the group work was negotiation between opposing parties.
Intelligent Decision Support Systems (IDSS)	The application of artificial intelligence techniques to decision support.
Knowledge Management-Based DSS (KMDSS)	Systems that support decision-making by aiding knowledge storage, retrieval, transfer and application by supporting individual and organizational memory and inter-group knowledge access.
Data Warehousing (DW)	Systems that provide the large-scale data infrastructure for decision support.
Enterprise Reporting and Analysis Systems	Enterprise focused DSS including executive information systems (EIS), BI, and more recently, corporate performance management systems (CPM). BI tools access and analyse data warehouse information using predefined reporting software, query tools, and analysis tools.

The emphasis in industries has shifted from being focussed on management of internal business and transactional data-to-data analysis and rapid business decision-making based on huge volumes of information (Chen, et al., 2012). Nelson, Todd, & Wixom (2005) highlight the major DSS sub-fields as depicted in Table 2.1. Considering the relationship between BI and DSS, Nelson, et al., (2005) places BI within the Enterprise Reporting and Analysis System subfield of DSS (refer to Table 2.1).

The opportunities associated with data and analysis thereof (refer to Section 2.10) have helped to generate significant interest in BI, which is often referred to as the techniques, technologies, systems, practices, methodologies, and applications that analyse critical business data to help an enterprise better understand its business and market and make timely business decisions (Chen, et al., 2012).

In order to contextualise the study, the BI tool employed as BI decision support in the study environment is Cognos7 Upfront (refer to Section 1.9.1 and Section 2.5.5) for more detail.

2.2.1 Definition of Decision Support Systems

Decision Support Systems (DSS) were developed to support the decision-making process (Coronel, et al., 2011). DSS can be defined as support for and improvement of managerial decision-making by means of collecting, storing and managing data to generate information for the sake of decision-making (Zuo & Panda , 2008, Coronel, et al., 2011). DSS has also been a major area of IT focus; decisions made using IT-based decision support can have a considerable effect on the nature and performance of an organization (Arnott & Pervan, 2008).

2.2.2 Background to Decision Support Systems

Decision support systems began in the 1960's and developed throughout the mid-80's (Cupoli, et al., 2012). Decision-making in organizations is based on a complex mix of rational and intuitive thinking (Lamont, 2007). Enterprises, after having invested a lot of time and resources to build large and complex information systems, ask for support in obtaining quick summary information which may help managers in planning and decision-making (Golfarelli, Maniezzo, & Rizzi, 2004). Data must be gathered, transformed into information, and compared against targets, thus enabling their evaluation and completing the management cycle (March & Hevner, 2007). Even with data being readily available, organizations find it difficult to make decisions in which they are confident (Lamont, 2007). March & Hevner (2007) argue that profit maximization, the general economic goal of a business, does not occur spontaneously. This is relevant as decision support systems should be utilised for profit maximization. In an interview Lamont had with Mychelle Mollot (Vice President of Market strategy and Strategic communications at Cognos), Mollot remarked that despite the availability of data, many organizations were information-rich and insight-poor (Lamont, 2007).

Optimal decision-making requires true systems integration, focused on the seamless network of data fusion, data filtering and ultimately resulting into a managed information flow that entails information-rich situational awareness (i.e. integration built around users' needs, the task environment, and system's characteristics) (Véronneau & Cimon, 2007). Unexpected results may eventually affect the ability to decide and react in a timely and efficient manner adversely. Therefore, true systems integration comes as an enabler of efficacious decision-making (Véronneau & Cimon, 2007).

Therefore, for a Decision Support System to be successful, managerial decision-making is critically dependent upon the availability of integrated, high quality information organised and presented in a timely and easily understood manner. Measurable standards must be established against which the performance of each process can be evaluated (March & Hevner, 2007). To cut costs, streamline operations, and fuel continual process improvements, employees must be empowered to make better decisions at every level in the organization (Microsoft, 2009).

Hence, it is in this context of DSS that BI as management support tool becomes important. The rest of this chapter will discuss the concept of BI, and how BI can support decision-making in supply management systems.

2.3 DEFINITION OF BI

A BI system is a form of decision support system (DSS) (Cupoli, et al. 2012). Lin, et al., (2009) defines BI as the tool used by enterprises to collect, manage and analyse structural and non-structural data and information by taking advantage of modern IT. BI is also a collection of best practices and software tools developed to support business decision-making (Coronel, et al., 2011). BI is an analysis mechanism by which automated decision-making regarding business status, sales analysis, customer demand, product preference can be provided for enterprises through large database system analysis as well as mathematical, statistical, artificial intelligence, data mining and online analysis processing (OLAP) (Lin, et al., 2009).

The term BI denotes integrated infrastructures for management support (Sims, 2011). Such infrastructures currently encompass components for data transformation (ETL – Extract, Transform, Load), data storage (data warehouses, data marts, and/or operational data stores), and for data analysis (Baars, et al., 2008, Choy, Lee, Lau, Lu, & Lo, 2004). Baars, et al., (2008) concurs with Choy et al., (2004) on the inclusion of reporting platforms, Online Analytical Processing (OLAP) solutions for a multidimensional navigation in data, and 'data mining', also called pattern recognition tools. Vural, Sengül, Davis, & Günther, 2008 is in agreement with Baars, et al. (2008) and Choy et al. (2004) that BI systems typically support querying, reporting, and multidimensional analysis of company data. BI could be considered a performance management framework that helps companies set their goals, analyse their progress, gain insight, take action, and measure their success (Golfarelli, et al., 2004, March & Hevner, 2007, Sims, 2011).

BI includes an effective data warehouse and also a reactive component capable of monitoring the time-critical operational processes to allow tactical and operational decision-makers to tune their actions according to the company strategy (Golfarelli, et al., 2004, Microsoft, 2009). This definition aligns with the Sahay & Ranjan (2008) definition that a BI system is a combination of data warehousing and decision support systems. (Gangadharan & Swamy, 2004) define BI as the result of in-depth analysis of detailed business data, including database and application technologies, as well as analysis practices. They argue that BI potentially encompasses knowledge management, enterprise resource planning, decision support systems and data mining. Their (Gangadharan & Swamy, 2004) summary definition of BI is the use of technology to collect and effectively use information to improve business potency.

According to Sahay & Ranjan (2008) experts view BI in different ways:

- Data warehousing experts view BI as supplementary systems. These experts treat BI as a technology platform for decision support applications.

- To data mining experts BI is a set of advanced decision support systems with data mining techniques and applications of algorithms.
- To statisticians BI is viewed as a forecasting and multidimensional analysis tool.

In summary Cupoli, et al., (2012) define BI in two discrete ways. *Firstly*, as encompassing all architecture, technologies and methodologies used to support business decision-making; and *secondly*, presenting BI as the user-facing application layer on top. The user-facing application layer is of interest in this study, since this is where supply chain decisions are made, based on the human-computer interaction that occurs.

Figure 2.2 adapted from (Manh, Schiefer, & Min, 2005) depicts the various components of BI. The picture originally showed the various elements of BI, however this study would like to emphasise the research focus, to be precise the interaction of the end user with the system. It is at this point of contact with the BI application where communication and exchange of information occurs, that the value of the BI system is extracted, and user insight occurs.

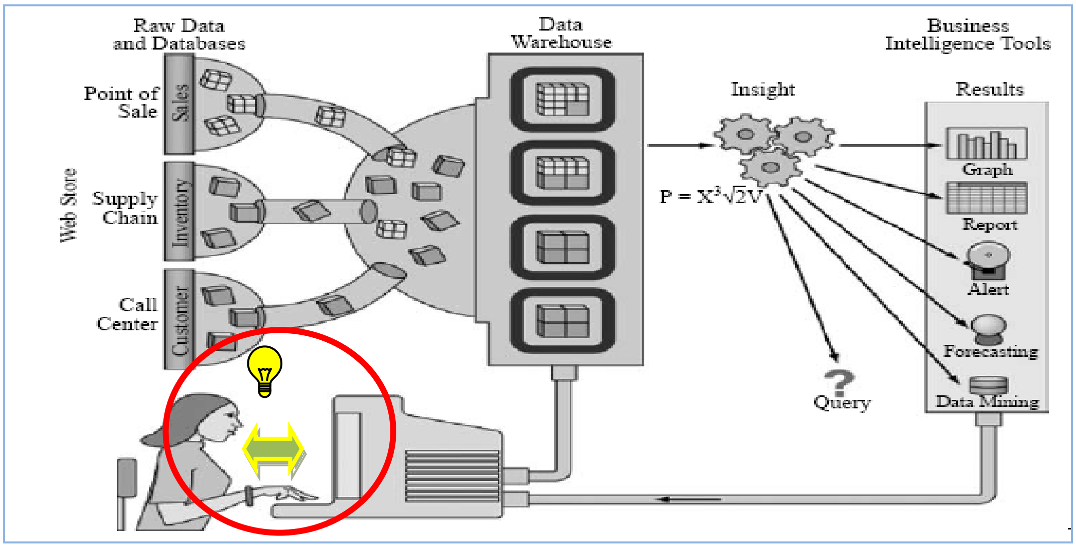


Figure 2.2 Human-BI interaction focus of the study adapted from Manh, et al., (2005)

An ideal BI system gives an organization's employees, partners, and suppliers easy access to the information they need to effectively do their jobs, and the ability to analyse and easily share information and insights with others (Gangadharan & Swamy, 2004, Microsoft, 2009). Therefore to reiterate the rationale as part of this study is that the BI application should be usable to enable optimal decision-making in Supply Chain management systems (SCMS).

Based on the literature presented in Section 2.2 and Section 2.3 the following working definition is selected for the purpose of the study: BI is a set of advanced decision support systems that allows tactical and operational decision-makers to direct their actions according to the company strategy. Thereby establishing a performance management framework that helps companies set their goals, analyse their progress, gain insight, take action, and measure their success. The focus of this research is on the user interface where interaction with end-users takes place.

2.4 PURPOSE OF BI

Managing an enterprise requires access to information and efficient data management in order to monitor activities and assess performance of various business processes (Sahay & Ranjan, 2008). As the business and economic environment is becoming more and more dynamic, businesses need to respond to changes in real time, the nature of the business needs to be taken into consideration as well as what actions can businesses take to predict and prepare for change (Microsoft, 2009). To compete in the rigorous corporate environment, the advancement in electronics has enabled business to deploy BI systems for the purpose of decision-making (Lin, et al., 2009).

To accomplish this, it is necessary to have a system for establishing the status of a business at any moment in time in relation to its performance objectives (Sahay & Ranjan, 2008). However, most people waste a lot of time searching for information (Corcoran, 2007) and BI systems might not be able to make decisions based on the information, but can present users with organised, analysed data (Sahay & Ranjan, 2008).

The purpose of BI therefore is to provide users with the best possible assistance in the process of decision-making (Lin, et al., 2009). BI can thus be considered a performance management framework that helps companies set their goals, analyse their progress, gain insight, take action, and measure their success.

Delivering the right information to the right person at the right time is important (Bak, 2008, Microsoft, 2009). To make informed decisions an integrated view of management requires that each unit not only function efficiently and effectively within, but also understand how its activities and decisions affect the functions of other units (Chang, Cheung, Cheng, & Yeung, 2008). Data visibility and collaboration is made easier for geographically distributed branches of an organization (Omerali, 2012). Thereby connecting information systems that have been developed in an ad-hoc manner; and preventing islands of information in the organization (Chang, et al., 2008).

(Bak, 2008) agrees with (Mulani, 2008) and March & Hevner (2007) that a vast amount of data (of enterprises) are input into data mining systems for data analysis so that decision-makers can obtain useful information promptly for making correct judgment; that is, in regard to enterprise operating contents, abilities of fast understanding and deducing are provided, and thus enhancing the quality of decision-making and improving performance and expediting processing speed.

The main functions of BI are summarized by Lin, et al., (2009) as:

- Acquiring standardised data elements and changing process to ensure the quality of data acquired.
- Integrating all strategic objectives within the organization.
- Designing strategic map and transmitting important corporate value.

BI tools are widely accepted as a new middleware between transactional applications and decision support applications, thereby decoupling systems tailored to an efficient *handling* of *business transactions* (that is the traditional ERP's) from systems tailored to an efficient *support of business decisions* (such as Cognos7 in this study). BI allow for easy on-going tracking and monitoring of key metrics, without the cumbersome, and often prohibitive, effort to collect the data (Mulani, 2008). Information is provided that enables managers to identify situations requiring action and to understand the situation and its causes. It enables a manager to locate and apply relevant organizational (experience-based) knowledge and to predict and measure the impact of a decision over time (March & Hevner, 2007). BI can help you improve organizational performance by meeting your company's individual, organizational, and IT information and analytical needs (Microsoft, 2009).

To summarise, the purpose of BI includes: decision support, statistical analysis, forecasting, data mining and business management (Baars, et al., 2008, Gangadharan & Swamy, 2004, Lin, et al. 2009, Sahay & Ranjan, 2008).

2.5 COMPONENTS OF BI

From the functions mentioned in Section 2.4 it follows that BI covers a wide range of tools and scope, and among the commonly mentioned important applications are data warehouse, data mining, OLAP, decision support system (DSS), balance scorecard (BSC) (Chaudhuri, et al., 2011, Lin, et al., 2009). Section 2.5.1 to Section 2.5.4 discuss the basic components of BI such as: data sources, data marts, query and reporting tools, data storage and analysing tools as well as the BI application evaluated in this study.

Traditional BI systems consist of a back-end database, a front-end-user interface, software that processes the information to produce the BI itself, and a reporting system (Sahay & Ranjan, 2008). The data warehouse extracts data from multiple sources such as operational databases as well as from external sources, thereby providing a more comprehensive data pool (Coronel, et al., 2011). A key role of the data warehouse is to provide compelling BI to the decision-maker facilitating an understanding of business problems, opportunities, and performance. It must incorporate internal and external knowledge acquired over time and adapt it to current business conditions (March & Hevner, 2007). The data warehouse supports the physical propagation of data by handling the numerous enterprise records for integration, cleansing, aggregation and query tasks. It can also contain the operational data which can be defined as an updateable set of integrated data used for enterprise wide tactical decision-making of a particular subject area. It contains live data, not snapshots, and retains minimal history (Sahay & Ranjan, 2008).

It is important to differentiate between a data warehouse, a repository for integrated data, and data warehousing, the development, management, operational methods, and practices that define how these data are collected, integrated, interpreted, managed, and used (March & Hevner, 2007). Organizations use data warehousing to support strategic and mission-critical applications.

Data deposited into the data warehouse must be transformed into information and knowledge and appropriately disseminated to decision-makers within the organization and to critical partners in various capacities within the organizational value chain (Chaudhuri, et al., 2011). Intelligence is rooted in acquiring the appropriate data (environmental scanning) and processing the data. BI is rooted in interpreting that data with respect to a business task (contextualisation). Once the data acquisition and integration systems are implemented, the procedures for effectively using the resultant information to derive BI must be put into place (Sims, 2011, March & Hevner, 2007).

Data is the plural of the Latin word *datum* meaning *to give*, and therefore something that is provided to users. Data on its own have limited significance, in order for data to be meaningful it has to be interpreted by means of connections and relationships, then only can value be extracted, thereafter the information can be further developed into knowledge, which entails the strategic use of the information obtained (Pearsall, 1999, Allesi & Trollip, 2001, Dix, et al., 2004).

From a functional point of view, the data warehouse (DW) process consists of three phases depicted in Figure 2.3 (Golfarelli, et al., 2004): Phase 1 is the 'extraction' part, where data is collected from multiple operational sources; Phase 2 is the transformation portion where data is organised and integrated into the data warehouse; Phase 3 is where data is made available for users to access in an efficient and suitable manner.

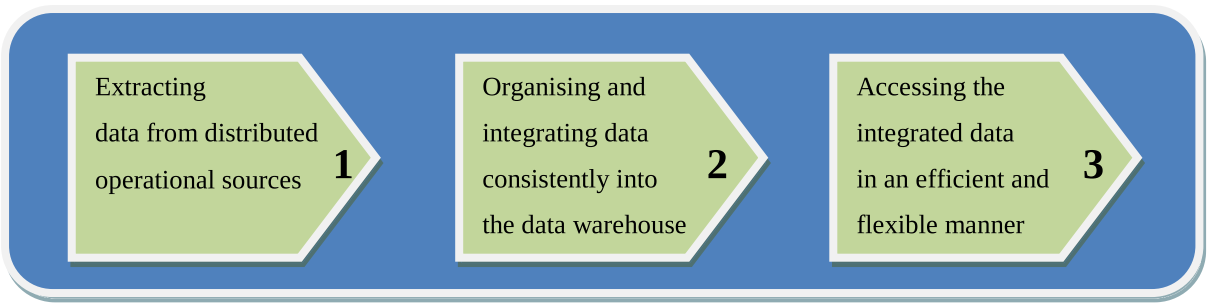


Figure 2.3 Data warehouse process adapted from Golfarelli, et al., (2004)

2.5.1 Data sources

Data sources can be operational databases, historical data, external data, or information from the already existing data warehouse environment (Sahay & Ranjan, 2008, Coronel, et al., 2011). The data sources can be relational databases or any other data structure that supports the line of business applications. They also can reside on many different platforms and can contain structured information, such as tables or spread sheets, or unstructured information, such as plaintext files or pictures and other multimedia information (Microsoft, 2009). The data from different sources are extracted, transformed and loaded (ETL) by means of collection, filtering, integrating and aggregating into a data store (Coronel, et al., 2011).

2.5.2 Data marts

Data stores are represented by data warehouses or data marts (Coronel, et al., 2011). Similar to data warehouses, data marts contain operational data that helps business experts to strategize based on analyses of past trends and experiences. The key difference is that the creation of a data mart is predicated on a specific, predefined need for a certain grouping and configuration of select data. There can be multiple data marts inside an enterprise. A data mart can support a particular business function, business process or business unit (Cupoli, et al., 2012, Sahay & Ranjan, 2008).

2.5.3 Query and reporting tools

BI solutions at the enterprise level are charged with collecting and reporting a company's most important metrics, sometimes called key performance indicators (KPIs) (Vural, et al., 2008). Online Analytical Processing (OLAP) tools support multidimensional views of the data warehouse. OLAP (cubes) are frequently extracted from the data warehouse and made available to managers for specific decision-making situations. Using tools such as ORACLE Discoverer, CognosPowerPlay, MicroStrategy, Business Objects, or even pivot tables in Excel spread sheets managers can 'slice, dice, drill-down, and rollup' instance-level data along pre-defined dimensions (Cupoli, et al., 2012, March & Hevner, 2007). These systems process queries required to discover trends and analyse critical factors (Chen et al., 2012). Reporting software generates aggregated views of data to keep the management informed about the state of their business (Sahay & Ranjan, 2008). Processing tool development has introduced additional processing features such as Relational Online Analytical Processing (ROLAP) and Multidimensional Online Analytical Processing (MOLAP) (IBM, 2012).

2.5.4 Analysing tools and knowledge storage

Analysing tools comprise of decision support systems and forecasting; document warehouses and document management; knowledge management; mapping, information visualization, and dash-boarding; management information systems, geographic information systems; trend analysis (Chen, et al., 2012, Sahay & Ranjan, 2008). Dashboards provide summary data from BI systems. Indicators can be in the form of speedometers, gauges, traffic lights or other graphical representations, and are often colour coded to provide red, yellow and green alerts (Microsoft, 2009). Early versions of dashboards were called executive information systems and had a similar goal, but they were not connected to the original source data (Lamont, 2007). They were derived from various databases and required significant input from the IT department, which made these dashboards unsustainable (Lamont, 2007). Today's dashboards draw directly from data warehouses or multiple databases, and are more interactive (Microsoft, 2009, IBM, 2012). The technology is robust allowing users to drill down and ask a series of related questions, therefore providing the company with a competitive advantage (Chen, et al., 2012).

To reiterate, it is at this point where the interaction of the user with the system takes place where usability is emphasised. Data is gathered, stored, processed and presented on screen where a human user must make decisions. Hence the rationale is: if the interaction (i.e. usability) was problematic then the decision made might not be as good as it could have been.

2.5.5 BI application employed in this study

In order to contextualise the literature reviewed, Figure 2.4 was adapted (Info-alchemy, 2010) to illustrate the Cognos7 BI application as in the researcher's environment. IBM Cognos analytic applications are custom business analysis and reporting solutions that provide professionals with manageable, cross-functional insight extracted from information locked up in ERP's and additional data sources. Allowing business users at all levels to quickly access the insight they require, enabling smarter decisions and outcomes better aligned with business strategy (IBM Business Analytics - Cognos 2012). Supply chain cubes and reports are published to Cognos7 Upfront to be viewed for analysis by end-users. In this environment the users are only able to view the data and changes made to cubes and reports do not impact the data sources.

In summary, many BI tools are highlighted by the various authors (Chen, et al., 2012, Lamont, 2007, March & Hevner, 2007, Sahay & Ranjan, 2008 and Vural, et al., 2007), but the concept of *BI usability* is not discussed with regard to BI component requirements.

According to the literature consulted, information could not be found of how wide-spread the deployment of BI usability evaluation is in software development practice.

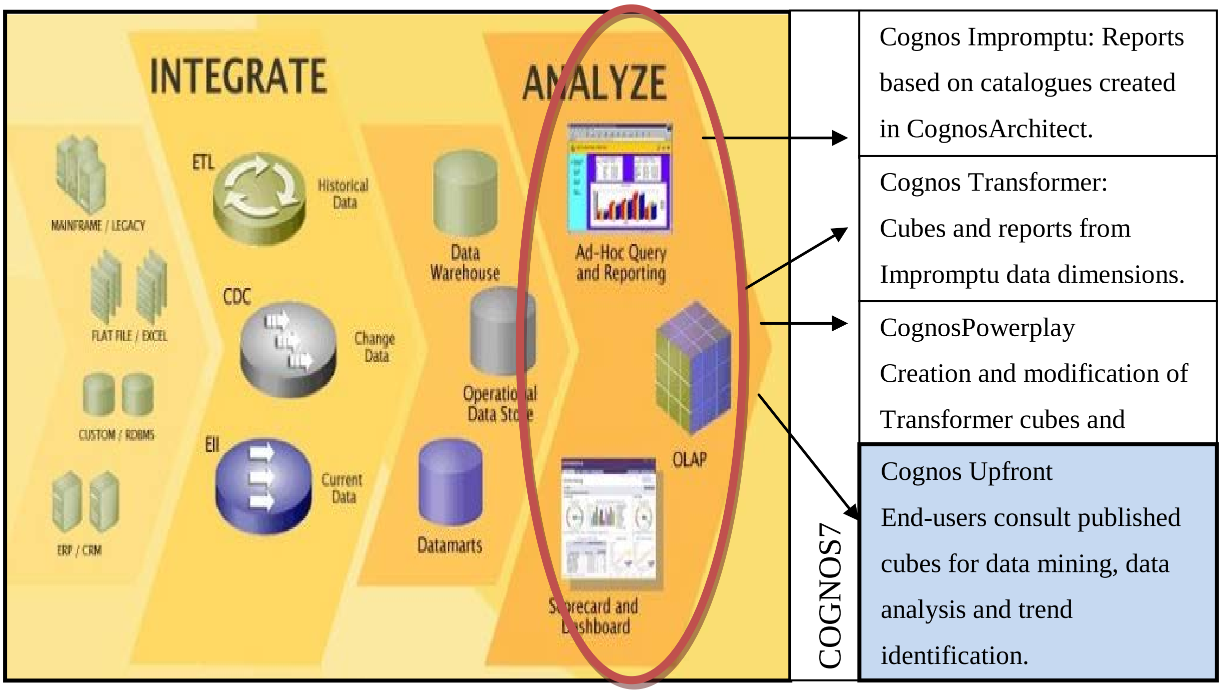


Figure 2.4 Adapted illustration of a data warehouse to present Cognos7 in the context of a data warehouse (adapted from Info-alchemy, 2010)

Cognos (Cognos Incorporated) was established as an Ottawa, Ontario-based company making BI and performance management software. The company was founded in 1969, at its peak Cognos employed 3,500 people and served more than 23,000 customers in over 135 countries (Riley, 2007, COGNOS (IBM), 2012). BI and performance management solutions are evaluated yearly by Gartner Incorporated based on completeness of vision and ability to execute (Gartner, 2009, Prnewswire, 2012). The completeness of vision and ability to execute attributes are used as axis to plot software in the market. The graph is split into four sections and positions software companies as visionaries, challengers, leaders or niche players (Prnewswire, 2012) in the market.

In recent years Cognos (now IBM, since it was acquired by IBM in 2008) has been part of the leaders and visionaries group of BI solutions positioned on the top right quadrant of Gartner's Magic Quadrant as depicted in Figure 2.5. The placement of Cognos on Gartner's magic quadrant serves an indication of the quality of the BI application that was evaluated during this study.

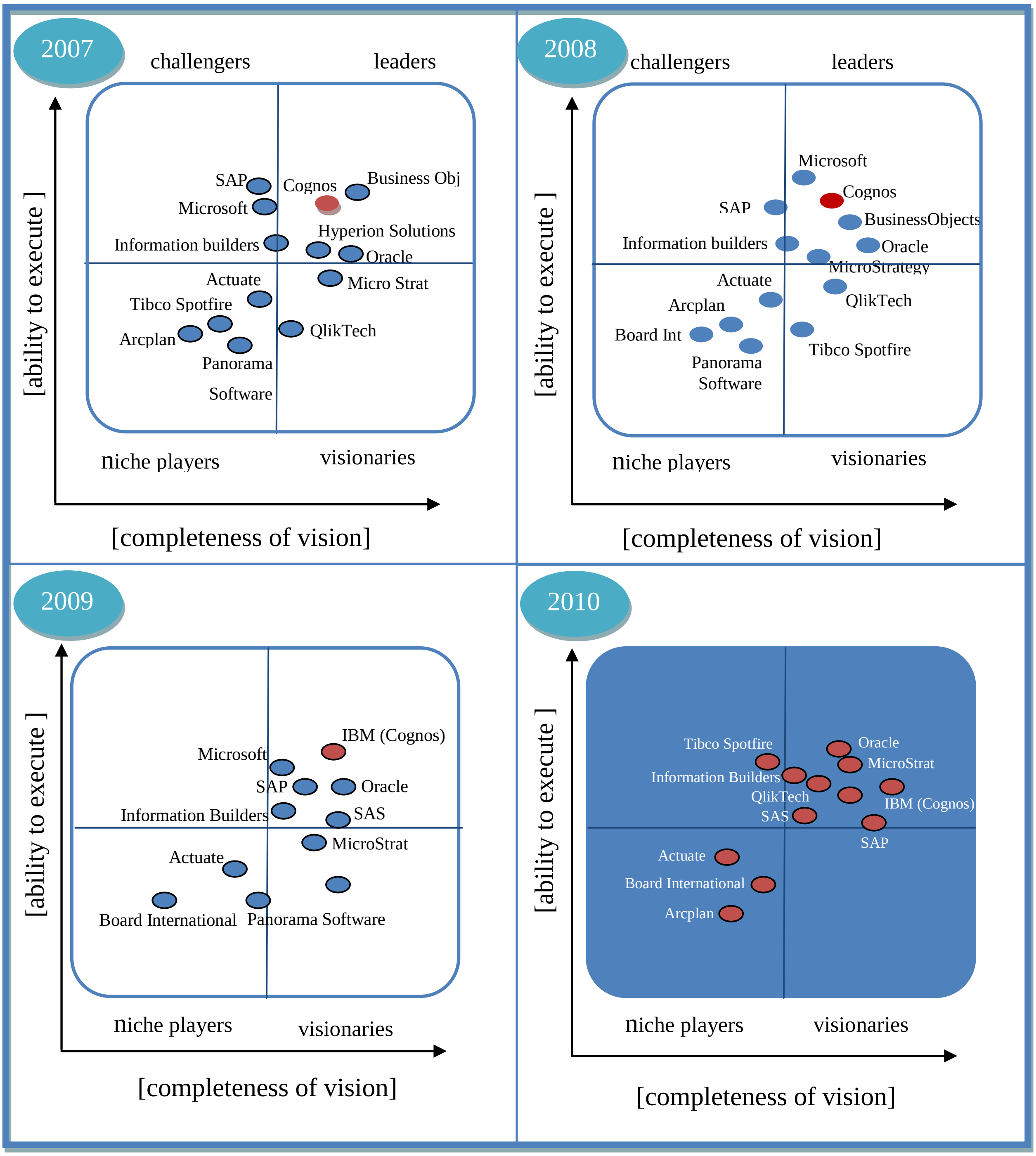


Figure 2.5 Placement of Cognos (IBM) on Gartner's magic quadrant

2.6 REQUIREMENTS OF BI

Understanding the data, adaptability and profiting from experience are three important components of intelligence that need to be designed into data warehouses. Therefore data warehouses must be understandable, adaptable, and include experience-based organizational knowledge (March & Hevner, 2007) to achieve the objective of efficient business support.

Literature searches (in Scopus, ScienceDirect, Techno-link, ACM Digital Library, JStor, Scitopia and SpringerLink) were conducted to determine if BI usability is mentioned as a BI component or BI requirement by published authors. Despite isolated references to the usability of BI (Corcoran, 2007, Bernabeu & Garcia-Mattio, 2011) no evidence of a coherent effort to theorise BI usability could be found. Published BI literature mainly focuses on IT support, data quality and organizational alignment (Sims, 2011, Chen, et al., 2012, Matei, 2010).

2.6.1 IT support

BI requires substantial IT support (Lin, et al., 2009). Such as providing access to many kind of database management systems (DBMS), flat files, aggregated data warehouse data as well as detail data from operational databases (Coronel, et al., 2011). Sound and proper planning abilities are needed when constructing a BI working environment, for example, ensuring the delivery and implementation of BI projects; ability of acquiring standardised data elements and changing process to ensure the quality of data acquired, integrating all strategic objectives within the organization, and designing strategic map and transmitting important corporate value (Lin, et al., 2009).

2.6.2 Data quality

The issue of quality data is addressed by Bak (2008), Corcoran (2007), Chaudhuri, et al., (2011), Lin, et al., (2009) and March & Hevner (2007). Decisions are based on data from the BI applications, therefore the data has to be accurate, consistent, complete, valid and timely (Otto & Reichert, 2010). Corcoran (2007) argue that users need clean and accurate information - as well as consistent definitions of that information to fully understand its purpose and validity. Mechanisms for protecting a data warehouse from poor quality data are crucial (March & Hevner, 2007).

These mechanisms should address capturing of data, instance-level data integration, data quality, particularly consistency and timeliness, identifying and accessing the appropriate data sources, coordinating data capture from data sources in an appropriate timeframe, assuring adequate data quality (March & Hevner, 2007). Recently Master Data Management (MDM) is employed to manage data as a corporate asset (Coronel, et al., 2011). MDM is a collection of concepts, techniques and processes for the identification, definition, and management of data within an organization; it also ensures uniform views on data and governance of data (Coronel, et al., 2011).

2.6.3 Organizational alignment

It is important that the enterprise operation contents and business objectives are understood, from the beginning and at all further BI life cycle stages (planning, implementing and go-live), in order to properly plan related performance measurement indices and ensure the correctness and validity of the information provided by BI (Lin, et al., 2009, Vural, et al., 2007). To understand where a company is and where it is headed organizations make extensive use of Key Performance Indicators (KPIs). These KPIs are quantifiable measurements that assess the organizational effectiveness in reaching its strategic and operational goals (Coronel, et al., 2011). To summarise, as a result of the literature reviewed, the above requirements were highlighted for BI, but again BI *usability* was limited to a couple of texts (Corcoran, 2007, Bernabeu & Garcia-Mattio, 2011).

2.7 CHALLENGES OF BI

In spite of major investments in enterprise resource planning (ERP), supply chain management (SCM) and customer relationship management (CRM), businesses have not achieved the competitive advantage estimated (Sahay & Ranjan, 2008). This can be attributed to BI challenges such as complexity and cost, which will be discussed in more detail in Section 2.7.1 – Section 2.7.3.

2.7.1 Complexity

Information systems collect and process vast amount of data in various forms in organizations. Complexities increase as the business or the environment become more dynamic (Chen, et al., 2012). Companies still feel that BI has technology-related complexities and is designed for technically trained specialists (Sahay & Ranjan, 2008). In a real world situation business people have little interest (or time) in spending hours learning a complex BI environment let alone creating reports and running queries (Corcoran, 2007). Hence, some organizations have hesitated to develop BI systems because of complexity of software tools (Vural, et al., 2008). Véronneau & Cimon (2007) on the other hand argue that critical operations require more than technical expertise, they require teams to work well together as a cohesive unit.

2.7.2 Cost

Many BI solutions are expensive, they are resource-intensive because they require that multiple, non-integrated systems and tools are maintained (Microsoft, 2009). The high cost of BI make companies hesitant to acquire BI (Vural, et al., 2008). Other cost implications are that data marts required to store the large data volume that is necessary for BI operations are expensive, the same applies to implementation and start-up costs (Sahay & Ranjan, 2008). Additionally, BI also takes a long time to yield correct analysis (Vural, et al., 2008). However, lower cost alternatives have become available recently, for example the Microsoft SQL suite (Microsoft, 2009).

2.7.3 Other challenges of BI

Current BI solutions fail to meet the challenges of ad-hoc and collaborative decision support, slowing down and hurting organizations (Berthold, Rosch, Zoller, Wortmann, Carenini, Campbell, Bisson, & Strohmaier, 2010). The lack of detailed guidance on the BI features is another challenge (Vural, et al., 2008). Additionally the user's needs should be met: These needs include a BI solution that supports the skill sets of the organization, easily accessible to all, that features familiar tools and interfaces which will increase adoption rates while reducing training time and cost (Microsoft, 2009). The usability barrier forces people to learn BI tools rather than simply access timely information, BI solutions that can only be mastered by a few highly-trained users will not generate widespread insights or better decision-making (Corcoran, 2007).

The challenges mentioned in Section 2.7.3 are all related to BI usability, but are not called as such. Besides Corcoran (2007) and Bernabeu & Garcia-Mattio, (2011), literature specifically mentioning the usability of BI could not be found. Subsequently Corcoran (2007) argues that currently it is one of BI's shortcomings. In summary we can say that BI systems face challenges in terms of complexity, cost and usability.

2.8 BI AS DECISION SUPPORT

Users spend much time making decisions, whether routine or of major importance, as decision-making is essential to problem-solving. The user must constantly demonstrate an ability to solve problems in rapidly changing and uncertain situations in which poor decision-making can be costly (Swansburg & Swansburg, 1999). BI provides critical insight that helps organizations make informed decisions (Gangadharan & Swamy, 2004, Microsoft, 2009). BI has remarkable impact on decision-making activities at most companies (Corcoran, 2007). Summary data from BI systems enable CEO's, managers and employees alike to get an instant overview of key performance indicators for their organization's activities (Lamont, 2007).

Consequently the aim of BI is to enhance decision support rather than decision automation, so experts will still be responsible to derive decisions based on their background knowledge (Baars, et al., 2008). This view is supported by Gebus & Leiviska (2009) who argue that problem-solving is a knowledge intensive activity. On the other hand Shelton & Darling (2001) argues that a person (user) should have adequate information to take a decision, previous experience is not enough to come up with the ideal solution for all problems.

Successfully supporting managerial decision-making is critically dependent upon the availability of integrated, high quality information organised and presented in a timely and easily understood manner (Golfarelli, et al., 2004, March & Hevner, 2007).

The difference between decision support data and operational data is of importance to provide proper decision support (Coronel, et al., 2011). Operational data is not well suited to decision support, from the end-user's point of view, decision support data differ from operational data on three levels: time span, granularity and dimensionality (Coronel, et al., 2011).

Keeping in mind that the traditional customer base is typically not an information professional (Microsoft, 2009). BI have emerged to meet this need and serve as an integrated repository for internal and external data; intelligence critical to understanding and evaluating the business within its environmental context (March & Hevner, 2007).

However, the usability of the system is critical in enabling users to make optimal decisions. With the addition of models, analytic tools, and user interfaces, users can access BI data that supports effective problem and opportunity identification, critical decision-making, and strategy formulation, implementation, and evaluation (March & Hevner, 2007). In summary the effectiveness of BI is a function of the presentation and analysis of the data which provides management with input to their understanding and evaluation of the business performance, and thus its support to the decision-making regarding future action to be taken (Sims, 2011).

2.9 BI WITHIN SUPPLY CHAIN

This study focussed on BI within a supply chain context. The focus of Supply Chain Management (SCM) systems is to provide operational and transactional efficiencies in the fields of manufacturing, sourcing and distribution within an organization and across its supply chain. BI provides an integrated infrastructure that extracts, transforms and loads the data from multiple sources like ERP, SCM, CRM, customer data, supplier data, product data, manufacturing data, quality management data, shop floor manufacturing data, legacy system data, online web-based SCM data, demographic market places-based data and marketing data from third party data suppliers, necessary for high quality supply chain analytics (Sahay & Ranjan, 2008). Companies with leading supply chain capabilities have typically made significant shifts in their use of advanced analytics to transform historical data captured in ERP systems into predictive insights (Dwyer, Umbenhauer, & Agarwal, 2010).

Effective supply chain management requires integration across functions or departments. Some of the most useful reporting is around cross-functional processes such as total cost to own; product or customer profitability incorporating logistics, ordering, fulfilment, selling and other costs; vendor scorecards; the perfect order; order-to-cash cycles; and variable cost productivity (Golfarelli, et al., 2004, Lamont, 2007, Mulani, 2008). Each of these reports requires assembling data from different sources and to query large databases efficiently (Mulani, 2008).

Cost reduction programs that deliver the promise of cost saving through value engineering, use predictive modelling techniques to forecast the probabilities for success in the firms' new product line, identifying dead or obsolete stock and manage it through product aging strategies (Sahay & Ranjan, 2008, Dwyer, et al., 2010). For configuring supply chain functions, data collected across the supply chain is assimilated, numbers are analysed, and information is generated for decision-makers. Drill down and roll up operations yield figures to reveal what caused the performance level. Ordering products, global outsourcing, and web-based buying and selling, Just In Time (JIT) manufacturing are the major key business drivers for supply chain analytics (Sahay & Ranjan, 2008).

Applying the concepts of BI to data from SCM systems, supply chain analytics seek to provide strategic information to decision-makers in organizations (Sahay & Ranjan, 2008). Mulani (2008) claims there are a growing need for better analytics and management reporting across all areas of supply chain management. The concept of supply chain analytics promise to extract and generate meaningful information for decision-makers in the enterprise from the vast amounts of data generated and captured by supply chain systems (Sahay & Ranjan, 2008). New and complex changes in the global economy are emerging that force companies to operate in innovative ways. Subsequently the interconnectedness of supply chains, markets and businesses represents a new challenge for all enterprises.

Supply chain analytics provides a single view across supply chain. It also assists an organization with the driving forces behind supply chain processes-planning, procurement, manufacturing, logistics, and returns. An organization is able to analyse and act to increase the supply chain efficiency. Supply chain analytics addresses measuring supply chain performance against goals and over time, identifies opportunities to reduce costs, improves supplier management, increases manufacturing efficiency and optimises delivery (Sahay & Ranjan, 2008). Subsequently supply chain managers can be one step ahead in seeing trends, identifying opportunity areas, operating more strategically, and best leveraging the valuable data in your transactions systems (Mulani, 2008). This allows for establishing key strategies for creating competitive advantage, the key is to understand the data, which will shape the networked marketplace (Gangadharan & Swamy, 2004).

In order to capitalize on the business opportunities; organizations will distinguish themselves by the capability to leverage information about their market place, customers, and operations (Gangadharan & Swamy, 2004, Mulani, 2008, Sahay & Ranjan, 2008). BI plays a central part in this strategy for long-term sustainable success (Gangadharan & Swamy, 2004).

2.10 VALUE OF BI AND FUTURE WITHIN SUPPLY CHAIN

Much research has been published on BI, focused on gaining the advantage in a global competitive environment, e.g. Lin, et al., (2009), Matei (2010), Maghrabi, Oakley, Thambusamy, & Iyer (2011), Ribeiro, Barata, & Colombo (2009) and Repoussis, Paraskevopoulos, Zobolas, Tarantilis, & Ioannou (2009). IT is present everywhere and an increasingly critical part of the modern organization, supporting its day-to-day operations and all aspects of the decision-making process as well as its strategic position (Sahay & Ranjan, 2008). Taking into consideration that IT alone does not produce value – it is the application thereof that gives benefit (Sims, 2011). In the researcher's coal mining organization data harvested from BI applications enable not only organizational efficiency, but also supplier spend consolidation which enables benefit driven negotiations with key suppliers. Making use of BI for smart business decisions, measure business processes, and to collect and use trusted, timely, relevant data (McCrea, 2006).

Lin, et al., (2009) adds that by enabling competitiveness in a meticulous environment; electronic advances have enabled business to deploy BI systems for the purpose of decision-making. McCrea (2006) agrees with Lin, et al., (2009) and argues that BI allows companies to gain insight into operations, enabling smarter, faster decisions. With access to relevant data, employees can find opportunities to operate more efficiently and grow revenues, so the company can emerge stronger from any economic environment (Microsoft, 2009).

Sometimes an analysis across different business units can reveal solutions that are hidden otherwise. For example in one case, different retail stores from the same company (that were only a couple of kilometres apart) used completely separate processes to procure everything from landscape maintenance services to large capital equipment – and these retail stores were paying two significantly different prices for building materials from the same supplier (Dwyer, et al., 2010).

Understanding the data, transforming, and shaping the data into networked market places is a key strategy for any organization to achieve competitive advantage. The business success factor for any enterprise is finding ways to bring vast amount of data flowing within the business processes together and making sense out of the data (Sahay & Ranjan, 2008).

Firms can make better decisions, particular concerning their customers, suppliers, employees, logistics, infrastructure and gather, store, access and analyse huge amounts of records with BI (Sahay & Ranjan, 2008).

Additional advantages of the use of BI are: better matching supply to demand, and 'agility' in responding to change in the market place. Visibility increases, and forecasts can effectively be aligned to production plans (McCrea, 2006). Companies effectively apply BI to supply chain operations to improve visibility, and performance (McCrea, 2006). Malhotra (2000) concurs and points out BI benefits that facilitate the connections in the new-form organization, bringing real-time information to centralized repositories and support analytics that can be exploited at every horizontal and vertical level within and outside the firm.

Regarding less quantifiable value-added, Powell & Bradford (2000) argues that the direct effect on the strategic decision-making processes can be tangible. The effect of this is not only to enhance the status of the competitive intelligence function of the firm, but also to improve the policy generation process (Powell & Bradford, 2000). Improved policy generation is supported by proper governance which ensures consistency throughout the organization (Coronel, et al., 2011).

Arnott & Pervan, (2008) mentioned that the 2008 DSS industry of BI was one of the most optimistic areas of investment despite the IT downturn of the early to mid-2000's. This is important to highlight in the context of this study; since this shows that companies invested large sums of money into BI systems because they believed it would yield value-add outcomes to their organizations. BI has evolved from centralised reporting to current mobile BI in just more than a decade and technology advancements are accelerating the adoption of BI to new levels (Coronel, et al., 2011).

BI facilitates scrutinizing every aspect of business operations to find new revenue or squeeze out additional cost savings by supplying decision support information (Gangadharan & Swamy, 2004). A successfully implemented BI system assists in understanding business status, measures organization performance, improves stakeholder relationship, and creates profitable opportunities (Lin, et al., 2009). BI is not just an IT initiative or even a set of specific projects; it is a basic business competency.

From the literature (Gangadharan & Swamy, 2004, Lin, et al., 2009) there is a general expectation that BI assists in adding value to the organization, not only in terms of information or knowledge sharing but also by adding quantifiable value to the bottom line. Sahay & Ranjan, (2008) on the other hand maintain that BI technology will always entail complex deployment and data preparation and is not easy to link directly to either reducing costs or increasing revenue and that any firm should not expect a tool to produce value on its own.

Supply Chain vendors foresee BI as a powerful engine that hooks into all sorts of process and work flows to monitor anomalies and changes in trends in supply chain (Sahay & Ranjan, 2008).

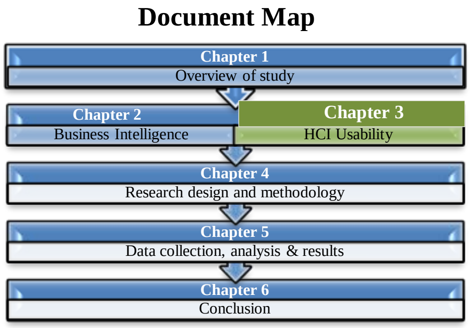
BI vendors are responding in a number of ways to cope with the quick-paced change (Corcoran, 2007, Coronel, et al., 2011):

- Improved data storage technologies such as solid state drives (SSD) and Serial Advanced Technology Attachment (SATA) drives offer increased performance and larger capacity making data storage not only faster but also more affordable.
- BI search capabilities that make it easy to find enterprise content and share results are incorporated.
- Introduction of highly portable 'active reporting' technology that can deliver information to users when they are offline (not connected to a work pc or laptop), even to cell phone browsers. Mobile BI is extending business decision-making some examples are MicroStrategy, QlikView and Actuate.

2.11 CHAPTER SUMMARY

BI enables the prospect of cost reduction and encourages revenue growth. It also enables the gathering of intelligence regarding strategic, tactical and operational business areas in the supply chain. BI generally maintains historical data and enables an understanding of total expenditure. Therefore, there is a renewed interest in BI as companies see the financial and operational efficiency benefits in aligning spend, procurement, logistics, and finance (Coronel, et al., 2011). Furthermore, evidence was presented on the benefit of BI in supply chain management and the fact that BI usability has not been well researched (Bak, 2008, Corcoran, 2007, Bernabeu & Garcia-Mattio, 2011). Recent studies focusing on the evaluation of BI applications according to sets of listed criteria still falls short of mentioning *usability* as an attribute of BI applications (Ghazanfari, et al., 2011, Rouhani, et al., 2012, Chaudhuri, et al., 2011). Given this background HCI *usability* will be considered in the next section as this study concerns the assessment of the *usability* of BI applications.

End of Chapter 2



Chapter 3: HCI Usability

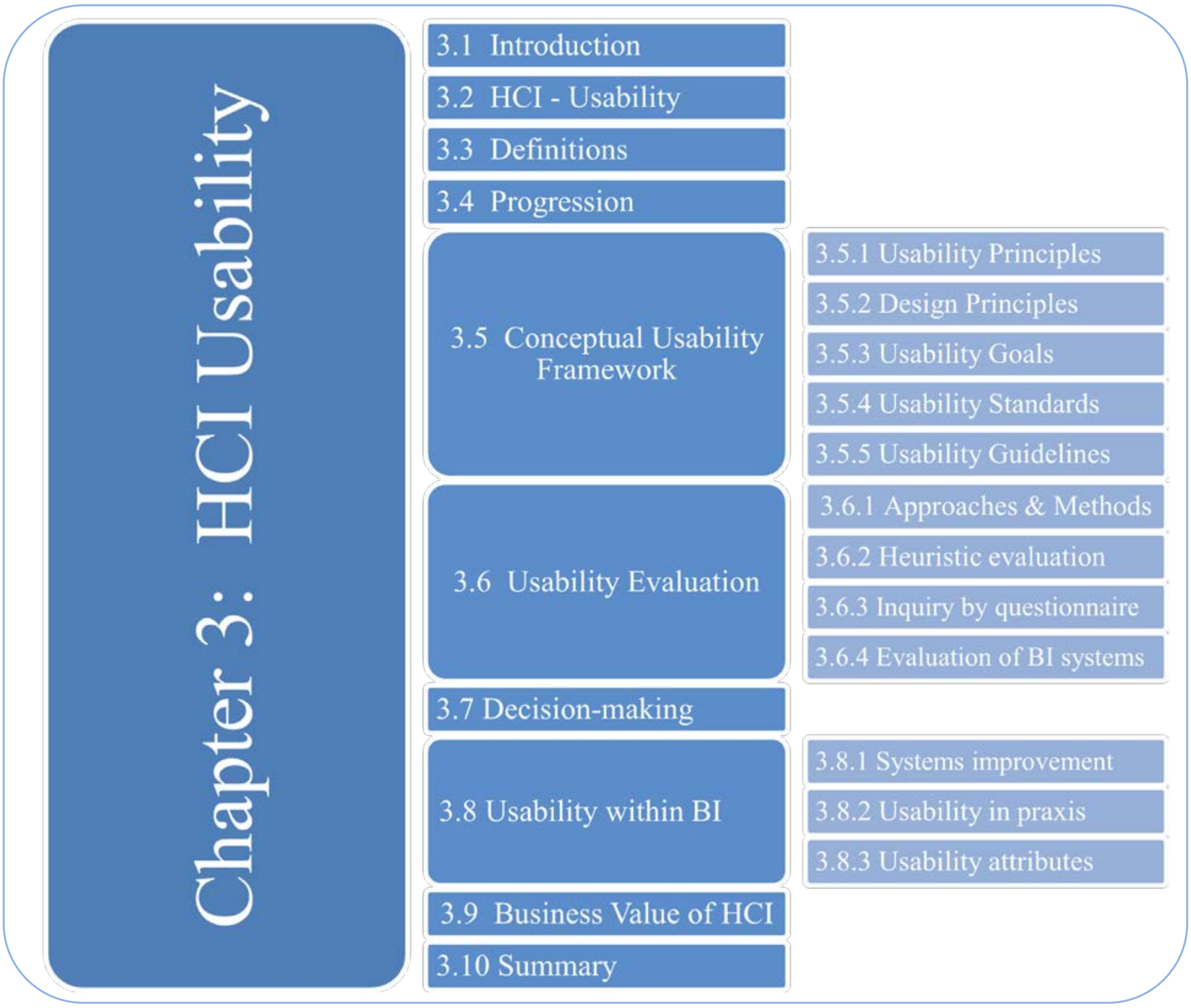


Figure 3.1 Composition of chapter 3

3.1 INTRODUCTION

The use of IT systems in the workplace is mainly non-discretionary, that means the user has little control over what systems to use, when and why (Gulliksen, Boivie, & Göransson, 2006, Lutsch, 2011). Chapter 2 considered BI and provided evidence that the usability of BI applications has been neglected. Human-Computer Interaction (HCI) usability will therefore be investigated (as further background to this study) focussing on usability principles, standards and guidelines. Usability evaluation (criteria and methods), will be addressed towards deciding on usability evaluation for BI applications. See schematic depiction of the chapter composition in Figure 3.1. Towards the end of this chapter, usability will also be considered with regards to IT, decision-making, BI and ultimately the business value of Human-Computer Interaction.

3.2 HUMAN-COMPUTER INTERACTION USABILITY

Karahoca & Karahoca (2009) define HCI as an interdisciplinary field of science focused on the interaction of people and systems and the way they influence each other. HCI originated from graphical user interfaces (Bernsen & Dybkjaer, 2009). Chou & Hsiao (2007) define the human-computer interface as the point of contact between the application and end user. This interactive communication between users and computers takes place via computer hardware and software interfaces (Chou & Hsiao, 2007).

Upon reflection the disciplines involved in HCI is illustrated as a cross sectional cut through an orange, each discipline has its place in HCI, and each discipline is able to function independently, differing in size and making up part of the orange as a whole. See Figure 3.2 for the illustration of the concept. The disciplines referred in this schematic representation are selected from Beccue (2007), Dix, et al., (2004), and Rogers, et al., (2012).

HCI is concerned with the design, evaluation, and implementation of interactive computing systems for human use and with the study of major phenomena surrounding them (Jakubowska, 2008). According to Gulliksen, et al., (2006) usability is one of the main concepts that have emerged from the HCI field.

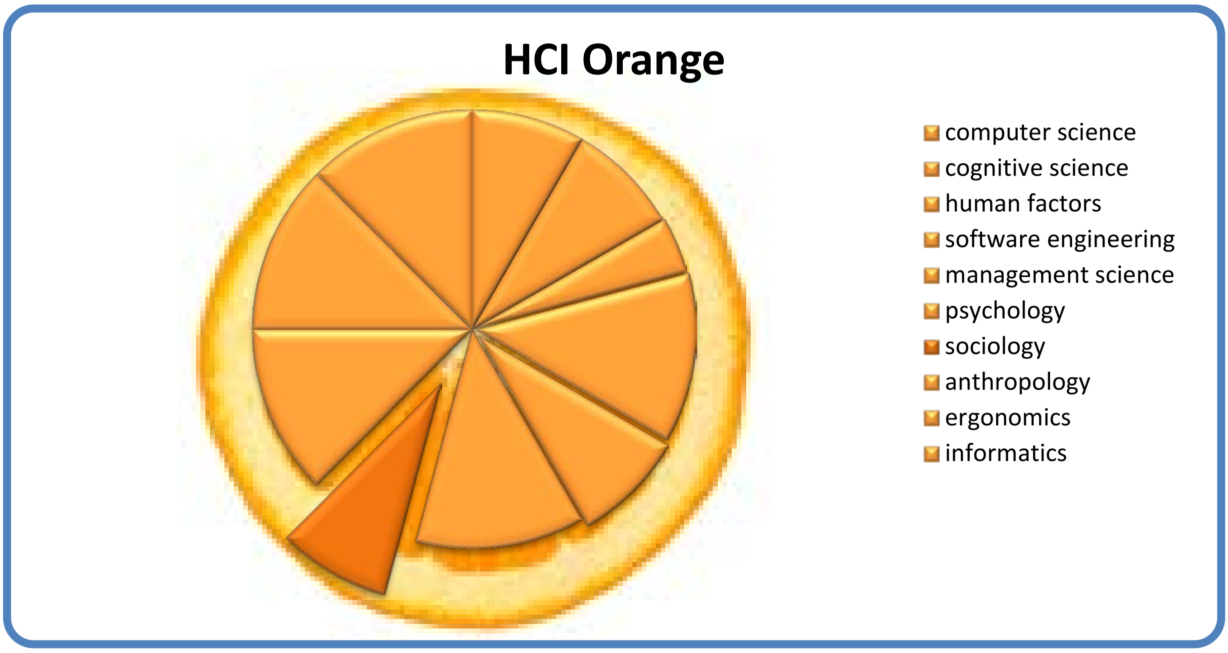


Figure 3.2 The HCI 'orange' illustrates disciplines involved in HCI

3.3 DEFINITION OF USABILITY

Nielsen (1993) defines usability as comprising of five quality components namely: learnability, efficiency, memorability, errors and satisfaction. Jones (1997) defines usability as the total effort required to learn, operate, and use software or hardware. Gebus & Leiviska (2009) maintains usability is the degree to which the design of a particular user interface (UI) takes into account the psychology and physiology of the users, and makes the process of using the system effective, efficient and satisfying. Chou & Hsiao (2007) argue that *usability* refers to the extent to which the user and the system can *communicate* clearly and without misunderstanding through the interface. Usability is considered to be inherent in the human–computer interface because it expresses the relationship between end users and computer applications. According to Rogers, et al., (2012) usability refers to ensuring that interactive products are easy to learn, effective to use and enjoyable from the user's perspective. They break this down into the following goals: effectiveness, efficiency, safety, utility, learnability and memorability.

This resonates with the quality components as previously proposed by Nielsen (1993) except that satisfaction seen on a higher level, rather as a result of these goals being met while errors are handled on a lower level per component. Tullis & Albert (2008) on the other hand, point out that usability definitions share three common themes, namely that the user is involved, the user is doing something and the user is doing this something with a product or system.

Proper interaction design allows products to support the way people communicate and interact in their everyday and working lives Preece, Rogers, & Sharp (2002). The main difference between Interaction Design (ID) and Human-Computer Interaction (HCI) is one of scope. With HCI having a narrower focus, mainly on the design, evaluation and implementation of interactive computing systems for human use (Rogers, et al., 2012) refer to Figure 3.3.

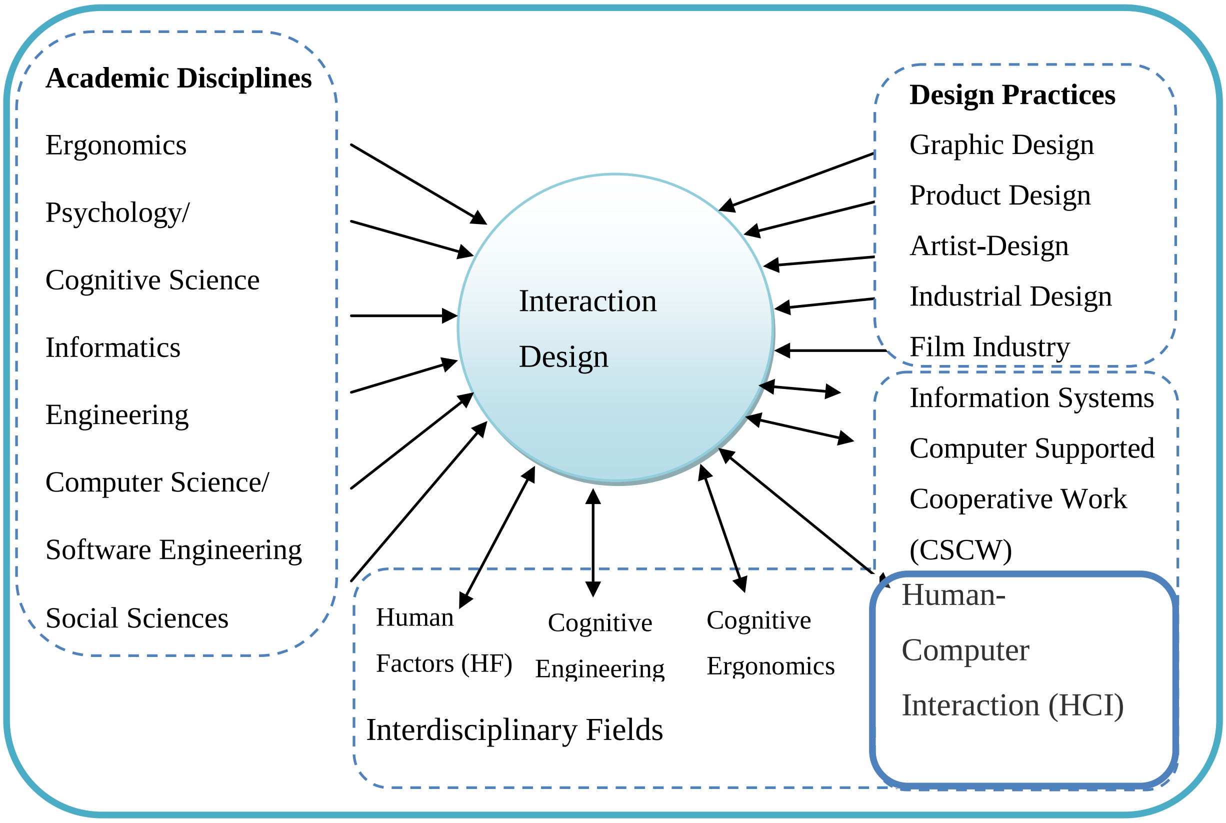


Figure 3.3 The relationship between contributing academic disciplines, design practices, and interdisciplinary fields concerned with interaction design as adapted from Preece, et al., (2002)

In addition to academic definitions, standards for HCI and usability have been developed under the auspices of the International Organization for Standardization (ISO) and the International Electro-technical Commission (IEC). A number of international standards regarding usability have been formulated during the past, such as ISO 9241-11, ISO/IEC 9126, and ISO/IEC FDIS 9126-1. According to ISO 9241-11, usability is defined as 'the extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use' (ISO 9241-11, 1998). The 2010 version of the international standard for human centred design refers to the term user experience instead of usability, refer to Section 3.5.1 where the difference between the two are discussed (ISO 13407, 1999).

The ISO 9241-11 operationalizes the definition by defining usability as the effectiveness, efficiency, and satisfaction with which users of an application are able to achieve specific goals. The ISO 9241-11 definition of usability is the basis for usability as defined by Gebus & Leiviska (2009), Gulliksen, et al., (2006) and Gonzalez, Lores, & Granollers (2008).

The term *BI usability* could only be found in the literature from Bernabeu & Garcia-Mattio, (2011). Bernabeu & Garcia-Mattio, (2011) define BI usability as the design of software dedicated to BI that includes an interface that is friendly, intuitive, and easy to use (and easy to learn to use), an interface that allows for the creation of new contents (interactive analysis, reporting and dashboards) as well as content navigation, with an emphasis on the presentation of these contents, all in a visual and interactive manner, so the user feels comfortable with the tool and takes full advantage of the data.

Based on the literature presented in Section 3.2 and Section 3.3 the following working definition is selected for the purpose of the study: *usability* is the extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use.

3.4 PROGRESSION OF USABILITY

The foundations of usability evaluation were established in the early 1990s (Kay, 2009). During that period (90's), usability expertise was rare and usability activities were primarily limited to evaluations and tests (Gulliksen, et al., 2006, Kay, 2009). Most usability experts in industry were autodidacts (that is, a self-taught person). Early approaches to systems integration leant toward a juxtaposition of systems' information flows within a common system or display (i.e. integration built around the technical aspects of the system) (Véronneau & Cimon, 2007).

However gradually, awareness grew of its (usability's) importance, organizations that produce software products have been expending resources for *doing usability* - building enviable usability laboratories, buying usability equipment, training developers in usability engineering (UE) methods, and conducting usability testing (Howarth, Smith-Jackson, & Hartson, 2009).

These investments have helped to make UE an important part of the overall software development lifecycle (Howarth, et al., 2009). With increasing attention and recognition of the importance of usability came an increasing understanding of the need for knowledge and expertise and the need for integrating usability issues and knowledge into the development process (Gulliksen, et al., 2006). The use of human factors approach in the design of process control systems throughout the industry presents many opportunities for improvements with regard to system effectiveness, efficiency, reliability and safety (Carvalho, Dos Santos, Gomes, Borges, & Guerlain, 2008) and this is important in BI usability too.

3.5 CONCEPTUAL USABILITY FRAMEWORK

A review of the usability literature produced a number of usability principles, standards, guidelines and goals (Dix, et al., 2004; Gebus & Leiviska, 2009; Gould & Lewis, 1985; Nielsen, 1993; Norman, 1990; Preece, et al. 2002; Tabachneck-Schijf & Geenen, 2009; Tognazzini, 2003). Usability *principles* are abstract design rules with high generality and low authority (Dix, et al., 2004). Rogers, et al., (2012) on the other hand refer to *principles* as a general guidance intended to inform the design and evaluation of a system. Therefore, it seems that principles are on a higher level, followed by guidelines and standards on lower levels, with standards being the most specific. Dix, et al., (2004) maintain *standards* are specific design rules, high in authority and limited in application, whereas *guidelines* are lower in authority and more general in application. Usability always depends on the *users*, their *needs* (goals) and the *context* - three variables that are inconsistent and unstable in themselves (Gebus & Leiviska, 2009). This focus on *goals* concurs with the portion of the ISO definition (*ISO-9241: Guidance on Usability Standards 1998*) and Rogers, et al., (2012). A conceptual framework is shaped by theories and broad ideas harvested from literature reviews (Smyth, 2004). This study's theoretical framework enabled the compilation of Table 3.1 consisting of usability goals, principles and rules as adapted from Rogers, et al., (2012), by means of identifying links in the literature with this study's research aims.

Table 3.1 Usability goals, principles and rules as adapted from Rogers, et al., (2012)

Guidance level	Concept	Also called	How to use
General	Usability goals		Setting up usability criteria for assessing the acceptability of a system.
	User experience goals	Pleasure factors	Identifying the important aspects of the user experience.
	Design principles	Heuristics when used in practice design concepts	As reminders of what to provide and what to avoid when designing an interface.
Specific	Usability principles	Heuristics when used in practice	Assessing the acceptability of interfaces, used during HE.
	Rules		To determine if an interface adheres to a specific rule when being designed and evaluated.

3.5.1 Usability principles

Various usability principles have been proposed for different contexts. The usability principles of Nielsen and Dix as seminal to usability development will be discussed, followed by an explanation of the components. Additional theorists are referred to in Table 3.2 as well as Table 3.6, which includes the usability principles propagated by Tognazzini (2003). Nielsen (1993) proposed the following usability principles: learnability, memorability, efficiency, design consistency, error prevention, error messages, appropriate systems feedback, clearly marked exits, help and documentation, satisfaction, making use of the user's language or natural cue, instructions need to be visible and retrievable.

Dix, et al., (2004) proposed the following usability principles:

- **Learnability** consisting of predictability**,** synthesizability**,** familiarity**,** generalizability and consistency.
- **Flexibility** consisting of dialogue initiative**,** multi-threading**,** task migratability**,** substitutivity and customisability.
- **Robustness** consisting of observability**,** recoverability**,** responsiveness and task conformance.

The usability principles mentioned above will now be considered in more detail, see Table 3.2. The decision to employ the works from Nielsen, Dix and Tognazzini's work was taken as a point of departure at the outset of the study in 2009 and, when the combined set of principles (see Table 6.1) are compared with later publications like the book of Rogers, et al., (2012) they are still adequate and correct in describing the core usability goals.

Table 3.2 Usability principles

Principle	Description	References
Predictability	Predictability of an interactive system means that the user's knowledge of the interaction history is sufficient to determine the result of his future interaction with it. Predictability deals with the user's ability to determine the effect of operations on the system. It also deals with the user's ability to know which operations can be performed. This principle supports the superiority in humans of recognition over recall. Without it the user will have to remember when he can perform the operation and when he cannot.	Dix, et al., 2004, Gunawardana, Paek, & Meek, (2010), Pretorius, Calitz, & Van Greunen, 2005, Dong, Chen, Liu, Bu, Liu, & Zheng, 2007, Jarke, Loucopoulos, Lyytinen, Mylopoulos, & Robinson, 2011.
Synthesisability	Synthesis is the ability of the user to assess the effect of past operations on the current state of the system. The user builds up a predictive model of the system's behaviour, as it is important to assess the consequences of previous interactions in order to formulate a model of the system behaviour. This principle of synthesisability relates strongly to the ability of the user interface to provide an observable and informative account of change (system honesty).	Dixet, al., 2004, Dehinbo, 2010.
Dialogue initiative	This describes who (computer or user) initiates communication. If the system initiate all dialogue and the user simply responds to requests for information it is called system pre-emptive dialogue. On the other hand, if the user is free to initiate any action toward the system, the dialogue is said to be user pre-emptive. From the user's perspective, system-driven interaction hinders flexibility whereas user-driven interaction favours flexibility.	Dix, et al., 2004, Engelbrecht & Möller, 2010; Lee, Jung, Kim, Lee, & Lee, 2010.

Table 3.2 Usability principles (continued)

Principle	Description	References
Learnability	Gebus & Leiviska (2009) is of the opinion that for humans, learning is not simply a matter of acquiring a description. It involves taking something new and integrating it fully with existing thought processes. Thus, the ease of solving a problem is also determined by the way information is encoded into the memory. According to Scott & Walczak (2009) learning theory explains that you can motivate learning with tools that are fun to use. The resulting positive attitudes associated with intrinsic motivation, intrinsic interest and focused attention will improve competence, which is a basic need and essential for Computer self-efficacy (CSE). Norman (1990) stressed that 'It's not your fault': Prior to Norman's (1990) work, people felt that they were to blame when they could not learn to use their high-tech gadgets. Norman (1990) has made it the responsibility of the creators of the technology to put individuals at ease. This ties to Scott & Walczak's (2009) argument that perceived ease of use (PEOU) is strongly anchored to general beliefs about computers, such as Computer self-efficacy (CSE), an individual self-assessment of ability to use a computer. Low CSE may hinder computer learning. Consequently, assessing CSE and its determinants could help an organization understand the role of PEOU on acceptance of a multimedia. As mentioned previously, principles that support learnability are: predictability, synthesisability, familiarity, generalizability and consistency.	Gebus & Leiviska, 2009, Scott & Walczak, 2009, Norman, 1990.
Responsiveness	Responsiveness measures the rate of communication between the system and the user. Response time is generally defined as the duration of time needed by the system to express state changes to the user. Ideally there must be some indication to the user that the system has received the request for action and is working on a response.	Dix, et al., 2004.

Table 3.2 Usability principles (continued)

Principle	Description	References
Familiarity	For a new user, the familiarity of an interactive system measures the relationship between the user's existing knowledge and the knowledge required for effective interaction. New users bring a wealth of experience across a wide number of application domains. This experience is obtained both through interactions in the real world and through interaction with other computer systems. Some psychologists suggest that there are intrinsic properties (or affordances) of visual objects that suggest how they can be manipulated.	Dix, et al. 2004, Rogers, et al., 2012.
Generalizability	The generalizability of an interactive system supports users when they try to extend their knowledge of specific interaction behaviour to situations similar but not previously encountered. This leads to a more complete predictive model of the system for the user. We can apply generalisation to situations in which the user wants to apply knowledge that helps achieve one particular goal to another situation where the goal is similar. Generalizability can also be viewed as a form of consistency.	Dix, et al., 2004, Pretorius & Van Biljon , 2010, Paavilainen, 2010.
Consistency	Consistency relates to the likeness in behaviour arising from similar situations or similar task objectives. Users rely and expect a consistent interface. Consistency is applied to an element of the system interaction, for example it (consistency) can be expressed in terms of the form of input expressions or output responses with respect to the meaning of actions in a conceptual model of the system. Consistency can also be a dangerous principle to follow, due to its relative nature, for example the development of the natural typewriter.	Dix, et al., 2004, Lee, et al., 2010, Rusu, Rusu, & Roncagliolo, 2008, Grudin, 1989.

Table 3.2 Usability principles (continued)

Principle	Description	References
Flexibility	Flexibility refers to the multiplicity of ways the end-user and the system exchange information (Dix et al. 2004). For example accelerators (unseen by novice users) may often speed up the interaction for the expert user such that the system can cater to both inexperienced and experienced users. Flexibility also allows users to tailor frequent actions (Preece 2009). Flexibility's affiliated terms are: changeability, adaptability, compatibility, expandability, extendibility, extensibility and portability. The wide variety of usage of the term flexibility increases the risk of misinterpretation. Flexibility has the potential to improve usability by taking into consideration the knowledge of the user, and also the knowledge of the interactions, the task/domain, and the system (Gebus & Leiviska, 2009). Constabile (2006) maintains that interactive systems supporting people activities, even those designed for a specific application domain should be very flexible, i.e., they should be easily adapted to specific needs of the user communities. Ribeiro et al. (2009) is in agreement with Constabile (2006) and emphasise the need for flexibility. Flexibility appears as criteria in Nielsen's Heuristics (1993), Muller's Heuristics (1998) and Dix's principles (Dix et al. 2004). As mentioned previously principles that support flexibility consist of dialogue initiative**,** multi-threading**,** task migratability**,** substitutivity and customisability.	Dix et al. 2004, Preece, et al., 2002, Gebus & Leiviska, 2009, Constabile, Fogli, Lanzilotti, Mussio, & Piccinno, 2006, Ribeiro, et al., 2009, Nielsen, 1993, Muller, Matheson, & Gallup, 1998.
Substitutivity	Substitutivity requires that equivalent values can be substituted for each other. Input substitutivity contributes towards flexibility by allowing the user to choose whichever form best suits the needs of the moment. Output substitutivity is when the system provides information regarding the system's state information.	Dix, et al., 2004.

Table 3.2 Usability principles (continued)

Principle	Description	References
Multi-threading	Multi-threading of the user-system dialogue allows for interaction to support more than one task at a time. Concurrent multi-threading allows simultaneous communication of information pertaining to separate tasks. Interleaved multi-threading permits a temporal overlap between separate tasks, but stipulates that at any given instant the dialogue is restricted to a single task. A windowing system naturally supports a multi-threading dialogue that is interleaved amongst a number of overlapping tasks.	Dix, et al., 2004, Karimi & Mosleh, 2012.
Task Migratability	Task migratability concerns the transfer of control for execution of tasks between system and user. It should be possible for the user or system to pass the control of a task over to the other or promote the task from a completely internalised one to a shared and cooperative venture. Hence a task that is internal to one can become internal to the other or shared between the two collaborators.	Dix, et al., 2004, Ji, Park, Lee, & Yun, 2006,
Observability	Observability allows the user to evaluate the internal state of the system by means of its perceivable representation at the interface. This allows the user to compare the current observed state with his intention within the task-action plan, possibly leading to a plan revision. This usability principle relates to the usability principle of system feedback from Nielsen (2004). This is confirmed by Preece (2007) who maintains the system should always keep users informed about what is going on, through appropriate feedback within reasonable time. Seffah (2008) argues that user feedback information, such as application status, must be carefully designed and exchanged on the client and server part of the application, anticipating response time of each component and exception handling.	Dix, et al., 2004, Preece, et al., 2002, Seffah, Mohamed, Habieb-Mammar, & Abran, 2008.

Table 3.2 Usability principles (continued)

Principle	Description	References
Customisability	Customisability is the modifiability of the user interface by the user or the system. We distinguish between the user–initiated and system-initiated modification, referring to the former as adaptability and the latter as adaptivity. Adaptability refers to the user's ability to adjust the form of input and output. Adaptivity is automatic customization of the user interface by the system. The distinction between adaptivity and adaptability is that the user plays an explicit role in adaptability, whereas his role in an adaptive interface is more implicit.	Dix, et al., 2004, Rogers, et al., 2012
Robustness	In a work or task domain, a user is engaged with a computer in order to achieve some set of goals. The robustness of that interaction covers features that support the successful achievement and assessment of the goals. Zuo & Panda (2008) asserts the robustness (or fault-tolerance) of a software program describes one functional feature about the program. The robust design of the decision system, entails an ability to accept variability in process and field usage. This feature helps an evaluator in making a decision regarding the quality of the software. Hence, this attribute is considered a trust-related attribute for the type of software (Véronneau & Cimon, 2007).	Dix, et al., 2004, Loer & Harrison, 2001, Zuo & Panda, 2008, Véronneau & Cimon, 2007.
Recoverability	Recoverability is the ability to reach a desired goal after recognition of some error in a previous interaction. Recovery can occur in two directions, forward or backward. Forward error recovery involves the acceptance of the current state and negotiation from that state towards the desired state. Forward error recovery may be the only possibility for recovery if the effects of interaction are not revocable. Backward error recovery is an attempt to undo the effects of previous interaction to return to a prior state.	Dix, et al., 2004, Bevan, 1995.

Table 3.2 Usability principles (continued)

Principle	Description	References
Task conformance	Task conformance aims to address whether the system supports all of the tasks in the way the user wants. Task completeness addresses the issue of coverage and task adequacy addresses the user's understanding of the tasks. It is also desirable that the system services be suitably general so that the user can define new tasks.	Dix, et al., 2004.
Efficiency	Efficiency refers to the way a product supports users to carry out tasks (Preece 2007). Efficiency appears as criteria in Nielsen's (1993) heuristics, Muller et al.'s (1998) Participatory HE and SUMI questionnaire and is normally applied in a context of measurement (Nielsen, 1993, Reul, 2009, Karahocha, et al., 2009). Efficiency looks at the user's productivity, not the computer's' and ease of learning and ease of use are underlying design heuristics. This guideline is important because the users of DSSs are very often demanding users, which are users whose time is precious. This is supported by Evans' (2007) statement that the traditional customer base is typically not information professionals; it is usually a business user that needs to make decisions based upon information. The faster and more conveniently they can interact with the system, the better they will comply with the system's demands and the more they will use the system (Tabachneck-Schijf & Geenen, 2009, Ribeiro, et al. 2009).	Preece, et al., 2002, Nielsen, 1993, Reul, 2009, Karahocha, et al., 2009, Evans, 2007, Ribeiro, et al., 2009.
Natural Dialogue/ User's Language	Users unable to remember a command or lost in a hierarchy of menu, require a computer that is able to understand instructions expressed in everyday word. However, the ambiguity of natural language makes it very difficult for a machine to understand. Language is by nature vague and imprecise: this gives it its flexibility and allows creativity in expression; computers on the other hand require precise instructions.	Dix, et al., 2004.

Table 3.2 Usability principles (continued)

Principle	Description	References
Help and Documentation	Documentation is designed to provide a full description of the system's functionality and behaviour in a systematic manner. It provides generic information that is not directed at any particular problem. It is better if the system can be used without documentation; however it is still necessary to provide help and documentation. Any such information should be easy to search, focussed on the user's task, list concrete steps to be carried out, and not too large.	Dix, et al., 2004, Preece, et al., 2002.
Error prevention and Error messages	Error messages should be expressed in plain language (no codes), precisely indicate the problem, and constructively suggest a solution. Even better than good error messages is a careful design which prevents a problem from occurring in the first place. The ideal is to eliminate error-prone conditions or check for them and present users with a confirmation option before they commit to the action. Human errors are classified into slips and mistakes; these can be distinguished using Norman's (2000) gulf of execution. Slips are if the user understands a system well and knows exactly what to do to satisfy his/her goals, however he mistypes or accidentally pressed the mouse button at the wrong time. Mistakes on the other hand are when the user does not know the system well, and the goal might not be formulated correctly. It is therefore essential to identify whether the errors made are slips or mistakes. Slips may be corrected by better screen design; mistakes however, need users to have a better understanding of the system.	Preece, et al., 2002, Dix, et al., 2004.
User Satisfaction (US)	Is the sum of one's feelings and attitudes toward a variety factors related to the delivery of information products and services. Karahocha & Karahocha (2009) maintain that user satisfaction is the key parameter in software.	Ives, Olson, & Baroudi, 1983, Karahocha & Karahocha, 2009.

Table 3.2 Usability principles (continued)

Principle	Description	References
User Experience (UX)	Focuses on the entire user experience of an interactive product. There are three main interactive components that make up User Experience as a whole: • Emotion (consequence of a user's internal state). • Motivation (causal for activated product experience). • Reflection (spatiotemporal dimension).	Schulze & Kromker, 2010, Battarbee & Koskinen, 2005, Beauregard, Younkin, Corriveau, Doherty, & Salskov, 2007.

Table 3.2 also includes user experience (UX) as a usability principle, even though UX is a later development not propagated as such by zeitgeist such as Dix et al. (2004), Preece, et al., (2002) or Nielsen (1993) it will now be briefly discussed. Since the use of interactive applications has become an integral part of everyday life, users expect usable and tangible user interfaces (Schulze & Kromker, 2010). A shift in design in both the industry and the academia has widened the design scope from pursuing usability and visual attraction to covering user's comprehensive experience (Kim, Park, Hassenzahl, & Eckoldt, 2011).

To contextualise UX, the main difference between User Experience and Usability is that *usability* features as a(product) component of UX, as depicted in Figure 3.4. The ISO definition of user experience also implies measures of user experience are similar to measures of *satisfaction* (also known as affect) in usability.

When the ISO definition of usability is compared to the ISO definition of user experience there is a difference in focus and scope, namely task performance (for usability) and overall pleasure (from user experience) (Bevan, 1995). For the purpose of this study the basic definition and difference between Usability and User Experience is according to the ISO FDIS 9231-210:

- **Usability** is the ***extent*** to which a system, product or service ***can be used*** by specified users *to achieve* specific *goals* with effectiveness, efficiency and satisfaction in a specified context of use.

- **User Experience** involves the user's subjective ***perceptions and responses*** that ***result from the use*** *and/or anticipated use* of a product, system or service.

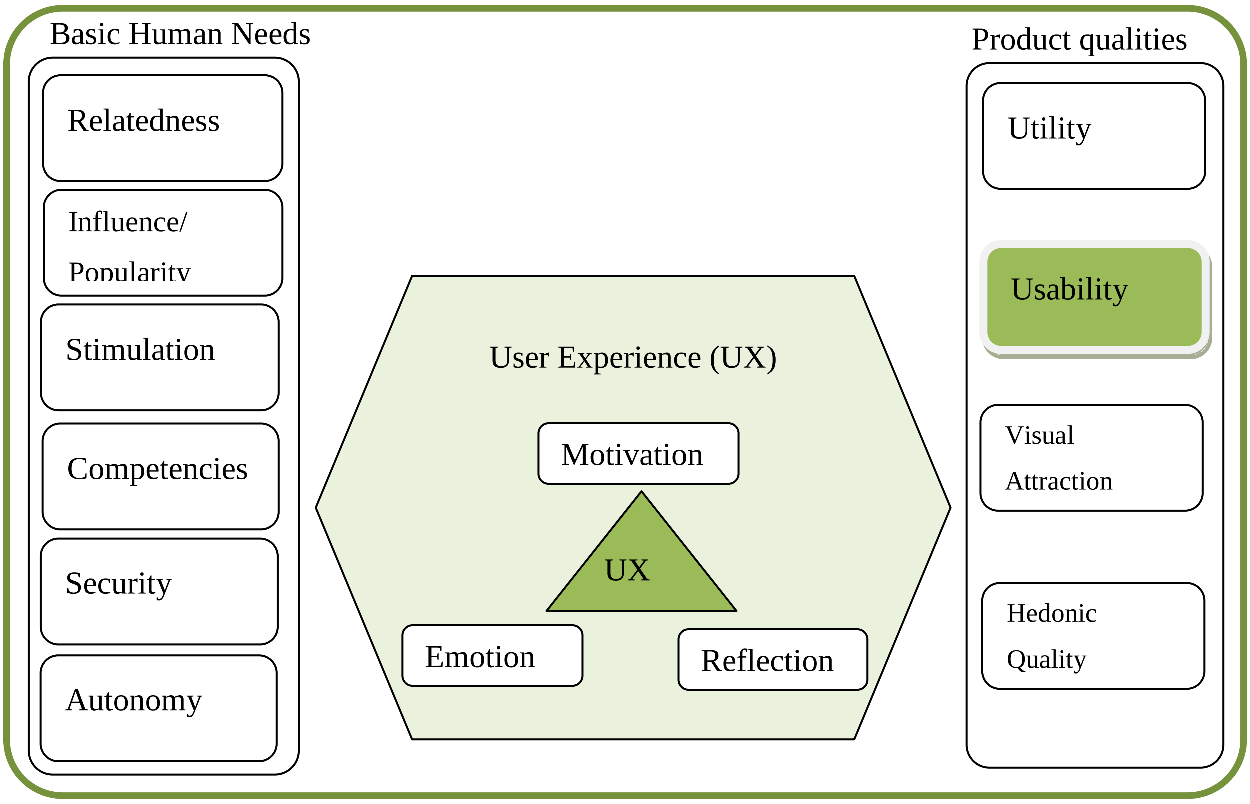


Figure 3.4 Framework of UX depicting influencing factors adapted from Schulze & Kromker (2010)

Further exploration is beyond the scope of this study but the difference between usability and user experience is investigated further in the work of Mozarny (2011) and Moczarny, De Villiers & Van Biljon (2012).

3.5.2 Usability design principles

Apart from usability principles, Nielsen (1993) originally classified design principles into five factors namely: interface, response time, mapping and metaphors, interface style and multimedia and audio-visual. Nielsen (1999) later added: navigation, credibility and content. The design principles from Nielsen (1993), Norman (1990) and Gould & Lewis (1985) are summarised in Table 3.3.

To summarize, the design principles in Table 3.3 are used by interaction designers when designing for usability. The design principles are generalizable abstractions intended to orient designers to think about different aspects of design (Rogers, et al., 2012).

Table 3.3 Nielsen (1993), Norman (1990) and Gould & Lewis (1985) design principles

Author	Design principles
Nielsen (1993)	i. Use simple and natural dialogue. ii. Speak the user's language. iii. Ensure that instructions are easily visible or retrievable. iv. Practice design consistency. v. Give user appropriate system feedback. vi. Provide clearly marked exits. vii. Provide shortcuts. viii. Display easily interpreted error messages. ix. Design to prevent errors. x. Provide help and documentation.
Norman (1990)	i. Conceptual models: Make sure that the operation of the device is apparent and lawful, rather than hidden and arbitrary. ii. Feedback: Let the user see the effect of the action right away. iii. Constraints: Make it easy to use the device correctly, impossible to do otherwise. iv. Affordances: Make appropriate actions clear and inappropriate actions invisible.
Gould & Lewis (1985)	i. Early focus on users and tasks: First, designers must understand who the users will be. This understanding is arrived at in part by directly studying their cognitive, behavioural, anthropometric, and attitudinal characteristics, and in part by studying the nature of the work expected to be accomplished. ii. Empirical Measurement: Second, early in the development process, intended users should actually use simulations and prototypes to carry out real work, and their performance and reactions should be observed, recorded, and analysed. iii. Iterative Design: Third, when problems are found in user testing, as they will be, they must be fixed. This means design must be iterative: There must be a cycle of design, test and measure, and redesign, repeated as often as necessary.

3.5.3 Usability goals

Usability *goals* provide guidance at a general level and can be defined as setting up usability criteria for assessing the acceptability of a system (Rogers, et al., 2012). These usability goals are usually operationalised as questions (Rogers, et al., 2012).

Usability is broken down into the following goals (Nielsen 1993, Rogers, et al., 2012):

- Effective to use (effectiveness, refer to Table 3.4).
- Efficient to use (efficiency addressed in Table 3.2).
- Safe to use (safety, refer to Table 3.4).
- Having good utility (utility, refer to Table 3.4).
- Easy to learn (learnability addressed in Table 3.2).
- Easy to remember (memorability, refer to Table 3.4).

From these goals, *efficiency* and *learnability* were discussed in Table 3.2, as they also fall under usability principles. Effectiveness, safety, utility and memorability will be addressed in Table 3.4. Note that beside the semantic difference between the constructs of goals and principles, these are both operationalised into the same set of usability criteria and therefore no further distinction will be made between usability goals and usability principles.

Table 3.4 Definition of effectiveness, safety, utility and memorability

Goal	Description	References
Effectiveness	The accuracy and completeness with which specified users can achieve specified goals in particular environments. In other words, the degree to which a person or system realises its goals and objectives.	Dix, et al., 2004, Rogers, et al., 2012.
Safety	Safety in this context pertains to protecting the user from dangerous conditions and undesirable situations.	Rogers, et al., 2012.
Utility	Refers to the design's functionality: Does it do what users need? Usability and utility are equally important: It matters little that something is easy if it is not what the users want. Similarly, it is of no use if the system can hypothetically do what you want, but you cannot make it happen because the user interface is too difficult. To study a design's utility, you can use the same user research methods that improve usability.	Nielsen 2003, Rogers, et al., 2012.
Memorability	The Merriam-Webster dictionary defines memorability as the quality or state of being easy to remember or worth remembering. Nielsen proposes the following definition: Memorability is when users return to the design after a period of not using it, how easily can they re-establish proficiency?	Merriam-Webster dictionary, 2011, Nielsen, 1993.

3.5.4 Usability Standards

The ISO 9241 (ISO, 1998) was consulted (see definition in Section 3.2) and compared with the usability principles as suggested by Nielsen (2004) and Dix, et al., (2004). As stated previously the ISO 9241 definition of usability is defined as the effectiveness, efficiency and satisfaction with which users achieve their goals in a particular environment.

Where *effectiveness* is the precision and entirety with which users can achieve particular goals in specific environments, *efficiency* is the resources expended in relation to the precision and entirety of goals achieved and *satisfaction* is the ease and tolerability of the work system to its users and other people affected by its use. Refer to Table 3.5 for correspondence between the following usability principles and the ISO 9241 usability standard components.

Table 3.5 Correspondence between usability principles and ISO usability standards

Usability Principles	Usability Standards
Predictability, familiarity, consistency	Conformity with user expectations
Error prevention, error messages, recoverability	Error tolerance
Learnability	Suitability for learning
Satisfaction/Affect	Suitability for individualisation

During the literature review, the researcher aimed to find correspondence between the most acknowledged usability principles as proposed by various usability experts such as Dix, Preece, Rogers, Sharp, Nielsen, Norman, Schneiderman, and Tognazzini; and the generally accepted usability standards in order to identify the appropriate instrument(s) for the study. The researcher then created a theoretical framework from which criteria could be identified and selected for use towards usability evaluation guidelines, specifically for BI applications.

This comparison of usability standards and principles is presented in Table 3.6. Note that the usability metric of effectiveness (Tulli & Albert, 2008) is not measured directly as it is based on other principles like control, suitability for task, etc. that contributes to the amount of effort required completing the task. Also note that despite the semantic difference between usability goals and usability principles both are operationalised into the same set of criteria and therefore no further distinction will be made.

Table 3.6 Mapping of usability principles

Usability Standard	Usability Principles		
ISO 9241	**Dix, et al., (2004)**	**Nielsen (1993)**	**Tognazzini (2003)**
			Fitt's Law,
Self-descriptiveness		Natural Dialogue / User's language, Instructions visible and retrievable	Use of metaphors, Readability
	Flexibility		
Controllability			Track state
Suitability for learning	Learnability	Learnability	Learnability
		Efficiency	Efficiency
Suitability for task			
Conformity with user expectation	Predictability, familiarity		Anticipation
	Consistency	Design consistency	Consistency
Error tolerance	Recoverability (task conformance)	Error prevention / Error messages	Protect user's work
		Clearly marked exits	Explorable Interfaces, Visible navigation
Suitable for Individualisation	Customisability, task migratability, (synthesisability)		
			Autonomy
		Help / Documentation	
Satisfaction rating		Satisfaction	
	Responsiveness	Appropriate system feedback	Latency Reduction
		Memorability	
			Colour Blindness
			Default

3.5.5 Usability guidelines

Rogers, et al., (2012) refer to guidelines as a general term used for all forms of guidance and rules as the low-level guidance that refer to a particular prescription to be followed, and heuristics as a general term used to refer to design and usability principles when applied to a particular design problem. From the literature reviewed no usability guidelines could be found specifically for BI applications.

3.6 USABILITY EVALUATION

A usability evaluation is any analysis or empirical study of the usability of a prototype or system (Foltz, Schneider, Kausch, Wolf, Schlick and Luczak 2008, Tullis & Albert, 2008). This involves usability metrics which are observable, quantifiable and focused on measuring something about the interaction of the person with the system or product under investigation (Tullis & Albert, 2008). Foltz, et al., (2008) propagates the goal of usability evaluation as to provide feedback in software development and supporting an iterative development process. A combination of different evaluation methods like usability testing, HE, questionnaires, log file analysis or focus groups could be a way to address different questions at different design stages (Lutsch, 2011).

Dix, et al., (2004) maintain usability evaluation has three main goals:

- To measure the extent and accessibility of the system's functionality.
- To measure users' experience of the interaction.
- To identify any particular issues within the system.

Foltz, et al., (2008) propose that in general, two types of evaluation can be distinguished: formative and summative. *Formative evaluation* takes place during the design phase to identify aspects of the design to be improved and to provide direction in how to make changes (to the design). *Summative evaluation* measures a design result and happens towards the end of a design phase.

Consequently, evaluation methods can be separated into two different classes: *analytic* and *empirical*, respectively. *Analytic evaluation methods* can be used early in the development process, well before there are users or prototypes available for empirical tests. Furthermore, it is often less expensive than making studies with users. Examples of analytic methods are HE, cognitive walkthroughs, usability-expert reviews, group design reviews. A hazard of analytic evaluation is that system developers or software designers may feel that they are being evaluated (Foltz, et al., 2008).

Empirical evaluation methods involve actual or designated users. The methods can be relatively informal, such as observing people while they explore a prototype, or they can be quite formal and systematic, such as a tightly controlled laboratory study of performance times and errors or a comprehensive survey of many users (Foltz, et al., 2008).

Nielsen (1990) proposes four ways to evaluate a user interface:

- Formally by some analysis technique.
- Automatically by a computerised procedure.
- Empirically by experiments with test users.
- Heuristically by simply looking at the interface and passing judgment according to one's own opinion (guideline based).

According to Howarth, et al., (2009) all usability evaluation sub-processes, whether they use empirical or analytical techniques, have three basic stages: usability data collection, usability problem (UP) analysis, and usability evaluation reporting. In the usability data collection stage, the usability practitioner performs lab- based usability testing or an inspection method, such as HE, and produces raw usability data in the form of notes perhaps with associated video and audio clips and screen images. The usability practitioner then reviews and establishes relationships among data in the UP analysis stage to create UP descriptions. In the usability evaluation reporting stage, the usability practitioner generates usability evaluation reports based on the UP descriptions. Law & Hvannberg (2008) supports Howarth et al.'s view that process consolidating usability problems (UP's) is an integral part of usability evaluation involving multiple users/analysts, and influence how developers redesign the system.

Nielsen (1993) also maintains that many usability evaluation methods contain design guidelines. Usability principles can be operationalised as questions; this provides the interaction designer with a concrete means of assessing aspects of an interactive system and the user experience (Rogers, et al., 2012). For example, is the product capable of allowing people to learn, carry out their work efficiently, access the information they require? Through answering these questions designers can be alerted early on in the design process to potential design problems and conflicts that might exist (Preece, et al., 2002).

Usability evaluation is therefore an important part of software development, providing results based on quantitative and qualitative estimations (Gonzalez, et al., 2008). Since this section concerns usability evaluation the following sub-section will explore usability evaluation approaches and methods.

3.6.1 Usability evaluation approaches and methods

Preece, et al., (2002) propose three main evaluation approaches:

- Usability testing: involves measuring typical users' performance on typical tasks.
- Field studies: done in a natural setting with the aim of understanding what people do naturally and how products mediate their activities.
- Analytical evaluation: consists of two categories of evaluation methods: inspections (including HE's and walkthroughs) and theoretically based models used to predict user performance.

Each of these approaches has respective methods associated with them. Evaluation makes use of the following methods: observing users, asking users, asking experts, user testing, inspections, and modelling users' performance. Depending on the evaluation approach, some methods may be combined to get a broad understanding of the efficacy of a design (Preece, et al., 2002). See Table 3.7 for more detail regarding the different evaluation types, their methods and purpose.

3.6.1.1 Inspection methods

Inspection methods involve expert evaluators only, who inspect the application and provide judgments based on their knowledge and expertise (Ardito, Lanzilotti, Buono, & Piccinno, 2006). *HE* is such an inspection method. HE is a popular inspection method that involves few experts inspecting the system, and evaluating the interface against a list of recognised usability principles: the heuristics (De Kock, et al., 2009, Tullis & Albert, 2008). *Cognitive walkthrough* is a usability inspection method aimed at evaluating the ease of learning user interfaces (Kato & Hori, 2006). Cognitive walkthroughs simulate a user's problem-solving process at each step in the human-computer dialogue, and checking to see how users progress from step to step in their interactions with the system or application (Rogers, et al., 2012).

3.6.1.2 Inquiry methods

Inquiry Methods such as *contextual inquiry* extracts requirements that are important for the interviewed user groups from the context (Reul, 2009). Another inquiry method is the use of questionnaires. *Questionnaires* are a well-established technique for collecting demographic data and user opinions (Tullis & Albert, 2008). They are similar to interviews in that they can consist of open or closed questions. Questionnaires are ideal for retrieving answers to specific questions from a large group of people spread across a wide geographical area. They can also be used in conjunction with other methods to clarify answers. Questionnaire are also generally cheaper to administer and easier to organise (Nielsen, 1990, Rogers, et al., 2012).

3.6.1.3 Observation methods

Observation methods help designers understand the users' context, tasks, and goals. It can also help to investigate how well the developing prototype supports the users' goals and tasks (Rogers, et al., 2012). These observation methods consist of the following methods: 1) direct observation in the field; 2) direct observation in controlled environments. In controlled environments *Testing Methods such* as the *Think Aloud method* may be used to get some idea of what the user is thinking. Indirect observation such as diaries and interaction logs may also be considered for unobtrusive observation alternatives (Rogers, et al., 2012).

3.6.1.4 Think aloud method

The *think aloud method* states that this is a systematic qualitative technique also known as protocol analysis to examine usability (Chou & Hsiao, 2007). Beaton, Brad, Myers, Stylos, & Jeong (2008) proclaimed this usability evaluation technique as the gold standard of usability testing, but can be difficult to apply when in an unconstrained environment, such as during programming. If subjects can potentially choose any of a wide array of optional solutions, none of them obviously wrong, testing can be very time consuming without identifying definite usability problems.

The purpose of the think aloud technique appears to be solely to understand why targets are not being met (Cockton, 2008). Norman (1990) emphasizes that users' problems are designers' problems; and, if designers make systematic observations, the problems can be explained and solved. Table 3.7 summarizes usability evaluation types, the methods associated with these types and their respective purposes.

HE was selected as appropriate expert method type for the study of BI in Supply Chain Management due to its cost effectiveness, the fast execution thereof, the ease of use, the fact that HE is not resource intensive and the possibility of method combination (Nielsen, 1993, Ardito, et al., 2006) therefore HE will now be discussed in more detail.

Table 3.7 Usability evaluation types, methods and purposes compiled from Dix, et al., (2004) and Nielsen (1993)

Evaluation Type	Method Type	Purpose
Expert Evaluation	Cognitive walkthrough	To establish how easy a system is to learn, by means of evaluators that 'step' through action sequences to check for potential usability problems.
Expert Evaluation	Heuristic evaluation	Several evaluators independently critique a system to establish potential usability problems (5 to 8 evaluators sufficient).
Expert Evaluation	Model-based evaluation	Certain cognitive and design models provide a means of combining design specification and evaluation into the same frame work.
Expert Evaluation	Using previous studies in evaluation	Making use of previous results as evidence to support (or refute) aspects of the design (usability).
User based Evaluation	Experimental evaluation	This provides empirical evidence to support a particular claim or hypothesis (Can be used for wide range of issues and at different levels).
User based Evaluation	Think aloud and cooperative evaluation	This is a form of observation where the user is asked to talk through what he is doing as he is being observed.
User based Evaluation	Protocol analysis	To record user actions (for example: audio, video, computer logging, user notebooks).
User based Evaluation	Post-task walkthroughs	To reflect the participants actions back to them after the event. Also ensures a subjective viewpoint on the user's behaviour.
User based Evaluation	Query techniques	To elicit detail of the user's view of a system (for example interviews, questionnaires).
User based Evaluation	Monitoring physiological responses	This allows us to see more clearly exactly what users do when they interact with computers, and also measure how they feel.

3.6.2 Heuristic evaluation

HE is a popular informal inspection method that involves a few experts inspecting the system, and evaluating the interface against a list of recognised usability principles: the heuristics (Ardito, et al., 2006). Nielsen calls the method the *discount usability* method; and it has been shown that it has a high benefit-cost ratio (Nielsen, 1993). In short, HE is an informal method of usability analysis where a number of evaluators are presented with an interface design and asked to comment on it (Nielsen, 1990). In addition to its attributes of low cost and relative simplicity, HE shows to be effective, efficient, and sufficient to identify usability problems (Ardito, et al., 2006, Nielsen, 1990, Ssemugabi & de Villiers, 2007). Experiments showed that individual evaluators were not satisfactory in doing such HE and that they only found between 20% and 51% of the usability problems in the interfaces they evaluated. On the other hand, we could aggregate the evaluations from several evaluators to a single evaluation and such aggregates fare better (Nielsen, 1990).

Depending primarily upon a list of heuristics, each reflecting an archetypical problem that can be identified by its symptoms in such a straightforward manner that the solution also becomes clear (Beaton, et al., 2008). The heuristic guidelines of Kwon, Ham, & Yoon (2007), Muller, et al., (1998), Nielsen (1993), Norman (1990), Schneiderman (1998) and Tabachneck-Schijf & Geenen (2009) are outlined in ANNEXURE G. Many popular computing companies also have developed their own sets of user interface guidelines, such as the Apple Human Interface guidelines and the Microsoft user interface guidelines (Dix, et al., 2004, Reul, 2009).

3.6.2.1 Heuristic evaluation guidelines

HE has several *advantages* (De Kock, et al., 2009, Jeffries & Desurvire, 1992, Karat, Campell, & Fiegel, 1992, Nielsen 1990):

- They are cost effective.
- Intuitive (people are keen to contribute).
- No advanced planning is required.
- Can be used in the early stages of development to identify usability problems.
- Is reliable and predictive of laboratory testing methods.
- Is not time consuming.

To summarise the, the HE guidelines of Schneiderman (1998), Muller, et al., (1998), and Nielsen (1993) are set out in Table 3.8.

Table 3.8 Heuristic evaluation guidelines of Schneiderman (1998), Muller, et al., (1998), and Nielsen (1993)

Author	HE guidelines
Schneiderman (1998)'s eight golden rules of interface design	(1) Strive for consistency. (2) Enable frequent users to use shortcuts. (3) Offer informative feedback. (4) Design dialogue to yield closure. (5) Offer simple error handling. (6) Permit easy reversal of actions. (7) Support internal locus of control. (8) Reduce short-term memory load.
Muller, et al., (1998) Participatory heuristic evaluation	(1) System Status. (2) User Control and Freedom. (3) Task sequencing. (4) Emergency exits. (5) Flexibility and efficiency of use. (6) Consistency and relevance. (7) Match between system and the real world. (8) Consistency and standards. (9) Recognition rather than recall. (10) Aesthetic and minimalist design. (11) Help and documentation. (12) Error Recognition and Recovery. (13) Help users *recognise*, *diagnose*, and *recover* from errors. (14) Error prevention. (15) Task and Work Support. (16) Skills. (17) Pleasurable and respectful interaction with the user. (18) Quality work. (19) Privacy.
Nielsen's Heuristics (1994) to assist usability experts in heuristic evaluation	(1) Visibility of system status. (2) Match between system and the real world. (3) User control and freedom. (4) Consistency and standards. (5) Error prevention. (6) Recognition rather than recall. (7) Flexibility and efficiency of use. (8) Aesthetic and minimalist design. (9) Help users recognise, diagnose, and recover from errors. (10) Help and documentation.

However HE also has *disadvantages*, listed as (Kasarskis, Stehwien, Hickox, Aretz, & Wickens, 2001, Law & Hvannberg, 2008, Nielsen, 1990, Pretorius, et al., 2005):

- May identify a usability problem without providing suggestions for a solution.
- The method could be biased by the evaluator mind-sets.
- Does not create breakthroughs in the evaluated design.
- The reliability of the effectiveness measure.
- The large influence of rater experience.
- Lack of theoretical underpinning.

3.6.3 Inquiry via questionnaire

Another form of user-based query technique is inquiry via questionnaire to extract detail of a user's view of a system, see Table 3.7. Usability questionnaires were first introduced by Bailey & Pearson (1983); who developed a valid and useful user satisfaction (US) measure with 39 items. The instrument provided a broad and complete base of satisfaction-related themes. Shortly thereafter Ives, et al., (1983) established a 13-item *short-form* instrument. The instrument is comprised of three factor measures: 1) information product; 2) EDP (MIS) staff and service; 3) user knowledge and involvement. Baroudi & Orlikowski (1988) confirmed the three-factor structure and supported the diagnostic utility of the short-form instrument. Igbaria & Machman (1990) and Doll & Torkzadeh (1988) respectively re-examined the instrument of Ives, et al., (1983) and provided the empirical evidences that supported the 13-item instrument as a measure of user satisfaction.

The short-form instrument has been useful in measuring user satisfaction in a traditional IS environment or in the context of large IS-developed transaction processing information systems, where user involvement is thought to play an important role (Wu, Barash, & Bartolini, 2007). Sengupta & Zviran (1997) later reconfirmed the usefulness of the short form and added a new factor namely, contractor services.

Chou & Hsiao (2007) remarks that a wide variety of usability evaluation tools has been documented (questionnaires are one of the inquiry-based techniques generally used in usability research). A well-designed questionnaire can give valuable feedback from the user point of view, and also can assist researchers in collecting useful information. Data analysis plays an important role in usability studies (Tullis & Albert, 2008).

Given the user-centred nature that computer interfaces should be used by specified users to achieve specified goals in a specified context of use, data should be reasonably representative of the population involved in the research. To make the collected data available for interpretation, various mathematical methods have been developed and used (Chou & Hsiao, 2007, Karahocha, et al., 2009, Lin, et al., 2009).

Karahocha, et al., (2009) maintains that the measurement of software usability in terms of quantifiable means is realized with extension metric concepts. Therefore many software usability questionnaires have been developed to determine user satisfaction such as SUMI (software usability measuring inventory) developed by Kirakowski during 1994 (Kirakowski, The Use of Questionnaire Methods for Usability Assessment, 1994), QUIS (Questionnaire for User Interface Satisfaction) (Chin, Diehl, & Norman, 1988) and PSSUQ (Post-Study System Usability Questionnaires) (Karahocha, et al., 2009). These questionnaires generally are not specific enough (for evaluation purposes) and too generic (Ryu & Smith-Jackson, 2005). Subsequently developers of those questionnaires indicated that deficiencies in their questionnaires can be taken care of by the establishment of a context of use, characterisation of end user population, and understanding of tasks for the system to be evaluated (Van Veenendaal, 1998). In response to that, deficiency questionnaires tailored to particular groups of software have been developed (Ryu & Smith-Jackson, 2005) for example MUMMS (measuring the usability of multi-media), WAMMI (website analysis and measurement inventory) (Kirakowski & Cierlik, 1998) and UFOS (Usability Questionnaire for Online Shops) (Konradt, Wandke, & Christophersen, 2003). The need for updated usability questionnaires for consumer products is inevitable, not only in terms of the new domain of target products but also in terms of evolving definitions and concepts of usability (Ryu & Smith-Jackson, 2005).

3.6.4 Evaluation of BI systems

The research of Lin, et al., (2009) summed up 40 criteria of evaluating information system performances. The efficiency of an information system can be assessed as the key element in the successful implementation of a BI system (Lin, et al., 2009). In this study BI is regarded as an informative decision support system refer to Section 2.2.1. Key criteria are then picked out through experts' questionnaires as the major basis for constructing a BI system performance assessment model. Lin, et al., (2009) maintains that the *efficiency* of information systems can be classified into the assessment of *effectiveness* and the assessment of system *satisfaction.* HCI professionals (Preece, et al., 2002, Nielsen, 1993, Tullis & Albert, 2008) on the other hand, view these constructs as separate yet related so that efficiency refers to the way a product supports users to carry out tasks or the measure of being able to complete the task (Tullis & Albert, 2008).

Of the nine effectiveness criteria (Lin, et al., 2009), system response time, system security, and output information accuracy belong to BI systems, the criteria regarding meeting user's needs include, support degree of user and conformity to the requirements. Finally, support of organizational efficiency and support in decision-making in organizations, are the indicators of the criteria of meeting enterprise requirements (Lin, et al., 2009). Thus we are aware of the research conducted about IS usability and the lack thereof regarding BI usability.

Figure 3.5 aims to illustrate that the components of usability, namely effectiveness, efficiency and satisfaction are all connected and influence each other (Preece, et al., 2002, Nielsen, 1993, Tullis & Albert, 2008), the figure also makes use of Lin, et al., (2009)'s criteria for satisfaction, effectiveness and effectiveness sub-criteria.

Assessing the performances of an information system is about finding whether the information system can be accepted by users**,** their work-related needs can be met and objectives at the initial implementation can be achieved.

Having reviewed the most prominent usability evaluation methods in Section 3.6.1 it was concluded that the most appropriate methods for this study would be a combination of HE and empirical user testing making use of the SUMI survey. The context of the study which influenced the choice of the evaluation method will be discussed in more detail in Chapter 4, motivating the methods chosen. These usability evaluation methods support the research objective to develop usability guidelines for BI applications during this study.

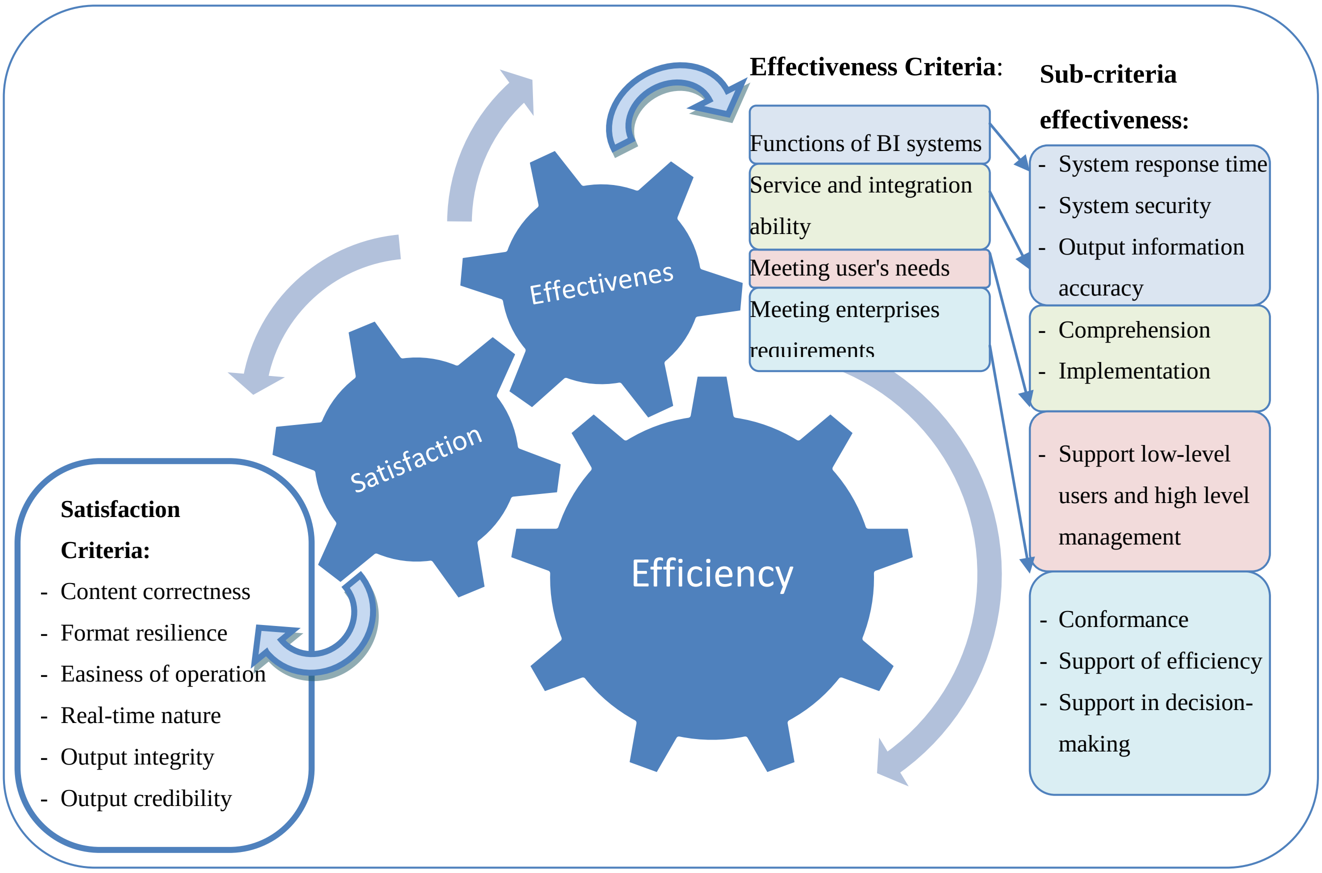


Figure 3.5 Components of usability: effectiveness, efficiency and satisfaction

3.7 USABILITY WITHIN DECISION-MAKING

Interfaces are usually very context-specific tools (Gebus & Leiviska, 2009). Better design and functionality, fitting better with user needs and tasks, can be achieved through better knowledge about customers and technologies ultimately leading to higher quality of HCI design and better usability (Heimgärtner, Windl, & Solanki, 2011). It has also been established that attractive user interfaces are perceived by users to be easier to use than unattractive ones (Preece, et al., 2007). Subsequently usability elements are important in BI. Subsequently the following will be considered: usability, the use of natural language, user control, flexibility, portability, robustness, psychological factors and user satisfaction (affect).

With the right information at the tips of their fingers, everybody in the organization becomes a potential decision-maker (Corcoran, 2007). Still Lamont warns that some poor decisions can be alleviated by the use of technology, whilst others cannot (Lamont, 2007). Therefore the BI should be as ***usable*** as possible, where usability is defined as the extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use, refer to Section 3.3. The complexity of any interface must be sufficient enough to catch the full scope of information, but simultaneously keep the data extraction process as simple as possible (Gebus & Leiviska, 2009). Lack of innovation, due to a lack of personal freedom to acquire new knowledge and skills, leads to substantial competitive disadvantages (Heimgärtner, et al., 2011).

When building a BI application, the vocabulary used by domain experts is often inadequate for end-users because it is not generally understandable. The ***use of natural language*** (propagated by Nielsen, 1993), and the right knowledge representation is therefore a vital task when generating a knowledge-base and an essential aspect of sharing and manipulating knowledge (Gebus & Leiviska, 2009). BI users are often presented with an exhaustive amount of data, on which they have to base decision they make, without necessarily having the proper understanding or knowledge to do so (Gebus & Leiviska, 2009). Therefore, to work efficiently with a system, the user needs to be able to ***control*** (Nielsen, 1993) the system, but also to assess its state so that he can define the proper course of action.

Software with dedicated interfaces has been developed using a knowledge representation that supports ***portability*** and ***flexibility*** of the system. Semi-automatic knowledge acquisition and generation of comprehensive reports resulted in an improvement of the *usability*, *usage*, and *usefulness* of the decision support system (Bevan, 1995, Gebus & Leiviska, 2009). Another building block in the ***robust*** decision framework within critical operations is the ***psychological*** dimension(s) (Véronneau & Cimon, 2007). This view is supported by Karahoca & Karahoca (2009) who states that according to their study it is not enough to implement software designing steps successfully, end-users' psychometric test results also need to be taken into account in the software designing steps for usability purposes.

There is more to *psychological* elements that impact decision-making, especially in a decisive operations environment. The influence of the social context also must be taken into consideration, the effect of exhaustion, the effect of stress, and the degree of risk-taking (Véronneau & Cimon, 2007). Doll, Raghunathan, Lim, & Gupta (1995) argues results suggest that decision issues that are relevant in improving ***user affect*** or productivity are few and focused mainly around information needs analysis. The importance of the fulfilment of the user's needs for differentiated enjoyment of user experience design is highlighted in recent studies, and literature suggests a practical design method (Kim, et al., 2011). An experience design process and method should be adopted, which helps to generate innovative design concepts based on the user's psychological needs (Kim, et al., 2011).

In summary literature highlights elements of usability required within decision-making systems and BI since BI is regarded as a subset of DDS, refer to Section 2.2.1.

3.8 USABILITY WITHIN BI

Research has been published concerning ERP usability and usage Chang, et al., (2007), Scott & Walczak (2009), Wu, et al., (2007); however research about BI usability is not readily available. Therefore the focus is on the improvement of systems from usability, the practical reality of a system's usability in the work place and system usability attributes, as will be discussed in Sections 3.8.1-3.8.3.

3.8.1 System improvement in terms of usability

To improve the usability outcome of an IT system, usability practitioners need to be involved in the system design (Bruno & Martin, 2007). Ardito, et al., (2006) underlines this by stating that usability is a significant aspect of the overall quality of interactive applications. End users have difficulty with using generic tools not designed to support specific roles or job functions (Ardito, et al., 2006). Therefore, a usability specialist is required with experience and expertise in HCI in general and user-centred design, as well as basic mastery of the technology, processes, methods and tools used in systems development and finally knowledge of the application domain (Gulliksen, et al., 2006).

However, many of the existing general usability criteria lists are oriented towards the design of the interface instead of assisting the performance of business activities (Cronholm, 2008). It is therefore critical to build up sufficient knowledge and understanding of the context of use (the working environment), but this requires user involvement (Gulliksen, et al., 2006). It is also important to articulate usability goals and requirements as early as possible (in systems design), in conjunction with user and business goals and requirements, and to avoid technological constraints where possible that may require usability workaround (Bruno & Martin, 2007).

Another way to improve the usability of BI systems is by establishing a BI educated population, this will remove barriers that stand between people and information (Corcoran, 2007). In addition to this, the divide (lack of integration) between BI environments and the personal productivity tools - namely, Microsoft Excel and other Microsoft Office applications (task migratability) need to be resolved (Corcoran, 2007). Microsoft has addressed this (Excel) issue with the development of the data warehouse tool SQL Server 2005 Integration Services, SQL Server 2005 Analysis Services and SQL Server 2005 Reporting Services, which can be integrated with Microsoft Excel, which is an important part of BI due to the application's agility and portability.

3.8.2 System usability in praxis

IT systems in the work place are often used intensively, for long periods. Therefore, users depend on the systems to enable them to complete their work (Gulliksen, et al., 2006). Cosmetic changes of the software in order to comply with ISO 9241 will not be sufficient and will most likely end in collaborative risks and problems affecting the quality of the software (Lutsch, 2011).

Technology has a substantial effect on the way information is stored, accessed and utilised by users (Dix, et al., 2004). Subsequently BI applications are becoming part of the standard technology set used by most businesses and emphasises the synergy with future Supply Chain applications (Shobrys, 2003). Technology can help most with analysis and presentation of data, and subsequently also has a significant effect on the organization and work environment (Lamont, 2007). With the influence of the emergence of technology on HCI the focus has turned to the management and manipulation of information within an organization (Dix, et al., 2004). Ultimately, an information system should provide value to the system users through the ability to get information into and out of the system easily and efficiently (Jagadish & Yu, 2007).

The importance of the human–computer interface in the data warehouse environment as the primary determinant of success from the end-user perspective needs to be kept in mind (March & Hevner, 2007), as a poor user interface often leads to frustrated users and lowers the productivity of the employees who must work with the system (Reul, 2009). Ultimately without support in the organization, human-centred design will fail (Lutsch, 2011).

3.8.3 System usability attributes

BI provides users the capability to drill down and ask a series of related questions, this makes the system robust, and allows for competitive advantage (Lamont, 2007). Usability is a key factor in the success of information presentation in the work environment, also the value of convenience and simplicity should be recognised, the correct information needs to be accessible, and the system should engage the user (Lamont, 2007).
Corocoran (2007) is one of the few authors who explicitly talk about usability within a BI context, mentioning the issue of learnability and portability. Business people have little time learning a complex BI environment (this includes creating reports and running queries). In order to support analysis and reporting tasks, the data warehouse must have high quality data and make data accessible through intuitive interface technologies.

System portability would also improve the usability of a BI system. This attribute is not an acknowledged usability principle, but could play a part in future usability research (usability criteria discussed in Section 3.2). Corocoran (2007) proposes that by combining data and interactive controls into a single, self-contained HTML file, active reports deliver analytic capabilities in a completely portable and disconnected environment, with no client-side software required. Active reports are ideal for mobile employees who are frequently disconnected from the local work network, such as operational supply managers or commodity managers who spend the majority of their time visiting mine sites. Since Corocoran's (2007) article technological advancements have made the use of remote BI tools a reality (Coronel, et al., 2011).

3.9 BUSINESS VALUE OF HUMAN-COMPUTER INTERACTION

The notion of a *value proposition* has been present for some time in the marketing literature (Mulani, 2008, Sahay & Ranjan, 2008, Corocoran, 2007) but there has been much less written about the concept of *how* HCI delivers value to the end-user (Gilmore, Cockton, Kujala, Henderson, Churchill, & Hammontree, 2008). Bias & Mayhew (2005) wrote a classic text on return on investment from usability work. An entirely separate thread of HCI is the delivery of business value through an application of HCI (Gilmore, et al., 2008). Donoghue (2002) offers a less economically driven perspective, but is still in the economic space of justifying investment in user centred design. Less work has been focused on persuading people of the value of HCI, but rather focus on understanding how HCI does or does not deliver business value.

Cockton (2008) proposes the term *value-centred HCI* after reviewing the history of HCI and offering a view of the *system-centred 70s, user-centred 80's* and *context-centred 90's* with the shift between these eras being triggered by the introduction of a new discipline. Initially computer science was a strong player, followed by psychology during the user-centred years, with sociology and anthropology being the dominant force in the context-centred 90's. Cockton (2008) offers value-centred HCI as the important next step forward, with *design* as the new discipline. A key part of his argument for design as the new driver is that HCI cannot deliver value as an objective, only as an applied science. Hence evaluating software systems for usability has been documented to be economically beneficial, as it determines to assess to what extent HCI has been applied in terms of: increased sales, increased user productivity, decreased training costs and decreased needs for user support (Bak, 2008).

Evaluation is required to check that users can use the product and that they like it. From a business and marketing perspective there are also good reasons to invest in usability evaluation, these include: designers get feedback about their early design ideas; major problems are fixed before the product goes on sale; designers focus on real problems rather than debating what each other likes or dislikes about the product (Preece, et al., 2002) These advantages of early usability evaluation mentioned is supportive to the usability evaluation goals mentioned in Section 3.5.3.

In addition Kerr, Knott, Moss, Clegg, & Horton (2008) have also addressed assessing the monetary value of ergonomic interventions and list the advantages of usability within the information systems as:

- Time savings for users in terms of asking for, providing and receiving relevant information when querying the system leading to increased productivity.
- Time and money are also saved in re-using up-to-date technical information and knowledge to solve similar problems across the organization.
- Usability recommendations have increased system usage, and contributed additional administrative and operational cost reductions.
- Improvements in system and data quality
- Improved system usability and higher levels of usage.
- Value through more efficient distribution and retrieval of information; reduced duplication by re-using technical knowledge to solve similar problems and improved sharing of good working practices, lessons and resources.
- There is a tendency to under-estimate the value of savings and benefits of human factors initiatives; this is addressed through a number of methods. Breaking up the problem into manageable sub-sets of questions helps specify the key metrics for the financial assessments.

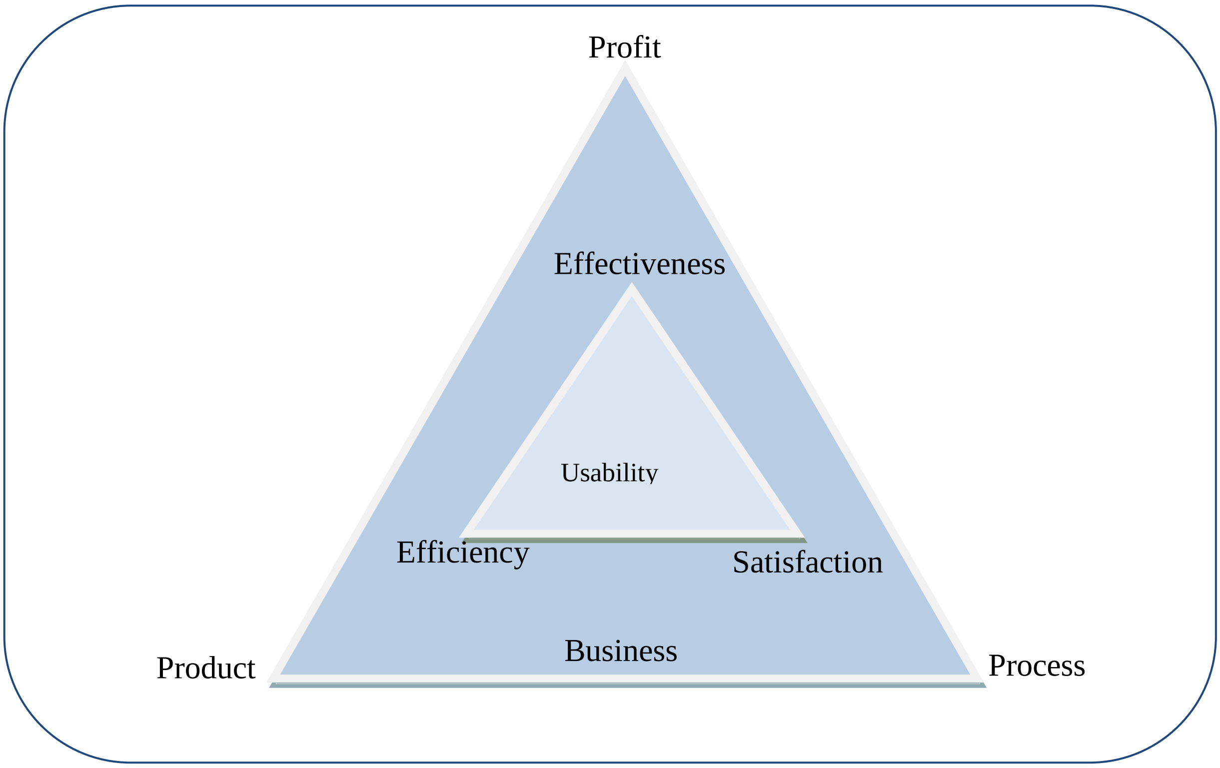


Figure 3.6 Collaboration of usability with business (Wiebe, 2000)

Investment in the initial HCI design is returned upon via its effects in the form of higher productivity and product quality with regards to financial gain but also in other ways like exponentially increased loyalty, motivation, or innovation emerging due to the development of synergy effects (e.g. via the feeling of being associated with an organization which is successful for this reason) (Heimgärtner, et al., 2011).

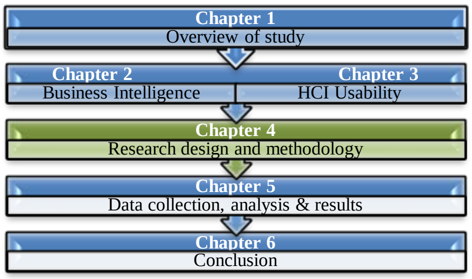
Wiebe (2000), one of the few authors to have mentioned usability in business systems at the time, proposed a collaboration of usability with business in a juxtaposition model illustrating the focus of Business (profit, product and process) alongside the definition of *Usability* (ISO 9241-11) efficiency, effectiveness and satisfaction as depicted in Figure 3.6. The importance of usability within BI has thus been recognised and underlined. Keeping this in mind the focus moves to finding usability evaluation guidelines for BI.

3.10 CHAPTER SUMMARY

This chapter discussed HCI Usability as further background to this study. Usability is generally accepted as the effectiveness, efficiency, and satisfaction with which users of an application are able to achieve their specific goals. The various usability principles, standards and guidelines extracted from the literature were explored and presented. Usability evaluation, specifically making use of a heuristic approach was looked at. Finally, usability within the context of decision-making and BI was presented in order to connect the two concepts of BI and usability. The chapter was concluded with the potential value of incorporating human-computer interaction in business. Now that the theoretic basis has been formed (based on the literature presented) the research design and methodology followed in this study will be presented in Chapter 4.

End of Chapter 3

Document Map



Chapter 4: Research design and methodology

Figure 4.1 Composition of Chapter 4

4.1 INTRODUCTION

A research design is a strategic framework for action serving to connect the research questions with the execution of the research (Terre Blanche, Durrheim, & Painter, 2006). This chapter presents the research design that was followed.

A research design is the logical sequence that links the empirical data to be collected to the initial research questions of a study, and ultimately to the research conclusions (Yin, 2009). According to Mouton (2003) a research design is a plan or blueprint of how the research intends to be conducted. Mouton (2003) characterises research design as: focusing on the end-product; the point of departure is the research problem or question; and focusing on the logic of the research. This corresponds to the suggestion that the research design is the action plan for getting from here to there. *Here* being defined by an initial set of questions, and *there* a set of conclusions or answers about the questions. Between the *here* and *there* a number of major steps may be found such as identification, collection and analysis of data relevant to the study (Korpel, 2005, Mouton, 2003, Yin, 2009). This idea of a journey could also be demonstrated by the 'research-onion' by Saunders, Lewis, & Thornhill, (2000) since the onion is layered and one could proceed to the inner layers of the onion by peeling away the outer layers as demonstrated in Figure 4.2.

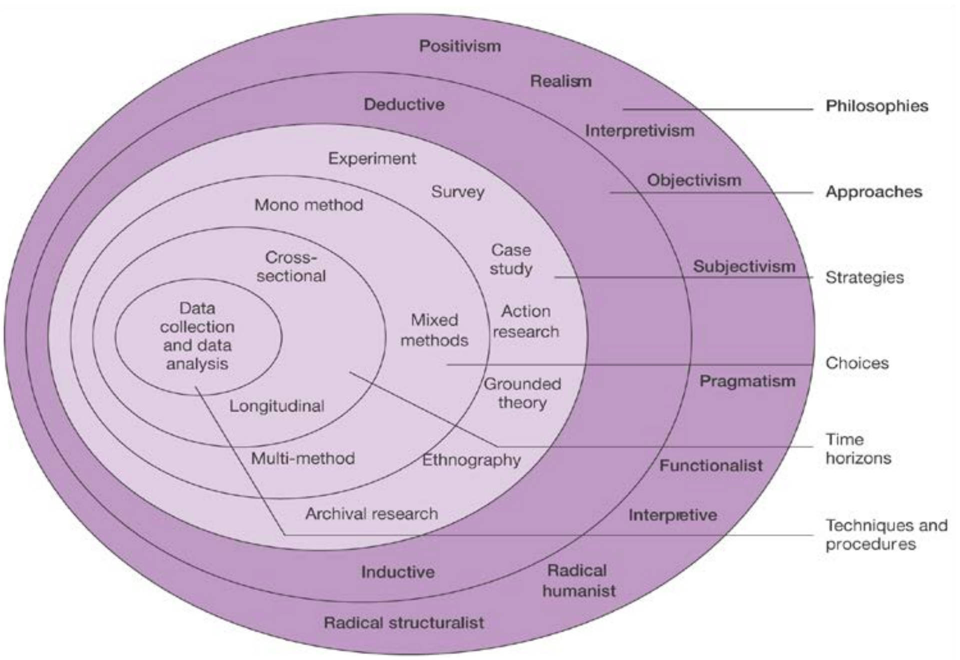


Figure 4.2 The research 'onion' (Saunders, et al., 2000)

Figure 4.3 depicts the application of the research 'onion' and its layered components to this study, indicating the choice of philosophy, approach, strategy, method choices, time horizons as well as techniques and procedures chosen.

The research 'onion' as presented in Figure 4.3 will guide the discussion in the first half of Chapter 4.

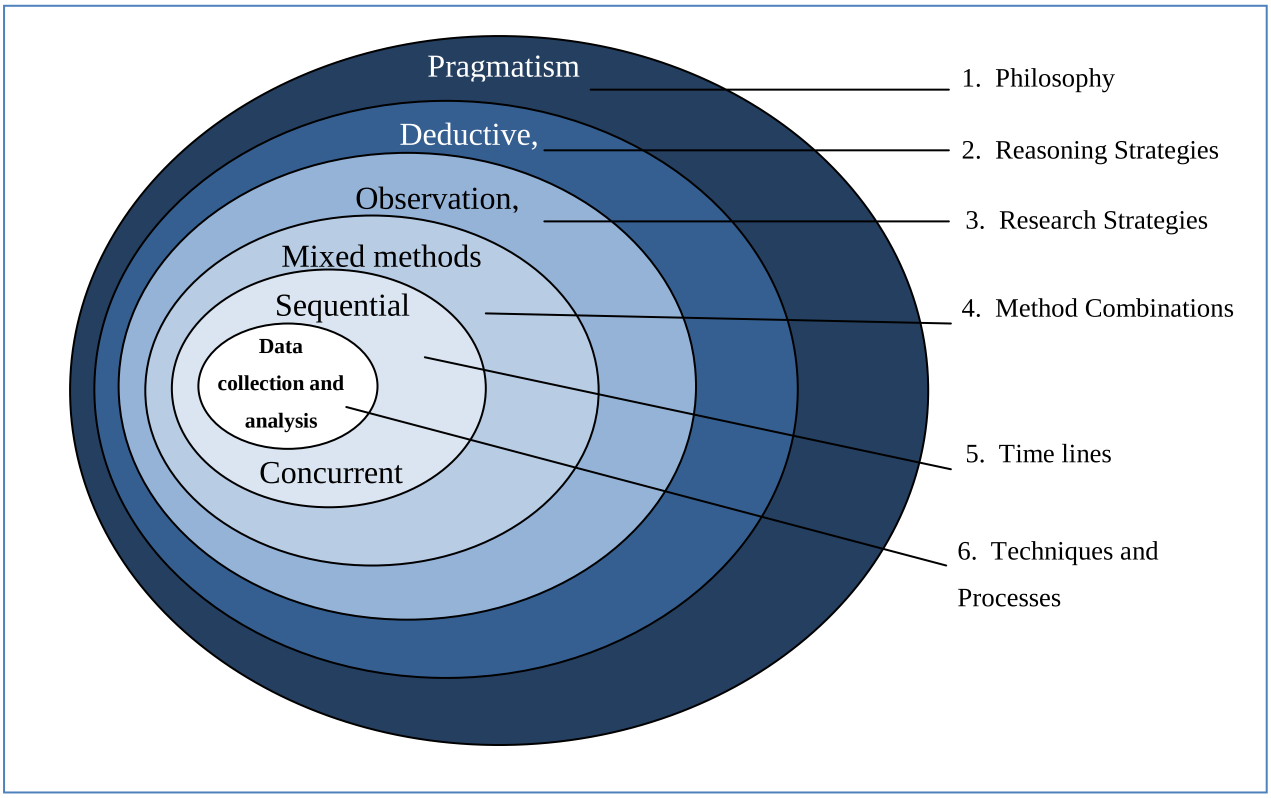


Figure 4.3 The 'research onion' as applied to this study

Thereafter the research execution, data triangulation, rigour of the study and limitations of the study will be discussed as fundamental to the idea of the 'onion'. Denzin & Lincoln (2011) propagate that a *research design* positions the investigator in the world of understanding. Five basic questions structure the issue of design (Denzin & Lincoln, 2011). Table 4.1 depicts the questions and corresponding document references; throughout the course of this chapter each of these questions will be addressed.

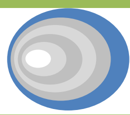
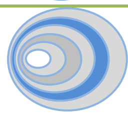
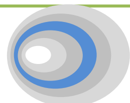
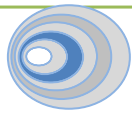
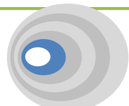
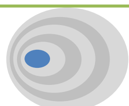
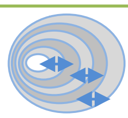
In the following sections of the chapter, the layers of the 'research onion' will be 'peeled' away, starting from the outside and working towards the centre, this will allow for the research design and methodology to be discussed according to the different layers of the *research onion*.

Table 4.1 Questions that structure research design adapted from Denzin & Lincoln (2011)

Five questions structure research design (Denzin & Lincoln, 2011)	Section Reference
1. How will the design (in this case mixed methods) connect to the (pragmatic) paradigm or perspective used?	Section 4.2
2. Within the (pragmatic) paradigm the mixed method design will lead to what problems and what changes will the study lead to?	Section 6.5
3. Who or what will be studied?	Section 4.5
4. What strategies of inquiry will be used?	Section 4.4
5. What methods or research tools for collecting and analysing empirical materials will be utilised?	Section 4.5

A visual cue will be used indicating the layer or concept of the ‘research onion’ that will be addressed in a particular section. See Table 4.2 for legend.

Table 4.2 Chapter 4 legend to visual cues

Description	Section Reference	Visual Key
Philosophy Layer	Section 4.2	
Reasoning Strategies Layer of Research Onion	Section 4.3	
Research Methods Layer	Section 4.5	
Study Type Layer (Quantitative/ Qualitative/Mixed)	Section 4.4	
Time horizons Layer	Section 4.4.4	
Data collection and analysis	Section 4.5	
Process flow and study execution	Section 1.8	

4.2 PHILOSOPHICAL VIEWS

A research philosophy (as depicted in the outer ring of the diagram in Figure 4.2) is a belief about the way data about a phenomenon should be collected and analysed (Levin, 1988). According to Myers (1997) all research is based on underlying assumptions about what constitutes *valid* research and which research methods are appropriate. In order to conduct and evaluate research, it is therefore important to know what these assumptions are.

For a theoretical model to explain anything there must be an appropriate relationship between the statements made, the methods used to make such statements, and the philosophical perspective deployed to inform the methods (Abbott, 1998). In each of these respects, there are issues pertaining to ontology, epistemology, and methodology. Ontology is concerned with the nature of reality. Ontology's main question is whether social bodies can, or should be deemed social constructions built-up from the perception (or opinion) and action of social actors (Limpanitgul, 2009).

Epistemology, on the other hand, concerns what constitutes knowledge in an area of study. Epistemology provides the philosophical foundation – the credibility – which legitimises knowledge and the framework for a process that will produce a rigorous methodology (Saunders, et al., 2000). The most significant philosophical assumptions are those which relate to the supporting epistemology which guides the study. In other words epistemology refers to the assumptions about knowledge and how it can be obtained (Hirschheim, 1992).

Epistemological assumptions for both quantitative and qualitative research are represented as in Figure 4.4 adapted and extended from Myers (1997) to include Pragmatism, as only Positivist, Interpretive and Critical epistemology were included in the original illustration.

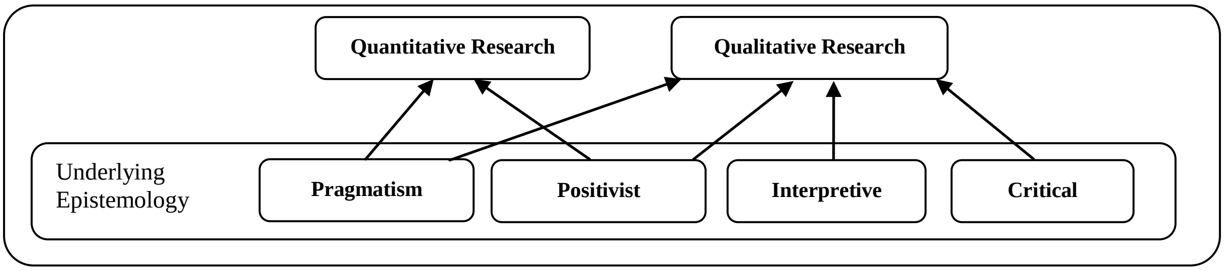


Figure 4.4 Epistemological assumptions for quantitative and qualitative research as adapted from Myers (1997) and extended to include Pragmatism

In the subsequent section, paradigms as related to the *philosophy layer* of the research onion will be discussed in more detail. Paradigms are shared belief systems that influence the kinds of knowledge researchers seek and how they interpret the evidence they collect (Plano Clark & Creswell, 2008, Mouton, 2003). Morgan (2007) maintian paradigms are:

- Worldviews, an all-embracing perspective on the world.
- Epistemologies, incorporating ideas from the philosophy of science such as ontology and methodology.
- Preferred or usual solutions to problems.
- Common beliefs of a community of scholars in a study area of interest.

There is considerable disagreement as to whether these research paradigms or underlying epistemologies are necessarily opposed or can be accommodated within the one study (Myers, 1997). The following four major philosophical perspectives Pragmatism, Positivist, Interpretive and Critical are discussed in Sections 4.2.1 to 4.2.4.

4.2.1 Pragmatic Research

Pragmatism builds a direct link between theory and praxis, as propagated by the pioneers Dewey, James and Peirce (Diggins, 1994). In addition pragmatic inquiry results in 'warranted' assertions that guide both action and theory/method developments (Denzin & Lincoln, 2011).

Pragmatism is also not committed to any one system of philosophy and reality (Creswell, 2000). Schwandt (1989) referred to paradigms as *world views* and beliefs about the nature of reality, knowledge, and values. Creswell (2009) concurs with Schwandt (1989) in making use of the term *world view*, and defines pragmatism as a worldview arising out of actions, situations, and consequences rather than antecedent conditions (Creswell, 2009). Advocates also describe pragmatism as a philosophical partner for mixed method research (Johnson & Onwuegbuzie, 2004).

Creswell (2009), present the characteristics of a pragmatic worldview as:

- Not committed to any one system of philosophy and reality.

- This applies to mixed methods research, where inquirers draw from both qualitative and quantitative assumptions from research.
- Individual researchers have freedom of choice to choose the methods, techniques, and procedures that best meet the needs and purpose of their research.
- Allows for multiple methods, different worldviews, different assumptions and different forms of data collection and techniques.

Taking a pragmatic and balanced or pluralist position will help improve communication among researchers from different paradigms as they attempt to advance knowledge (Watson, 1990, Maxcy, 2003, Watson, 1990). Pragmatism also helps to shed light on how research approaches can be mixed fruitfully (Hoshmand, 2003); therefore research approaches should be mixed in ways that offer the best opportunities for answering important research questions (Johnson & Onwuegbuzie, 2004).

4.2.2 Positivist Research

Myers (1997) maintain that positivists generally presume that reality is impartially given and can be described by measurable attributes, which are independent of the observer (researcher), and his or her instruments (Saunders, et al., 2007). Positivist studies generally attempt to test theory, in an attempt to increase the predictive understanding of occurrences. In line with this Orlikowski & Baroudi (1991) classified Information Systems research as positivist if there was: evidence of formal propositions, quantifiable measures of variables, hypothesis testing, and the drawing of inferences about a phenomenon from the sample to a stated population. Principal positivist methods consist of observations, experiments and survey techniques, and often involve complicated statistical analysis in order to generate the findings and to test hypotheses empirically (Schiffman & Kanuk , 1997).

A beneficial aspect of the positivist approach to information systems research is that it has led to a focus on the need for good tools and methods that could safeguard against the fallibility of the human mind. Substantial contributions to information systems research have emerged due to the adoption of this model of science.

The domination of the empirical approach to information systems research has however led to criticism that information system research has frequently sacrificed *relevance* for *rigor*. Another danger of the empiricist approach when applied to practical problems is the lessening of the problem scope to those characteristics, which are researchable by means of standard quantitative methods (Bharadwaj, Bharadwaj, & Konsynski, 1996).

4.2.3 Interpretive Research

Interpretive researchers set off with the assumption that access to reality is only through social constructions such as language, consciousness and shared meanings (Myers, 1997). The philosophical base of interpretive research is hermeneutics and phenomenology (Boland, 1985). The interpretive philosophy is based on the belief that science is subjective and therefore allows alternative models of reality (Bharadwaj, et al., 1996). Interpretive studies generally attempt to understand phenomena through the meanings that people assign to them and interpretive methods of research in information systems are aimed at producing an understanding of the context of the information system, and the process whereby the information system influences and is influenced by the context (Walsham, 1993). Interpretive research does not predefine dependent and independent variables, but focuses on the full complexity of human sense making as the situation emerges (Kaplan & Maxwell, 1994).

The interpretive view is pertinent to information systems research for several reasons. First, since the human element is inextricably linked with the technological aspect of information system research, it is only appropriate that the underlying philosophical perspective mirrors the links (Bharadwaj, et al., 1996). Second, it effectively overcomes the problems associated with the pure empirical paradigm which views the construction of information systems as merely technical artifacts (Cooper, 1988). Finally, this view has led to the development of several research programs in IS where behavioral research issues abound. Examples of an interpretive approach to qualitative research include Boland's (1985) and Walsham's (1993) work.

4.2.4 Critical Research

Critical researchers assume that social reality is historically constituted and that it is produced and reproduced by people (Myers, 1997). Critical research focuses on the oppositions, conflicts and contradictions in contemporary society, and seeks to be emancipatory (Horkheimer, 1972) i.e. and should help to eliminate the causes of alienation and domination. The main task of critical research is seen as being one of social critique, whereby the restrictive and alienating conditions of the status quo are brought to light (Myers, 1997).

Horkheimer (1972) defines critical theory as adequate only if it meets three criteria: it must be explanatory, practical and normative, all at the same time. That is, it must explain what is wrong with current social reality, identify actors to change it, and provide both clear norms for criticism and achievable practical goals for social transformation.

See Table 4.3 for a summary of the philosophical perspectives and their defining knowledge claim positions as adapted from Creswell (2003). When considering the different characteristics of each perspective, a pragmatic philosophical view was clearly the best fit for this study. This is due to the facts that: 1) the setting of the problem is in a work environment, which cannot be duplicated in a controlled environment; 2) both subjective and empirical data is used to understand the problem better; 3) the reality that the environment investigated is problem centred, and 4) the ontological reality of BI in this context. The first layer of the *research onion* has been addressed in this Section 4.1 (which addressed philosophical views) in the following section the *research approaches* layer will be discussed according to the application in this study.

A pragmatic philosophical paradigm (also known as worldview or methodology) was followed in this research. The research approach was shaped by the worldview in that there was liberty to explore both quantitatively and qualitatively how users experience usability of the BI application at question. Also this worldview allowed for data gathering to be executed even though limitations were present in the data gathering domain. Thereby, permitting concurrent data collection, i.e. not having to wait for the first sample data before proceeding to gather the next sample's data (Creswell, 2009).

Table 4.3 Alternative knowledge claim positions (Creswell 2009)

Positivism	Interpretive
Determination	Understanding
Reductionism	Multiple participant meanings
Empirical observation and measurement	Social and historical construction
Theory verification	Theory generation
Critical	**Pragmatic**
Political	Consequences of actions
Empowerment issue-oriented	Problem-centred
Collaborative	Pluralistic
Change-oriented	Real-world practice oriented

4.3 Reasoning Strategies

The logical construct of an argument could follow either a deductive or an inductive path. The distinction between the two reasoning approaches is as follows: (Martin, 1991). Deduction is referred to as reasoning from the general to the particular, while induction was reasoning from the particular to the general (Plano Clark & Creswell, 2008). As can be seen from Table 4.4, which indicates that quantitative research uses deductive or dialectic reasoning, while in qualitative research inductive, exploratory methods are used.

4.3.1 Deductive Reasoning

Mouton (2003) summarises deductive inferences or deduction as drawing conclusions from premises that necessarily follow from such premises. Deductive reasoning moves from the general to the specific or from a general premise to a particular situation or conclusion (Burns & Grove, 2005, Plano Clark & Creswell, 2008). A premise or hypothesis is a statement of the proposed relationship between two or more variables (Burns & Grove, 2005).

Sentence construction also serves as an indication of the type of reasoning, such as that the conclusions in a deductive argument are already contained in the premises (Johnson & Onwuegbuzie, 2004). The use of the phrase ‘following this’ is already an indication that a deductive inference is being made. Other phrases that usually indicate that deductive reasoning is being formulated are: ‘on the basis of the aforementioned’, ‘hence’, ‘thus’, ‘therefore’, and ‘this leads to’.

4.3.2 Inductive Reasoning

Inductive generalisation involves applying inferences from specific observation to a theoretical population. Any form of statistical inference in which you generalise from a sample to the target population is a form of inductive generalisation (Mouton, 2003). With inductive logic there is an emphasis on arguing from the particular to the general, or an emphasis on ‘grounded’ theory (Plano Clark & Creswell, 2008). For clarification purposes, grounded theory is a method of qualitative enquiry in which data collection and analysis reciprocally inform each other through an emergent iterative process. The term ‘grounded theory’ refers to a theory developed from successive conceptual analyses of empirical materials (Denzin & Lincoln, 2011). With inductive reasoning, the truth of the conclusion does not necessarily follow from the truth of the premises and denial of the conclusion does not logically contradict the premises. Inductive arguments provide less certainty, than deductive arguments. Inductive arguments may be strong or weak depending on the evidence collected in support of a conclusion (Johnson & Onwuegbuzie, 2004).

Section 4.3 addressed the second layer of the research onion. In Section 4.4 the third layer of the research onion will be discussed, where the focus will be on the research strategies chosen for the study.

4.4 RESEARCH STRATEGIES

The third layer of the ‘research onion’ focuses on the strategy employed for the study. A research strategy is a method of inquiry, which moves from the underlying philosophical assumptions to research design and data collection. The choice of research method also influences the way in which the researcher collects data (Myers, 1997).

Sections 4.4.1 and 4.4.2 aim to describe the difference between qualitative and quantitative research strategies, this will in turn influence decisions with regards to the skills required to conduct the research, assumptions about the research method and research practices (Myers, 1997).

4.4.1 Qualitative

A qualitative strategy is one in which the inquirer make knowledge claims based primarily on constructivist perspectives (i.e., the multiple meanings of individual experiences, meanings socially and historically constructed, with an intent of developing a theory or pattern) or advocacy/participatory perspectives (i.e., political, issue-oriented, collaborative, or change oriented) or both (Creswell, 2009). Burns & Grove (2005) argue that the philosophical orientation of qualitative research is holistic and the purpose of the research is to examine the whole rather than the parts. It also uses strategies of inquiry such as narratives, phenomenologies, ethnographies, grounded theory studies, or case studies.

Open-ended, emerging data is collected with the primary intent of developing themes from the data (Creswell, 2009). Hence qualitative researchers are more interested in understanding complex phenomena than in determining cause-and-effect relationships among specific variables (Burns & Grove, 2005). Qualitative refers not simply to verbal data but rather to an overarching interpretivist, hermeneutic, constructionist or participatory perspective on how an inquiry should be conducted (Plano Clark & Creswell, 2008).

4.4.2 Quantitative

Quantitative research is a formal, objective, systematic process in which numerical data are used to obtain information about the world (Burns & Grove, 2005). A quantitative strategy is one in which the investigator primarily uses positivist claims for developing knowledge (i.e., cause and effect thinking. Reduction to specific variables and hypotheses and questions, use of measurement and observation, and the test of theories), employs strategies of inquiry such as experiments and surveys, and collects data on predetermined instruments that yield statistical data (Creswell, 2009).

With regards to HCI usability, from a quantitative viewpoint, condensing results in singles scores, metrics or statistical functions is an acceptable solution for processing huge amounts of usability related information (Gonzalez et al., 2008). It should also be noted that some researchers believe that quantitative research provides a sounder knowledge base than qualitative research (Norbeck, 1987).

Generally, qualitative and quantitative methods of both data collection and analysis can be distinguished. While quantitative research focuses on how to operationalised (or quantify) the attributes to be measured, qualitative research interprets verbal (or non-numerical) data (Foltz et al., 2008). Table 4.4 provides the different characteristics of quantitative and qualitative research as compiled and adapted from Burns & Grove (2005) and Hennink, Hutter & Bailey (2011) since the different authors addressed overlapping but also different characteristics of quantitative and qualitative research.

4.4.3 Mixed Methods

In the third layer of the research onion *choices* regarding the type of study are made, in other words, will the study be a mono method study, that is either qualitative or quantitative, or will the study employ a multi-method study, if the study comprises of both qualitative *and* quantitative methods it is known as *mixed methods.* A mixed method approach was followed in this study. Plano Clark & Creswell, (2008) presents mixed methods research as an approach to inquiry that combines both qualitative and quantitative structures. It involves philosophical assumptions, the use of qualitative and quantitative approaches, and the mixing of both approaches in the study in order for the overall strength of a study to be greater than either qualitative or quantitative research (Plano Clark & Creswell, 2008).

A mixed method strategy is one in which the researcher tends to base knowledge claims on pragmatic grounds (e.g. consequence-oriented, problem centred, and pluralistic). It employs strategies of inquiry that involve collecting data either simultaneously or sequentially to best understand research problems. The data collection also involves gathering both numeric information (i.e. on instruments) as well as text information (e.g., on interviews) so that the final database represents both quantitative and qualitative information (Creswell, 2009).

The goal of mixed methods research is not to replace either of these approaches but rather to draw from the strengths and minimise the weaknesses of both in single research studies and across studies (Burns & Grove, 2005). Qualitative and quantitative research methods are not mutually exclusive (De Villiers, 2005). A variety of research benefits are derived from adopting mixed research method approaches as each research method has different assumptions and procedures that complement one another (Trauth & Jessup, 2000) refer to Table 4.4 for the different characteristics of each research methods.

Table 4.4 Quantitative and qualitative research characteristics as adapted from Burns & Grove (2005) and Hennink, et al., (2011)

Characteristic	Quantitative Research	Qualitative Research
Philosophical origin	Logical positivism	Naturalistic, interpretive, humanistic
Focus	Concise, objective, reductionist	Broad, subjective, holistic
Reasoning	Logistic, deductive	Dialectic, inductive
Basis of knowing	Cause-and-effect relationship	Meaning, discovery, understanding
Theory focus	Test theory	Develops theory
Researcher	Control	Shared interpretation
Methods of measurement	Structured interviews, questionnaires, observations, scales or physiological instruments	Unstructured interviews and observations
Data	Numbers or numerical data	Words (textual data)
Analysis	Statistical analysis	Individual interpretation
Objective	Quantify data and extrapolate results to a broader population.	Gain a detailed understanding of underlying reasons, beliefs, and motivation.
Purpose	Measure, count, quantify a problem. How much? How often? What proportion? Relationships in data.	Understand *why*, how, *what* is the process? What are the influences or contexts?
Study Population	Large sample size of representative cases.	Small number of participants or interviewees, selected purposively.
Data collection methods	Population surveys, opinion polls, exit interviews.	In-depth interviews, observation, group discussions.
Outcomes and findings	Generalise to a broader population, accept or reject theoretical propositions, identify prevalence, averages and patterns in data.	Develop initial understanding, identify and explain behavior, beliefs or actions. Uniqueness, dynamic, understanding of phenomena and new theory.

Literature indicate that mixed methods research should use a method and philosophy that attempt to fit together the insights provided by qualitative and quantitative research into a workable solution. Diggins (1994) advocate the consideration of the pragmatic method of the classical pragmatists (e.g., Charles Sanders Peirce, William James, and John Dewey). The combination of both methods was subsequently chosen to be aligned with the pragmatic philosophy of the study.

Table 4.5 presents the characteristics of quantitative, mixed and qualitative methods. In accordance to the mixed methods column, this study made use of both open and closed ended questions, multiple forms of data, statistical and text analysis.

Table 4.5 Quantitative, qualitative and mixed methods (Creswell, 2009)

Quantitative Methods	Mixed Methods	Qualitative Methods
Pre-determined	Both pre-determined and emerging methods	Emerging methods
Instrument based questions	Both open- and closed-ended questions	Open-ended questions
Performance data, attitude data, observational data, and census data	Multiple forms of data drawing on all possibilities	Interview data, observation data, document data and audio-visual data
Statistical analysis	Statistical and text analysis	Text and image analysis
Statistical interpretation	Across databases interpretation	Themes , patterns interpretation

Advantages of using mixed method research strategy:

- Most researchers are familiar with the mixed methods model.
- Can result in well validated and substantiated findings.
- Concurrent data collection results in shorter data collection time periods.

Limitations of mixed methods research strategy:

- It requires effort and expertise to adequately study a phenomenon with two separate methods.
- Can be difficult to compare results of analysis using data of different forms.
- Can be difficult for a researcher to resolve discrepancies that may arise from comparing result.

4.4.4 Research Timelines

The concurrent mixed method strategy of enquiry (research methodology) employs procedures where the study merges quantitative and qualitative data in order to provide a comprehensive analysis of the research problem. In a concurrent mixed method design the researcher collects both forms of data at the same time and then assimilate the information in the interpretation of the overall results. Also, in this design the study may embed one smaller form of data (such as the HE incorporated in this study) within another larger data collection (such as the usability survey data) in order to analyse different types of questions (for example where the qualitative addresses the process while the quantitative, the outcomes) (Creswell, 2009).

The quantitative and qualitative data collection is concurrent, happening in one phase of the research study, see Figure 4.5 for the research process flow. The mixing during this approach is to integrate or compare the results of the two datasets side by side. This side by side integration first provides a discussion of quantitative statistical results followed by qualitative quotations that support or disconfirm the quantitative results.

4.5 DATA COLLECTION DESIGN

It is accepted to combine data gathering techniques in a data gathering exercise to triangulate findings (Plano Clark & Creswell, 2008, Creswell, 2009). Determining which data gathering techniques (Table 4.6) to use depend on factors pertaining to the focus of the study, the participants involved (Section 4.5.1.2), the nature of the technique (Section 4.5.1.3) and the resources available (Section 4.6.1.1 and Section 4.6.2.1) (Preece, et al., 2002).

4.5.1 Sample design

This section aims to provide a background to sample design. The basic idea regarding sampling is to select a portion of elements within a population, and come to conclusions that are applicable to the entire population (Cooper, 1988). A sampling frame is a kind of list or group of the entire population of people that could be included in a survey, from which a sample will be chosen (Oates, 2009).

4.5.1.1 Sample size and sampling criteria

Instrument 1 - SUMI: To be able to generalise findings from a sample to the entire population, the sample needs to be of an adequate size. The greater the required accuracy, the bigger the sample needs to be. Researchers usually work to a 95% confidence level and accuracy range of ±3%. Accuracy ranges indicates how close to the true population value the research was, while the confidence level indicates how sure the researcher is that the true population value falls within the range of values obtained from the sample (SurveySystems, 2012).

When the principle above is applied to this study, the SUMI questionnaire required a sample size of **58** for a 95% confidence level and ± 3 per cent accuracy range, where the target population size was 61 and the actual sample size was 60. The accessible target population (61) consisted of Anglo Coal employees, who use Cognos as BI application. Therefore, sample size was derived from the number of population elements available for the sample, which is limited to Cognos7 Upfront users.

Instrument 2 - HE: According to Oates (2009) when deciding how big a sample should be the researcher must keep in mind the non-response rate of participants. As a rule-of-thumb the final sample should not be less than 30, as the statistical analysis of sample size less than 30 is not reliable (Oates, 2009).

Nielsen (1990) recommends a HE is conducted with between three and five evaluators and that any additional resources are spent on alternative methods of evaluation. Nielsen (1990) measured usability problems, not user performance, hence the difference in the recommended sample sizes compared with the Common Industry Format, which recommends a minimum of 8 users (Moczarny, De Villiers, & Van Biljon, 2012). Subsequently, for Instrument 2 (the BI HE), four usability experts served as the sample.

4.5.1.2 Sample profile

Instrument 1 - SUMI: Fifty eight Cognos7 users on different managerial levels with a distribution of: technical users (4), super-users (10), managers (8), and general users (36), served as the sample for the SUMI questionnaire (Instrument 1). All of the users selected for participation had a Cognos Upfront sign-on and all of the users had previously made use of the application. Users were identified from a data log regarding the system usage, listing particular cubes that each of the users consulted during an extended period. This application usage data was requested from the data warehouse department (see ANNEXURE H). De Vos , Strydom, Fouche, & Delport (2006) outline that purposive sampling is based on the judgment of the researcher by choosing the sample that has elements of interest to be studied.

Instrument 2 – HE: The four expert evaluators who served as the sample for the HE (Instrument 2) have diverse educational and career backgrounds. Three of the four expert usability evaluators that participated in this study have established themselves in the field of usability and are currently employed by the University of South Africa, the fourth usability expert that participated was obtained in-house from the researchers organization. The sample consists of both genders and include participants in their 30's, 40's, 50's and 60's. This sample population allowed for a balanced review of the application, even though their evaluation was subjective to their own frame of reference.

4.5.1.3 Sampling techniques

The sampling technique describes how a sample is selected from a sampling frame (Oates, 2009). See Table 4.6 for a summary of sampling techniques. Two kinds of sampling will be discussed in the following section: Probability sampling and non-probability sampling to identify an appropriate sampling technique for this study.

Probability sampling is when a sample has been chosen because the researcher believes that there is a high probability that the sample of respondents chosen is representative of the overall population being studied. In other words, the sample forms a representative cross-section of the overall population.

On the other hand, **non-probability sampling** indicates that the researcher does not know whether the sample of people is representative. Non-probability sampling provides a weak basis for generalisations to the wider population. However, sometimes researchers are not interested in generalisation that applies to a larger population, rather they want to explore a topic in depth, so that a wide number of issues can be raised and examined (Mouton, 2003, Oates, 2009).

Table 4.6 Sampling techniques as collated from Oates (2009)

Sampling technique	Sampling types	Description
Probabilistic	Random	The required number of people (or things) is randomly selected.
Probabilistic	Systematic	This builds on random sampling by adding a system of choosing people at regular intervals.
Probabilistic	Stratified	The types of members in the sample are in the same proportion as they are in the overall population.
Probabilistic	Cluster	This type of technique uses the fact that instances of the types of people could occur together naturally in clusters.
Non-probabilistic	Purposive	The researcher intentionally hand-picks the sample, choosing instances that are likely to produce valuable data to meet the purpose of the research.
Non-probabilistic	Snowball	The researcher finds one person who comes from the target population, after data has been gathered from this person, the researcher asks for suggestions about other people relevant to the research, this process is repeated with the new people, and their suggested people, this leads to the sample snowballing in size.
Non-probabilistic	Self-selection	When researchers advertise, their interest in a topic and their requirement for respondents, and collect data from anyone who responds.
Non-probabilistic	Convenience	The researchers select respondents who are convenient for them, because they are easy to reach or willing to help.

In this study non probabilistic purposive samples were employed specifically for the reason that the individuals that made use of the BI application, and the expert evaluators could be easily identified. These groups of people would be able to add a valuable contribution due to their system knowledge and interaction with the BI Cognos7 Upfront application or alternatively in the case of expert evaluators, their expertise regarding system usability.

4.5.1.4 Data collection sources

According to Mouton (2003) data collection sources can be classified into 4 categories, observation, self-reporting, archival or documentary sources and physical sources, see Table 4.7 for examples of each of the categories.

Table 4.7 Classification of data collection sources and techniques (Mouton, 2003)

Category	Examples
Observation	Systematic observation under controlled experimental or laboratory conditions.
	Participant observation in natural field setting
Self-reporting	Personal and group face-to-face interviewing
	Telephone interviewing
	Mail and electronic surveys
Archival/documentary sources	Historical documents, diaries, letters, speeches, literary texts, narratives, official memoranda, business plans, annual reports, medical records, etc.
Physical sources	Blood samples, cell tissue, chemical compounds, materials, etc.

This classification as applied to this research study made use of the categories of observation and self-reporting. Data collection will be discussed in more detail in Chapter 5, which focuses mainly on data collection and the analysis thereof, see Section 5.2.

4.5.1.5 Data collection techniques

After considering sampling techniques (Section 4.5.1.3) to compile appropriate samples for a study as well as the available data collection sources (Section 4.5.1.4), practical data collection techniques will be considered. Table 4.8 provides a summary of data collection techniques and each technique's respective strength, associated data types, and a comparison of the technique's advantages and disadvantages. Based on Table 4.8 we identified the techniques most suitable to the study, namely questionnaires (SUMI and HE) because of the advantage of being able to reach many people with minimal resources, indirect observation was also selected as a data collection technique in order to foster an understanding for the BI user's working environment (the context of the study). Since this study made use of a combination of indirect observation, an expert evaluation (the HE) and inquiring user based evaluation (online questionnaire) these will be discussed in more detail in Sections 4.5.2 - 4.6.2.1.

Table 4.8 Overview of data collection techniques as adapted from Preece, et al., (2002)

Techniques	Strength	Data Type	Advantages	Disadvantages
Interviews	Exploring issues.	Mostly qualitative, some quantitative.	Interviewer able to guide interviewee. Encourages contact between developers and users.	Time consuming. Artificial environment my intimidate interviewees.
Focus groups	Collecting multiple viewpoints.	Mostly qualitative, some quantitative.	Highlights areas of consensus and conflict. Encourages contact between developers and users.	Possibility of dominant characters.
Question-naires	Answering specific questions.	Quantitative and qualitative.	Can reach many people with low resources.	Design is crucial. Response rate may be low. Responses may not be what you want.
Direct observation in the field	Understanding context of user activity.	Mostly qualitative.	Observing actual work provides insights that other techniques cannot provide.	Very time consuming. Huge amounts of data.
Direct observation in controlled environment	Learning about procedures, regulations and standards.	Quantitative and qualitative.	Can focus on the details of a task without interruption.	Results may have limited use in the usual environment because conditions were artificial.
Indirect observation	Observing users without disturbing user activity; data captured automatically.	Quantitativ e (logging) and qualitative (diary).	User is not distracted by the data gathering; automatic recording enables collection over long periods.	Large amount of quantitative data needs tool support to analyse (logging); participants' memories may exaggerate (diary).

4.5.2 Observations

Observation is a research method that enables researchers to systematically observe and record people's behaviour, actions and interactions. The method also allows researchers to obtain a detailed description of social settings or events in order to situate people's behaviour within their own socio-cultural context (Hennink, et al., 2011).

Terre Blance, et al., (2006) classify observations as:

- Descriptive observation – making use of general questions, and leads to a descriptive account, of what was witnessed, usually in sequence of events.
- Focused observation – entails asking focussed questions.
- Selective observation – where particular events are selected for questioning.

In this study, indirect unstructured descriptive observation was conducted for a period from 2009 to 2010 on the users of the BI application Cognos7. This allowed for an understanding of what the users come across in the work environment, the indirect observation also allowed users to be observed without disturbing their working activity. A logbook was kept noting the researchers impressions of user issues and problems experienced with the BI application. See ANNEXURE F.

4.5.3 Questionnaires

Questionnaires are a well-established technique for collecting demographic data and users' opinions. They are similar to interviews in that they can have open or closed questions. Effort and skill are needed to ensure that questions are clearly worded (unambiguous and to the point) and that data collected can be analysed efficiently. Questionnaires can be used on their own or in conjunction with other methods to clarify or deepen understanding. For example, information obtained through interviews with a small selection of interviewees (or in the case of this study through HE) can be corroborated by sending a questionnaire to a wider group to confirm (or disprove) the conclusions. The methods and questions used depend on the context, target audience and data gathering goals (Dix, et al., 2004, Preece, et al., 2007).

Questionnaires with negative questions can be confusing and may lead to respondents giving false information. Some questionnaires are designed with a mixture of negative and positive questions to check the users' intention. In contrast, the designers of QUIS (questionnaire for user interaction satisfaction) decided not to mix negative and positive statements because the questionnaire was complex enough without forcing participants to pay attention to the direction of the argument (Preece, et al., 2007, Chin, et al., 1988, Shneiderman, 1998). Based on the argument above, the statements of the HE questionnaire developed during this study comprised only of positively directed statements. Refer to ANNEXURE K.

4.5.3.1 Choice of questionnaires

Given the advantages of a standardised questionnaire as discussed in Section 4.6.1, the following standardised post-test questionnaires were considered:

- SUS, which is a simple, ten-item attitude Lickert scale giving a global view of subjective assessments of usability developed by John Brooke (Brooke, 1996). SUS has been widely used in carrying out comparisons of usability between systems since it provides a high-level subjective view of usability. Factor analysis of two independent SUS data sets reveals that the SUS actually has two factors – Usability (8 items) and Learnability (2 items) (Brooke, 1996). Usability encompasses many other factors making it impossible to match to the guidelines in the table.
- USE is a 30 item, seven-point Lickert scale with seven as the highest available score and one the lowest. The responses are grouped to measure the following constructs: ease of use; ease of learning and satisfaction.
- SUMI (Software Usability Measurement Inventory) was developed by the Human Factors Research Group (HFRG) at the University College Cork, Ireland. SUMI is a 50-item questionnaire for assessing software-system usability (Karahocha, et al., 2009).

- The SUMI questionnaire has five sub degrees:
  - Efficiency: the degree to which users feel the software assists them in their work.
  - Affect: users' general emotional response to the software.

- Helpfulness: the degree to which users feel the software assists them in using it.
- Control: the degree to which users feel they, and not the software, are in control.
- Learnability: the ease with which users feel they have been able to get started using the software and learn new features.

- QUIS: Questionnaire for User Interaction Satisfaction. The main function of this questionnaire is to:
  - Guide the design of a system.
  - Provide managers with a tool for measuring possible areas of system enhancement.
  - Provide researchers with a validated instrument for conducting comparative evaluations.
  - Serve as an experiment instrument in usability laboratories.

When the constructs (sub-degrees) in the questionnaires are mapped against other standard usability measures such as the ISO usability standard, the Dix, et al., (2004) guidelines and Nielsen's (1993) guidelines, it can be observed that SUMI is a more comprehensive and specific measure than the other three questionnaires considered, namely SUS (see extract from questionnaire in ANNEXURE P), USE, QUIS (see extract from questionnaire in ANNEXURE O). This contributed to the use of SUMI for study phase A. For additional considerations of use see Section 4.6.1.1.

4.5.4 Online questionnaires

Online questionnaires are becoming increasingly common because they are effective in reaching large number of people quickly and easily. There are two types of online questionnaires available i.e. email and web-based. Web-based questionnaires (such as SUMI that was used in this study) can provide immediate data validation and can enforce rules such as select only one response (Preece, et al., 2002).

Well-designed questionnaires are good at getting answers to specific questions from large groups of people, and especially if the sample is spread across a wide geographical area, making it infeasible to visit all of them (Tullis & Albert, 2008). Questionnaires are also easy to administer and cheaper to execute, compared to other inquiry methods such as observation or interviews. Online web-based questionnaires also have faster response rates and automatic transfer of responses into a database for analysis (Kirakowski, 1994, Rogers, et al., 2012).

4.6 INSTRUMENT SELECTION

The instrument chosen for a study should be appropriate for the study (refer to Section 4.5.1.5 as well as Table 4.8 which presents the various data collection techniques). In the Sections 4.6.1 to Section 4.6.2 the two instruments employed in this study will be presented, this will include a description of the instrument as well as the considerations taken into account for selection during this study.

4.6.1 Instrument 1: SUMI

SUMI (Software Usability Measurement Inventory) has been developed to provide an authoritative, standardised measurement of user satisfaction with software and it is publicly available. It can be used for the evaluation and comparison of products (or versions of a product) and to set and track verifiable targets regarding satisfaction. SUMI is a classical Lickert-type measure of attitude toward a software package. The questionnaire comprises five subscales: efficiency, affect, helpfulness, control and learnability.

SUMI analysis also provides a ‘global’ satisfaction score; it is marked against a database of previous usability measurements. Part of the ESPIRIT MUSiC (Metrics for Usability Standards in Computing) project, SUMI is developed and administered by the Human Factors Research Group at the University College Cork, Ireland (Kirakowski & Corbett, Effective Methodology for the Study of HCI, 1990).

In this research the standard SUMI questionnaire was used as an instrument, acquiring quantitative data concerning users’ view on usability of the Cognos Upfront BI application.

The testing was done under the same conditions to those under which the application is used, and in the same environment the users work on the application.
The SUMI Questionnaire consists of 50 attitude statements, users are requested to respond to these statements by *agreeing, not knowing* or *disagreeing* (3-point response format). Each of the subscales (i.e. efficiency, affect, helpfulness, control and learnability) is represented by 10 items. The ‘affect’ subscale is supposed to measure the user’s general emotional reaction to the software’ or the ‘likeability’ of the software. Additionally, 25 items are used to calculate a general usability or satisfaction score. The developers of the SUMI proposes the questionnaire can also be used in a survey, with larger groups of respondents (300+) (Kirakowski, 1994). See ANNEXURE D for SUMI questionnaire.

Kirakowski (1994) is of the view that *affect* is related to *likeability*. *Efficiency* assesses to what extend the user is assisted in doing their work (related to the concept of *transparency*). *Helpfulness* measures to what extend the software are *self-explanatory* (adequacy and *documentation*). *Control* assesses to what extend the user feels in control of the software, as opposed to being controlled, when carrying out a task. *Learnability* measures the speed and facility which measures the user effort to master the system, or learn how to use new features (Jordan, 1996).

4.6.1.1 Considerations for selecting SUMI

Table 3.6 presented the generally accepted usability principles of Dix, et al., (2004), Nielsen (1993), Tognazzini (2003) mapped against the ISO usability standard. This table has now been extended to include and map the principles as measured by the standardized SUMI instrument in order to identify corresponding constructs, as depicted in Table 4.9.

To summarize the considerations for the selecting SUMI as research instrument include:

- Participants can be reached via e-mail, therefore the wide demographic distribution (participants are situated at collieries across Mphumalanga and Gauteng) can be overcome.
- By making use of a standardised questionnaire, credibility of results is improved.

Table 4.9 Mapping of usability principles to a standardised usability instrument

Usability Standard		Usability Principles		Standardised Instrument
ISO 9241	**Dix, et al., (2004)**	**Nielsen (1993)**	**Tognazzini (2003)**	**SUMI**
			Fitt's Law	
Self-descriptiveness		Natural Dialogue /User'slanguage, Instructions visible and retrievable	Use of metaphors Readability	Helpfulness
	Flexibility (Responsiveness)			
Controllability			Track state	Control
Suitability for learning	Learnability	Learnability	Learnability	Learnability
Suitability for task		Efficiency	Efficiency	Efficiency
Conformity with user expectation	Predictability, familiarity,		Anticipation	
		Efficiency	Efficiency	Efficiency
	Consistency	Design consistency	Consistency	
Error tolerance	Recoverability (task conformance)	Error prevention / Error messages	Protect user's work	
		Clearly marked exits	Explorable Interfaces Visible navigation	
Suitable for individualisation	Customisability, task migratability, (synthesisability)		Autonomy	Control
		Help / Documentation		Helpfulness
Satisfaction rating		Satisfaction		Affect
		Appropriate system feedback	Latency Reduction	
		Memorability		
			Colour Blindness	
			Default	

- These participants are able to complete the questionnaire online and questionnaire answers are sent automatically to the Human Factors Research Group for collation and analysis, thus increasing the ease of use.
- Another consideration for making use of a standardised questionnaire is the fact that results can be compared to other similar type system's results, thereby creating a benchmark against which this study's system results can be measured.
- According to the mapped constructs in Table 3.6 it can be observed that SUMI align well with the research objectives and a proven total system evaluation as shown in Table 4.9.
- SUMI is also a more comprehensive and specific measure than the other three questionnaires (SUS, USE, QUIS) considered in Section 4.5.3.1.
- SUMI is also the only survey that is administered independently (including data analysis), thereby enhancing the study's credibility of findings.
- When Table 3.6 is extended to include the SUMI usability components (see Table 4.9) the corresponding constructs identify core usability aspects.
- This query technique permits the extraction of detail of the user's view of an application (Dix, et al., 2004).

After comparing the intersecting set of usability principles and usability guidelines with the SUMI questionnaire, SUMI was selected. In order to get the best coverage in terms of usability criteria from multiple usability questionnaires, the researcher identified elements from Nielsen's usability principles, Tognazzini (2003), Dix, et al., (2004)'s usability principles and ISO usability standards), where the different columns have certain elements common, see Table 4.10. As the focus of this study is on usability, further comparison discussion is beyond the scope of this study.

4.6.2 Instrument 2: Heuristic evaluation

The HE was aimed at gathering quantitative and qualitative data from usability experts by means of identification of usability errors within the BI application, in this case Cognos7 Upfront, making use of a self-compiled HE questionnaire. The HE questionnaire was compiled (specifically focussed on BI applications), to derive subjective input from evaluators in order to determine if there are corresponding or alternative themes that emerge from what were identified from the SUMI questionnaire.

Table 4.10 Mapping of user issues to usability principles

Usability Standard	**Usability Principles**			**BI User Requirements**
ISO 9241	**Dix et al. (2004)**	**Nielsen (1993)**	**Tognazzini (2003)**	Observations
			Fitt's Law	
Self-descriptiveness		Natural Dialogue / User'slanguage, Instructions visible and retrievable	Use of metaphors Readability	User's language, Legibility; Task icons visible and logic
	Flexibility (Responsiveness)			Data availability Data portability
Controllability			Track state	System Control;
Suitability for learning	Learnability	Learnability	Learnability	Learnability
		Efficiency	Efficiency	Efficiency
Suitability for task				
Conformity with user expectation	Predictability, familiarity,		Anticipation	
	Consistency	Design consistency	Consistency	
Error tolerance	Recoverability (task conformance)	Error prevention / Error messages	Protect user's work	
		Clearly marked exits	Explorable Interfaces; Visible navigation	Explorable interface; Visible page navigation; Visible system navigation
Suitable for Iindividualisation	Customisability, task migratability, (synthesisability)		Autonomy	Customization; Formatted data export
		Help / Documentation		System Training; Manuals
Satisfaction rating		Satisfaction		
		Appropriate system feedback	Latency Reduction	System speed; Status display
		Memorability		Memorability
			Colour Blindness	
			Default	
				Decision support
				Knowledge sharing

As can be seen from Figure 4.5 the research process was broken down into the following consecutive steps (in order to compile the HE questionnaire). Research process steps:

Step 1: Literature and comparison of general usability principles.

Step 2: Indirect, unstructured observation of Cognos7 Upfront users, with naturalistic impressionistic logging of events.

Step 3: Compilation of usability requirements (criteria) for BI.

Step 4: Compilation of HE questionnaire.

Step 5: Compilation of BI-specific, heuristic guidelines.

In other words during the initial literature review general usability principles were identified. This made the researcher aware of the usability principles and the researcher attempted to identify these principles in a real working environment, BI users were observed indirectly in an unstructured fashion with naturalistic logging of issues as they appeared. The list of user usability issues (requirements) with the BI application listed in ANNEXURE F, together with the recognised usability principles as discussed in Chapter 3 contributed to the identification of usability criteria specifically for BI, as well as the creation of a HE Instrument in order to measure the usability of BI applications, see Table 4.10.

The HE questionnaire was broken up into three Sections:

- Section A focussed on the criteria identified for the evaluation of BI applications.
- Section B focussed on the user experience with regards to the interaction with the BI application.
- Section C concentrated on the overall usability evaluation of BI.
- This was further broken down into:
    i. Demographics of the participant.
    ii. Inquiry about previous exposure to or experience with BI.
    iii. Post-test performance questions on the BI application.

The questionnaire made ample provision for participant comments or thoughts, and encouraged participants to express explicit usability issues identifiable from their interaction with the system.

4.6.2.1 Considerations for heuristic evaluation

HE requires a limited number of participants; it is an intuitive user evaluation, in order to identify usability errors. Nielsen (1990) highlights the advantages of this evaluation method as: It is inexpensive; it is intuitive and easy to motivate people to do the evaluation.

Additional factors that were taken into consideration:

- The availability and accessibility of respondents due to working commitments.
- Waiting period to receive answered questionnaires due to data samplings method.
- Geographical distribution of respondents.
- The suitability of HE in a pragmatic research approach.
- The suitability to HE within the BI context.

Here ends the discussion on the research design as applied to the various layers of the *research onion*. In Chapter 5 the process of data collection and analysis will be discussed in more depth, in the following Sections 4.7 – 4.10 the research execution, research triangulation, the rigour of the study as well as limitations of the study will be considered.

4.7 RESEARCH EXECUTION

As a first step in the research, literature was consulted to explore the research topics, with a focus on usability principles. This was to determine if there is a set of usability principles specifically advocated for BI applications. The literature consulted could not provide such a set, and no usability principles specifically propagated for BI applications could be found.

For the purpose of background information to the study, it is stated that the researcher's role at Anglo American Thermal Coal is one of a BI and Process Coordinator within Supply Chain. This entails amongst other things ensuring information availability and providing technical support which brought the usability problem with the BI application to light. Concurrent to the literature review mentioned in the previous paragraph, the researcher made observations of BI users within the study environment (i.e. supply chain department). The observations were made during week 32 of 2009 to week 48 of 2010, and the focus was on user requirements with regards to the use of the BI application (Cognos7). These users were supported technically when they required help with the application. During this stage usability problems were identified and user requirements were captured as listed in ANNEXURE F.

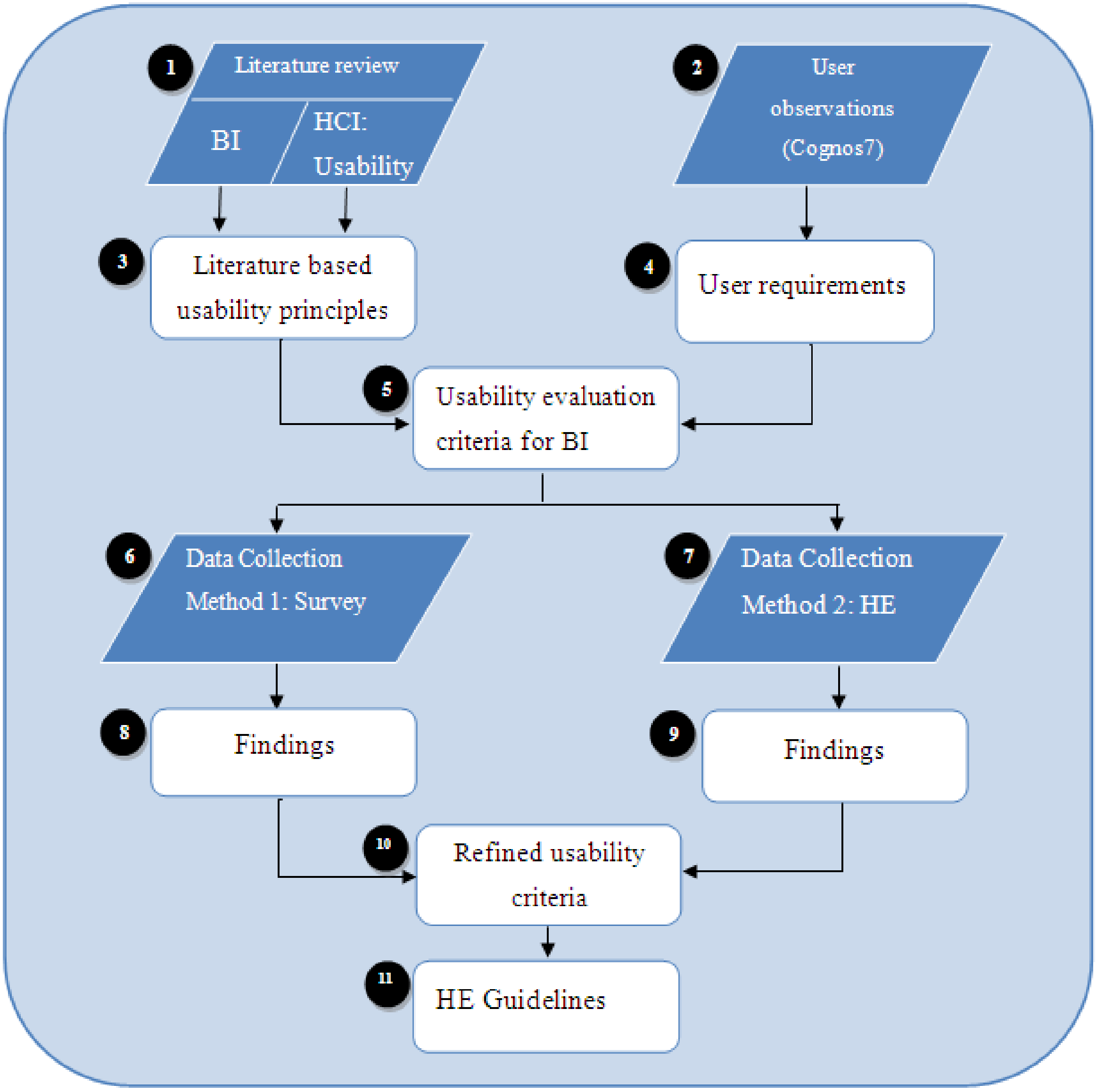


Figure 4.5 Research design process flow

Traditionally a usability evaluation is followed by a post-test questionnaire. Given the operational context it was not possible to take users out of their work place to a usability laboratory for usability testing and therefore the observations were used to capture the data from which to elicit usability problems experienced. This was followed by a survey using a standard questionnaire (SUMI). The research process execution is depicted in Figure 4.5.

Note that the parallelograms indicate data sources as with standard flowchart convention (refer to Section 1.8 where processes 1 to 10 were detailed).

The usability post-test and HE guidelines and observation were integrated and compared to provide an initial set of HE guidelines. Four heuristic evaluators performed the HE. They were asked to perform specific tasks on the application. The finding from the HE was triangulated with the qualitative and quantitative results from the survey and these findings on usability were then used to update the initial set of BI guidelines for HE.

4.8 RESEARCH PROBLEM, QUESTIONS AND OBJECTIVES

The research problem has been formulated as despite the observed and documented problems with the usability of BI systems for decision-making, very little literature (Corocan 2007) is available on the topic of evaluating the usability of BI. Therefore the problem statement for this study is:

There are no clear guidelines on how the usability of BI applications used for decision-making in a mining organization should be evaluated.

Based on the stated research problem, the main research question is formulated as follows:

How should the usability of BI applications for decision-making in a mining organization be evaluated?

The main question can be decomposed into the following sub-questions:

- RQ1: Which usability principles form the core of usability criteria?
- RQ2: What are the user requirements regarding the usability of BI applications?
- RQ3: What are the criteria for usable BI applications?
- RQ4: What are the HE guidelines (based on the usability criteria) by which to evaluate the usability of BI applications in a (mining) organization?

A set of HE guidelines will be suitable to address this problem due to the following factors:

- The pragmatic approach followed in this study.
- The context of BI applied to the heuristics.

The research questions can be operationalised into the following objectives:

- RO1: Identify usability principles that form the core of usability criteria.
- RO2: Identify the user requirements regarding the usability of BI applications.
- RO3: Identify criteria for usable BI applications.
- RO4: Develop usability guidelines (based on the usability criteria) to evaluate the usability of BI applications in a (mining) organization.

Table 4.11 Illustrates the mapping of research objectives to the research design.

Assumptions and delimiters:

1. The core usability criteria are used as basis from which to generate HE usability guidelines specifically for BI applications.
2. Post-test questionnaires are normally used together with user testing. However, this context is operational. It was impossible to do usability testing with the users as users could not be expected to interrupt their usual tasks to perform test tasks as required in usability testing, and furthermore there was no usability testing facility nearby to use as the various mine (operations) are distributed across Mpumalanga.

4.9 TRIANGULATION

Triangulation refers more generally to the use of multiple perspectives against which to check one's own position (Terre Blance, Durrheim and Painter, 2006). Triangulation is also defined as a strategy that entails using more than one data gathering technique to accomplish a goal, or using more than one data analysis approach on the same set of data. For instance, using observation to understand the context of task performance, interviews to target specific user groups, questionnaires to reach a wider population, and focus groups to build a consensus view is one example of a triangulated data gathering program. Consequently, triangulation provides different perspectives and corroboration of findings across techniques, thus leading to more rigorous end defensible findings (Preece, et al., 2007).

Table 4.11 Research objectives mapped to the research design

Objective	Method
Identify usability principles that form the core of usability criteria	Literature review.
Identify the usability requirements of BI users	Observations of BI users.
Identify criteria for usable BI applications.	Literature survey and information synthesis on usability principles and usability requirements for BI application.
Develop guidelines by which to evaluate the usability of BI applications for decision-making in a (mining) organization.	Study A: Survey with Cognos7 users using SUMI as post-test questionnaire.
	Literature study to develop HE criteria. Adapt for BI based on the usability principles for BI applications.
	Study B: HE on Cognos7 using HE criteria based on the usability principles most applicable to BI application.
	Triangulation of HE and survey results to inform and update HE guidelines for BI applications.

In order to satisfy the recommendation that one does not rely exclusively on HE during the usability assessment (Molich & Nielsen, 1990) and to facilitate triangulation of results, this study made use of a HE as well a survey comprising of a standardised usability questionnaire.

Denzin & Lincoln (2011) identify four basic types of triangulation:

- *Data triangulation* refers to the use of a variety of data sources in a study. It is important to be cautious about particular kinds of data, such as the following: data that is vivid and have been given emphasis in an account because it is all that was remembered, but not necessarily the whole story: personal experience which has filtered out important features of the context and is presented in a compelling way purely because it is currently relevant in the person's life; thematised data, leading toward interpretation of situations as more patterned than they really are, and data from particular informants whose accounts can seem more compelling, charming, or illuminating. A concurrent data triangulation approach (used in this study) is a familiar mixed method model. In this type of approach, the researcher collects both quantitative and qualitative data concurrently and then compares the two databases to determine if there is convergence, differences, or some combination. (Creswell, 2009).

- *Investigator triangulation* refers to the use of several different researchers or evaluators, which is useful in drawing our attention to previously unnoticed researcher effects.
- *Theory triangulation* refers to the use of multiple perspectives to interpret a single set of data, and this also means finding that the research findings can be incorporated into a more macro-analytical level of inference.
- *Methodological triangulation* refers to the use of multiple methods to study a single problem, looking for convergent evidence from different sources, such as interviewing, participant observation, surveying, and a review of documentary resources.

In this study:

- *Data triangulation* is ensured by incorporating data gathered from observation, data from the standardised SUMI questionnaire and data from the HE.
- *Methodological triangulation* is ensured by the choice of methods followed in the study, such as expert evaluators and a user based evaluation refer to Table 3.7, Section 3.6.1.

This study also makes use of methodological triangulation since multiple data sources are employed such as a survey, participant observation and a HE.

4.10 ETHICAL CONSIDERATIONS AND RIGOUR OF THE STUDY

The study supported the epistemic imperative of science as described by Mouton (2003). The epistemic imperative refers to the moral commitment that scientists are required to make to the search for truth and knowledge (Mouton, 2003). A request to conduct the study was submitted to the UNISA Ethical Clearance Committee and subsequently an ethical clearance form was obtained with approval to conduct the study. See ANNEXURE C for permission to conduct research, as well as the ethical guidelines followed. See Table 4.12 for detail regarding ethical considerations for this study.

Validity and reliability were ensured for the quantitative portion of the study by means of the following:

1. The study was introduced in a cover letter to the selected sample. The study incorporated the knowledge and expertise of the researcher in the area of BI gathered the past six years while working at Anglo American Thermal Coal. The researcher has been working with the participants of the study for five years, and has had the opportunity to observe the sample group in a variety of problem spaces focussing on how they make use of the BI application on a daily basis.

2. Informed consent was obtained from each participant before they participated in the study. The purpose of the study was explained to every participant before commencing with the structured, standardised SUMI questionnaire. Participants were informed about the procedure to be followed, the nature of participation expected during the answering of these questionnaires/HE and estimated duration of the questionnaire.

3. The research was planned and executed in a way that fostered justice and excluded harm and exploitation of participants. The participants were informed that they could terminate their participation in the research study if they felt that they would not like to continue, but they would be informed that the information they had given by the time of termination would be used for the purpose of the study.

The participants were made aware that they would not be forced to answer any question if they feel it would violate their rights and confidentiality. Permission to conduct a research survey within Anglo Coal was requested from the Business Process and Intelligence Manager as well as the general management forum. Once approval was obtained, the research project was explained to users of BI applications.

Table 4.12 Ethical considerations for the study

Consideration	Definition	Reference
Validity	Validity refers to the degree to which the research conclusions are sound. Quantitative researchers ensure validity by making use of tried and tested measures, experimental arrangements and statistical techniques to ensure that accurate conclusions can be drawn from the research results. Exploratory research typically values internal validity over external validity, while descriptive surveys value representativeness and Generalizability of the findings. Validity is concerned with whether the evaluation method measures what it is intended to measure. This applies to both the method itself and the way it is performed	Preece, et al., 2002, Terre Blanche, et al., 2006
Credibility	Qualitative researchers suggest research can be evaluated according to its credibility. In this study, credibility will be ensured by engagement through conducting a survey through structured questionnaires with some open-ended questions. The participants of the HE will be allowed to describe their experiences with regard to BI application studied until data saturation occurs. Evaluation of content and identification of applicable usability criteria will be ensured by involving a usability specialist outside the context of the study in the data collection stage. Credibility will also be addressed by making use of triangulation, employing different research methodologies to identify discrepant findings.	Babbie & Mouton, 2001, Terre Blanche, et al., 2006
Generalizability	Generalizability (also referred to as external validity) is the extent to which it is possible to generalise from the data and context of the research study to broader populations and settings. Generalizability is important in survey research, but there generalizability refers to other samples and populations, not to other situations or contexts, surveys use representative samples to ensure that descriptions of samples can be used to describe populations.	Terre Blanche, et al., 2006

Table 4.12 Ethical considerations for the study (continued)

Ethical Consideration	Definition	Reference
Transferability	Transferability refers to the extent in which the findings of the study can be transferred to another context or with other participants. Transferability is achieved by producing detailed and rich descriptions of contexts. Thick (comprehensive) descriptions of the research contexts were completed in chapter 2 and chapter 3.	Babbie & Mouton, 2001, Terre Blanche, et al., 2006.
Dependability	Interpretive and constructionist researchers propose finding should be dependable instead of reliable as proposed by positivists. Dependability refers to the degree to which the reader can be convinced that the findings did indeed occur. Indirectly, the measures of credibility will ensure dependability. Dependability in this study will be ensured by a thick (comprehensive) description of the research methods (provided in chapter 4).	Babbie & Mouton, 2001, Terre Blanche, et al., 2006.
Reliability	Reliability or consistency of a method is how well it produces the same results on separate occasions under the same circumstances, in other words the degree to which the results are repeatable. This applies to subjects' scores on measures (measure reliability) as well the outcome of the study as a whole.	Preece, et al., 2002, Terre Blanche, et al., 2006.
Confirmability	The findings of this research will be the product of the inquiry and not the researcher's bias. In this study, it will be ensured by the involvement of the independent coder. The data from the standardised SUMI questionnaire was processed by questionnaire developer and administrator, Dr. Kirakowski. The HE data from the individual HE will be compared to this SUMI questionnaire data.	Babbie & Mouton, 2001, Mouton, 2003.
Trustworthiness	Trustworthiness of the study will be maintained by using Guba's model criteria that is: 1) credibility; 2) transferability; 3) confirmability; and 4) dependability as discussed.	De Vos, et al., 2006, Babbie & Mouton, 2001.
Biases	Bias occurs when the results are distorted. Researchers may selectively gather data that they think is important, and interviewers may unconsciously influence responses from interviewees with their tone of voice, their facial expressions or the way questions are phrased. Throughout the study the research method followed was aimed to be reliable, valid and unbiased.	Preece, et al., 2002.

To ensure confidentiality and anonymity participants were informed that their names were not required for the study. See ANNEXURE A for the participant consent form, the cover letter to the consent form, the letter from UNISA stating ethical clearance was granted to conduct the study.

The following principles as stipulated by Guba & Lincoln (1998) were adhered to and applied in this study to ensure the trustworthiness of the data obtained:

1. **Credibility**
   i. *Prolonged involvement* with the sample group fostered trust as well as the sharing of values and insight into everyday context.
   ii. *Continuous observation* allowed for depth of understanding challenges experienced by users and perspectives of the users.
   iii. *Triangulation* of research methods (observation, standardised SUMI survey, as well as the heuristic expert evaluation) allowed for converging evidence from divergent sources.
   iv. *Target group consensus* was achieved by means of informed and voluntary participation.
   v. *Adequate referencing* was obtained by means of the collection of raw data, and the collection of data until saturation occurred.

2. **Transferability**
   i. Time-frame context influence.
   ii. *Thick descriptions* of the research contexts were compiled in Chapter 2 and Chapter 3.
   iii. *Transferability to similar context* allows for the evaluation of BI systems in different contexts based on the guidelines developed from the context of this study.

3. **Dependability**
   i. Has been *indirectly ensured* through steps taken to ensure credibility.
   ii. Has been *directly ensured* through triangulation of research methods.

4. **Confirmability**
   i. Findings are based on *raw data*.
   ii. All effort has been applied to avoid *inference* of any sort.

iii. *Analytical thought* has gone into the analysis and scrutiny of the data that was collected.
iv. The *applicable categories* were identified in order to make sense of the data in an optimal manner.
v. The study was conducted in a *methodological logical* manner, ensuring the observation, and surveys occur at the appropriate times and according to recommended mixed method procedure.
vi. The *sampling method* was based on the available users that made use of the BI application to be evaluated. Even though the sample size for the SUMI questionnaire is fairly small (50 respondents), the sample size was almost inclusive of all the users in the population of users that make use of Cognos7, and therefore the representation across the entire population was very high.
vii. The *triangulation methods* employed, made use of the qualitative data obtained from prolonged user observation (in their original work context) and the comparison with quantitative data obtained from the standardised independently administered SUMI questionnaire. The identification of usability problems by the usability expert evaluators from the HEs were also compared with these results.
viii. The study was conducted in an *unbiased* manner, and allowed for findings to emerge based on the data collected and analysed.
ix. *Critical reflection* allowed the study to be conducted, data analysed and results presented in an impartial fashion.

4.11 RESEARCH DESIGN SUMMARY

At this stage in the research, the research questions still appear to be valid and meaningful. The research questions will pave the way for the proposal of usability evaluation guidelines specifically for BI applications. Table 4.13 shows development of proposed research objectives from Table 4.11 to current research outcomes.

The BI user requirements were obtained through indirect unstructured user observation. Names for the sample population were obtained from a cube usage data sheet (see Annexure H) to ensure all these participants did in fact make use of the application.

Table 4.13 Updated research objectives map

Objective	Method	Outcome	Chapter
Identify the usability requirements of BIS users	Observations, Literature review	Usability requirements for BIS	Chapter 2, Chapter 3, Annexure F
Identify the usability principles that would be most important in the evaluation of BI applications.	Literature survey and information synthesis.	Mapping: Usability standard (ISO) to guidelines (Dix, Nielsen and Tognazzini) considering BI context	Chapter 3, Usability Principles Comparison Table 3.6
Develop guideline criteria by which to evaluate the usability of BI applications for decision-making in a (mining) organization.	Study A: Survey with Cognos7 users using SUMI as post-test questionnaire.	Identify usability issues in BI from quantitative and qualitative results of survey.	Chapter 5, SUMI data analysis
Heuristic evaluation	Literature study to develop HE criteria. Adapt for BI based on the usability principles and user requirements for BIS.	HE criteria for BI applications.	Chapter 3, Table 3.6 HE BI criteria column.
	Study B: HE on Cognos7 using HE criteria based on the usability principles most applicable to BI application.	HE results.	Chapter 5 HE data analysis
	Triangulation of HE and survey results to inform and update HE guidelines for BI applications.	Final set of criteria to guidelines for the evaluation of BI applications.	Chapter 5 and Chapter 6 Results and proposed HE guidelines for BIS

Ideally, the application should have been tested using a procedural usability test and that would have been followed by a post-test questionnaire survey. However due to the facts that the participants could not be interrupted from work for a usability test, there was no usability test facility available nearby, and these participants all had knowledge of the application, the data was captured by observations followed by a questionnaire driven survey.

A mixed method design was followed to analyse, explore and describe experiences with regard to 'usability'. The exploratory design was incorporated to gain insight in and an understanding of the phenomenon of usability within BI. An independent, standardised survey was employed to empirically verify the usability of the BI application. A concurrent mixed method strategy was adopted in this study, and hence the survey was administered simultaneously to the HE. This enabled the study to make optimal use of available time to conduct SUMI parallel to HE.

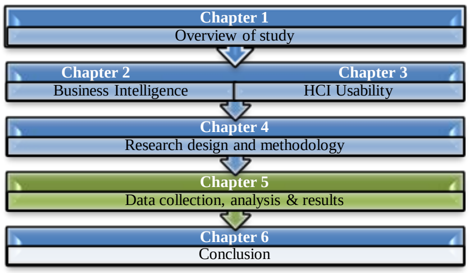
4.12 CHAPTER SUMMARY

This chapter was dedicated to the presentation of the research design and the methodology employed during this study. A pragmatic philosophical paradigm was followed, as this research approach was shaped by the worldview in that there was liberty to explore both quantitatively and qualitatively how users experience usability of the BI application at question. This worldview allowed for data gathering to be executed in a preferred manner (concurrent) not having to wait for the first sample data to be able to proceed to the next sample data gathering (Creswell 2009).

In the following chapter the collection of data and the analysis thereof will be addressed.

End of Chapter 4

Document Map



Chapter 5:

Data collection, analysis and results

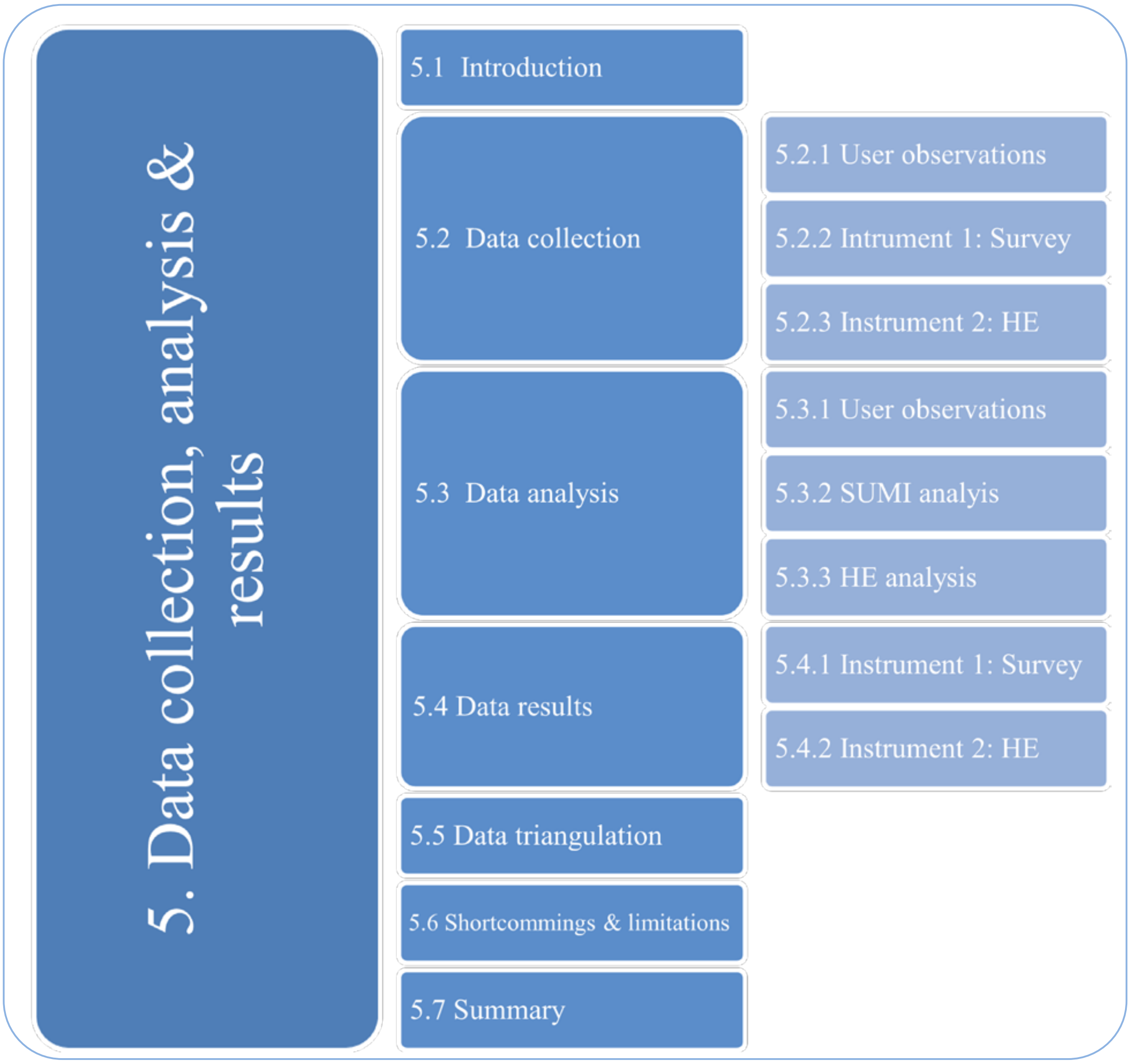


Figure 5.1 Composition of Chapter 5

5.1 INTRODUCTION

The chapter map as set out in Figure 5.1 provides an overview of the aspects covered in this chapter. Thus far, the study has been introduced, literature was presented for both BI as well as usability, and the research design and methodology discussed. Next, the data collection process will be considered, the analysis thereof and the interpretation of the results obtained in order to satisfy the research objectives as set out in Table 4.13.

5.2 DATA COLLECTION

The data for this study was collected in accordance with ethical requirements as discussed in detail in Section 4.10, respecting the individual's right to refuse participation, termination of participation, anonymity and ensuring trustworthiness (see ANNEXURE C for the approved ethical clearance form for this study). Both the SUMI questionnaire and the HE were accompanied by consent forms, which had to be signed by the participant in order to participate, see ANNEXURE B. The user observations were conducted with approval from supply chain management as part of the research.

The classification of data collection sources and techniques are set out as per Mouton (2003) in Table 4.7. After consideration of the study environment and philosophical perspective the following methods were employed for the purpose of data collection during this study:

1) The observations of participants while in a natural field setting (their work environment)
2) Two electronic surveys (self-reporting), these included:
    i. Instrument 1 - A standardised questionnaire (SUMI) (refer to Section 4.6.1 for more detail, and ANNEXURE D for questionnaire)
    ii. Instrument 2 - A HE questionnaire compiled as from literature reviewed in Chapters 2 and 3 and user observations made during the study, specifically designed for BI applications (refer to Section 4.6.2 and ANNEXURE K)

5.2.1 User observations

As this study is conducted within a pragmatic framework, the observation of users in their work environment enabled the researcher to understand the practical implication of the user problems with the BI application. Indirect unstructured observations (refer to Section 4.5.2 and Section 4.7) were made from August 2009 to July 2011 of the BI application users. These observations allowed for an understanding of what the users come across in a natural uncontaminated field setting, the indirect observations also allowed users to be observed without disturbing their working activity. This allowed the users to focus on their work tasks, and prevented the users from becoming distracted by the data gathering process. Refer to ANNEXURE F logged user issues.

These observations were captured by means of informal notes on user issues. The researcher was subjective in concluding contributing factors to user issues since these notes were based on the researchers impressions (this was a manual entry process) of user issues and problems experienced with the BI application. In cases like these, where participants are observed, events and impressions noted afterward, Preece (2002) is of the opinion that researchers' memory may exaggerate certain problems, care was taken in this regard and notes were captured in a consistent manner.

5.2.2 Instrument 1: Survey

An e-mail was sent to the sample members of Instrument 1, fifty-eight Cognos7 Upfront users. For more detail on the sample design, please refer to Section 4.5.1. This e-mail invited the sample individuals to participate in the survey. (See attached ANNEXURE B). The email explained the purpose of the research, the anticipated time required to complete the survey and placed emphasis on the participant's right to refuse to participate as well as the participants guaranteed anonymity should he or she wish to partake in the study. The e-mail contained the link to the survey website and since the SUMI questionnaire is completely anonymous, respondents were encouraged to confirm completion afterwards. Forty-eight people confirmed completion, while fifty completed questionnaires were received at the Human Factors Group's survey administration centre (refer to Section 4.6.1 for more detail).

Raw data from the survey consists of the respondents' answers to the questions (Preece, et al., 2002). In this study, which made use of the SUMI questionnaire as Instrument 1, the data was processed by the Human Factors Group at the University of Cork, Ireland, through which the SUMI questionnaire is administered.

The participant clicks on the survey link (in the email), which opens up the web page where the survey is completed. On completion of the survey, the data is sent automatically to Dr. Kirakowski, thereby ensuring credibility of the data.

5.2.3 Instrument 2: Heuristic evaluation

The researcher made individual appointments with each of the expert evaluators. The researcher gave the evaluators a tour of the application, and asked whether there were any questions from the evaluator's side. The usability experts were then given the opportunity to explore the live BI application (refer to ANNEXURE J for screenshots of the BI application), and were given simple tasks to complete (refer to ANNEXURE I), thereafter the HE questionnaire (refer to ANNEXURE K) was completed by each of the expert evaluators. Throughout this entire process, the researcher was present and was available to assist, clarify, answer questions or help where it was required.

The HE data was recorded in Microsoft Excel, and sorted in numerical order. The score scale had (***1)*** as the worst score and (***5)*** as the best score for all 35 questions in the evaluation. The participant answers were subsequently captured per question, and the participants were labelled as Participant A, Participant B, Participant C and Participant D in order to keep within the conditions of anonymity.

5.3 DATA ANALYSIS

In Sections 5.3.1-5.3.3 the analysis of the three sets of data will be discussed, firstly the analysis of the observational data will be considered, then the analysis of the survey data and lastly the data analysis of the HE.

5.3.1 User Observations

The researcher's notes on user requests were periodically reviewed and the researcher subsequently attempted to identify usability issues (if possible) related to each of the user requests received. For example a user contacted the researcher to assist with the filtering of data for a specific colliery, to only show that particular colliery's achievement against a particular KPI. This request was noted and mapped to possible usability issues that would prevent the user from completing the task themselves, such as issues of learnability, control, and helpfulness. The BI specific issues that were identified assisted in the selection of the HE criteria that were compiled specifically for the evaluation of BI applications. See Table 6.2 for extended list mapping of user issues to usability principles.

5.3.2 Instrument 1: SUMI data analysis

As noted SUMI (Software Usability Measurement Inventory) is a 50-item questionnaire for assessing software-system usability (Karahocha, et al., 2009). The questionnaire has five sub degrees namely: efficiency, affect, helpfulness, control, and learnability. Subsequently these usability principles were identified in the literature review as the independent variables addressed in the SUMI questionnaire (for an explanation of each variable refer to Table 3.2).

Additional independent variables included in the analysis of the survey data included:

- Number of users per area assessed: this variable looked at the number of users in a particular department within the organization.
- Frequency of application usage.
- In order to contextualise user work areas were divided into:
    - Supply chain.
    - Information management.
    - Engineering.

The SUMI Questionnaire consists of 50 attitude statements, users are requested to respond to these statements by *agreeing*, *not knowing* or *disagreeing* (3-point response format). The SUMI data is then analysed by a program called SUMISCO, this ensures that errors are minimised. The raw question data is coded, combined, and transformed into a global subscale, and five additional subscales called efficiency, affect, helpfulness, controllability, and learnability. The z-score transformation is used to make the scales have an expected (population) mean of 50, and a standard deviation of 10. The survey answers are compared against a benchmark of responses from surveys of other BI applications. Each organization using the SUMI survey sends back their results to the Human Factors Research Group (HFRG) who provide statistical results from the database compiled from all SUMI users.

The SUMI data that was collected from this survey was analyzed by the Dr. Jurek Kirakowski from the University of Cork, Ireland, who developed and administers the SUMI questionnaire. The process followed in the data analysis is as follows (Kirakowski, 2010):

1. The expected numbers of responses to each response option for each question of SUMI is generated by multiplying probability data from the standardization base by the number of responses in the sample. (Not all response options have the same probability in the standardization database).

2. The actual (observed) responses are then compared with those predicted by the database from step (1) using the standard chi square formula of $[\sum (o\text{-}e)^2/e]$ where o is observed frequencies and e is expected frequencies and you sum over all the response options for the question.

3. If the fit between observed and expected is good then the value of the statistic is small. There are probability values for chi square which in this case should be looked up with df = k - 1 = 3 - 1 = 2. The critical region is from the tabled value to infinity. However, the use of the probability distribution is more of a guide than anything definite. The survey statements are arranged in descending order of magnitude of the statistic and encourage analysts to look at the first six or seven statements. This is due to the fact that the highest scores will indicate the areas which are the most different from the expected scores, which in turn indicates areas of concern regarding usability as perceived by the users.

4. The statements with the highest value of the statistic are the ones, which have the WORST goodness-of-fit compared to the standardization database. Thus, they are the ones that stand out characteristically in the evaluation. The goodness-of-fit of each response is looked at and main differences are identified. For example we expect a lot more respondents to AGREE and a lot fewer to DISAGREE with the statement that ‘I can understand and act on the information provided by this software.’ Thus, the respondents are telling very definitely that they cannot ‘understand and act on the information provided by this software.’

5.3.3 Instrument 2: Heuristic evaluation data analysis

The answers from the HE were sorted according to a particular usability concept, for example Question 5.7 states that the system is useful to reveal trends and patterns that would otherwise not be visible was allocated to usability's principle of *efficiency* due to the fact that such a feature would allow the user to be more efficient at work, see Section 2.4 for the purpose of BI systems.

After each of the questions in the HE was mapped to a usability principle, the different question's answers were grouped accordingly and averages calculated for each of these usability concepts according to the expert evaluator scores (see ANNEXURE L for HE data sheet). These scores were then compared to the scores of the corresponding usability principle form the SUMI questionnaire (refer to Section 5.5 for triangulation detail).

5.4 DATA RESULTS

Now that the data from the various sources (observations, instrument 1 and instrument 2) have been collected and analysed these results will now be presented in Sections 5.4.1 – 5.4.2. Firstly the results of instrument 1 (the survey) will be presented, thereafter the results of the HE will be discussed. Note that the user observations function as a source to the HE and will therefore not be discussed separately.

5.4.1 Data results: Instrument 1 (SUMI survey)

The SUMI data results are summarized in the Tables 5.1 – 5.10 these results were investigated and analyzed for confirmation of the heuristic guidelines as proposed in RQ3 of the study. Table 5.1 presents a summary of the results from instrument 1, namely the SUMI survey. The results are broken up into the usability principles addressed in the survey.

Table 5.1 SUMI scores per usability principle

	Global	Efficiency	Affect	Helpfulness	Control	Learn-ability
(No. cases)	50	50	50	50	50	50
(Mean)	49.28	46.48	50.26	50.08	45.52	47.12
(Standard Dev)	16.24436	17.74219	16.99557	14.00414	16.20688	17.40237
(Upper Fence)	81.11894	81.25469	83.57132	77.52811	77.28548	81.22864
(Lower Fence)	17.44106	11.70531	16.94868	22.63189	13.75452	13.01136

As can be seen from Table 5.2 all the mean scores for each usability attribute lie between 45% and 51%, this implies that the largest variance between the scores is only 4.74%, which in turn indicates that the perception regarding the usability elements are more or less the same for the different attributes.

Table 5.2 SUMI Standard error of mean scores

	Global	Efficiency	Affect	Helpfulness	Control	Learn-ability
(Std Err of Mean)	2.297299	2.509125	2.403537	1.980484	2.291999	2.461067
(Upper 95% CL)	53.78271	51.39788	54.97093	53.96175	50.01232	51.94369
(Mean)	49.28	46.48	50.26	50.08	45.52	47.12
(Lower 95% CL)	44.77729	41.56212	45.54907	46.19825	41.02768	42.29631

Each of the 50 SUMI question statements were analysed and scored as can be seen from the example in Table 5.3. This example shows the numbering of questions on the SUMI questionnaire, in this case 'Item 23' as the questions are called on the SUMI questionnaire, the statement made which the participant has to evaluate and either agree, disagree or mark as undecided. In this case 6 participants agreed with the statement, 5 participants were undecided and 38 participants disagreed with the statement made.

Table 5.3 SUMI question example

Item 23	I can understand and act on the information provided by this software.		
	Agree	Undecided	Disagree
Observed	6	5	38
Expected	35.60603	9.437743	3.956226
Chi Square	319.6543		

Kirakowski (2010) explained the data analysis of each question statements as follows: Table 5.3 analyses the responses to the statement made. What this means is that 38 people disagreed with the statement that they could 'understand and act on the information provided by this software.' 6 people agreed, and 5 were undecided. When this data is compared against the profiles in his database, it would be expected that the ratios would be as given in the 'expected' row. That is, that 35.60 people would agree, 9.43 would not know, and only

3.95 would actually disagree. In other words the analysis indicates problem here as the discrepancy is surprising large. The Chi square statistic computes that discrepancy: the bigger the Chi square value, the larger the statistic discrepancy.

In this type of analysis it is not *only* the number of people who agree; the discrepancy between the expected and the observed data that is especially important to notice (Kirakowski, 2010). The observed or expected discrepancy for each category of response should be inspected; this will help to get a deeper understanding of what issues are uppermost in the respondents' minds. For survey data detail and data analysis per question, please refer to ANNEXURE E.

5.4.1.1 Global usability of SUMI

The Figure 5.2 depicts the distribution of scores with regard to the Global (or overall) usability perception of the application. The *global* score combined with the individual comments highlights concerns about the application.

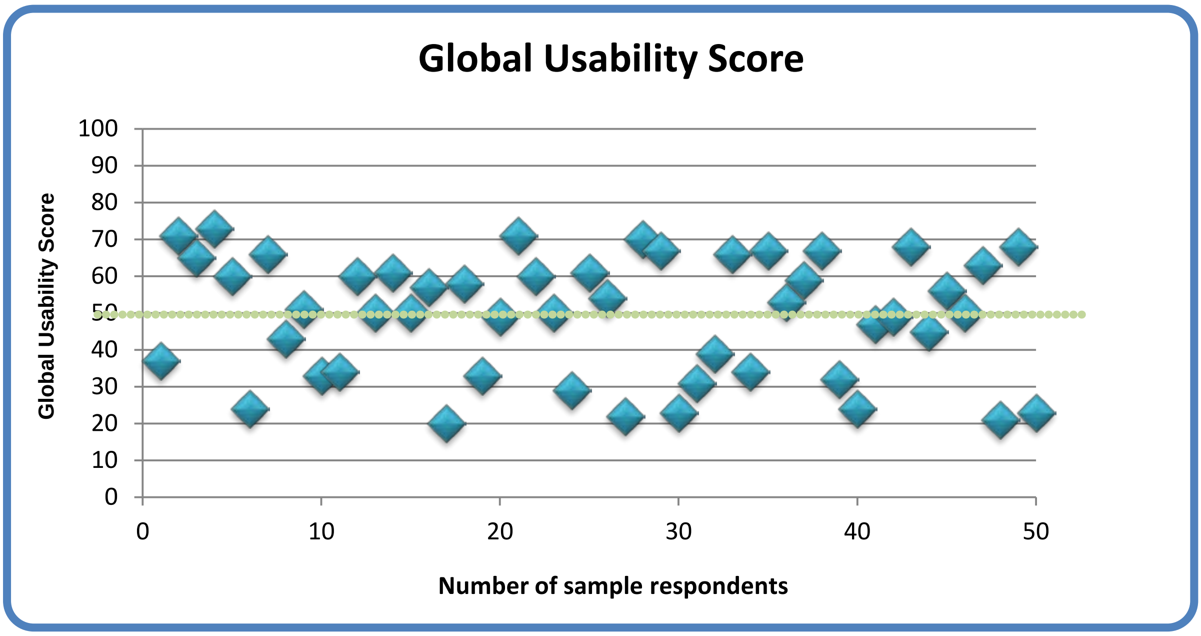


Figure 5.2 SUMI global usability score distribution

This graph shows the well-distributed scores for the sample group. Indicating that the average score obtained is not a result of the high number of poor scores, but rather as the result of the severity of the poor scores. Table 5.4 summarises the SUMI scores for the category: Global, indicating the number of respondents that answered questions about the category, the Mean score for the category, the Standard Deviation for the category, as well as the Upper and Lower fences for the category. From these results the BI system is positioned relative to other BI systems. According to Kirakowski (2010), Cognos Upfront scored slightly better than the evaluation averages for other BI systems.

Table 5.4 SUMI Global usability scores

Global	
(No. cases)	50
(Mean)	49.28
(Standard Dev)	16.24436
(Upper Fence)	81.11894
(Lower Fence)	17.44106

The sample was divided into 7 categories representing the frequency of use of the application. Where the question was 'How often do you use this software?' options 1 – 7 made up the possible answers, see Table 5.5:

Table 5.5 Frequency categories of application usage.

Frequency of application usage	Category ranking
Several times a day	1
Not more than once a day	2
Several times a week	3
Not more than once a week	4
Several times a month	5
Not more than once a month	6
Less than once a month	7

The frequency (count) shows the number of participants, which make use of the application as per the application usage (frequency) question, where 1 is several times a day and 7 is less than once a month. The frequency with which the application is used is depicted graphically in Figure 5.3. This means that most users, more than 90% use the application at least once a month, while 54% use the application at least once a week.

The Global scores averages are the averages of the Global score divided by the number of people according to the group they belong to based on the frequency of use. The rationale behind this is to determine whether the frequency of application usage influence their perception of the application usability (see Figure 5.4).

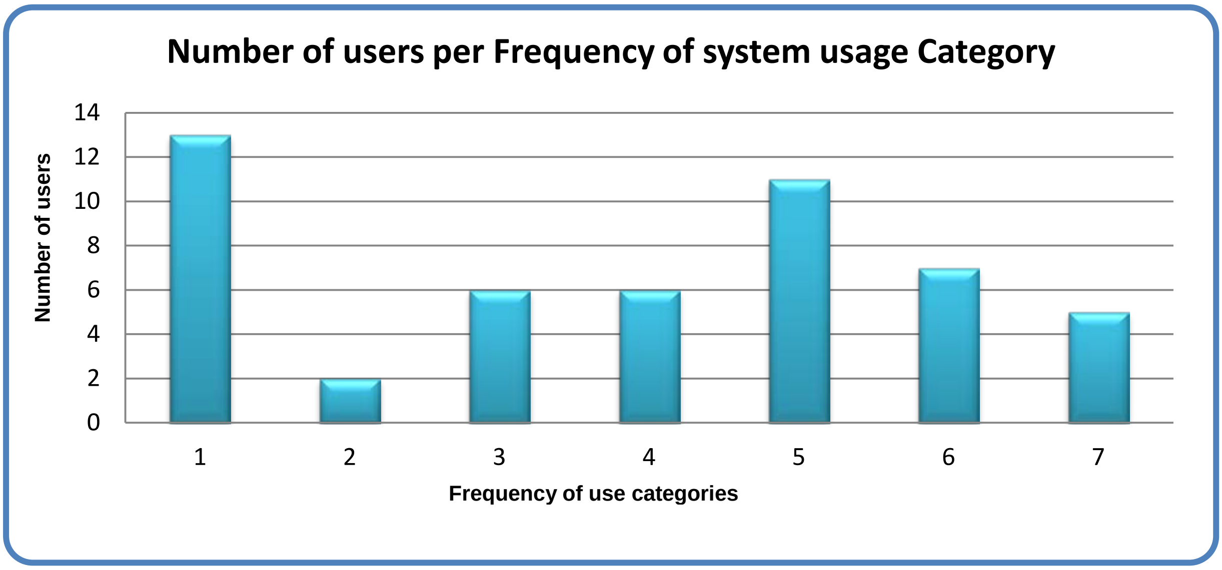


Figure 5.3 Frequency of application usage per application usage category

From observation it can be said that the most frequent users, in category 1, 2 and 5, scored the overall usability of the application slightly higher than the mean score (49.28%), with category 1 (52.5%) being the user group who uses the application more than once daily, category 2 (55.5%) the user group that uses the application daily and category 5 (52.36) users that use the application several times a month. The lowest scoring category (7) was also the category of users that uses the application the least.

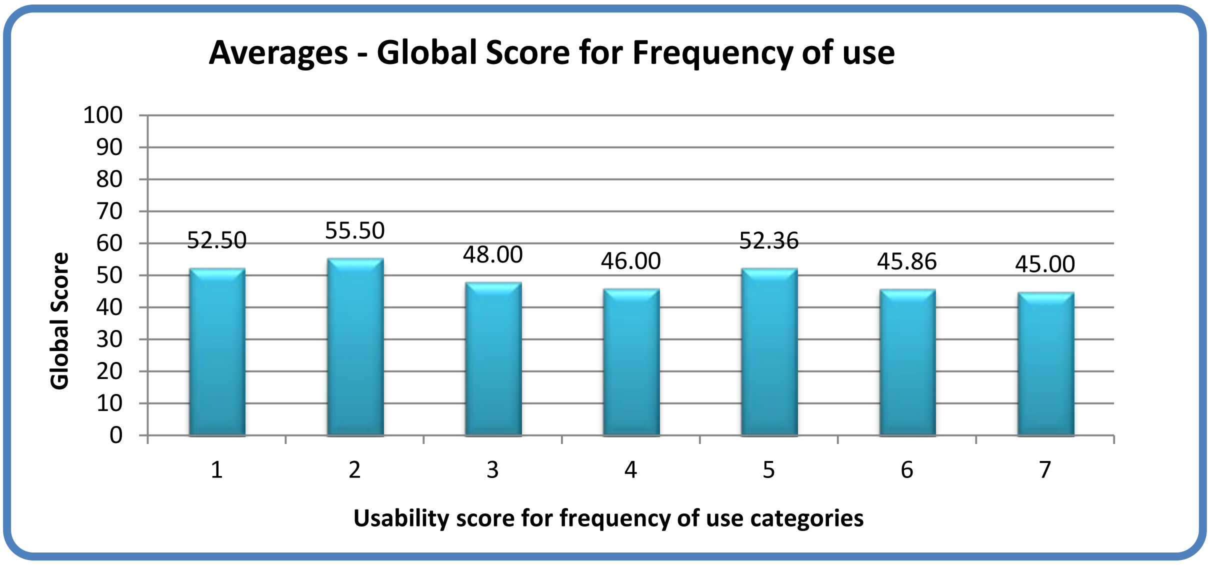


Figure 5.4 Global score for frequency of use

5.4.1.2 Efficiency

The distribution of efficiency scores for the individual respondents is depicted in Figure 5.5. From this figure the wide distribution of participant scores become clear, it is however notable that the efficiency scores tend to be lower compared to the other usability principles measured, with a lower fence of 11.7%.

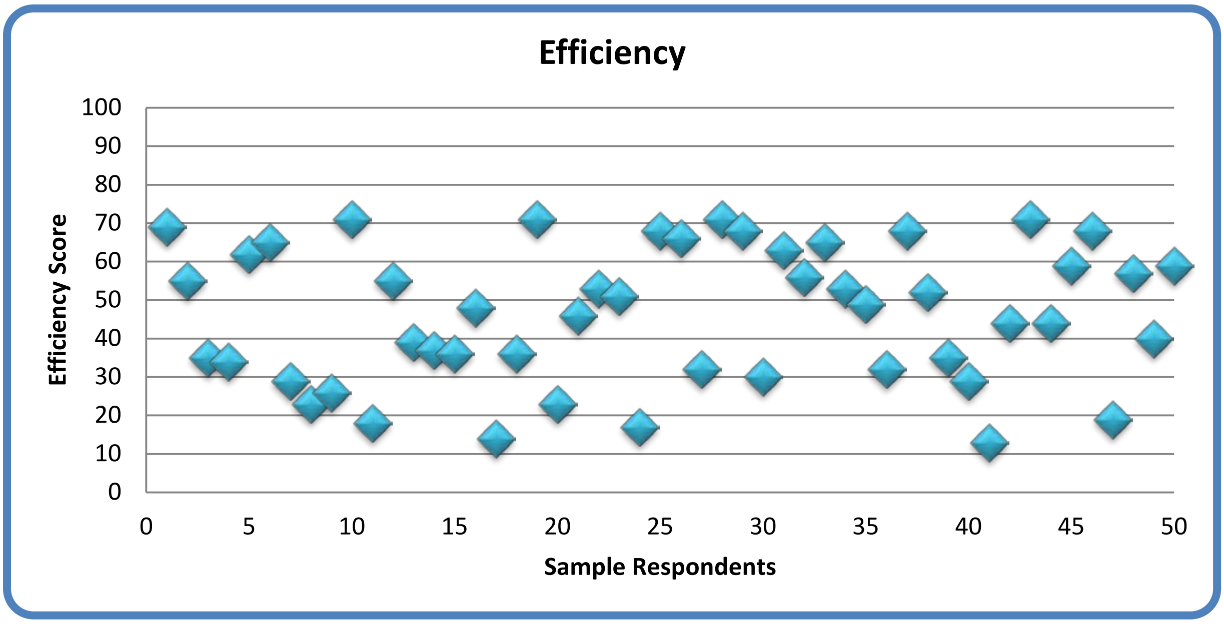


Figure 5.5 Distribution of efficiency scores

Table 5.6 provides a summary of the *efficiency* scores for all 50 participants. A mean of 46.48 could indicate that the BI application is not regarded as aiding users to work efficiently and could possibly be a source of frustration for these users. This is underscored by the low lower fence scores for this usability principle.

Table 5.6 SUMI efficiency scores

	Efficiency
(No. cases)	50
(Mean)	46.48
(Standard Dev)	17.74219
(Upper Fence)	81.25469
(Lower Fence)	11.70531

Figure 5.6 depicts the efficiency averages for different usage categories, from this graph it appears that the groups making use of the application several times a day (category 1) and several times a month (category 5) tend to perceive the application as being more efficient that the other groups of participants making less use of the system, namely categories 2, 3, 4, 6 and 7.

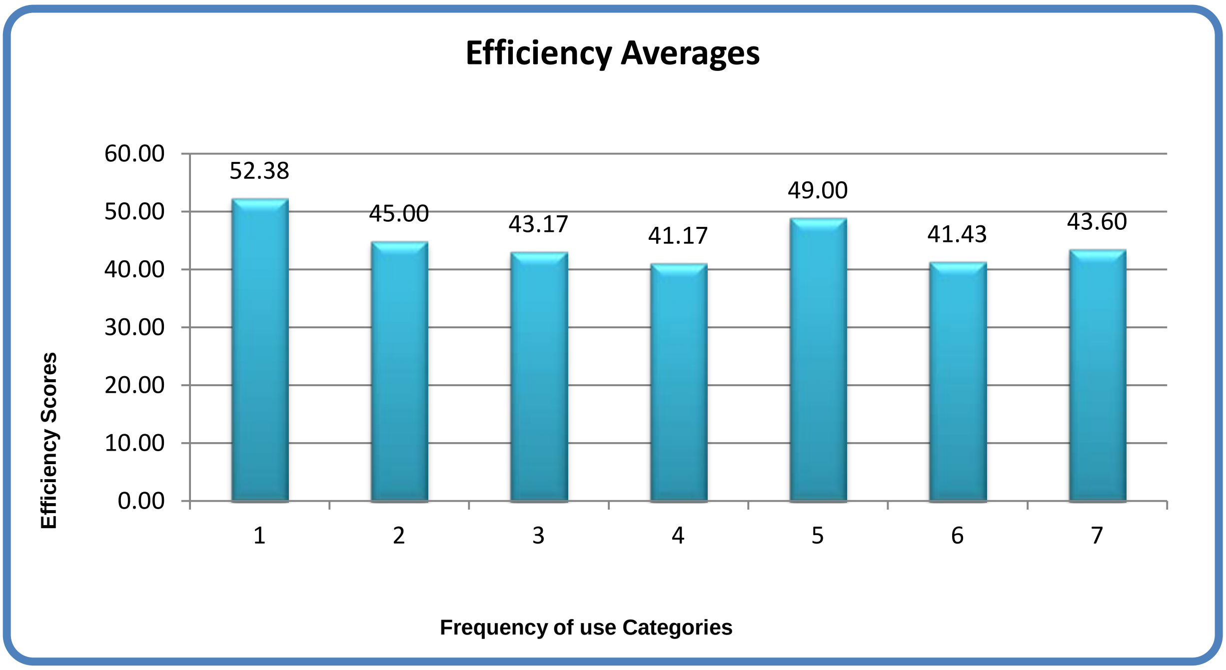


Figure 5.6 Efficiency averages for different frequency of use categories

5.4.1.3 Affect

The distributions of affect scores for the individual respondents are depicted by Figure 5.7. The mean is 50.26 even though there are a couple of respondents that scored the affect for the application as very low (below 20). This is however countered by the clear clustering of respondent answers just below the 60% line.

The *affect* attribute mean scored the highest of all the usability attributes tested, additionally the *affect* attribute also have the highest upper fence value (83.57%) of the survey.

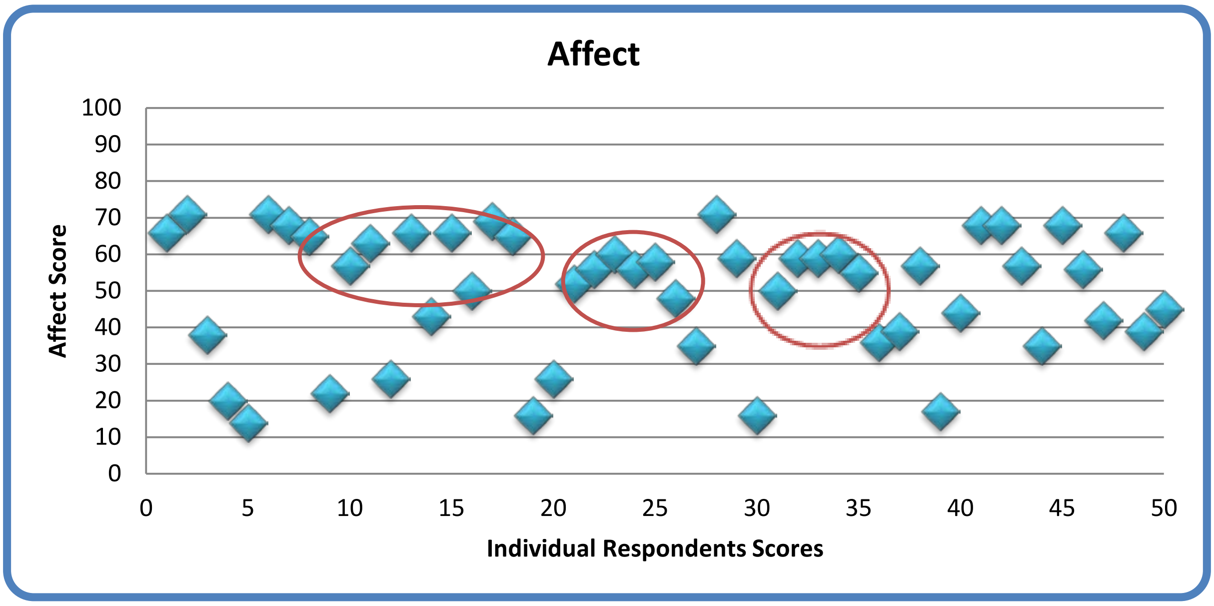


Figure 5.7 Distribution of affect scores

This usability attribute mean scored the highest of all the other principles being scored with a variance of 4.74 between the highest scoring attribute (affect) and the lowest scoring attribute (application control).

Table 5.7 depicts more data on how affect scored, showing that there is a large deviation in the individual user scores

Table 5.7 SUMI affect scores

	Affect
(No. cases)	50
(Mean)	50.26
(Standard Dev)	16.99557
(Upper Fence)	83.57132
(Lower Fence)	16.94868

5.4.1.4 Helpfulness

The distribution of helpfulness scores by the sample respondents are represented in Figure 5.8. The mean score of the *helpfulness* mean is in line with the other SUMI variable values. However the lower fence score is slightly higher than the other SUMI variables lower fence scores at 22.63%, resulting in a 10.93% variance compared to the lowest variable fence, which is the efficiency score of 11.7%.

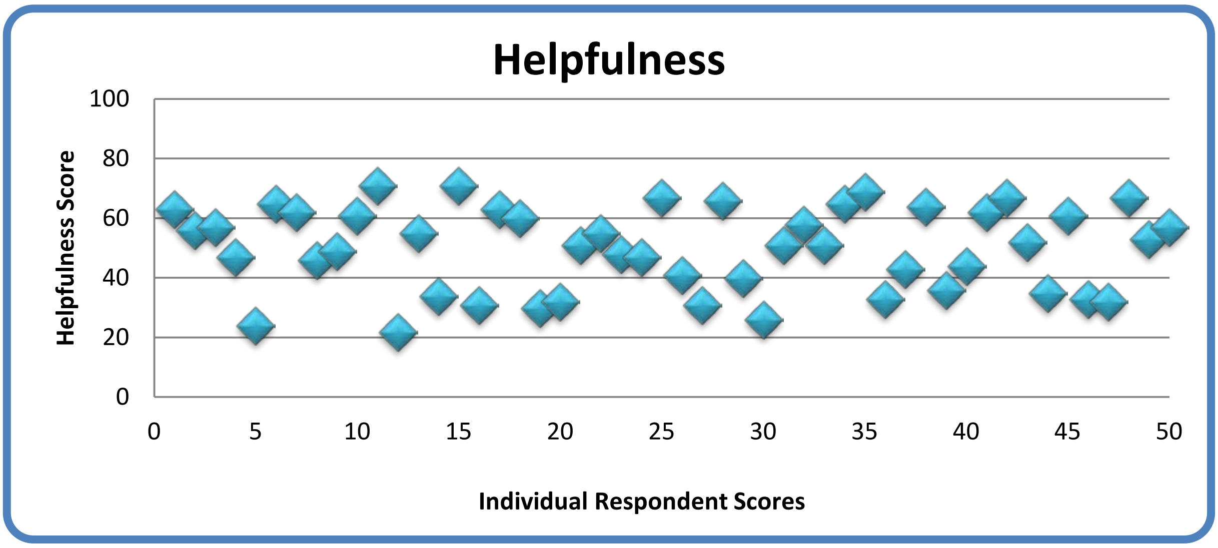


Figure 5.8 Distribution of helpfulness scores

The summary for the respondent scores can be seen from Table 5.8, which shows a smaller standard deviation than for the global score, efficiency or affect. The mean score for this attribute was the second highest ranking score of all the usability attributes measured in this survey.

Table 5.8 SUMI helpfulness scores

	Helpfulness
(No. cases)	50
(Mean)	50.08
(Standard Dev)	14.00414
(Upper Fence)	77.52811
(Lower Fence)	22.63189

5.4.1.5 Control

The distribution of control scores for the individual respondents is represented in Figure 5.9. According to the survey results the control attribute is perceived as lacking the most usability. As a result, the low mean indicates a general perception that there is a problem with the control of the application, in the sense that users do not feel that they have enough control over the application.

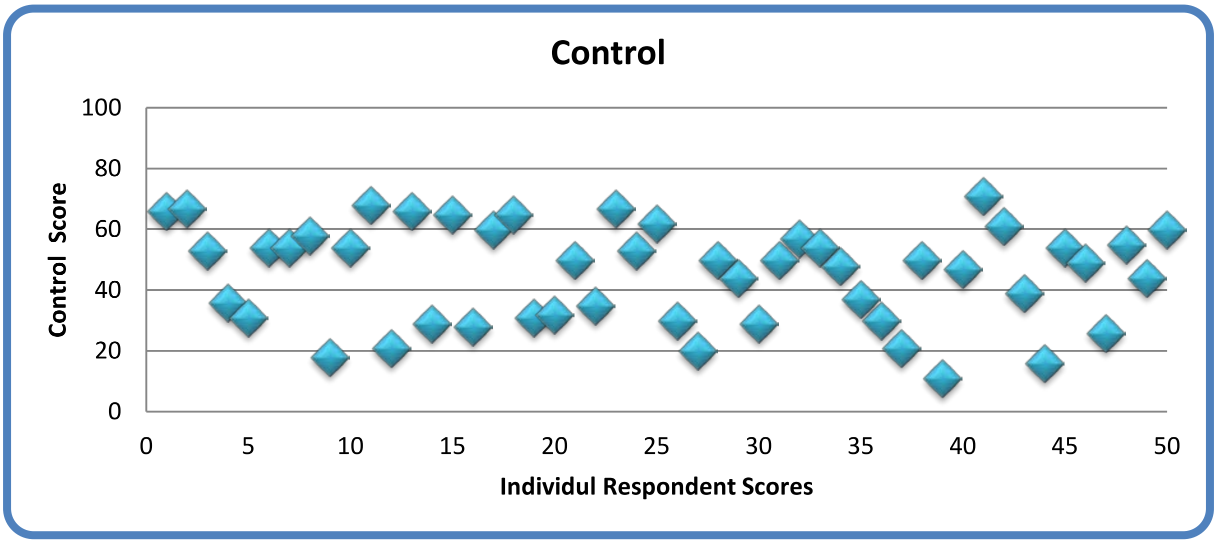


Figure 5.9 Distribution of control scores

For summary information on control scores please see Table 5.9, which shows a large standard deviation for control.

Table 5.9 SUMI control scores

	Control
(No. cases)	50
(Mean)	45.52
(Standard Dev)	16.20688
(Upper Fence)	77.28548
(Lower Fence)	13.75452

5.4.1.6 Learnability

The distribution of learnability scores for the individual respondents is presented in Figure 5.10. From the graph it can be seen that 2 clusters of users stand out, the one group perceives the application as being relatively learnable (scores between 58 and 78), whilst the second group perceives the application as not learnable (scores between 20 and 40).

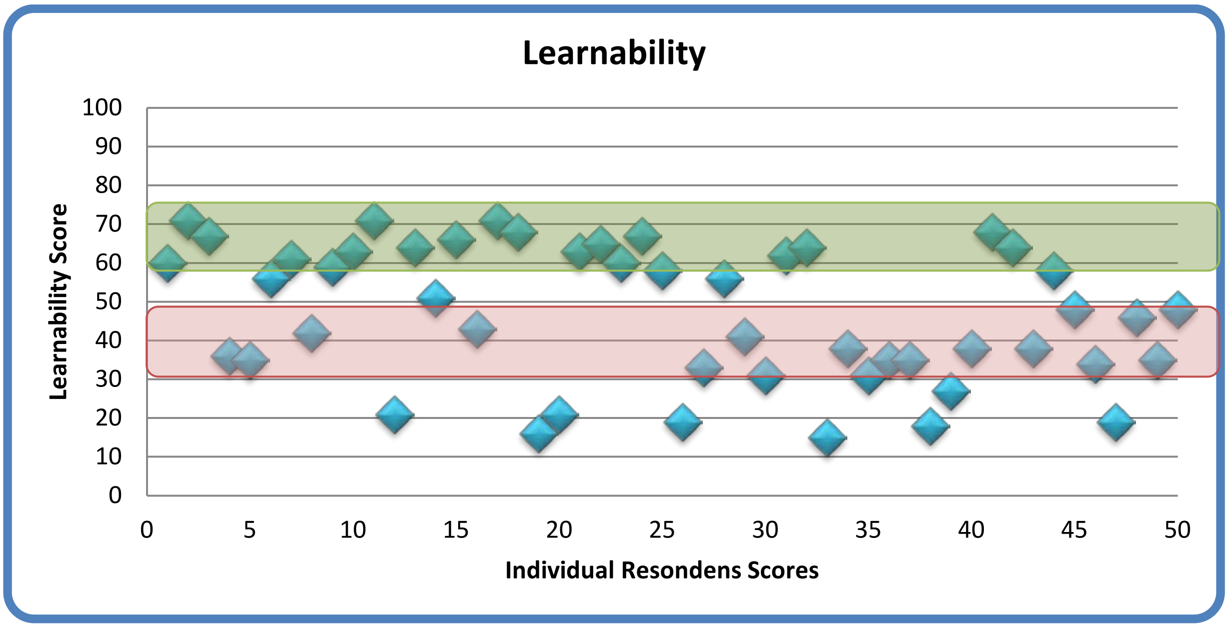


Figure 5.10 Distribution of learnability scores

The summary data for learnability scores can be seen from Table 5.10, this reflects a large deviation in perceived learnability**.**

Table 5.10 SUMI learnability scores

Learnability	
(No. cases)	50
(Mean)	47.12
(Standard Dev)	17.40237
(Upper Fence)	81.22864
(Lower Fence)	13.01136

Interestingly enough, when the average score per area (department) is compared to the number of participants in that category, there seem to be a positive correlation between the two independent variables (to different extents). See Figure 5.11 this suggests that the number of users impact the perception surrounding the application, the more users there are, the more positive the perception. This phenomenon could possibly indicate:

- Different user requirements (needs) from different user types with regards to the usability of the BI application.
- Differing educational backgrounds and systems expertise.
- Different training provided to different groups of users.
- Differing user morale or attitude influencing the perception of the application of the various user groups.

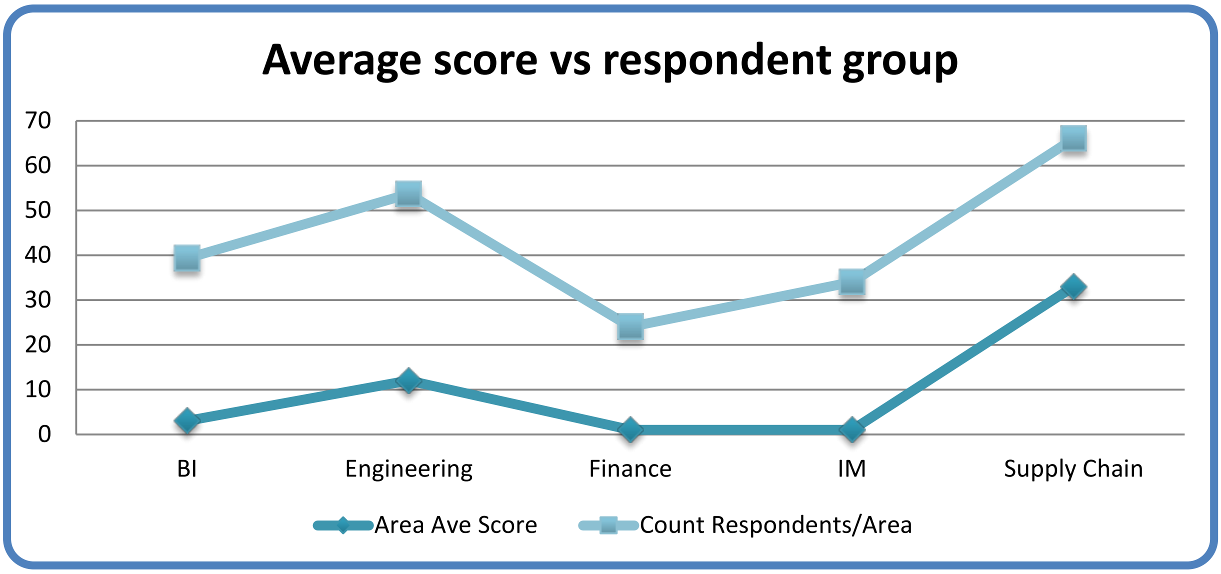


Figure 5.11 Correlation between average score and sample group sizes

The SUMI data results will be discussed in further detail in Section 5.4.1.7 making use of recognised statistical methods.

5.4.1.7 Statistic results summary (SUMI)

For detail regarding the frequencies of the usability attribute variables, and the frequencies of attribute variables condensed into categories with sufficient frequencies see ANNEXURE M.

Please note: the initial means of the BI variables differ slightly from the values in the ANOVA results presented due to the fact that the University of Cork who administers the

SUMI questionnaire lost 7 completed questionnaires due to a hardware failure. This data has also been analysed by two independent groups. It is stressed that the means analysis of the variables (usability principles) were done on the full data set (refer to Sections 5.4.1 - 5.4.6) and the analysis of the predictor variables (Section 5.4.1.7) was done on the smaller set of 43 of 50 users. Also **note that the *complete set of data* (all 50) results was employed in the triangulation with the HE data**.

5.4.1.7.1 Frequencies of predictor variables

In Table 5.11 the number of participants in each of the categories regarding the frequency of application usage is indicated. The rationale is that frequent application users should know the application better than ad hoc application users; and hence be more able to answer usability related questions regarding application usage. This participant makeup leads us to believe that 38 of the 50 participants (76%) are *regular application* users, making use of the application several times during a month. The categories for the three predictor variables had to be condensed to be able to do *meaningful* analyses.

The participants were also categorised into *user types* (refer to Table 5.12) based on their area of work, in order to determine whether the *type* of application user influenced their perception of the application's usability.

Lastly, the users were categorised according to their experience with the application (for yearly use refer to Table 5.13, for monthly use refer to Table 5.14) in order to see if that would influence their perception of application usability.

Table 5.11 Predictor variable: Frequency

Frequency	Frequency	Percent	Cumulative Frequency	Cumulative Percent
Several times a day	13	26.00	13	26.00
Not more than once a day	2	4.00	15	30.00
Several times a week	6	12.00	21	42.00
Not more than once a week	6	12.00	27	54.00
Several times a month	11	22.00	38	76.00
Not more than once a month	7	14.00	45	90.00
Less than once a month	5	10.00	50	100.00

Table 5.12 Predictor variable: User type

User_Type	Frequency	Percent	Cumulative Frequency	Cumulative Percent
Other	17	34.00	17	34.00
SupplyChain	33	66.00	50	100.00

Table 5.13 Predictor variable: Duration of use (yearly)

Duration of use (yearly)	Frequency	Percent	Cumulative Frequency	Cumulative Percent
< year	11	22.00	11	22.00
>year	39	78.00	50	100.00

Table 5.14 Predictor variable: Duration of use (monthly)

Duration of use	Frequency	Percent	Cumulative Frequency	Cumulative Percent
< a month	2	4.00	2	4.00
2-6 months	3	6.00	5	10.00
6-12 mnths	6	12.00	11	22.00
>12 mnths	39	78.00	50	100.00

5.4.1.7.2 Means

A first exploratory step was taken to obtain an overview of whether differences between category mean scores can be expected – in other words whether the effect of a predictor variable can be expected to prove statistically significant in analyses of variance or other relationship tests.

Attribute score means were also arranged according to user type, namely: supply chain and *other* (comprising of engineering and information management (IM)) to see whether the user type could have a significant effect. Refer to Table 5.15. From this table it is shown that the global usability scores of supply chain users are significantly higher than those of *other* (IM and engineering) users, with an 8.9% variance between the two sample categories scores, indicating a higher usability perception from supply chain application users than for engineering and IM.

Table 5.15 Overall score means – general overview of how the aspects were perceived

User Type	N Obs	Variable	Mean	N	StdDev
Other	17	Global	43.4117647	17	16.4090631
		Eff	40.1764706	17	16.6817089
		Aff	44.0000000	17	18.6077941
		Helpf	48.5294118	17	14.3575662
		Contr	39.4117647	17	16.4698923
		Learna	44.2352941	17	19.7564211
SupplyChain	33	Global	52.3030303	33	15.5472764
		Eff	49.7272727	33	17.6321311
		Aff	53.4848485	33	15.4153357
		Helpf	50.8787879	33	13.9748828
		Contr	48.6666667	33	15.3799111
		Learna	48.6060606	33	16.1824353

Table 5.16 represents the attribute score means arranged according to frequency of use. From this table it appears that the more the users make use of the application, the higher the usability perception regarding the application. This can be seen from the 3.08% variance between the daily application users and the monthly application users.

Table 5.16 Score means arranged according to frequency of use

Frequency	N Obs	Variable	Mean	N	StdDev
Daily	15	Global	51.8666667	15	15.0231567
		Eff	51.4000000	15	15.6469988
		Aff	53.0666667	15	14.7040649
		Helpf	51.1333333	15	13.1522223
		Contr	46.4666667	15	16.4658377
		Learna	49.6666667	15	16.3648869
Weekly	12	Global	47.0000000	12	16.7820250
		Eff	42.1666667	12	18.2648860
		Aff	52.7500000	12	15.4043972
		Helpf	51.3333333	12	15.0896312
		Contr	43.7500000	12	14.5109676
		Learna	40.5000000	12	18.5839618
Monthly	23	Global	48.7826087	23	17.1939644
		Eff	45.5217391	23	18.7322512
		Aff	47.1304348	23	19.1864165
		Helpf	48.7391304	23	14.4700864
		Contr	45.8260870	23	17.4581374
		Learna	48.9130435	23	17.3124050

Table 5.17 shows the attribute score means arranged according to time period BI tool has been used. According to the means of the global usability score for the different categories (namely: more than a year, and less than a year) the duration of user experience with the application shows a deterioration in perception regarding application usability for users making use of the application for longer than a year, this can be seen from the 6.52% variance.

Table 5.18 groups the score means according to user type and frequency of application use. From this table it is noticeable that the user type *other* (engineering and information management) users' perception tend not to change with increased application usage (frequency), this can be seen from the 0.1% variance between the daily and monthly user groups. On the other hand the supply chain users' perception regarding application usage seems to increase with increased application usage, as can be seen from the 8.97% variance.

Table 5.17 Score means arranged according to period BI tool has been used

HowLong	N Obs	Variable	Mean	N	StdDev
< year	11	Global	54.3636364	11	13.4109860
		Efficiency	53.1818182	11	14.5245873
		Affect	53.5454545	11	14.1941089
		Helpfulness	51.7272727	11	12.6260913
		Control	51.1818182	11	12.5205286
		Learnability	49.3636364	11	15.8636233
>year	39	Global	47.8461538	39	16.8328289
		Efficiency	44.5897436	39	18.2680595
		Affect	49.3333333	39	17.7605911
		Helpfulness	49.6153846	39	14.4888621
		Control	43.9230769	39	16.8981229
		Learnability	46.4871795	39	17.9558989

Table 5.18 Score means arranged according to user type and frequency of use

User Type	Frequenc	N Obs	Variable	Mean	N	StdDev
Other	Daily	8	Global	45.7500000	8	16.6626186
			Eff	45.5000000	8	16.1067865
			Aff	46.5000000	8	17.1714048
			Helpf	49.3750000	8	13.8351261
			Contr	39.3750000	8	19.0108052
			Learna	45.7500000	8	18.8053944
	Weekly	3	Global	32.6666667	3	14.8436294
			Eff	25.6666667	3	9.2915732
			Aff	40.3333333	3	21.5483951
			Helpf	43.6666667	3	19.1398363
			Contr	36.3333333	3	11.8462371
			Learna	22.6666667	3	7.2341781
	Monthly	6	Global	45.6666667	6	17.3397424
			Eff	40.3333333	6	17.9183333
			Aff	42.5000000	6	22.1065601
			Helpf	49.8333333	6	15.0919405
			Contr	41.0000000	6	17.2394896
			Learna	53.0000000	6	18.9208879

Table 5.18 Score means arranged according to user type and frequency of use (continued)

User Type	Frequenc	N Obs	Variable	Mean	N	StdDev
Supply Chain	Daily	7	Global	58.8571429	7	9.7882339
			Eff	58.1428571	7	13.0054933
			Aff	60.5714286	7	6.1062029
			Helpf	53.1428571	7	13.0948918
			Contr	54.5714286	7	8.2027870
			Learna	54.1428571	7	12.9798378
	Weekly	9	Global	51.7777778	9	15.1474237
			Eff	47.6666667	9	17.3493516
			Aff	56.8888889	9	11.5373789
			Helpf	53.8888889	9	13.8604153
			Contr	46.2222222	9	15.0646754
			Learna	46.4444444	9	17.4005108
	Monthly	17	Global	49.8823529	17	17.5388225
			Eff	47.3529412	17	19.1961623
			Aff	48.7647059	17	18.5085433
			Helpf	48.3529412	17	14.7009403
			Contr	47.5294118	17	17.7310379
			Learna	47.4705882	17	17.0811213

Table 5.19 presents the attribute score means arranged according to user type and duration of application use. From this table it can be seen that the type of user impact the usability perception more than the period of use. The table also indicates that there is only a global usability variance of 3.09% between the supply chain users that make use of the application for less and more than a year. This (10.95% variance) contrasts to the global usability score of the other types of users (IM and engineering) who perceive the usability of the application to be poor after making use of the application for more than a year.

5.4.1.7.3 Correlation between attribute variables

Correlation indicates whether inter-dependencies between attribute variables exist – in this case the attribute variables are inter related – especially with the 'global' attribute, as can be seen from Table 5.20, where the lowest Spearman correlation coefficient is 0.74362 smaller than 0.0001 for application *learnability* and 0.91477 smaller than 0.0001 for application control.

Table 5.19 score means arranged according to user type and length of use/ time period

User Type	HowLong	N Obs	Variable	Mean	N	StdDev
Other	>year	17	Global	43.4117647	17	16.4090631
			Efficiency	40.1764706	17	16.6817089
			Aff	44.0000000	17	18.6077941
			Helpf	48.5294118	17	14.3575662
			Contr	39.4117647	17	16.4698923
			Learna	44.2352941	17	19.7564211
Supply Chain	< year	11	Global	54.3636364	11	13.4109860
			Eff	53.1818182	11	14.5245873
			Aff	53.5454545	11	14.1941089
			Helpf	51.7272727	11	12.6260913
			Contr	51.1818182	11	12.5205286
			Learna	49.3636364	11	15.8636233
SupplyChain	>year	22	Global	51.2727273	22	16.7137862
			Eff	48.0000000	22	19.0762879
			Aff	53.4545455	22	16.3145488
			Helpf	50.4545455	22	14.8699994
			Contr	47.4090909	22	16.7578243
			Learna	48.2272727	22	16.6959699

Table 5.20 Correlation between attribute variables

Spearman Correlation Coefficients, N = 50 Prob > |r| under H0: Rho=0						
	Global	Efficiency	Affect	Helpful	Control	Learn
Global	1.00000	0.89734 <.0001	0.87619 <.0001	0.83391 <.0001	0.91477 <.0001	0.74362 <.0001
Efficiency	0.89734 <.0001	1.00000	0.77973 <.0001	0.66446 <.0001	0.82896 <.0001	0.76332 <.0001
Affect	0.87619 <.0001	0.77973 <.0001	1.00000	0.74839 <.0001	0.79946 <.0001	0.57118 <.0001
Helpful	0.83391 <.0001	0.66446 <.0001	0.74839 <.0001	1.00000	0.71294 <.0001	0.54403 <.0001
Control	0.91477 <.0001	0.82896 <.0001	0.79946 <.0001	0.71294 <.0001	1.00000	0.65595 <.0001
Learn	0.74362 <.0001	0.76332 <.0001	0.57118 <.0001	0.54403 <.0001	0.65595 <.0001	1.00000

5.4.1.7.4 Analysis of variance result

Table 5.21 indicates that for all attribute variables (except helpfulness) the significance of the effect of the type of user on perceptions regarding the usability of BI efficiency, affect, control and learnability could be established on at least the 10% level of significance. This implies that the mean attribute scores for the two types of users differ statistically significantly from each other on at least the 10% level of significance (+: Significance is indicated in the last column of the table by probabilities less than 0.1).

Table 5.21 Analysis of variance result

	DF	Sum of Squares	Mean Square	F Value	Pr > F
Global					
Model	1	886.99266	886.99266	3.54	0.0662+
Error	48	12043.08734	250.89765		
Corrected Total	49	12930.08000			
Effect					
Model	1	1023.46396	1023.46396	3.41	0.0709+
Error	48	14401.01604	300.02117		
Corrected Total	49	15424.48000			
Affect					
Model	1	1009.37758	1009.37758	3.69	0.0608+
Error	48	13144.24242	273.83838		
Corrected Total	49	14153.62000			
Helpfulness					
Model	1	61.929554	61.929554	0.31	0.5795
Error	48	9547.750446	198.911468		
Corrected Total	49	9609.680000			
Control					
Model	1	961.02902	961.02902	3.87	0.0548+
Error	48	11909.45098	248.11356		
Corrected Total	49	12870.48000			
Learnability					
Model	1	214.34239	214.34239	0.70	0.4058+
Error	48	14624.93761	304.68620		
Corrected Total	49	14839.28000			

Please note: The effect of *frequency of use* and *how long* the BI tool have been used were also investigated in analyses of variance, but the statistical significance of these effect could not be validated. The difference between the two types of users is apparent due to the differing means for these two groups of users for each attribute. By studying the graphics, *length-of-use* might be an influential factor for some of the attributes (one can detect some probable differences between the attribute score means for some of the length-of-use categories). The *frequency of use attribute* mean scores however, appear to be more or less the same over all categories of the frequency of use groups; which explains why no statistical significance could be determined in these analyses of variance. These analyses are not presented in the report.

At this stage the crux of the analyses confirms that type of user affect perceptions regarding the usefulness of BI applications, but that frequency of use and length of use do not affect perceptions on the usefulness of BI applications' use.

5.4.1.7.5 Further analysis of variance

The exploratory analyses – in the form of BI variables tables of means and bar graphs (arranged according to the *type of BI user*s, *their frequency of BI applications use*, and *length of use*) - all seemed to indicate that the *type of user* had an effect on the various BI variables.

One-way analyses of variance were therefore conducted on each of the six sets of BI construct scores as dependent variable and with the type of user entered into each anova-model as the explanatory or independent variable. The general linear model (GLM) approach to analysis of variance was used since this approach makes provision for unequal numbers of respondents per explanatory variable categories (user-type). Analysis of variance was deemed appropriate since the dependent variable could be defined as continuous and the explanatory variable of *user type* as a category variable – an assumption of the analysis of variance technique. The assumption of homogeneous group variances and normality of residuals were also investigated and complied with.

Please note that only the results of *type of user* as explanatory variable in analyses of variance model is presented in the table below. Analyses of variance models in which *the frequency of use of the BI application* and *how long respondents had been using the application* were also entered as explanatory variables in the models were also investigated – with interactive effects included, but only the effect of type of user proved to be statistically significant.

The results of these analysis are summarised in the table included below, Table 5.23. The degrees of freedom, sums of squares, mean squares, F test statistic and the F probability associated with each analysis of variance test are indicated for each dependent variable. Bonferroni least significant differences (LSD) on the 10% level of significance and BI variable mean scores per user-category are indicated in the last column. Category means for each BI variable suffixed with a different small letter identifies user category mean scores that differ statistically significantly from the other.

Note: for the two-category user-type explanatory variable, ordinary t-test could have been used – but initial exploratory analysis of variance originally started off with more than two user-categories, and also other explanatory variables (length of BI application use and frequency of BI use) with more than two categories which required analysis of variance techniques. The other exploratory variables proved to be non-significant and user-type categories were reduced to two – supply chain and other users.

Variance homogeneity test – Levene's test (the probability coupled to each of the tests indicated that the group variances are homogene for each of the variables) the F value and probability should be larger than 0.5 – or 0.001 to indicate homogeneity. See Table 5.22 below.

Table 5.22 Values for the f-statistic and probability achieved

	f-statistic	probability
Global	0.06	0.81
Effectiveness	0.18	0.67
Affect	0.87	0.36
Control	0.11	0.74
Learnability	0.244	0.12

Furthermore the residue also presented as 'normal' as a *normal probability plo*t of a residue can be presented as a straight diagonal line. In addition to this the Shapiro Wilks for each residue set was also acceptable. Analyses performed separately on the BI variables: global usability, efficiency, affect, helpfulness, control and learnability; with user-type entered as explanatory variable in each analysis of variance model. Bonferroni least significant differences (LSD) on the 10% level of significance and BI variable mean scores per user-category are indicated in the last column. Category means for each BI variable suffixed with different small letters differ significantly from one another, see Table 5.23.

Table 5.23 Results of analysis of variance and Bonferroni multiple comparisons of means tests

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F		Mean Score
Global						Bonferroni LSD	7.93
User type	1	886.99266	886.99266	3.54	0.0662+	supply chain	52.30 a
Error	48	12043.08734	250.89765			other	43.41 b
Corrected Total	49	12930.08000				overall	49.28
Efficiency						Bonferroni LSD	8.67
User type	1	1023.46396	1023.46396	3.41	0.0709+	Supply chain	49.73 a
Error	48	14401.01604	300.02117			Other	40.17 b
Corrected Total	49	15424.48000				OverAll	48.48
Affect						Bonferroni LSD	8.28
User type	1	1009.37758	1009.37758	3.69	0.0608+	Supply chain	53.49 a
Error	48	13144.24242	273.83838			Other	44.00 b
Corrected Total	49	14153.62000				Overall	50.26
Helpfulness						Bonferroni LSD	7.06
User type	1	61.929554	61.929554	0.31	0.5795 n.s.	Supply Chain	50.88 a
Error	48	9547.750446	198.911468			Other	48.53 a
Corrected Total	49	9609.680000				Overall	50.08
Control						Bonferroni LSD	7.88
User type	1	961.02902	961.02902	3.87	0.0548+	Supply chain	48.67 a
Error	48	11909.45098	248.11356			Other	39.41 b
Corrected Total	49	12870.48000				Overall	45.52
Learnability						Bonferroni LSD	8.74
User type	1	214.34239	214.34239	0.70	0.4058+	Supply chain	48.61 a
Error	48	14624.93761	304.68620			Other	44.24 a
Corrected Total	49	14839.28000				Overall	47.12

5.4.1.7.6 Statistical deductions

The results indicate that the *type of user* proved to have a statistically significant effect on user perceptions regarding the issues of BI global usability, effectiveness, affect, control and learn-ability. Statistical significance on at least the 10% level of significance could be established in these cases. This implies that the mean attribute scores for the two users types differ statistically significantly from each other on at least the 10% level of significance, (significance is indicated in the last column of the table by probabilities less than 0.1). The nature of these differences is described by the user-type category mean scores for each BI variable in the last column of Table 5.23.

Box plots illustrate the nature of the effect of user-type on BI perception scores in the graphs, Figure 5.12 to Figure 5.16

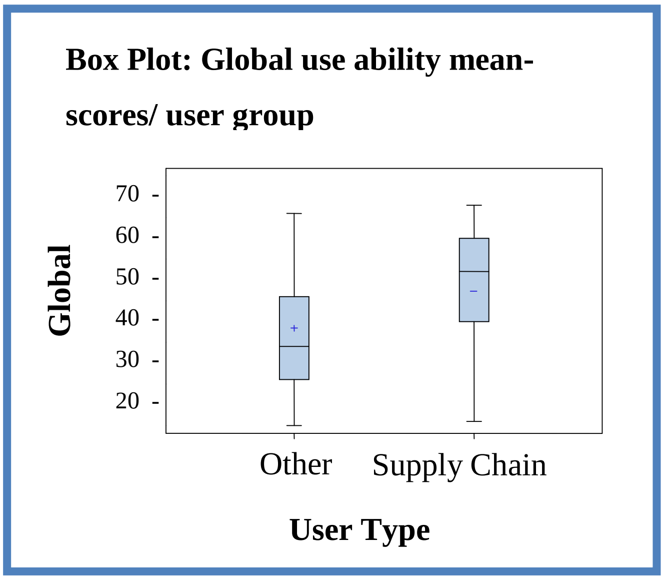


Figure 5.12 Global box plot

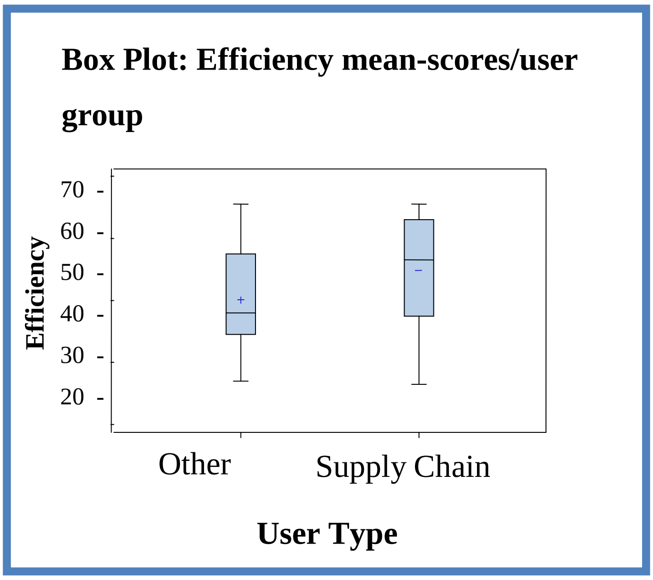


Figure 5.13 Efficiency box plot

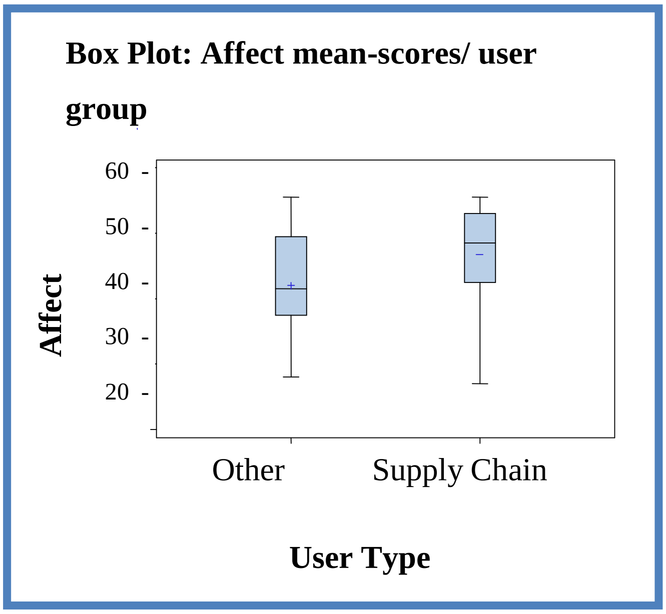


Figure 5.14 Affect box plot

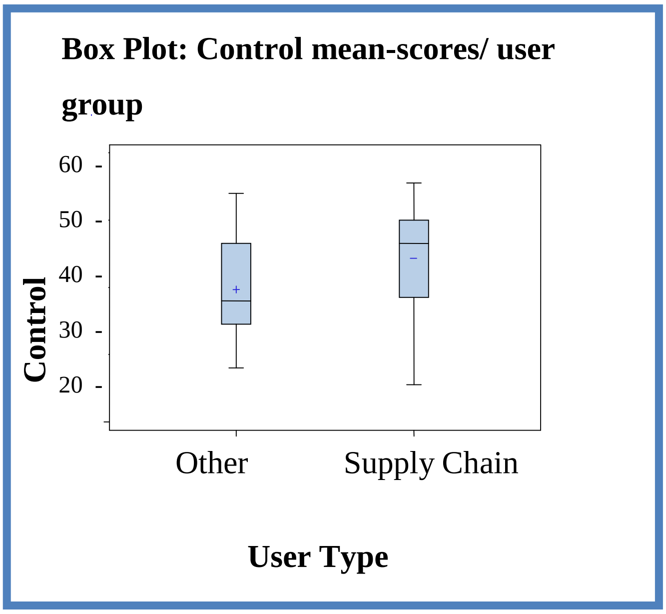


Figure 5.15 Control box plot

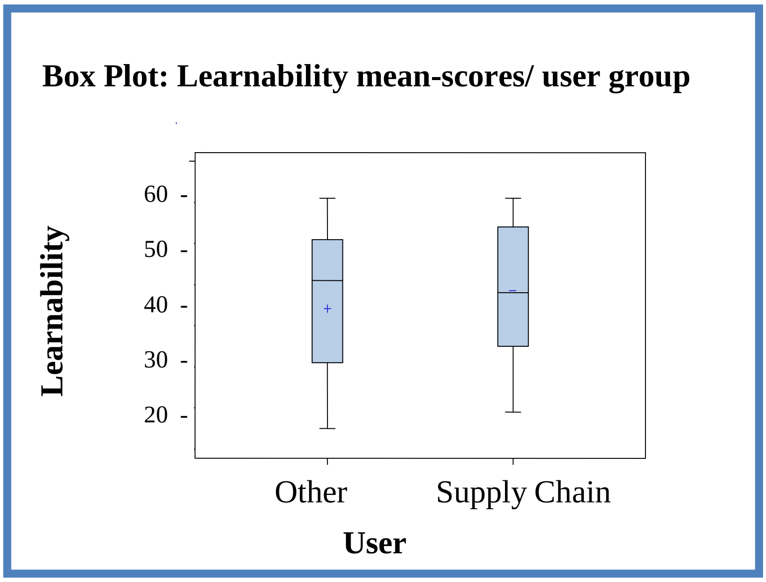


Figure 5.16 Learnability box plot

The crux of the analyses confirms that type of user affect perceptions regarding the usefulness of management information (MI) systems, but that frequency of use and length of use do not affect perceptions on the usefulness of MI systems and tools. The analyses further more supplied an overall mean score value for each BI construct, which provided a general indication of user perceptions for each BI aspect investigated.

5.4.2 Data Results: Instrument 2 (heuristic evaluation)

As discussed in Section 4.6.2 the HE questionnaire was compiled (specifically focused on BI applications), to derive subjective quantitative and qualitative input from evaluators in order to determine if there are corresponding or alternative themes that emerge from those identified from the SUMI questionnaire. See ANNEXURE K for the HE questionnaire. The data that emerged from the questionnaire was broken up into three similar sections, in line with the structure of the questionnaire evaluation. Each of the questions in Section A was mapped to a usability principle in order to satisfy BI's unique requirement. Section 5.4.2.1 to Section 5.4.2.6 presents the results of the HE, firstly by exploring the results obtained from the analysis of the coded HE data, and secondly by incorporating usability issues as identified by the usability experts that completed the evaluation.

5.4.2.1 Heuristic evaluation: Efficiency

Figure 5.17 shows the different *efficiency* scores by the expert evaluators. Their scores combined, resulted in an average of 52.8% rating for the application's efficiency. With an upper fence value of 60%, a lower fence value of 44% and the resultant variance between the two of 15.6%.

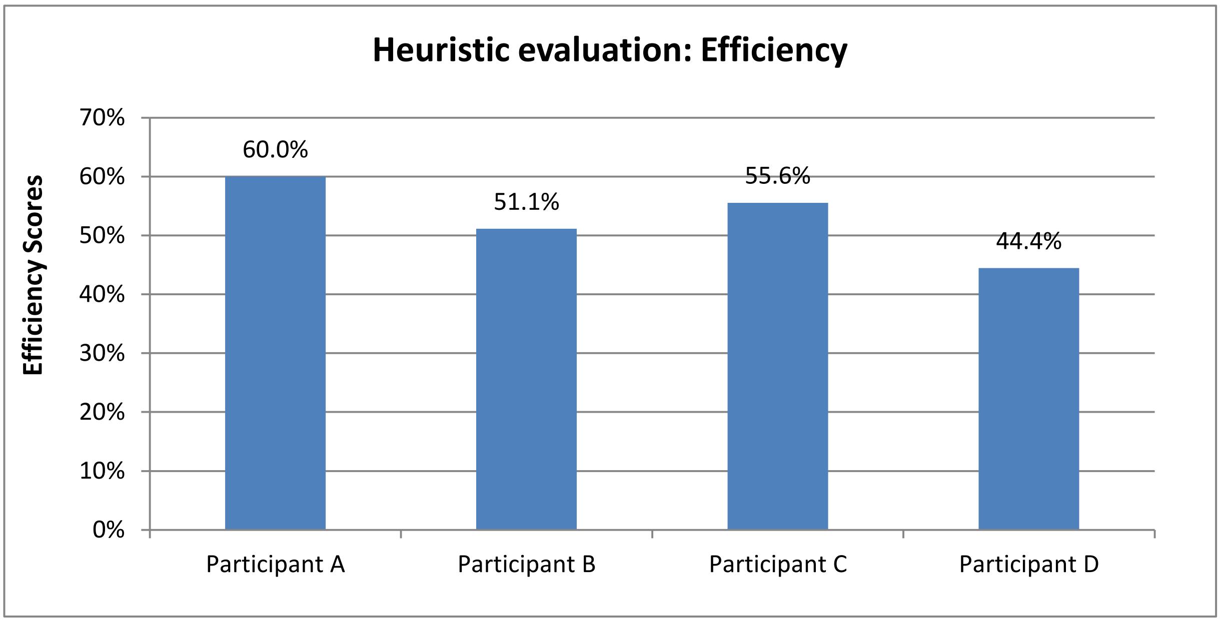


Figure 5.17 Heuristic evaluation: Efficiency

As *efficiency* can be thought of as the resources exhausted in relation to the precision and entirety of goals achieved (ISO 9241), it is one of the main aspects of importance to users and their employees in determining their performance at work.

With efficiency being a priority, the main issues raised by the expert evaluators were:

- The steep learning curve of the application that would affect user performance.
- The layout of elements on the screen forces the user to look for or scroll to certain parts, thereby attributing to time wastage.
- Cubes that do not update regularly will cause users to be inefficient at work.
- Slow response times of the application will not only cause inefficiency, but will also be a source of frustration in the workplace.

5.4.2.2 Heuristic evaluation: Affect

Figure 5.18 shows the average scores each of the expert evaluators awarded to questions regarding *affect*, or satisfaction of the application as it is also known. The average score for this category was 50.0%. The upper fence value was 60%, the lower fence value 40% and a resultant variance of 20%. As affect focuses on the likeability of a application, a poor score in this section could contribute to users not making use of the BI application.

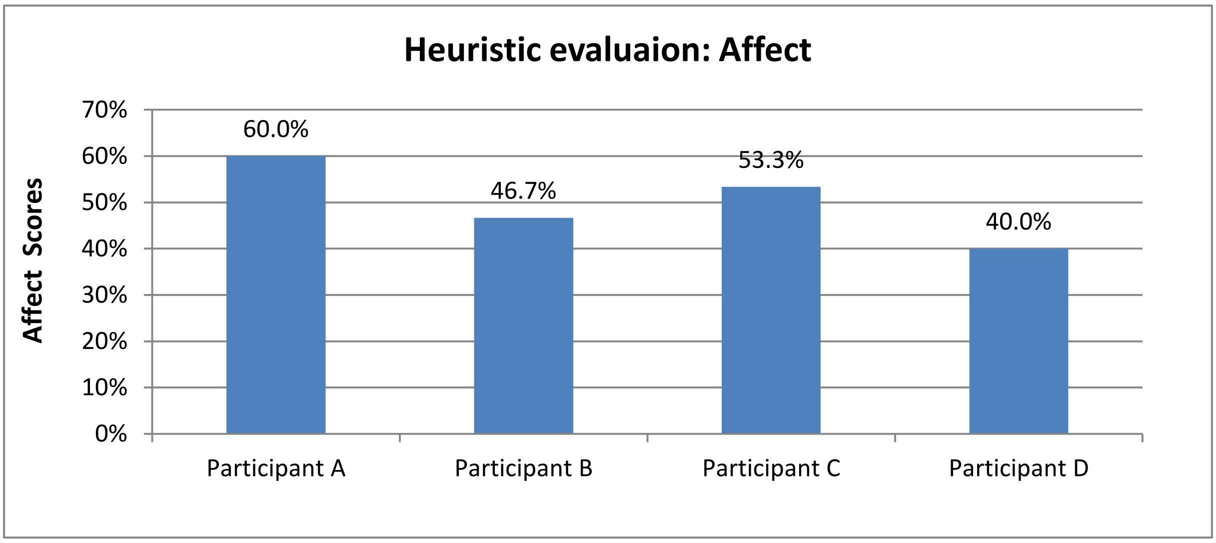


Figure 5.18 Heuristic evaluation: Affect

The usability problems concerning affect identified by the expert evaluators included:

- Dislike of the application due to cluttered interface.
- Dislike of the application due to mono-colour screens.
- Lack of satisfaction due to font size, and strain placed on a person's eyes.
- Lack of satisfaction due to limited flexibility with regards to placement of element on the screen.

5.4.2.3 Heuristic evaluation: Control

Figure 5.19 presents the summary scores for each expert evaluator regarding the BI application's perceived *control*. The average score for the Control of the application is 49.3%, the upper fence value of 60% and two lower fence values of 42.9%.

This results in a variance of 17.1%. Usability issues raised by the expert evaluators included:

- The inability of the application to stop executing a task or request, once the user has established that an inappropriate action has been selected.
- One of the expert evaluators explicitly mentioned that he/she does not *trust* the application, this was due to the application's use of a particular version of *internet explorer*.
- Whilst the user control is prohibited and certainly controlled strictly to the extent that the evaluator is of the opinion that he/she has not any control.

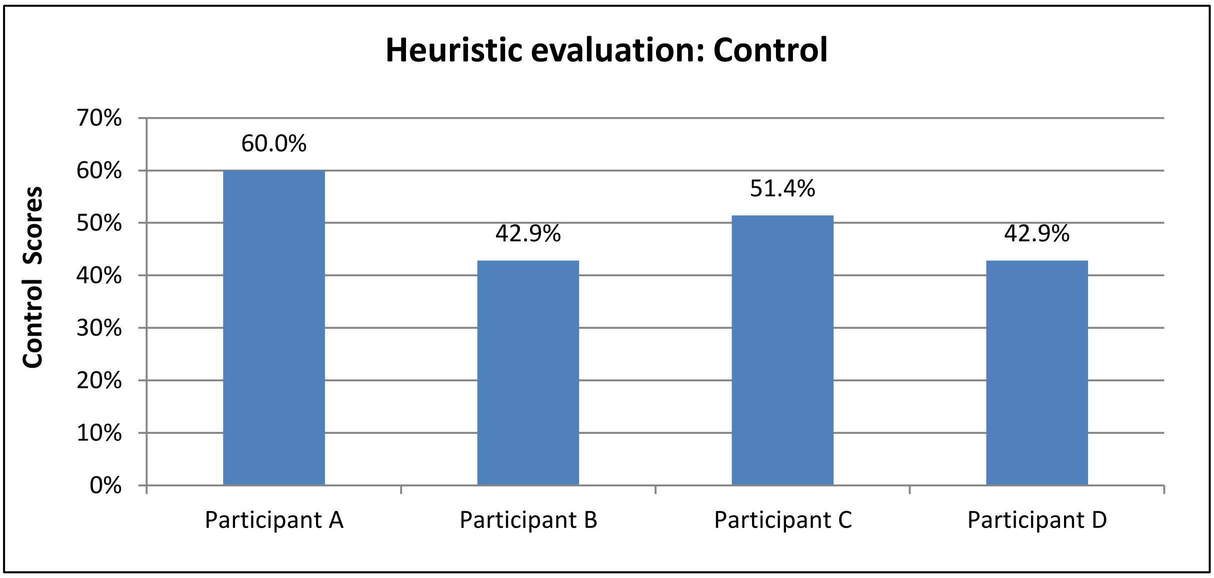


Figure 5.19 Heuristic evaluation: Control

5.4.2.4 Heuristic evaluation: Helpfulness

Figure 5.20 graphically represent the HE scores per expert evaluator for the perceived *helpfulness* of the application. The average score attained for *helpfulness* is 45.0%, the upper fence value achieved was 53.3% and the lower fence value was 33.3%, therefore the variance stands at 20%. The low scores are indicative of perceived lack of helpfulness of the application and could possibly be another contributing factor to employee and user frustration.

The following usability issues concerning helpfulness were raised by the expert evaluators:

- The lack of readily available manuals on the application.
- The accessibility of help features.
- The poor visibility of the help button on the application.
- The poor logic of some of the icons on the task bar.
- The lack of error prevention warnings and catches, the application allows users to create multiple nested queries, even though the application will not be able to handle such a request.

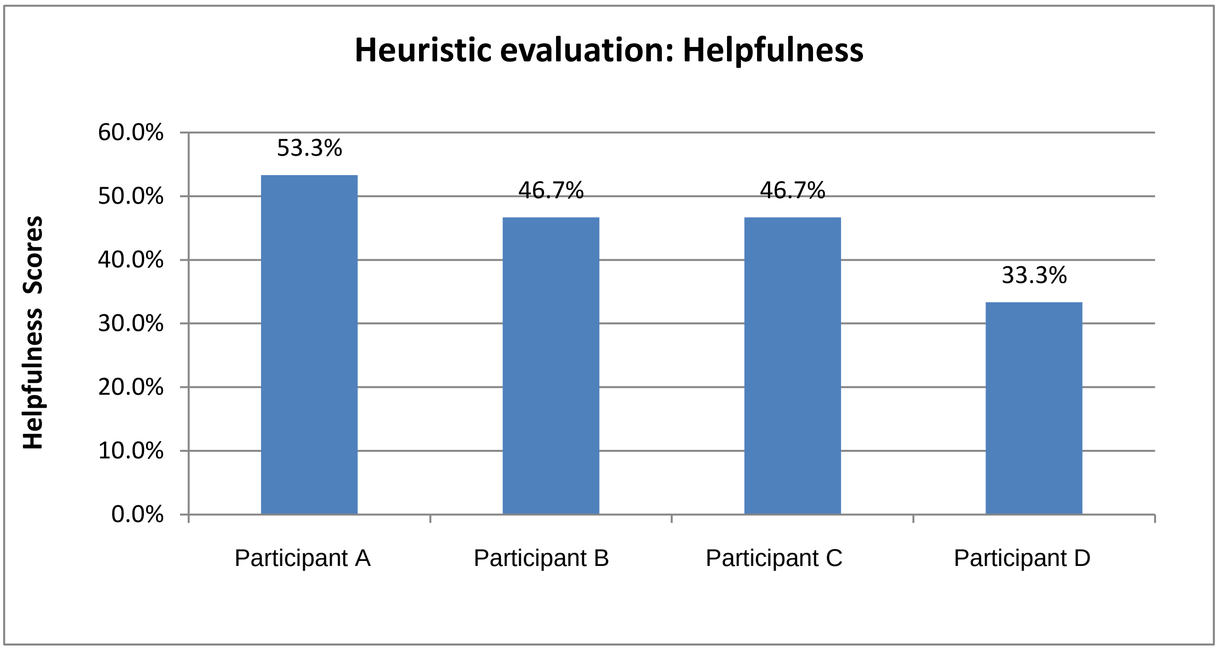


Figure 5.20 Heuristic evaluation: Helpfulness

5.4.2.5 Heuristic evaluation: Learnability

The average of the individual expert evaluator *learnability* scores of the application can be seen in Figure 5.21, the usability experts awarded the application 48.3% for ease of learning, the upper fence score achieved was 53.3%, the lower fence value 40%, resulting in a variance of 13.3%.

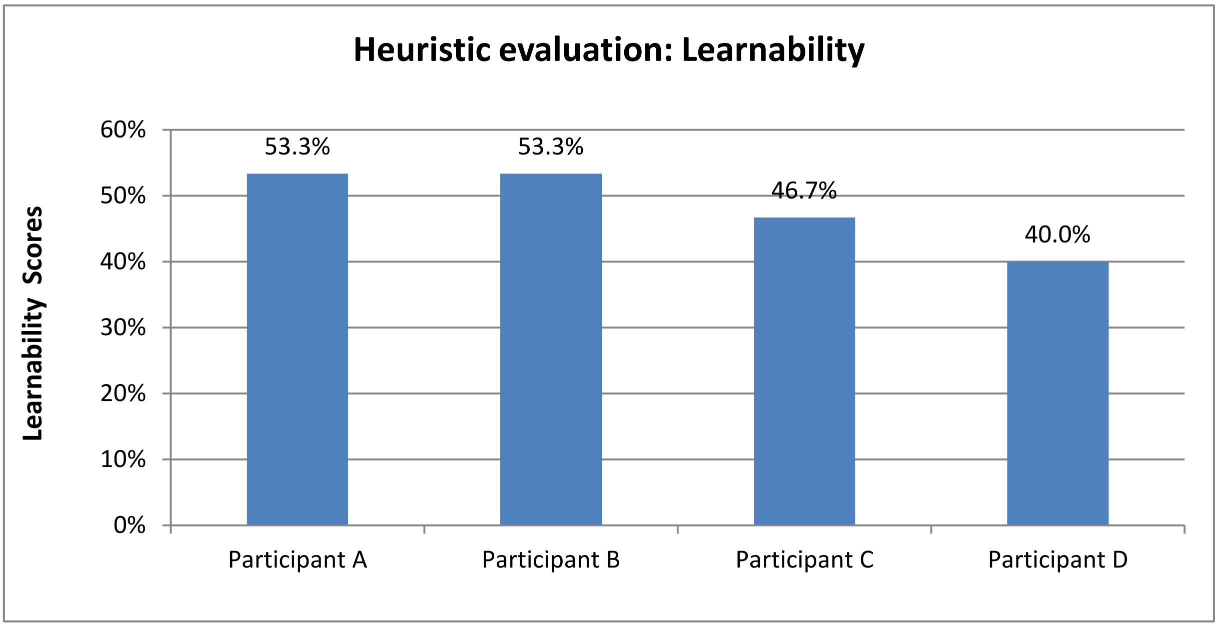


Figure 5.21 Heuristic evaluation: Learnability

During the evaluation the expert evaluators identified *learnability* problems such as:

- The visual memory load is problematic, hence the users are under pressure to remember a number of things.
- The difficulty in learning to use the application, as it is not entirely consistent with the real world experiences, therefore the user does not know what to expect.
- The application has a steep learning curve.
- The application would require technical assistance for users.

5.4.2.6 Heuristic evaluation summary

Figure 5.22 provides a graphical summary of the results of the HE, a total score of 50.7% was achieved for the application usability taking all the category scores into consideration. The large variance (7.8%) between the highest scoring attribute, efficiency (53%) and the lowest scoring attribute, helpfulness (45%) could be indicative of the time spend using the application, but also due to the seriousness of the usability problems identified by the expert evaluators. In the following Section 5.4 the results from the two methods will be compared, triangulated and discussed.

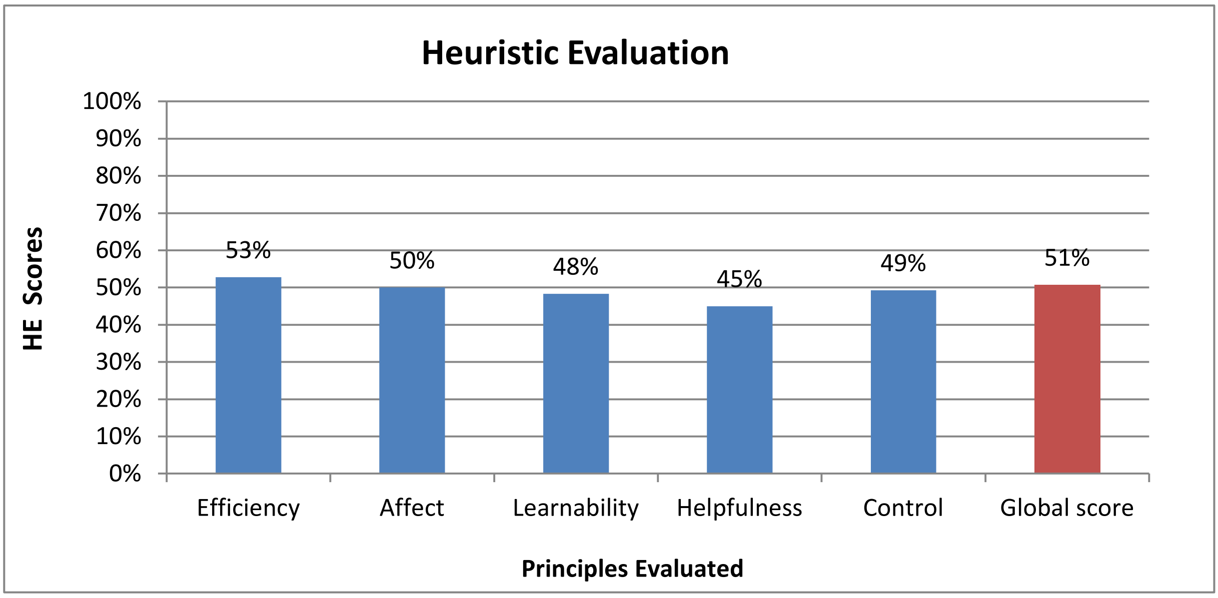


Figure 5.22 Heuristic evaluation summary

5.5 DATA TRIANGULATION RESULTS

The SUMI global score, resulted in a 49.3% rating of the application, compared to the results of the HE, which achieved a total score of 50.7% for the application's usability, resulting in a 1.4% variance on a whole. Figure 5.23 presents a comparison (per usability principle) between the SUMI results and the HE results.

Each of the usability components will subsequently be discussed as presented in Table 5.24 as further investigation of the results obtained from SUMI and the HE.

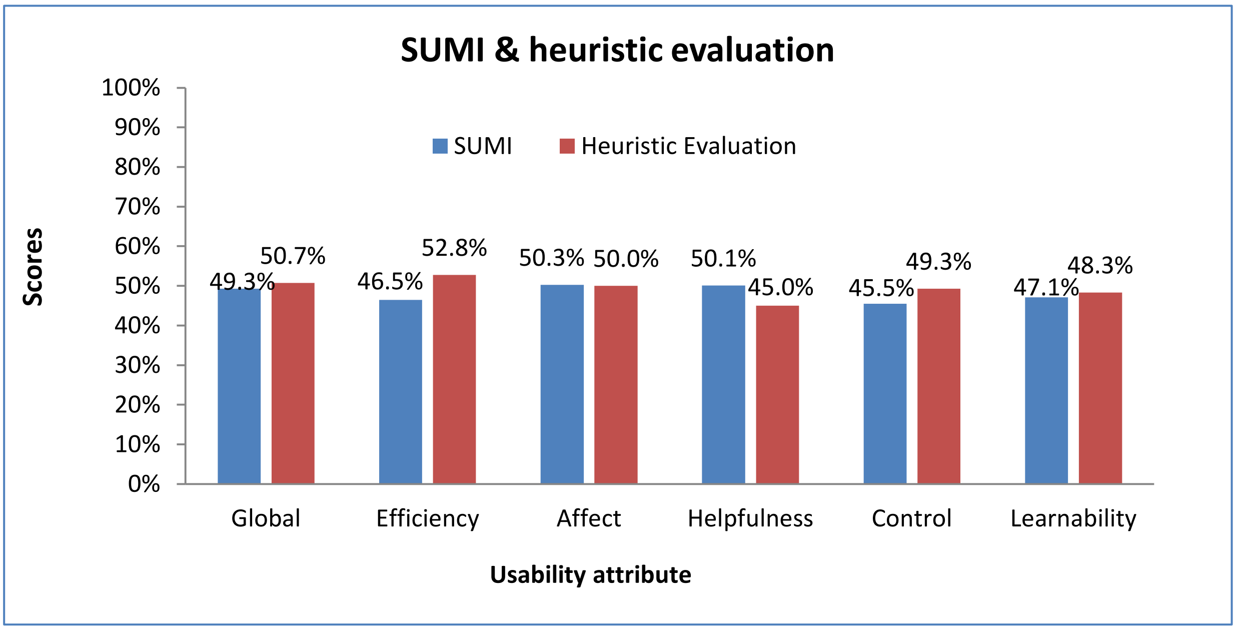


Figure 5.23 SUMI and heuristic evaluation results Comparison

Table 5.24 SUMI and heuristic evaluation comparison of average scores per usability principle

	Global	Efficiency	Affect	Helpfulness	Control	Learnability
SUMI	49.3%	46.5%	50.3%	50.1%	45.5%	47.1%
HE	50.7%	52.8%	50.0%	45.0%	49.3%	48.3%
Var	1.5%	6.3%	-0.3%	-5.1%	3.8%	1.2%

The data triangulation of the survey with the HE based on the five usability principles is addressed in Table 5.25.

5.6 SHORTCOMINGS AND LIMITATIONS

When the SUMI in depth analysis was performed and additional data was requested from the SUMI administrators, Kirakowski regrettably informed the researcher that a portion of the non-essential dataset went missing due to a hardware failure on their side (See e-mail correspondence attached as ANNEXURE O). Fortunately the original set of complete SUMI results data was preserved by the researcher, as received from Kirakowski, but the detail data (not usually provided to researchers for statistical analysis) that was lost affected 7 of the 50 sets of data. Only the SUMI statistical analysis for the predictor variables were impacted by this loss, therefore the data triangulation was conducted on the complete essential data set (50) responses as received from The Human Factors Group originally.

Table 5.25 Triangulation of survey data and heuristic evaluation data per usability principle

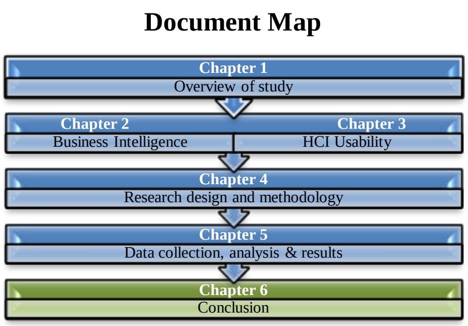
Usability Concept	SUMI	HE	Var	Findings
Efficiency	46.5	52.8	6.3%	Possible explanations for this discrepancy could be: • The limited exposure of the expert usability evaluators to the application. • The *simple task* that the usability experts were requested to perform, thereby not facing the problems normal users would experience with tasks that are more complex. • The expert evaluators' extensive interaction with and understanding of applications.
Affect	50.3%	50.0%	0.3%	This is confirmation of the SUMI score, therefore indicating a similar perception to the majority of the users that make use of the application, and also indicates similar subjective perceptions from the expert evaluators.
Control	45.5	49.3%	3.8%	The difference in scores can be contributed to the advanced knowledge the expert evaluators possess with regards to the inner workings of information applications.
Helpfulness	50.1	45.0%	5.1%	The expert evaluators scored this variable considerably lower than the participants that completed the SUMI questionnaire. This could be contributed to the following factors: • The expert evaluators had higher expectations of *helpfulness* due to their knowledge of usability standards and their knowledge of other applications. • The expert evaluators could not attempt to consult technical expertise in order to assist them, as the users would normally consult the help desk.
Learnability	47.1	48.3%	1.2%	This usability principle scored a low variance of results, indicating a similar perception from both groups. Interestingly enough, the SUMI group, consisting of regular application users, scored slightly lower, even though they have had ample time to master the application, there is still an impression that the application is difficult to learn. This leads the researcher to believe the application has real Learnability problems.

Due to the limited number of application users, the population (61 users) was small, the purposeful sample selected was 58 of the 61 users. However, the response rate of the completed SUMI questionnaire was 86.2%.

5.7 CHAPTER SUMMARY

This chapter mainly focused on the data collection methods employed during this study, the analysis of the data and the results obtained from the analysed data. The three sources of data were discussed and methods concerning data gathering were detailed. The data results were compared and triangulated to find meaningful explanations for result phenomenon. In the following chapter recommendations regarding data results (discussed in this chapter) will be presented and the study will be concluded.

End of Chapter 5



Chapter 6: Conclusion

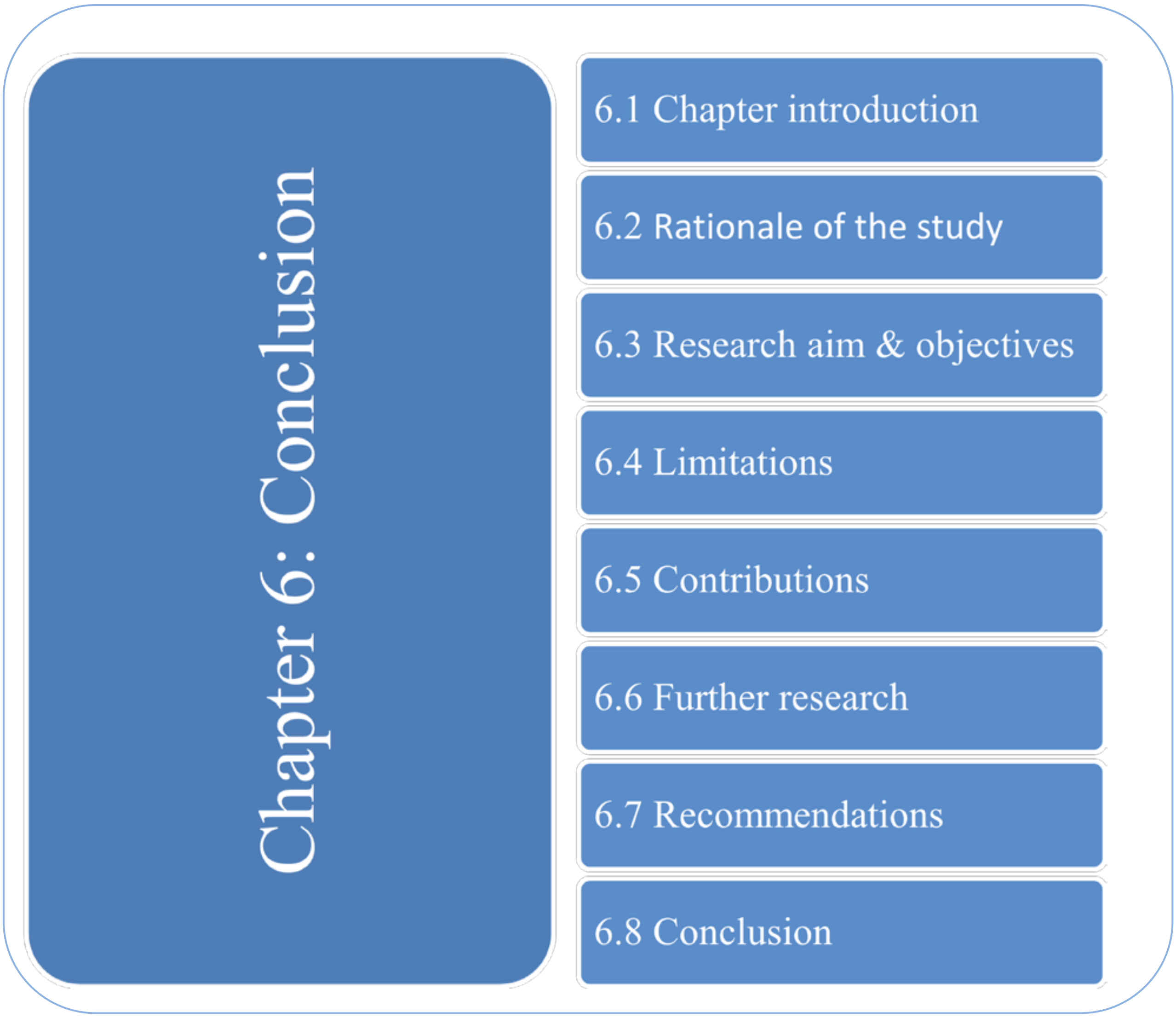


Figure 6.1 Chapter outline

6.1 INTRODUCTION

This chapter concludes this document by discussing the research findings, limitations to the study, contributions made, and recommendations from this study. Once more the rationale of the study is presented briefly to highlight the motivation for the study (refer to Section 6.2). In Section 6.3 the research aim and objectives are reflected upon, in order to determine whether these research objectives have been achieved. Section 6.4 presents the limitations of the study. The contributions made to the existing body of knowledge during this study will be highlighted in Section 6.5, whilst Section 6.6 proposes topics for further research, Section 6.7 presents recommendations made from the study, and lastly Section 6.8 concludes this study. Refer to Figure 6.1 for a schematic overview of the chapter.

6.2 RATIONALE OF THE STUDY

The rationale behind the study is that to realise the purpose of BI (as introduced in Section 1.2 and discussed in Section 2.4) and to unlock BI's full potential within supply chain (as presented in Section 2.9), the application needs to be as usable as possible. In an organization with an earth mineral resource mining focus and the current competitive economic environment, it is all about safety, time, production, and sustainability.

Accurate, accessible information assists the business and its employees to make timely informed decisions, allowing a bird's eye view on the entire organization, and providing detail down to the last piece of inventory on any operation, no matter how big or small. Therefore, for the purpose of investigating application usability, we require to establish *what* HCI usability is. This was addressed by identifying what constitutes *usability* in Chapter 3, by investigating HCI usability definitions (in Section 3.3), comparing widely accepted usability principles (in Section 3.5.1), looking at usability design principles (in Section 3.5.2), defining usability goals (in Section 3.5.3), and presenting usability standards (in Section 3.5.4).

Upon identifying the acknowledged usability attributes of information applications (in Section 3.5), the literature consulted could not provide adequate usability evaluation attributes specifically for BI applications (as was presented in Section 1.3 and Section 1.4) which addressed the lack of published BI usability guidelines. In reaction to this, the development of usability evaluation guidelines specifically for BI applications was justified as (Section 1.4) presented in the research problem statement. Usability evaluation methods were considered (in Section 3.6) to explore the usability evaluation of BI applications. Subsequently the necessity for user requirements regarding BI application usability was identified.

A pragmatic approach was employed to establish the context of the current BI application (Cognos7) usage, since this approach allowed for the collection of user perceptions in the actual working environment. The importance of user requirements was addressed by observing the BI application users in their work setting and noting their unique BI application usability issues. Data from this user issues log was used to identify a suitable sample group by means of purposeful sampling. This sample was invited to participate in a survey that consisted of a standardised usability survey, administered by the Human Factors group and the survey results were also independently verified.

The unique user issues from the observation issue log (identified in Section 5.3.1) were then compared and aligned to a set of recognised usability principles (defined in Section 3.5) in order to identify usability criteria for BI applications. From these proposed BI usability criteria a HE questionnaire was compiled which allowed expert usability evaluators to identify perceived usability problems.

The results from the HE allowed for comparison between the expert evaluators perceptions of the BI application and those perceptions of the regular BI Cognos7 users. This comparison allowed for the identification of usability criteria that could be addressed to improve the application usability and consequently assist users in everyday use of the application and their ease of decision-making.

6.3 RESEARCH AIM AND OBJECTIVES

This section will explain how the research problem (presented in Section 1.4) and the subsequent research questions (identified and discussed in Section 4.8) and their associated research objectives were addressed by the research presented in this document.

The first part of this study investigated which formally accepted usability principles are the core to usability (addressed by RO1, which will be discussed in Section 6.3.1), and secondly, which usability attributes were required by BI application users for the BI application to be regarded as *usable* (addressed by RO2), which will be discussed in Section 6.3.2. This then directed the study to identify the criteria for a usable BI application (RO3 is presented in Section 6.3.3).

The aim of this study was to develop a set of usability guidelines for the HE of BI applications (refer to discussion in Section 1.5 and in Section 6.3.4 RO4 is presented). These guidelines incorporated theory based usability principles, usability standards and user-identified usability issues; and produced a set of guiding principles to assist in the HE of the usability of BI applications.

The research also highlighted the importance of incorporating HCI usability into BI applications and the value obtainable as a result of making use of *usable* BI applications in a mining environment (refer to Section 2.9, Section 2.10 and Section 3.8).

The following research questions were formulated to guide the study towards achieving the overall aim of a set of usability guidelines for the HE of BI applications.

6.3.1 Research Question 1: Which usability principles form the core of usability criteria?

This research objective (refer Section 1.6) is achieved by identifying the core usability principles identified in Chapter 3 (see Section 3.5.1 as well as Table 3.6). Table 6.1 below presents a correlated list of theory based usability standards and usability principles; synthesised to a list of core usability principles as presented in column D (synthesised principles) of Table 6.1.

Table 6.1 Theory based usability principles and standards mapped and synthesised

Usability standard	Usability principles			Synthesised principles
ISO 9241	**Dix et al. (2004)**	**Nielsen (1993)**	**Tognazzini (2003)**	
			Fitt's Law	
Self-descriptiveness		Natural Dialogue / User'slanguage, Instructions visible and retrievable	Use of metaphors Readability	User's language, Visible instructions; Use of metaphors Self-descriptiveness
	Flexibility Responsiveness			Flexibility Responsiveness
Controllability			Track state	Controllability
Suitability for learning	Learnability	Learnability	Learnability	Learnability
Suitability for task		Efficiency	Efficiency	Efficiency
Conformity with user expectation	Predictability, familiarity,		Anticipation	Familiarity, Predictability
	Consistency	Design consistency	Consistency	Consistency
Error tolerance	Recoverability (task conformance)	Error prevention / Error messages	Protect user's work	Error tolerance
		Clearly marked exits	Explorable Interfaces; Visible navigation	Explorable interface; Visible navigation;
Suitable for Individualisation	Customisability, task migratability, (synthesisability)		Autonomy	Customisation; Task migration Synthesisability
		Help / Documentation		Help Documentation
Satisfaction rating		Satisfaction		Satisfaction
		Appropriate system feedback	Latency Reduction	System speed; System status display
		Memorability		Memorability
			Colour Blindness	Colour blindness
			Default	Default values

The synthesised principles consists of the comparison, contrast and integration of usability principles, from Dix et al. (2004), Nielsen (1993), Tognazzini (2003) from which corresponding usability elements of ISO 9241 were identified. The synthesised usability principles comprised of the following set of 26 principles: user's language, visible instructions, use of metaphors, self-descriptiveness, flexibility, responsiveness, controllability, learnability, efficiency, familiarity, predictability, consistency, error-tolerance, explorable interface, visible navigation options, customisation, task migration, synthesisability, help, documentation, satisfaction, application speed, application status display, memorability, colour blindness and default values. This is the response to research question 1, a broad set of usability principles that from the core of usability criteria.

To identify which of these recognised usability principles require attention in the area of interest namely BI applications, an issue log was kept of the issues experienced by the BI application users. This leads to the following research question.

6.3.2 Research Question 2: What are the user requirements regarding the usability of BI applications?

An issue log was compiled from BI application users to determine where there were issues with regards to the application's usability. The user issue log allowed for identification of usability principles perceived not to be sufficiently incorporated in the BI application.

The Research Objective 2 is achieved by means of identifying BI application usability issues as perceived by the BI application users. Table 6.2 provides a consolidated list of user issues (Table 6.2, Column A), as extracted from user observation previously discussed (in Section 5.3.1) see also Annexure F for the user issues log. From this list (Table 6.2, Column A) relevant BI attribute (Table 6.2, Column B) were identified and matched to accepted usability principles (from Section 3.5.1) (Table 6.2, Column C).

The synthesised usability principles from Table 6.1 were compared, contrasted and mapped to the BI user issues obtained in response to RQ1 and this led to RQ3.

Table 6.2 Synthesised BI usability issues

A	B	C	D
User Issue	**BI Attribute**	**Usability Principles**	**Synthesised usability issues**
Highest level information must be visible	Hierarchical display of data	*Visibility*	*Map of data landscape*
Page needs to be displayed clearly and uncluttered	Page display	*Visibility*	*Clear page display*
Navigational buttons must be visible	Navigational display	*Visible navigation*	*Visible navigation*
Task icons must be visible and logical	Task pane display	*Visibility*	*Visible and logical icons*
Cube name must be identifiable	Page layout	*Visibility*	*Visible cube name*
Cube dimensions should be displayed clearly	Page layout	*Legibility*	*Visible cube dimensions*
Easy exploration of cube dimensions	Cube navigation	*Navigation*	*Ease of cube navigation*
Easy viewing of cube measures	Cube navigation	*Visibility*	*Visibility of cube measures*
Data should be accessible and up to date	Data availability	*Efficiency*	*Data availability*
Possibility to export data from system	Data export	*Flexibility*	*Flexibility to export data*
Types of export formats need to be sufficient	Data export	*Flexibility*	*Flexibility to export data to multiple formats*
Data must be legible	Information presentation	*Visibility*	*Legible information*
System should show requests progress	System status display	*Robustness (Observability)*	*Observability - appropriate system feedback*
Data dimensions must be visible	Information presentation	*Visibility*	*Visible data dimensions*
Data measures must be formatted clearly	Information presentation		*Correct data format*
Graphical displays of data required (graphs)	Information presentation	*Visibility*	*Graphical presentation of information*
System must assist with data analysis	Reveal trends and patterns	*Help*	*Auto trend analysis*

Table 6.2 Synthesised BI usability issues (continued)

A	B	C	D
The screen must not present too much information	Page layout	*Visibility*	*Display should prevent information overload*
Make use of terminology users are familiar with	User's language	*User's language*	*User's language*
Task buttons required to carry out work effectively	Functionality to support user tasks	*Efficiency*	*Adequate functionality to support user tasks.*
Request for increased system speed	System response rate	*Latency reduction*	*Adequate system response rate*
Users need to be able to save views on cubes	'Save view' functionality - Customisation	*Customisation*	*Custimisation of views on cubes*
Request to share views on cubes with other users	Knowledge sharing functionality required		*Collaboration with other users*
Training required	Learnability reduces training required	*Learnability*	*Learnability; Training*
Require optional hover –over explanation of icons	System explorable	*Self-descriptiveness*	*Self-descriptiveness and optional explanations*
User cannot remember how to complete task	Support to assist user memory	*Memorabiltiy*	*Memorability*
Sign on required	System security/Control	*Control*	*Control*
User locked out	System security/Control	*Control*	*Control*

6.3.3 Research Question 3: What are the criteria for usable BI applications?

After the collation of recognised usability principles from literature (outcome of RO1); and usability issues experienced by the BI application users (outcome of RO2), a set of usability criteria were identified specifically for BI applications.

This research objective (RO3, refer Section 1.6) is achieved based on the lists of synthesised usability principles identified in the research Objective 1 (Table 6.1) and Objective 2 (Table 6.2) above, Objective 3 is achieved by identifying the criteria for usable BI applications as provided in Table 6.3.

HE criteria for BI applications were compiled from a literature study (see Chapter 3, Table 3.6); these usability principles identified from literature were adapted based on the BI user requirements obtained from user observations. See Table 6.3 for the mapped BI usability requirement attributes.

Study B (refer to Section 4.6.2) made use of the BI usability criteria generated to compile a HE instrument specifically for BI applications, also see Annexure K. The results obtained from this HE were presented in Chapter 5, Section 5.4.2. From this HE several usability problems were identified by the expert usability evaluators as explained in Section 5.4.2.

The BI application was also scored in terms of similar usability attributes as were used in Instrument 1. See Table 6.4 for mapped usability attributes.

The results obtained from the data analysis of the survey (SUMI) further supports findings from the HE in terms of the importance and significance of the criteria identified through the synthesis of literature based usability principles integrated with the criteria identified by the user requirements for:

- Perceived application *learnability*.
- Perceived system *control*.
- Perceived system *affect.*
- Perceived *global usability*.

After the usability principles (Table 6.3, Column A) were aligned to the BI user issues (Table 6.3, Column B), the BI usability criteria required for an HE were identified (see Table 6.4, Column C) and aligned to the evaluation principles as incorporated in the standardised usability instrument (SUMI) (see Table 6.4, Column D).

Table 6.3 BI user issues mapped to usability principles

Column A	Column B
Synthesised Usability Principles	BI User Criteria (Observation)
Fitt's Law	
User's language, Visible instructions; Use of metaphors, Self-descriptiveness	User's language, Legibility; Task icons visible and logic
Flexibility Responsiveness	Data availability
Controllability	System Control;
Learnability	Learnability
Efficiency	Efficiency
Familiarity, Predictability	
Consistency	
Error tolerance	Error prevention
Explorable interface; Visible navigation;	Explorable interface; Visible page navigation; Visible system navigation
Customisation; Task migratability Synthesisability	Customisation; Formatted data export
Help Documentation	System Training; Manuals
Satisfaction	
System speed; System status display	System speed; Status display
Memorability	Memorability
Colour blindness	Colour-blindness
Default values	
	Decision support
	Knowledge sharing

Table 6.4 Heuristic evaluation criteria identified against user requirements and usability principles

A Synthesised Usability principles Literature	B BI User Requirements Observation	C Heuristic Evaluation Criteria	D Usability Evaluation SUMI
Fitt's Law			
User's language, Visible instructions; Use of metaphors Self-descriptiveness	User's language, Legibility; Task icons visible and logic	Instructions visible and self-explanatory;	Helpfulness
Flexibility Responsiveness		Flexibility	
	Data availability		
Controllability	System Control;	Control	Control
Learnability	Learnability	Learnability	Learnability
Efficiency	Efficiency	Efficiency	Efficiency
Familiarity, Predictability		Expected behaviour	
Consistency		Consistent behaviour	
Error tolerance		Error prevention; Error tolerance	
Explorable interface; Visible navigation;	Explorable interface; Visible page navigation; Visible system navigation	Visible system/page navigation	
Customisation; Task migratability Synthesisability	Customisation; Formatted data export	Customisation	Control
Help Documentation	System Training; Manuals	Helpfulness	Helpfulness
Satisfaction		General Satisfaction	Affect
System speed; System status display	System speed; Status display	Visibility of system status	
Memorability	Memorability	Memorability	
Colour blindness	Colour Blindness		
Default values			
	Decision support	Support decision-making	
	Knowledge sharing	Support knowledge sharing	

6.3.4 Research Question 4: What are the most suitable HE guidelines (based on the usability criteria) by which to evaluate the usability of BI applications in a (mining) organization?

RO3 (see Tables 6.3 and Table 6.4), identified the HE criteria for BI applications based on the outcomes of RO1 (see Table 6.1) and RO2 (see Table 6.2). Therefore RO4 is to develop usability guidelines (based on the outcomes of RO1, RO2 and RO3) to evaluate the usability of BI applications in a (mining) organization.

The HE criteria for BI applications criteria identified in RO3 allowed for the extrapolation of guidelines to be applied for HEs for BI applications as outcome to RO4. In Chapter 4, Section 4.6.1, the considerations on a suitable standardised usability instrument motivated the use of the SUMI questionnaire. After comparing the supporting Table 4.10 to the extended Table 6.5 the BI usability guidelines were established.

The triangulation (refer to Section 4.9) of the HE (refer to Section 5.4.2) and the survey results (refer to Section 5.4.1) enabled an iterative process of the creation and the update of the criteria for guidelines for the evaluation of the usability BI applications (see Table 6.4, column C). This systematic process subsequently produced the final set of HE guidelines proposed for BI applications. These HE guidelines that were extracted (in response to the main research question) form the final set of criteria for HE presented in Table 6.5. The concepts used in developing this set of heuristic guidelines were delivered and synthesised both empirically and literally by making use of scientific research processes.

Table 6.5 presents in Column A the functional grouping of the HE guidelines, Column B presents the ***heuristic guidelines** that* were developed for the usability evaluation of BI applications, and Column C presents recommendations for each of the proposed HE guidelines with regards to BI usability as applied to this context of users within a mining organization. Table 6.5 is presented as the answer to the research goal stated in Section 1.6

Table 6.5 Proposed heuristic evaluation guidelines for BI

A	B	C
Functional Grouping	**HE Guideline for BI applications**	**Reference and application in practice**
A) Visibility	**1) Instructions should be visible and self-explanatory.**	This guideline is supported by Nielsen (1993), Tognazzini (2003) and identified as a BI user requirement. The recommendation entails the presentation of instructions in clear, unambiguous and logical manner. Users should be able to follow instructions without having to wonder what the instruction means or how it should be executed. This can be achieved by ensuring the screen is uncluttered, by providing visual cues (or reminders) and grouping buttons or links according to functions, buttons with more than one function should also be avoided as users get confused.
	2) Navigation options (links, shortcuts, home, back, forward, etc.) should be visible.	This guideline is supported by Nielsen (1993), Tognazzini (2003) and the user requirements identified in this study. Recommendations entail the application being inviting to users and encourage the users to explore the interface, this will foster learning at the same time and improve the overall navigation of the application. Buttons should be visible, they should be reactive and give feedback to the user to communicate that requests are being processed or indicate to the user that the page has changed, the information has updated or some movement has taken place. Global position systems should be incorporated into the screens to assist users in positioning themselves in the application, thereby enabling the user to navigate backward or forward (or up a level or down a level) to find the required information.
	3) The application should communicate the system status at all times (whether resting, processing, etc.).	This guideline is supported by Nielsen (1993), Tognazzini (2003) and identified as a user requirement. Recommendations entail the active display and communication of system status with users at all times, especially when the user has submitted a system request, and is therefore expecting a result to an intended action. This will assist in establishing a sense of control, and also promote anticipated application behaviour. If a application user knows how long an action will take, time wastage can be minimised, thereby improving efficiency, tasks can be prioritised and system response rates can be monitored.

B) Flexibility	**4) The application should be flexible.**	This guideline is supported by Dix, et al., (2004), and includes *responsiveness* as a sub-category of flexibility. From the user requirements it became apparent that users require the application to be flexible. Functions related to flexibility includes: users being able to adjust and change the application to suit their needs at that point in time. Recommendation for flexibility of the application include that users have options when viewing information presented, the way information is structured or presented on screen, the level of detail required.
	5) The application should be customisable for individual or collaborative usage.	This guideline is supported by Dix, et al., (2004), Tognazzini (2003) and identified by the BI application users as a requirement. Recommendation entails the option for users of groups of users to customise the application in order to meet the needs or requirements of different employee functions or user groups. This will assist users to focus on their individual priorities and lessen the amount of frustration experienced. This guideline also influences the perceived satisfaction with regards to affect or likeability of the application.
	6) The user should feel in control of the application.	This guideline is supported by the user requirements identified and the standardised SUMI survey. Recommendation entails customisation of user control according to the user's individual needs. User experience, knowledge and skill should be taken into consideration when control is selected. Novice users should have less control to benefit from the application than experienced users who require more control to achieve the results they are looking for.
C) Cognition	**7) The application should limit the amount of load on memory at all times.**	This guideline is supported by Nielsen (1993) and identified by users as a system requirement. Recommendations entail active user assistance by the application, the application should not only aid the user to remember certain things, but also aid the user that he or she does not have to remember certain elements that will draw their attention from the task at hand or place strain on them unnecessarily. The application should *recall* things as it is required, making the user *free* of the burden of having to remember things that will only be required at the later stage in a request of process.

C) Cognition	**8) The application should foster and promote learnability**	This guideline is supported by Dix, et al., (2004), Nielsen (1993), Tognazzini (2003), SUMI and the user requirements list. This is the only usability attribute that is recommended by all the sources consulted on Table 6.4. Recommendation for application learnabity entails promoting learning activities as the user makes use of the application, the learning process should be logical in order for the user to understand the reasoning behind actions or events. Learnability should be natural and should be incremental as the user masters the application according to the individuals pace. A steep learning curve should be avoided, to prevent the users from becoming discouraged after initial contact with the application. The users of a learnable application would be using the application optimally faster than a application that is difficult to learn and master, therefore influencing user productivity.
D) Application behaviour	**9) The application should behave in the expected manner.**	Dix, et al., (2004), Tognazzini (2003) and Nielsen (1993) support this guideline. Recommendations for application consistency entail the user knowing what to expect from the application. The same action should result in the same outcome, in order for users to work with an application, the application reaction should be consistent, this provides a sense of security and makes the user feel in control of the application. Consistency leads the user to expect certain behaviour, which is the next guideline to be recommended for inclusion in the set of guidelines.
	10) The application behaviour should be consistent.	Dix et al. (2004) presents predictability and familiarity, these core usability principles were mapped to Tognazzini (2003)'s principle of anticipation, this results in a proposed guideline that the application should behave in the expected manner. This recommendation entails the use of prior knowledge in order to master or learn the application, thereby enabling the user to make optimal use of the system. Anticipation will cause the application to be perceived as *easy* to use, due to the fact that the application reactions are anticipated in advance and subsequent actions are ready to be executed by the user.

D) Application behaviour(continued)	**11) The application should enhance user efficiency.**	This guideline is supported by Nielsen (1993), Tognazzini (2003), the user requirements, and the SUMI questionnaire. Thereby equipping the user to do more work and become less resource intensive. Recommendations for application efficiency entail: accessing the correct data, users do not have time to waste looking for data. Data should be available and current, the system's response rate should be sufficient in that users do not have to sit for minutes and wait for the application to execute requests. When users forget their login details they should be able to reset their login (perhaps with the aid of a cell phone number of email as reference) or even request a temporary low level access login in order to access the required data immediately.
E) Error control and help	**12) The application should make provision for error prevention and error tolerance.**	This guideline is supported by Dix, et al., (2004) calling it recoverability, by Nielsen (1993) who refers to error prevention and error messages, Tognazzini (2003) proposes that the application protects the user's work. To err is human and the application should be equipped to handle and prevent users from making unintentional errors. Recommendations entail the use of confirmation messages displayed or played audibly to engage the user's attention to regarding the chosen action, the display of application terminology definitions, for example what does it mean to *delete* a dimension from a cube, will it be retrievable, or will it be permanently erased? Another recommendation is the option to display different alternatives when a high-risk action is performed, in order to assist the user to realise the impact of the action taken.
	13) The application should have help at hand should it be required	This guideline is supported by Nielsen (1993), the usability principles evaluated by the SUMI questionnaire and was identified by the BI users as a requirement. Recommendations include the availability of help in the form of online manuals, terminology definitions, explanations, step-by-step instruction, context clarification, objective clarification and problem clarification. The user should also be able to select the type of assistance required, for example step by step audio explanation with pause and play functionality to enable the user to perform functions listening to the instructions.

F) Satisfaction	**14) The application should be visibly pleasing as well as being enjoyable to use.**	Nielsen (1993) and SUMI supports this guideline. The user should be satisfied with the application, SUMI refers to satisfaction as the application's affect. Recommendations entail the inclusion of elements that are visibly pleasing (colour, font, schematic, theme and format selection) as well as a application that is enjoyable to use (adjusting to user logic, task sequence, user requirements or special needs), this should encourage users to make use of a application en prevent users from not making use of a application just because they do not like the way the application looks or reacts. This will enhance the users working experience and overall job satisfaction.
G) BI elements	**15) The application should assist the user in decision-making.**	This guideline is identified by the application users as a requirement. Recommendations entail the active assistance of users, with regards to the decision-making process. Screen data analysis messages should be displayed in order for users to direct attention and also for users to learn actively from interaction with the application, for example possible results obtainable from intended actions (scenarios and forecasting).
	16) The application should encourage and promote knowledge sharing.	This guideline is identified as a requirement by the application users. Recommendations entail the option of users to share insight gained from a particular screen (or view on a cube or report) with subordinates or managers, this would foster collaboration, enable knowledge sharing and improve communication to achieve common goals.

Now that the proposed HE guidelines for BI applications have been presented the limitations as encountered during this study will be described, see Section 6.4.

6.4 LIMITATIONS OF THE STUDY

The following limitations were encountered during this study:

- The choice and suitability of a standardised, independently verified survey (SUMI) is discussed in Section 4.6, however, this survey is a generic measurement tool (Kirakowski 2010) and is not specifically intended for BI application usability evaluations.

- One (coal mining) organization cannot be generalised. Development of more general BI usability guidelines is proposed.

- Unfortunately the The Human Factors Group lost a portion of the non-essential data (not usually provided to researchers) due to hardware failure on their side (refer to correspondence in ANNEXURE O). Fortunately, the original essential set of complete SUMI data was preserved by the researcher, as received from Kirakowski. Therefore the data triangulation was based on the complete essential data set (50) responses as received from originally and the HE data.

- From the statistical analysis it was determined that the good response rate (86.2%) of the small population ensured validity.

- The BI user issues log identified BI application usability issues experienced. Subsequently it could be reasoned that only attributes that required attention or improvement would be identified by the application users, thereby possibly excluding application attributes that are important, but not experienced as problematic in the application that was evaluated. In other words, user issues highlighted requirements for the improvement of the application's usability, but would not necessarily identify essential BI usability attributes of the application that is working well, since the users are not experiencing problems with these features. This limitation was identified and offset by making use of SUMI as standardised survey, which address total system usability, not just the user requirements indicated.

6.5 CONTRIBUTIONS

This research, which was conducted within the context of Cognos7 BI users in a coal mining organization, contributes to the existing body of knowledge in the following manner:

6.5.1 Theoretical contributions

a) A compiled list of BI usability user issues.

Usability requirements unique to BI, were collated as extracted from BI application users by means of observations of these users, see Table 6.2.

b) BI HE criteria.

Academically accepted core usability principles were explored and aligned to usability requirements from BI users refer to Table 6.4.

6.5.2 Method contribution - HE questionnaire

The review of literature (refer to Chapters 2 and 3) identified a gap in the literature, as BI application's usability has not been well researched. No explorative instrument could be found to assist expert evaluators to identify usability problems for BI applications. A HE questionnaire was developed to address this need and employed in this study as instrument 2. This instrument was developed in order to evaluate the usability of the BI application (Cognos7 Upfront). This HE questionnaire will additionally assists expert evaluators to identify usability problems as perceived by usability experts in the BI application in question. The HE questionnaire was compiled by incorporating the identified BI HE criteria (refer to Annexure K).

6.5.3 BI HE guidelines

The BI HE criteria were updated on completion of the comparison between the HE and the SUMI survey results. This resulted in the development of a set of usability guidelines for the HE of BI applications as in the context of a coal-mining organization. These HE guidelines are shaped by BI user issues and the pragmatic environment in which this study was conducted. This allowed for the compilation a specialised set of BI guidelines to be applied in the business practise.

Table 6.6 summarises the heuristic guidelines that have been developed, grouped according to function.

Table 6.6 BI HE guidelines summarised

Functional Grouping	HE Guideline
Visibility	1. Instructions should be visible and self-explanatory
	2. Navigation options (links, shortcuts, home, back, forward, etc.) should be visibly displayed.
	3. The application should communicate the system status at all times (whether resting, processing, etc.).
Flexibility	4. The application should be flexible.
	5. The application should be customisable for individual or collaborative usage.
	6. The user should feel in control of the application.
Cognition	7. The application should limit the amount of load on memory at all times.
	8. The application should foster and promote learnability
Application Behaviour	9. The application should behave in the expected manner.
	10. The application behaviour should be consistent.
	1. The application should enhance user efficiency.
Error Control & Help	2. The application should make provision for error prevention and error tolerance.
	3. The application should help at hand should it be required.
Affect	4. The application should be visibility pleasing a well enjoyable to use.
BI Elements	5. The application should assist the user in decision-making.
	6. The application should encourage and promote knowledge sharing.

The contributions made during this study were presented in this Section 6.5, in Section 6.6 further research is proposed in light of what have been learnt from this study.

6.6 FURTHER RESEARCH

Recommendations are now made for further BI usability evaluation research. The usability of different applications needs to be researched further, in order to contextualise the application requirements. Usability requirements are dynamic and change according to technology and user environment.

It is the opinion of the researcher that the following topics would merit (further) exploration:

- Impact of application usability on user performance in terms of KPI achievement.
- Influence of user attitude in the utilisation of a BI application.
- Availability and utilisation of policies relating to usable BI system design.
- Knowledge and skills of end users with regards to BI usage.

6.7 RECOMMENDATIONS

Recommendations are made regarding the results obtained from the research and possible application of the generated guidelines in the usability evaluation of BI applications practice, and BI usability per se.

6.7.1 Recommendations for BI applications

From the usability principles measured by SUMI, the *control* attribute was perceived as the usability principle that required the *most* attention. This means that the application users experienced significant control issues when interacting with the application.

This result could assist system designers to emphasise the incorporation of *user control*, which would positively affect the following application attributes:

- Effectiveness
- Efficiency
- Task migratability
- Reliability
- User satisfaction
- Safety

The statistical analysis results of the survey indicated that the *type of user* proved to have a statistically significant effect on user perceptions regarding the issues of BI global usability, effectiveness, affect, control and learnability. Statistical significance on at least the 10% level could be established in these cases. This is an important result for this study as this proves that the *type of user* requirements are unique for different areas measured and would subsequently indicate that there are indeed a requirement for different sets of usability principles for different groups of users; alternatively a less expensive or resource intensive intervention in the form of training could be considered.

The result demonstrates that not one set of widely recognised usability principles are all encompassing, therefore care must be taken when selecting a particular set as critical usability attributes may be left out, which will impact the application usability. The argument that some sets include elements mentioned in other sets, while not explicitly naming them as such could cause confusion and uncertainty in the actual process of application usability evaluation. Therefore a requirement for terminology standardisation comes to light.

Older sets of usability principles are becoming out-dated, in that they are still applicable but potentially missing out on technological advancements, for example in terms of user interconnectivity and knowledge sharing requirements as a catalyst for usability enhancement. In other words, *usability principles* require to be more flexible, adaptable and dynamic to be able to change as the environment and context for application changes.

6.7.2 Recommendations for BI usability evaluation practice

In order to assist and enable supply chain users in the context of a mining organization the BI application which they consult should be as usable as possible. This BI application of an organization can be evaluated by usability experts according to the guidelines developed in order to identify application usability problems.

The guidelines may also be used in BI application design and development to ensure usability attributes are included into the system from the start. The HE questionnaire may be used in incremental development stages of the system to evaluate the system as development progresses to be able to monitor and track the progress of the application's usability.

The significance of these guidelines is that they may be used to shed light on inter-related usability principles, and promote the successful application thereof in practice.

Next, in Section 6.8 this chapter and the study in its entirety will be concluded.

6.8 CONCLUSION

This chapter has described the overall aim of the study in terms of the four objectives evaluated. The results, limitations and recommendations were presented at the hand of the HE guidelines with regard to BI usability evaluation practice and further BI usability evaluation research.

This research was conducted within the context of BI users making use of Cognos7 (Upfront). The study entailed the investigation and mapping of usability principles in a systematic manner based on theoretically accepted usability principles, usability standards and usability requirements from BI application users.

The unique and original set of heuristic guidelines was developed together with a HE questionnaire specifically focussed on BI attributes (which was developed during this study). This set of guidelines will assist expert evaluators to identify usability errors and equip them to address these usability issues, thereby ultimately ensuring a usable application for the end users that extract value from the system.

The study comprised of two application evaluation processes, which were conducted concurrently. Process A, employed a standardised survey (SUMI) to assess the usability of the BI software application Cognos7 Upfront. During process B, a HE was conducted to identify usability problems of the BI applications by making use of expert evaluators. The SUMI results indicated that the usability of the BI application (Cognos7 Upfront) achieved an average score compared to other BI applications with regard to general usability with a mean result of 49.28%, and indicated usability challenges especially with regard to control and efficiency. The HE of the same BI application scored the application's usability slightly higher at 51% making use of the HE questionnaire that was developed during this study.

The research also intends to highlight the importance of incorporating HCI usability into BI applications and the subsequent obtainable value as a result of making use of *usable* BI applications in the context of an organization in a mining environment.

On reflection of the research from initiation to completion, key discoveries included but were not limited to:

- The exploration of usability elements (standards, principles, goals and guidelines) their inter-connectedness and the far reaching effect of each of them with regards to BI applications.
- Opportunity for enrichment in the area of BI Usability.
- The benefit and value added to the bottom line for businesses by incorporating usability into BI applications.
- The realisation that the usability principles should evolve and develop with advances made in IT.

By making use of a pragmatic approach in the study, the results can now be applied in organizational work context to evaluate BI applications and to identify room for usability improvement regarding BI applications.

End of Chapter 6

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List of Annexure & Appendices

ANNEXURE A: RESEARCH COVERING LETTER

Research Cover Letter

To all interested parties, I, Chrisna Jooste, am currently enrolled as M Sc student at the University of South Africa. I am presently busy with my Masters degree in Information Systems.

You are invited to take part in a research project focusing on the ***usability evaluation of Business Intelligence applications in Thermal Coal.***

You will benefit by being given the opportunity to express your opinions and to receive feedback regarding the findings of the study.

I would require about 30 minutes of your time, during which you will be required to complete a questionnaire. Your name will not be disclosed. Your confidentiality and privacy will be respected and maintained at all times.

Should you not wish to partake in the study, it is your right to state so.

Should you wish to partake in this study, please be so kind to complete the attached consent form.

Your cooperation in this regard would be appreciated.

Yours sincerely,
Chrisna Jooste
(083 4470960)

ANNEXURE B: PARTICIPANT LETTER OF CONSENT

Dear Business Intelligence User,

We request a few moments of your time to assist us.

Background: This survey forms part of a research study about the usability of Business Intelligence toolsets.

Aim: The aim of this study is to determine how the usability of BI applications for decision-making in a mining organization should be evaluated.

Purpose of Use: This questionnaire will be used for research purposes only. The results of the questionnaire will be used to determine which usability features you currently experience when using the Cognos BI toolset, and which usability features would you like to experience.

Results: The data will be analysed after all completed questionnaires have been received. The research results will be made public after consolidation of the data, and you would not be personally identifiable. All individual responses obtained from this questionnaire will remain private and confidential.

Time Required: The questionnaire should take about 30 minutes to complete.

Questions

When it comes to answering the questions, there are no right or wrong answers. We request that you are as open and honest as possible in answering these questions. If you have any questions about this questionnaire, please contact Chrisna Jooste at 013 691 5290.

Your contribution is valued and appreciated.

Participant name (optional)

ANNEXURE C: Ethical Clearance

UNISA college of science, engineering and technology

Mrs Chrisna Jooste
PO Box 51852
Wierda park, 0149

19 August 2010

TO WHOM IT MAY CONCERN

Permission to conduct Masters Research Project **Ref: 004/SLG/2010**

The request for ethical approval for your research project entitled: "The impact of usability (principles) on the usage of Business Intelligence (BI) applications in decision-making in a (coal mining) organization" refers.

The School of Computing's Research and Ethics Committee has considered the relevant parts of the studies relating to the abovementioned research project and research methodology and is pleased to inform you that ethical clearance is granted for your study as set out in your proposal and application for ethical clearance.

Therefore involved parties may also consider ethics approval as granted. However, the permission granted must not be misconstrued as constituting an instruction from the School of Computing's Director or CSET Executive or CSET CREC that sampled interviewees (if applicable) are compelled to take part in the research project. All interviewees retain their individual right to decide whether to participate or not.

We trust that the research will be undertaken in a manner that is respectful of the rights and integrity of those who volunteer to participate, as stipulated in the UNISA Research Ethics policy. The policy can be found at the following URL:
http://cm.unisa.ac.za/contents/departments/res_policies/docs/ResearchEthicsPolicy_apprvCounc_21Sept07.pdf

Yours sincerely,

____

Prof L Labuschagne
Chair: School of Computing Research Committee

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Annexure D: Instrument 1 – SUMI Questionnaire

Software Usability Measurement Inventory

SUMI

Password ______

NB the information you provide is kept completely confidential, and no information is stored on computer media that could identify you as a person.

This questionnaire has fifty statements. Please answer them all. After each statement there are three boxes.

- Check the first box if you generally AGREE with the statement.
- Check the middle box if you are UNDECIDED, or if the statement has no relevance to your software or to your situation.
- Check the right box if you generally DISAGREE with the statement.

In checking the left or right box you are not necessarily indicating strong agreement or disagreement but just your general feeling most of the time.

		Agree	Undecided	Disagree
1.	This software responds too slowly to inputs.	☐	☐	☐
2.	I would recommend this software to my colleagues.	☐	☐	☐
3.	The instructions and prompts are helpful.	☐	☐	☐
4.	The software stops unexpectedly sometimes.	☐	☐	☐
5.	Learning to operate this software is full of problems initially.	☐	☐	☐
6.	I sometimes don't know what to do next with this software.	☐	☐	☐
7.	I enjoy my sessions with this software.	☐	☐	☐
8.	The help information given by this software is not very useful.	☐	☐	☐
9.	If this software stops, it is not easy to restart it.	☐	☐	☐
10.	It takes too long to learn how to work with this software.	☐	☐	☐
		Agree	**Undecided**	**Disagree**
11.	I sometimes wonder if I'm using the right command.	☐	☐	☐
12.	Working with this software is satisfying.	☐	☐	☐
13.	The way that information is presented is clear and understandable.	☐	☐	☐

14.	I feel safer if I use only a few familiar commands or operations.	☐	☐	☐
15.	The software documentation is very informative.	☐	☐	☐
16.	This software seems to disrupt the way I normally like to arrange my work.	☐	☐	☐
17.	Working with this software is mentally stimulating.	☐	☐	☐
18.	There is never enough information on the screen when it's needed.	☐	☐	☐
19.	I feel in command of this software when I am using it.	☐	☐	☐
20.	I prefer to stick to the operations I know best.	☐	☐	☐
		Agree	**Undecided**	**Disagree**
21.	I think this software is inconsistent.	☐	☐	☐
22.	I would not like to use this software every day.	☐	☐	☐
23.	I can understand and act on the information provided by this software.	☐	☐	☐
24.	This software is awkward when I want to do something which is not standard.	☐	☐	☐
25.	There is too much to read before you can use the software.	☐	☐	☐
26.	Doing what you want to do with this software is straightforward.	☐	☐	☐
27.	Using this software is frustrating.	☐	☐	☐
28.	The software has helped me overcome any problems I have had in using it.	☐	☐	☐
29.	The speed of this software is fast enough.	☐	☐	☐
30.	I keep having to go back to look at the guides.	☐	☐	☐
		Agree	**Undecided**	**Disagree**
31.	It is obvious that user needs have been fully taken into consideration.	☐	☐	☐
32.	There have been times in using this software when I have felt quite tense.	☐	☐	☐
33.	The organisation of the menus and lists seems fairly logical.	☐	☐	☐
34.	You don't have to do a lot of input to make this software work.	☐	☐	☐
35.	It is hard to learn to use new functions.	☐	☐	☐
36.	There are too many steps required to get something to work.	☐	☐	☐

		Agree	Undecided	Disagree
37.	Sometimes this software gives me a headache.	☐	☐	☐
38.	Error prevention messages are inadequate.	☐	☐	☐
39.	It is easy to make the software do exactly what you want.	☐	☐	☐
40.	I will never learn to use all the functions in this software.	☐	☐	☐
		Agree	**Undecided**	**Disagree**
41.	The software hasn't always done what I was expecting it to do.	☐	☐	☐
42.	The software has a very attractive presentation.	☐	☐	☐
43.	The amount or quality of the help information varies across the system.	☐	☐	☐
44.	It is relatively easy to move from one part of a task to another.	☐	☐	☐
45.	It is easy to forget how to do things with this software.	☐	☐	☐
46.	Sometimes this software behaves in a way which I don't understand.	☐	☐	☐
47	This software is very awkward to use.	☐	☐	☐
48.	You can see at a glance what the options are at each stage.	☐	☐	☐
49.	Getting data files in and out of the system is not easy.	☐	☐	☐
50.	I have to seek assistance when I use this software.	☐	☐	☐

Please be sure to check each item.
Thank you!

What, in general, do you use this software for? [ ]

How often do you use this software?

- ☐ Several times a day
- ☐ Not more than once a day
- ☐ Several times a week
- ☐ Not more than once a week
- ☐ Several times a month
- ☐ Not more than once a month
- ☐ Less than once a month

How long have you been using this software?

- ☐ Less than a month
- ☐ 2-6 months

- ☐ 6 months to a year
- ☐ For more than a year

What do you think is the best feature of this software? [ ]

What do you think is the feature which needs most improvement? [ ]

When you've answered all the questions, please click the SEND button. [Send] [Redo]

ANNEXURE E: SUMI DATA

SUMI for Chrisna Jooste, Anglo Coal 04-29-2010 12:02:45												
Global	Eff	Aff	Help	Cont	Learn	Pass word	Evaluation Date	What, in general, do you use this software for?	How often do you use this software?	How long have you been using this software?	Which is the best feature of this software?	Which feature needs most improvement ?
									1 Several times a day	1 Less than a month		
									2 Not more than once a day	2 2-6 months		
									3 Several times a week	3 6 months to a year		
									4 Not more than once a week	4 For more than a year		
									5 Several times a month			
									6 Not more than once a month			
									7 Less than once a month			
70	69	66	63	66	60	799BE	Thu, 1 Apr 2010 08:34:46 +0100	Contract spend per contractor/ vendor number	5	4	Accuracy	none
67	71	71	56	67	71	799BE	Tue, 20 Apr 2010 18:56:31 +0100	Spend	5	4	to build a cube for your need and use	n/a
50	55	38	57	53	67	799BE	Wed, 7 Apr 2010 14:04:11 +0100	Reports	7	4	Not too complex for end-users	GUI
37	35	20	47	36	36	799BE	Wed, 31 Mar 2010 13:58:15 +0100	User support	1	4	Navigation	Imported reports used by the PPX reports
23	23	14	24	31	35	799BE	Tue, 6 Apr 2010 11:20:58 +0100	Business history, budgets	5	4	the spend visibility	breaking categories into units
60	46	71	65	54	56	799be	Wed, 21 Apr 2010 11:10:22 +0100	stock movements	4	4	Checking stock movment	Tracking of Order numbers
63	62	68	62	54	61	799BE	Wed, 21 Apr 2010 09:44:30 +0100	Data Analysis , Trends, Sub Assembly consumption	7	4	Filtering of a report so each person can look at his own AOR and not at a Total Plant	Graphics
57	53	65	46	58	42	799BE	Wed, 14 Apr 2010 07:08:11 +0100	Detail Spend information	3	3	Saving information into excel for analysis	More easy to use tutorial
31	34	22	49	18	59	799BE	Wed, 31 Mar 2010 13:51:31 +0100	I used to maintain the software. It's primary use is data mining	5	4	easy access for end-users. Reached end-of-life status	administration is done via very manual processes or per-item basis.
61	51	57	61	54	63	799be	Wed, 28 Apr 2010 13:18:21 +0100	logistics side	2	4	as I only work on 204rganizat side I realy can't awnser	logistics side is sometimes confusing to look for figuers
71	65	63	71	68	71	799BE	Sun, 11 Apr 2010 17:27:34 +0100	Obtain information from the ERP for analysis	1	4	The easy of use	Speed of application

21	17	26	22	21	21	799BE	Wed, 31 Mar 2010 13:01:40 +0100	Draw KPI on assistant buyers	7	4	Ability to import data into Excel	Setting up data taht you require info on
65	68	66	55	66	64	799BE	Wed, 31 Mar 2010 13:59:10 +0100	Supply Chain KPI stats	1	4	You have all the information you need at your fingertips.	Time it takes to process complex requests.
39	29	43	34	29	51	799BE	Thu, 8 Apr 2010 07:09:07 +0100	Collecting statistical data	5	4	It collects pre-selected data or stats without you having to build new 'blocks' every day	The running / updating of stats. More frequent updates during a one day period.
73	66	66	71	65	66	799BE	Tue, 13 Apr 2010 12:25:24 +0100	Data and spend analysis	1	3	the lay out is easy to understand and to use your own initiative	Vendor allocation
32	32	50	31	28	43	799BE	Wed, 7 Apr 2010 14:20:04 +0100	spend analysis	6	2	Filters Attributes	Spend per item description
68	71	69	63	60	71	799be	Fri, 9 Apr 2010 10:22:15 +0100	a	7	1	a	a
66	68	65	60	65	68	799BE	Wed, 31 Mar 2010 13:53:48 +0100	downloading of spend data, and view correct allocation of commodities	5	2	the display of the menu	none
24	14	16	30	31	16	799BE	Tue, 13 Apr 2010 06:50:24 +0100	datawarehouse	6	4	none	Training
34	30	26	32	32	21	799BE	Thu, 1 Apr 2010 12:05:19 +0100	to collect spend data	5	3	?	Description for purchased items
60	63	52	51	50	63	799BE	Fri, 9 Apr 2010 12:53:07 +0100	To extract information for the spend analysis	1	3	Not sure	Searching for a supplier
50	56	56	55	35	65	799BE	Wed, 28 Apr 2010 10:57:43 +0100	To gather spend information on a supplier	4	4	you can remove information with zeroes in them	the category split data
67	65	60	48	67	60	799BE	Thu, 1 Apr 2010 12:27:10 +0100	Contract Spend	5	4	Lots of data	To be able to split contracts
53	53	56	47	53	67	799BE	Thu, 1 Apr 2010 10:39:51 +0100	Contractors' spend	5	4	I only use the spend records. No other features.	Develop a functionality to get Spend per contract instead of per Vendor number because one vendor can have a multiple contracts
59	49	58	67	62	58	799be	Tue, 6 Apr 2010 09:15:13 +0100	to get the suppliers spend	5	4	Where we see the spend for each mine and it can show contract and non contract spend	Show a spend per contract if we have more than one contract with a supplier
29	23	48	41	30	19	799BE	Wed, 7 Apr 2010 13:53:22 +0100	Data Warehouse reporting	4	4	A large amount of history is stored	The program should be more user friendly.
24	26	35	31	20	33	799BE	Wed, 31 Mar 2010 13:18:58	Everyday information (direct from Ellipse)	1	4	Once a report is set up, you can use it	Speed

							+0100				daily	
66	71	71	66	50	56	799BE	Mon, 12 Apr 2010 08:11:14 +0100	ENGINEERING REPORTS	1	4	IMMEDIATE REULTS	N/A
43	32	59	40	44	41	799BE	Wed, 31 Mar 2010 12:57:42 +0100	MANAGEMENT OF STAFF AND KPI'S/ALSO FEEDBACK – REPORTING	1	4	YOU CAN EXPORT TO EXCEL AND ARRANGE AS YOU SEE FIT	SPEED OF THE SYSTEM
20	18	16	26	29	31	799BE	Thu, 8 Apr 2010 06:21:50 +0100	Analysis, Presentation to HOD'd	3	4	Security	Printing, Graphical presentation
51	55	50	51	50	62	799BE	Wed, 31 Mar 2010 12:57:54 +0100	All my data: eg. – Downtime, Availablibilty,Equipments, Costing,ect.....	1	4	It is easy to learn, understand and make it work for you. Info available at any stage when needed urgently Short time period to get info	Can't realy say as I'm not aware of what the hole program can 206rganiza do as my training was limited
61	68	59	58	57	64	799BE	Wed, 7 Apr 2010 10:55:13 +0100	Spend analysis	4	4	Exporting to Excel	Data Integrity
50	39	59	51	54	15	799BE	Fri, 16 Apr 2010 09:25:49 +0100	Month Eng Reporting	2	4	Not sure, since I only use what I am familiar with	As above
58	52	60	65	48	38	799BE	Wed, 31 Mar 2010 14:31:18 +0100	To check on workflow and progress of each buyer	3	4	I get my information I am looking for and it does all the work for me	None
54	35	55	69	37	31	799BE	Wed, 31 Mar 2010 13:55:32 +0100	checking SLA, and KPI's information sharing	4	4	THE PERSONALISED CUBES	NA
33	29	36	33	30	35	799BE	Thu, 8 Apr 2010 07:19:39 +0100	reporting on spend for suppliers	3	4	You can set information out they you want to view it	Software is too slow
33	37	39	43	21	35	799BE	Mon, 12 Apr 2010 10:49:47 +0100	analise data	1	4	Very good if you know how to use	more user friendly
49	36	57	64	50	18	799be	Thu, 8 Apr 2010 09:07:14 +0100	FOR MANAGEMENT INFORMATION	3	4	SOMETIME WE PLANNERS WE ARE NOT PROGRAMMES AND IS BETTER FOR PROGAMMERS DO CUBES FOR US	NO COMMENTS
23	13	17	36	11	27	799BE	Thu, 8 Apr 2010 15:48:10 +0100	Getting Spend against various suppliers	7	4	Getting general spend is not a problem	Getting more detailed spend is not possible for me currently
47	44	44	44	47	38	799BE	Wed, 14 Apr 2010 08:10:24 +0100	spend on supplier	6	2	getting spend on a supplier	splitting the spend on a supplier between service, repairs & supply
71	71	68	62	71	68	799BE	Fri, 16 Apr 2010 13:01:36 +0100	Reporting	3	4	Report structures	The software is very user friendly and easy to use

67	48	68	67	61	64	799be	Tue, 20 Apr 2010 14:23:17 +0100	Statistics	5	4	Availability of data in required format	Data to be updated immediatedly
49	44	57	52	39	38	799be	Wed, 31 Mar 2010 12:59:43 +0100	Get BEE information totals	6	4	Getting various information on one sheet	Not sure
34	36	35	35	16	58	799BE	Wed, 31 Mar 2010 12:59:53 +0100	use Info	1	4	every body have access to it	userfriendly, Page&print setups,responding speed
60	59	68	61	54	48	799BE	Thu, 1 Apr 2010 07:15:09 +0100	Capturing Prices	1	1	Changing prices	Tendering
50	68	56	33	49	34	799be	Wed, 7 Apr 2010 06:10:51 +0100	Data analysis	1	4	Database retreival	Data presentation in upfront
22	19	42	32	26	19	799BE	Thu, 22 Apr 2010 08:09:07 +0100	Spend analysis	4	4	ability to obtain spend data	not user friendly
68	57	66	67	55	46	799be	Thu, 1 Apr 2010 05:13:45 +0100	Pulling past information (transaction history)	6	4	being able to gather &provide valuable transaction history	speed
45	40	39	53	44	35	799be	Tue, 13 Apr 2010 11:33:18 +0100	reporting	6	3	training on ground leval	need more training and a manual
56	59	45	57	60	48	799BE	Thu, 8 Apr 2010 08:11:44 +0100	to track office performance	6	3	207rgan have to go to many screens to get the information	none

SUMI Stats Summary & Individual Questions

50	50	50	50	50	50	(No. cases)
49.28	46	50	50.1	45.5	47.1	(Mean)
16.24	18	17	14	16.2	17.4	(Standard Dev)
81.12	81	84	77.5	77.3	81.2	(Upper Fence)
17.44	12	17	22.6	13.8	13	(Lower Fence)
2.297	2.5	2.4	1.98	2.29	2.46	(Standard Error of Mean)
53.78	51	55	54	50	51.9	(Upper 95% CL)
49.28	46	50	50.1	45.5	47.1	(Mean)
44.78	42	46	46.2	41	42.3	(Lower 95% CL)

Item 23 I can understand and act on the information provided by this software.

	Agree	Undecided	Disagree
Observed	6	5	38
Expected	36	9.4	3.96
Chi Square	320		

Item 33 The organization of the menus and lists seems fairly logical.

	Agree	Undecided	Disagree
Observed	6	12	31
Expected	36	7.2	5.48
Chi Square	147		

Item 2 I would recommend this software to my colleagues.

	Agree	Undecided	Disagree
Observed	8	9	32

Expected	31	12	6.15
Chi Square	126		
Item 13	The way that information is presented is clear and understandable.		
	Agree	Undecided	Disagree
Observed	10	5	34
Expected	31	12	6.82
Chi Square	126		
Item 7	I enjoy my sessions with this software.		
	Agree	Undecided	Disagree
Observed	6	14	29
Expected	28	15	6.2
Chi Square	101		
Item 34	You don't have to do a lot of input to make this software work.		
	Agree	Undecided	Disagree
Observed	10	10	29
Expected	31	11	6.53
Chi Square	92		
Item 44	It is relatively easy to move from one part of a task to another.		
	Agree	Undecided	Disagree
Observed	10	11	28
Expected	35	7.4	6.58
Chi Square	89		
Item 3	The instructions and prompts are helpful.		
	Agree	Undecided	Disagree
Observed	7	11	31
Expected	30	11	7.67
Chi Square	89		
Item 26	Doing what you want to do with this software is straightforward.		
	Agree	Undecided	Disagree
Observed	13	8	28
Expected	34	8.4	6.39
Chi Square	86		
Item 12	Working with this software is satisfying.		
	Agree	Undecided	Disagree
Observed	8	14	27
Expected	27	16	6.43
Chi Square	79		
Item 15	The software documentation is very informative.		
	Agree	Undecided	Disagree
Observed	6	16	27
Expected	17	24	7.29
Chi Square	64		

Item 42	The software has a very attractive presentation.		
	Agree	Undecided	Disagree
Observed	10	14	25
Expected	28	13	7.29
Chi Square	55		
Item 19	I feel in command of this software when I am using it.		
	Agree	Undecided	Disagree
Observed	10	17	22
Expected	29	13	7.39
Chi Square	42		
Item 50	I have to seek assistance when I use this software.		
	Agree	Undecided	Disagree
Observed	18	13	18
Expected	5.8	6.8	36.4
Chi Square	41		
Item 31	It is obvious that user needs have been fully taken into consideration.		
	Agree	Undecided	Disagree
Observed	11	11	27
Expected	19	18	11.5
Chi Square	27		
Item 48	You can see at a glance what the options are at each stage.		
	Agree	Undecided	Disagree
Observed	13	16	20
Expected	29	11	9.68
Chi Square	22		
Item 39	It is easy to make the software do exactly what you want.		
	Agree	Undecided	Disagree
Observed	11	14	24
Expected	20	17	11.6
Chi Square	18		
Item 47	This software is very awkward to use.		
	Agree	Undecided	Disagree
Observed	10	11	28
Expected	3.1	8.9	37
Chi Square	18		
Item 14	I feel safer if I use only a few familiar commands or operations.		
	Agree	Undecided	Disagree
Observed	30	11	8
Expected	20	8.2	21.2
Chi Square	15		
Item 5	Learning to operate this software is full of problems initially.		

	Agree	Undecided	Disagree
Observed	21	6	22
Expected	10	8.3	30.5
Chi Square	14		
Item 17	Working with this software is mentally stimulating.		
	Agree	Undecided	Disagree
Observed	8	19	22
Expected	19	17	12.5
Chi Square	14		
Item 32	There have been times in using this software when I have felt quite tense.		
	Agree	Undecided	Disagree
Observed	24	13	12
Expected	18	7.6	23.8
Chi Square	12		
Item 49	Getting data files in and out of the system is not easy.		
	Agree	Undecided	Disagree
Observed	14	11	24
Expected	6.9	18	23.7
Chi Square	10		
Item 28	The software has helped me overcome any problems I have had in using it.		
	Agree	Undecided	Disagree
Observed	12	18	19
Expected	14	25	10.2
Chi Square	9.7		
Item 29	The speed of this software is fast enough.		
	Agree	Undecided	Disagree
Observed	18	14	17
Expected	28	8	13.2
Chi Square	9		
Item 1	This software responds too slowly to inputs.		
	Agree	Undecided	Disagree
Observed	16	10	23
Expected	9.4	7.1	32.4
Chi Square	8.4		
Item 22	I would not like to use this software every day.		
	Agree	Undecided	Disagree
Observed	17	2	30
Expected	11	8.1	30.2
Chi Square	8.3		
Item 21	I think this software is inconsistent.		
	Agree	Undecided	Disagree
Observed	13	10	26

Expected	6.3	12	30.2
Chi Square	8.1		
Item 10	It takes too long to learn how to work with this software.		
	Agre e	Undecided	Disagree
Observed	11	7	31
Expected	5.1	7.9	36.1
Chi Square	7.8		
Item 16	This software seems to disrupt the way I normally like to arrange my work.		
	Agre e	Undecided	Disagree
Observed	8	16	25
Expected	4.3	11	33.7
Chi Square	7.6		
Item 24	This software is awkward when I want to do something which is not standard.		
	Agre e	Undecided	Disagree
Observed	22	12	15
Expected	15	20	14.6
Chi Square	6.9		
Item 20	I prefer to stick to the operations I know best.		
	Agre e	Undecided	Disagree
Observed	29	4	16
Expected	21	9.2	18.6
Chi Square	6.2		
Item 4	The software stops unexpectedly sometimes.		
	Agre e	Undecided	Disagree
Observed	21	9	19
Expected	24	4.7	20.5
Chi Square	4.5		
Item 43	The amount or quality of the help information varies across the system.		
	Agre e	Undecided	Disagree
Observed	19	26	4
Expected	15	25	8.87
Chi Square	3.7		
Item 18	There is never enough information on the screen when it's needed.		
	Agre e	Undecided	Disagree
Observed	13	8	28
Expected	8.2	11	30.2
Chi Square	3.6		
Item 35	It is hard to learn to use new functions.		
	Agre e	Undecided	Disagree
Observed	11	9	29
Expected	6.7	12	30.6
Chi Square	3.5		

Item 11	I sometimes wonder if I'm using the right command.		
	Agree	Undecided	Disagree
Observed	20	10	19
Expected	17	7.2	24.4
Chi Square	2.7		
Item 25	There is too much to read before you can use the software.		
	Agree	Undecided	Disagree
Observed	7	15	27
Expected	8	10	30.6
Chi Square	2.5		
Item 38	Error prevention messages are inadequate.		
	Agree	Undecided	Disagree
Observed	13	23	13
Expected	12	20	16.9
Chi Square	1.4		
Item 9	If this software stops it is not easy to restart it.		
	Agree	Undecided	Disagree
Observed	8	14	27
Expected	8.2	18	23.2
Chi Square	1.4		
Item 6	I sometimes don't know what to do next with this software.		
	Agree	Undecided	Disagree
Observed	17	10	22
Expected	15	8.1	26
Chi Square	1.4		
Item 36	There are too many steps required to get something to work.		
	Agree	Undecided	Disagree
Observed	13	9	27
Expected	10	9.4	29.6
Chi Square	1.1		
Item 41	The software hasn't always done what I was expecting it to do.		
	Agree	Undecided	Disagree
Observed	21	13	15
Expected	23	10	15.7
Chi Square	1.1		
Item 40	I will never learn to use all the functions in this software.		
	Agree	Undecided	Disagree
Observed	17	10	22
Expected	15	13	21.5
Chi Square	1		
Item 45	It is easy to forget how to do things with this software.		

	Agree	Undecided	Disagree
Observed	15	9	25
Expected	12	8.6	27.9
Chi Square	0.9		
Item 37	Sometimes this software gives me a headache.		
	Agree	Undecided	Disagree
Observed	14	9	26
Expected	11	10	27.4
Chi Square	0.8		
Item 27	Using this software is frustrating.		
	Agree	Undecided	Disagree
Observed	10	9	30
Expected	8.5	10	30
Chi Square	0.5		
Item 30	I keep having to go back to look at the guides.		
	Agree	Undecided	Disagree
Observed	9	12	28
Expected	9.7	11	28.7
Chi Square	0.2		
Item 8	The help information given by this software is not very useful.		
	Agree	Undecided	Disagree
Observed	11	17	21
Expected	10	16	22.5
Chi Square	0.2		
Item 46	Sometimes this software behaves in a way which I don't understand.		
	Agree	Undecided	Disagree
Observed	15	12	22
Expected	16	12	21.2
Chi Square	0.1		

ANNEXURE F: USER ISSUES LOG

User Issues Diary

Year	Week	Call Description
2009	32	User requires sign on
2009	32	User requires sign on
2009	32	User logged out
2009	32	User logged out
2009	32	Additional fields required for report
2009	32	Training required
2009	32	Training required
2009	32	User logged out
2009	32	Cube not being updated
2009	33	Want to modify measures in a report
2009	33	User logged out
2009	33	User requested refresher course on system
2009	33	User needs specific view on cube
2009	33	Requires help with report modifications
2009	34	Need to add measures to a report
2009	34	User requires sign on
2009	34	User logged out
2009	34	Training required
2009	34	Requires assistance with calculations in measure
2009	34	User logged out
2009	35	Want to group fields in a report
2009	35	User logged out
2009	35	Report not bringing in correct information
2009	35	Report not showing all the districts
2009	35	User logged out
2009	35	User logged out
2009	35	Report not running
2009	36	Require totals for certain fields in a report
2009	36	User requires sign on
2009	36	User logged out
2009	36	User logged out
2009	36	Training required
2009	36	Report not showing - link missing
2009	37	Require report to be sorted according to a series of fields
2009	37	Accidentally deleted report
2009	37	User logged out

2009	37	User logged out
2009	37	Cube not showing all data - do not know how to unhide
2009	37	Don't know how to nest fields
2009	37	Don't know how to add totals to fields
2009	38	Require additional data to be included in report
2009	38	User requires sign on
2009	38	User requires sign on
2009	38	Training required
2009	38	User wants to add graph to table
2009	38	User logged out
2009	39	Require certain data to be excluded from report
2009	39	User logged out
2009	39	User want info for specific mine
2009	39	User wants BEE data
2009	39	User needs specific view on cube
2009	39	User logged out
2009	40	Wants to filter on certain fields in report
2009	40	User logged out
2009	40	User logged out
2009	40	User requests local BEE spend for mine
2009	40	User requests total BEE spend for mine
2009	40	User requests KPI stats for Isibonelo
2009	40	User cannot view highest level of nested data
2009	40	User cannot identify how to navigate within the system
2009	40	User cannot identify cube on system
2009	40	User cannot identify dimensions on the system
2009	40	User logged out
2009	40	Cube not updated on system – orders stats
2009	40	Cube not updated on system – issue requisitions
2009	41	User logged out
2009	41	User logged out
2009	41	User wants to use system data outside the system – export assistance required
2009	41	User does not understand how measure is calculated
2009	41	User does not know how to modify cube to view information
2009	41	User requires access to another user's newsbox
2009	41	User requires sign on User requires training
2009	42	User cannot share views on cube
2009	42	User needs specific view on cube
2009	42	User logged out

2009	42	User not able to modify cubes
2009	42	System slow
2009	42	User requires assistance to pull report
2009	43	User cannot modify cube
2009	43	User requires sign on
2009	43	Training required
2009	43	User requests critical availability figures for year
2009	43	User requests stock codes of critical inabilities for the year
2009	43	User logged out
2009	43	User logged out
2009	43	Unique cube view created for user
2009	43	Data extracted from cube for user
2009	44	Usar cannot save cube
2009	44	User needs specific view on cube
2009	44	Data comparison of suppliers for user
2009	44	Cube not updated – auth of purchase requests
2009	44	Cube not updated – general spend visibility
2009	44	User cannot find cube on system
2009	44	User view on cube has been modified
2009	44	User logged out
2009	44	User unable to access data on cube
2009	45	Cube not updating - Inventory Avail & Error
2009	45	User requires sign on
2009	45	Training required
2009	45	User requires new cube for different data requirement
2009	45	User logged out
2009	45	User requires KPI sheet to be updated with yearly figures per mine
2009	45	User requires additional district to be included in data
2009	45	User logged out
2009	45	User requested refresher course on system
2009	46	Cube not updating - Orders Stats PWTL
2009	46	system speed - very slow
2009	46	User needs specific view on cube
2009	46	User requires detail data supporting cube –overdue orders
2009	46	User requested information of Supplier (Bucyrus) order status
2009	46	User logged out
2009	46	User requires report on supplier spend for the year Jormid.
2009	46	User requires cubes to be created for major commodities

2009	47	Cube not updating - Orders Stats Outstanding Orders
2009	47	User logged out
2009	47	User logged out
2009	47	system speed - very slow
2009	47	system speed - very slow
2009	47	User requested refresher course on system
2009	47	User needs specific view on cube
2009	47	User requires help with formulation of calculation
2009	47	User requires help to display correct transactions
2009	47	User requires help with the created on additional filters for the report
2009	47	User logged out
2009	48	User require excel data from cube (export)
2009	48	User requires sign on
2009	48	Training required
2009	48	User requires access to another user's newsbox
2009	48	User requires explanation of dimension names
2009	48	User logged out
2009	48	User logged out
2009	48	User cannot make sense of graph bar chart colour, data values required
2009	48	User cannot execute data cube
2010	3	User requires training on system
2010	4	User needs specific view on cube
2010	5	User requires number of transactions per buyer
2010	6	User need outstanding & overdue order list
2010	7	User sign on required
2010	8	User logged out
2010	9	User spend for supplier required (Shell)
2010	10	User spend for Bucyrus supplier request
2010	11	User spend for Diwydag requested
2010	12	User spend for Sasol Nitro requested
2010	13	User spend for AEL requested
2010	14	User cube view changed, correction required
2010	15	User requires training
2010	16	User requested manual on system
2010	17	User requested refresher course on system
2010	18	User complaint about system speed - very slow
2010	19	User cannot remember how to retrieve information
2010	20	User cannot sign in
2010	21	User requires refresher course
2010	22	User requires manuals on system
2010	23	User cannot access system, shortcut missing

2010	24	User requires split view on spend breakdown
2010	25	User requires graph to visually present data
2010	26	User requested per operation breakdown of data cube
2010	27	User requested filter in cube to view supplier spend
2010	28	User unable to access system
2010	29	System response is very slow
2010	30	User wants to customize system
2010	31	User wants to change font colour
2010	32	User is logged out
2010	33	User not able to view required data, does not know where to find data
2010	34	User is not able to save modifications on cube (access granted)
2010	35	User does not know how to navigate through the system
2010	36	User request calculation for measures
2010	37	User request dimension definitions
2010	38	User is not able to export data
2010	39	User is not able to create required view, assistance required
2010	40	User requires additional data field to cube
2010	41	User is logged out
2010	42	User requires a password reset
2010	43	User sign on required
2010	44	User access to data required
2010	45	User unable to save to multiple users' news boxes, access required
2010	46	User requires assistance with creation of data filter
2010	47	User requires detail data supporting cube
2010	48	User requires filter on supplier spend
2011	2	User requires graph for data sheet
2011	3	User logged out
2011	4	User requires password to be reset
2011	5	Cube not updated – inventory movement
2011	6	Cube not updated – inventory trend
2011	7	User requires suppliers to be flagged as influenceable on the system
2011	8	User requires training on the system
2011	9	User requires unique view on cube per colliery
2011	10	User requires assistance with hidden/visible dimensions in the cube
2011	11	User is unable to remember how to retrieve information
2011	12	User has deleted the view saved on the cube
2011	13	User would like to share the view on the cube with another user

2011	14	User is logged out
2011	15	User requires a password reset
2011	16	User is not able to extract the data requested
2011	17	User sign on required
2011	18	User complains about system speed
2011	19	User complains about data availability
2011	20	User requires training on system, creating nesting queries that cause the system crashes
2011	21	User requires assistance to create calculation in cube
2011	22	User requires assistance with 80/20 view on data
2011	23	User requires assistance with data from system (even though it is available)
2011	24	User not able to view expanded dimension fields in the manner required
2011	25	User not able to view dimension elements
2011	26	User not able to search for data (stock code) in the cube
2011	27	User do not know where to find information
2011	28	User locked out
2011	29	User password needs to be reset
2011	30	User requires data to be sorted.

ANNEXURE G: HEURISTIC EVALUATION GUIDELINES

Kwon (2007) propose a heuristic evaluation using the following 10 design principles or criteria. Kwon stress that these criteria need to be considered in relation to the quality attributes (Kwon, 2007):

(1) overall mental model/metaphor concepts,
(2) completeness/redundancy,
(3) consistency,
(4) operation image,
(5) information organization,
(6) compatibility,
(7) efficiency,
(8) error tolerance,
(9) user support
(10) smartness.

Karahoca made use of the Usability metrics based of ISO 9241, where 21 criteria are used to measure usability attributes (possible w They are

(1) Time to complete a task,
(2) Percent of task completed,
(3) Percent of task completed per unit time,
(4) Ratio of successes to failures,
(5) Time spent in errors,
(6) Percent or number of errors,
(7) Percent or number of competitors better than it,
(8) The number of commands used,
(9) Frequency of help and documentation use,
(10) Percent of favourable/unfavourable user comments,
(11) Number of repetitions of failed commands,
(12) Number of runs of successes and of failures,
(13) Number of times interface misleads the user,
(14) Number of good and bad features recalled by users,
(15) Number of available commands not invoked,
(16) Number of regressive behaviours,

(17) Number of users preferring the system,

(18) Number of times or average number of users need to work around a problem,

(19) Number of times the user is disrupted from a work task.,

(20) Number of times user loses control of the system,

(21) Number of times user expresses frustration of satisfaction.

- **Muller et. al.'s Participatory Heuristic Evaluation** (Cronholm, 2008):
  (1) System Status
    (i) System Status
  (2) User Control and Freedom
    (i) Task Sequencing
    (ii) Emergency Exits
    (iii) Flexibility and Efficiency of Use
    (iv) Consistency and Relevance
    (v) Match between System and the Real World
    (vi) Consistency and Standards
    (vii) Recognition rather than Recall
    (viii) Aesthetic and Minimalist Design
    (ix) Help and Documentation
  (3) Error Recognition and Recovery
    (i) Help Users Recognize, Diagnose, and Recover from Errors
    (ii) Error Prevention
  (4) Task and Work Support
    (i) Skills
    (ii) Pleasurable and Respectful Interaction with the User.
    (iii) Quality Work
    (iv) Privacy

- **Tabachneck's heuristic guidelines** are based on user-centered design principles targeted to prevent knowledge-transfer errors, distilled from their practical experience and from human–computer interaction theory (Tabachneck, 2009):
  (1) Preserving the precision of the probabilistic information.

(2) Using language and a workflow that is compatible with the user's profession (3) Using the so-called natural language.

(4) Hiding difficult to understand technological/mathematical constructs.

(5) Making the system as user-efficient as possible.

Usability Standards

- ISO9241 (ISO, 1998):
  - (1) Definition Suitability for the Task
  - (2) Self-Description
  - (3) Controllability
  - (4) Conformity with User Expectations
  - (5) Error Tolerance
  - (6) Suitability for Individualization
  - (7) Suitability for Learning

- ISO9241-10: Dialogue principles interaction between user and system
- ISO9241-151: usable web site/application (creation)
- ISO9241-12: Guidelines for arrangement presentation and data on a screen:
  - (1) Time to complete a task
  - (2) Percent of task completed
  - (3) Percent of task completed per unit time
  - (4) Ratio of successes to failures
  - (5) Time spent in errors
  - (6) Percent or number of errors
  - (7) Percent or number of competitors better than it
  - (8) The number of commands used
  - (9) Frequency of help and documentation use
  - (10) Percent of favorable/unfavorable user comments
  - (11) Number of repetitions of failed commands
  - (12) Number of runs of successes and of failures
  - (13) Number of times interface misleads the user
  - (14) Number of good and bad features recalled by users

(15) Number of available commands not invoked

(16) Number of regressive behaviors

(17) Number of users preferring your system

(18) Number of times or average number of users need to work around a problem

(19) Number of times the user is disrupted from a work task

(20) Number of times user loses control of the system

(21) Number of times user expresses frustration of satisfaction

ANNEXURE H: CUBE USAGE DATA COGNOS7 UPFRONT *(5 page excerpt, refer to included CD for complete data set)*

CharDate	UserName	Start_Time	End_Time	WorkCube
2010/02/08	Chrisna Jooste	2010-02-08:12:02:29.623	2010-02-08:12:02:29.623	/Materials/General Spend Visibility,D:/BI/Materials/Published Cubes/General Spend Visibility.mdc
2010/02/08	Chrisna Jooste	2010-02-08:12:01:49.545	2010-02-08:12:01:49.545	/Materials/General Spend Visibility,D:/BI/Materials/Published Cubes/General Spend Visibility.mdc
2010/02/08	Chrisna Jooste	2010-02-08:12:02:18.951	2010-02-08:12:02:18.951	/Materials/General Spend Visibility,D:/BI/Materials/Published Cubes/General Spend Visibility.mdc
2010/02/08	Chrisna Jooste	2010-02-08:12:07:12.170	2010-02-08:12:07:12.170	/Materials/General Spend Visibility,D:/BI/Materials/Published Cubes/General Spend Visibility.mdc
2010/02/08	Chrisna Jooste	2010-02-08:12:00:08.451	2010-02-08:12:00:08.451	/Materials/General Spend Visibility,D:/BI/Materials/Published Cubes/General Spend Visibility.mdc
2010/02/08	Chrisna Jooste	2010-02-08:12:05:21.389	2010-02-08:12:05:21.389	/Materials/General Spend Visibility,D:/BI/Materials/Published Cubes/General Spend Visibility.mdc
2010/02/08	Chrisna Jooste	2010-02-08:12:01:52.764	2010-02-08:12:01:52.764	/Materials/General Spend Visibility,D:/BI/Materials/Published Cubes/General Spend Visibility.mdc
2010/02/09	Tendani Masesane	2010-02-09:11:21:14.489	2010-02-09:11:21:14.489	/Materials/General Spend Visibility,D:/BI/Materials/Published Cubes/General Spend Visibility.mdc
2010/02/09	Gillian Radingwana	2010-02-09:11:15:58.599	2010-02-09:11:15:58.599	/Materials/General Spend Visibility,D:/BI/Materials/Published Cubes/General Spend Visibility.mdc
2010/02/09	Gillian Radingwana	2010-02-09:11:20:32.630	2010-02-09:11:20:32.630	/Materials/General Spend Visibility,D:/BI/Materials/Published Cubes/General Spend Visibility.mdc
2010/02/09	Gillian Radingwana	2010-02-09:11:20:32.036	2010-02-09:11:20:32.036	/Materials/General Spend Visibility,D:/BI/Materials/Published Cubes/General Spend Visibility.mdc
2010/02/09	Tendani Masesane	2010-02-09:11:18:37.317	2010-02-09:11:18:37.317	/Materials/General Spend Visibility,D:/BI/Materials/Published Cubes/General Spend Visibility.mdc
2010/02/09	Tendani Masesane	2010-02-09:10:59:24.771	2010-02-09:10:59:24.771	/Materials/General Spend Visibility,D:/BI/Materials/Published Cubes/General Spend Visibility.mdc
2010/02/09	Tendani Masesane	2010-02-09:10:59:22.692	2010-02-09:10:59:22.692	/Materials/General Spend Visibility,D:/BI/Materials/Published Cubes/General Spend Visibility.mdc
2010/02/09	Tendani Masesane	2010-02-09:11:18:36.864	2010-02-09:11:18:36.864	/Materials/General Spend Visibility,D:/BI/Materials/Published Cubes/General Spend Visibility.mdc
2010/02/09	Tendani Masesane	2010-02-09:10:59:56.255	2010-02-09:10:59:56.255	/Materials/General Spend Visibility,D:/BI/Materials/Published Cubes/General Spend Visibility.mdc
2010/02/09	Tendani Masesane	2010-02-09:11:17:15.052	2010-02-09:11:17:15.052	/Materials/General Spend Visibility,D:/BI/Materials/Published Cubes/General Spend Visibility.mdc
2010/02/09	Tendani Masesane	2010-02-09:10:59:24.755	2010-02-09:10:59:24.755	/Materials/General Spend Visibility,D:/BI/Materials/Published Cubes/General Spend Visibility.mdc
2010/02/09	Tendani Masesane	2010-02-09:11:21:13.927	2010-02-09:11:21:13.927	/Materials/General Spend Visibility,D:/BI/Materials/Published Cubes/General Spend Visibility.mdc
2010/02/09	Tendani Masesane	2010-02-	2010-02-	/Materials/General Spend Visibility,D:/BI/Materials/Published Cubes/General Spend Visibility.mdc

		09:10:59:56.536	09:10:59:56.536	
2010/02/09	Gillian Radingwana	2010-02-09:12:19:07.377	2010-02-09:12:19:07.377	/Materials/General Spend Visibility,D:/BI/Materials/Published Cubes/General Spend Visibility.mdc
2010/02/09	Tendani Masesane	2010-02-09:11:15:37.661	2010-02-09:11:15:37.661	/Materials/General Spend Visibility,D:/BI/Materials/Published Cubes/General Spend Visibility.mdc
2010/02/15	Chrisna Jooste	2010-02-15:09:11:05.088	2010-02-15:09:11:05.088	/Materials/General Spend Visibility,D:/BI/Materials/Published Cubes/General Spend Visibility.mdc
2010/02/15	Donald Mokomane	2010-02-15:11:13:28.869	2010-02-15:11:13:28.869	/Materials/General Spend Visibility,D:/BI/Materials/Published Cubes/General Spend Visibility.mdc
2010/02/15	Donald Mokomane	2010-02-15:11:08:59.275	2010-02-15:11:08:59.275	/Materials/General Spend Visibility,D:/BI/Materials/Published Cubes/General Spend Visibility.mdc
2010/02/15	Chrisna Jooste	2010-02-15:09:11:12.338	2010-02-15:09:11:12.338	/Materials/General Spend Visibility,D:/BI/Materials/Published Cubes/General Spend Visibility.mdc
2010/02/15	Chrisna Jooste	2010-02-15:09:11:15.275	2010-02-15:09:11:15.275	/Materials/General Spend Visibility,D:/BI/Materials/Published Cubes/General Spend Visibility.mdc
2010/02/15	Donald Mokomane	2010-02-15:11:08:40.838	2010-02-15:11:08:40.838	/Materials/General Spend Visibility,D:/BI/Materials/Published Cubes/General Spend Visibility.mdc
2010/02/15	Donald Mokomane	2010-02-15:11:13:13.619	2010-02-15:11:13:13.619	/Materials/General Spend Visibility,D:/BI/Materials/Published Cubes/General Spend Visibility.mdc
2010/02/15	Donald Mokomane	2010-02-15:11:13:30.322	2010-02-15:11:13:30.322	/Materials/General Spend Visibility,D:/BI/Materials/Published Cubes/General Spend Visibility.mdc
2010/02/15	Donald Mokomane	2010-02-15:11:12:48.150	2010-02-15:11:12:48.150	/Materials/General Spend Visibility,D:/BI/Materials/Published Cubes/General Spend Visibility.mdc
2010/02/15	Chrisna Jooste	2010-02-15:09:10:41.541	2010-02-15:09:10:41.541	/Materials/General Spend Visibility,D:/BI/Materials/Published Cubes/General Spend Visibility.mdc
2010/02/15	Chrisna Jooste	2010-02-15:09:11:07.197	2010-02-15:09:11:07.197	/Materials/General Spend Visibility,D:/BI/Materials/Published Cubes/General Spend Visibility.mdc
2010/02/15	Chrisna Jooste	2010-02-15:09:11:15.759	2010-02-15:09:11:15.759	/Materials/General Spend Visibility,D:/BI/Materials/Published Cubes/General Spend Visibility.mdc
2010/02/15	Chrisna Jooste	2010-02-15:09:11:20.775	2010-02-15:09:11:20.775	/Materials/General Spend Visibility,D:/BI/Materials/Published Cubes/General Spend Visibility.mdc
2010/02/15	Edward Makhanya	2010-02-15:14:47:27.314	2010-02-15:14:47:27.314	/Materials/General Spend Visibility,D:/BI/Materials/Published Cubes/General Spend Visibility.mdc
2010/02/15	Chrisna Jooste	2010-02-15:09:11:13.416	2010-02-15:09:11:13.416	/Materials/General Spend Visibility,D:/BI/Materials/Published Cubes/General Spend Visibility.mdc
2010/02/15	Donald Mokomane	2010-02-15:11:09:17.759	2010-02-15:11:09:17.759	/Materials/General Spend Visibility,D:/BI/Materials/Published Cubes/General Spend Visibility.mdc
2010/02/16	Beatrice de Carvalho	2010-02-16:11:58:53.484	2010-02-16:11:58:53.484	/Materials/General Spend Visibility,D:/BI/Materials/Published Cubes/General Spend Visibility.mdc
2010/02/16	Beatrice de Carvalho	2010-02-16:11:57:50.405	2010-02-16:11:57:50.405	/Materials/General Spend Visibility,D:/BI/Materials/Published Cubes/General Spend Visibility.mdc
2010/02/16	Beatrice de Carvalho	2010-02-16:11:59:30.624	2010-02-16:11:59:30.624	/Materials/General Spend Visibility,D:/BI/Materials/Published Cubes/General Spend Visibility.mdc
2010/02/16	Beatrice de Carvalho	2010-02-	2010-02-	/Materials/General Spend Visibility,D:/BI/Materials/Published Cubes/General Spend Visibility.mdc

		16:11:59:36.155	16:11:59:36.155	
2010/02/16	Beatrice de Carvalho	2010-02-16:11:59:40.468	2010-02-16:11:59:40.468	/Materials/General Spend Visibility,D:/BI/Materials/Published Cubes/General Spend Visibility.mdc
2010/02/16	Beatrice de Carvalho	2010-02-16:12:00:32.140	2010-02-16:12:00:32.140	/Materials/General Spend Visibility,D:/BI/Materials/Published Cubes/General Spend Visibility.mdc
2010/02/16	Beatrice de Carvalho	2010-02-16:12:00:42.062	2010-02-16:12:00:42.062	/Materials/General Spend Visibility,D:/BI/Materials/Published Cubes/General Spend Visibility.mdc
2010/02/16	Beatrice de Carvalho	2010-02-16:11:59:04.749	2010-02-16:11:59:04.749	/Materials/General Spend Visibility,D:/BI/Materials/Published Cubes/General Spend Visibility.mdc
2010/02/16	Beatrice de Carvalho	2010-02-16:12:00:24.530	2010-02-16:12:00:24.530	/Materials/General Spend Visibility,D:/BI/Materials/Published Cubes/General Spend Visibility.mdc
2010/02/16	Beatrice de Carvalho	2010-02-16:11:58:22.093	2010-02-16:11:58:22.093	/Materials/General Spend Visibility,D:/BI/Materials/Published Cubes/General Spend Visibility.mdc
2010/02/16	Beatrice de Carvalho	2010-02-16:12:00:21.655	2010-02-16:12:00:21.655	/Materials/General Spend Visibility,D:/BI/Materials/Published Cubes/General Spend Visibility.mdc
2010/02/16	Beatrice de Carvalho	2010-02-16:11:58:08.030	2010-02-16:11:58:08.030	/Materials/General Spend Visibility,D:/BI/Materials/Published Cubes/General Spend Visibility.mdc
2010/02/16	Beatrice de Carvalho	2010-02-16:12:00:30.452	2010-02-16:12:00:30.452	/Materials/General Spend Visibility,D:/BI/Materials/Published Cubes/General Spend Visibility.mdc
2010/02/16	Beatrice de Carvalho	2010-02-16:12:00:26.359	2010-02-16:12:00:26.359	/Materials/General Spend Visibility,D:/BI/Materials/Published Cubes/General Spend Visibility.mdc
2010/02/16	Beatrice de Carvalho	2010-02-16:12:00:25.562	2010-02-16:12:00:25.562	/Materials/General Spend Visibility,D:/BI/Materials/Published Cubes/General Spend Visibility.mdc
2010/02/16	Beatrice de Carvalho	2010-02-16:12:00:30.249	2010-02-16:12:00:30.249	/Materials/General Spend Visibility,D:/BI/Materials/Published Cubes/General Spend Visibility.mdc
2010/02/16	Beatrice de Carvalho	2010-02-16:11:59:15.999	2010-02-16:11:59:15.999	/Materials/General Spend Visibility,D:/BI/Materials/Published Cubes/General Spend Visibility.mdc
2010/02/17	Ardine Nieuwoudt	2010-02-17:13:32:29.968	2010-02-17:13:32:29.968	/Materials/General Spend Visibility,D:/BI/Materials/Published Cubes/General Spend Visibility.mdc
2010/02/17	Mohotsi Poo	2010-02-17:12:23:10.624	2010-02-17:12:23:10.624	/Materials/General Spend Visibility,D:/BI/Materials/Published Cubes/General Spend Visibility.mdc
2010/02/17	Mohotsi Poo	2010-02-17:12:21:29.061	2010-02-17:12:21:29.061	/Materials/General Spend Visibility,D:/BI/Materials/Published Cubes/General Spend Visibility.mdc
2010/02/17	Ardine Nieuwoudt	2010-02-17:13:32:31.218	2010-02-17:13:32:31.218	/Materials/General Spend Visibility,D:/BI/Materials/Published Cubes/General Spend Visibility.mdc
2010/02/17	Ardine Nieuwoudt	2010-02-17:13:35:56.889	2010-02-17:13:35:56.889	/Materials/General Spend Visibility,D:/BI/Materials/Published Cubes/General Spend Visibility.mdc
2010/02/17	Mohotsi Poo	2010-02-17:12:23:16.139	2010-02-17:12:23:16.139	/Materials/General Spend Visibility,D:/BI/Materials/Published Cubes/General Spend Visibility.mdc
2010/02/17	Chrisna Jooste	2010-02-17:10:14:06.279	2010-02-17:10:14:06.279	/Materials/General Spend Visibility,D:/BI/Materials/Published Cubes/General Spend Visibility.mdc
2010/02/17	Ardine Nieuwoudt	2010-02-17:13:32:45.936	2010-02-17:13:32:45.936	/Materials/General Spend Visibility,D:/BI/Materials/Published Cubes/General Spend Visibility.mdc
2010/02/17	Mohotsi Poo	2010-02-	2010-02-	/Materials/General Spend Visibility,D:/BI/Materials/Published Cubes/General Spend Visibility.mdc

		17:12:22:51.983	17:12:22:51.983	
2010/02/17	Ardine Nieuwoudt	2010-02-17:13:32:49.983	2010-02-17:13:32:49.983	/Materials/General Spend Visibility,D:/BI/Materials/Published Cubes/General Spend Visibility.mdc
2010/02/17	Mohotsi Poo	2010-02-17:12:21:32.436	2010-02-17:12:21:32.436	/Materials/General Spend Visibility,D:/BI/Materials/Published Cubes/General Spend Visibility.mdc
2010/02/17	Ardine Nieuwoudt	2010-02-17:13:33:48.499	2010-02-17:13:33:48.499	/Materials/General Spend Visibility,D:/BI/Materials/Published Cubes/General Spend Visibility.mdc
2010/02/17	Mohotsi Poo	2010-02-17:12:21:14.811	2010-02-17:12:21:14.811	/Materials/General Spend Visibility,D:/BI/Materials/Published Cubes/General Spend Visibility.mdc
2010/02/17	Mohotsi Poo	2010-02-17:12:22:01.139	2010-02-17:12:22:01.139	/Materials/General Spend Visibility,D:/BI/Materials/Published Cubes/General Spend Visibility.mdc
2010/02/17	Mohotsi Poo	2010-02-17:12:20:49.530	2010-02-17:12:20:49.530	/Materials/General Spend Visibility,D:/BI/Materials/Published Cubes/General Spend Visibility.mdc
2010/02/17	Mohotsi Poo	2010-02-17:12:23:18.280	2010-02-17:12:23:18.280	/Materials/General Spend Visibility,D:/BI/Materials/Published Cubes/General Spend Visibility.mdc
2010/02/17	Mohotsi Poo	2010-02-17:12:22:22.374	2010-02-17:12:22:22.374	/Materials/General Spend Visibility,D:/BI/Materials/Published Cubes/General Spend Visibility.mdc
2010/02/26	Beatrice de Carvalho	2010-02-26:10:04:27.681	2010-02-26:10:04:27.681	/Materials/General Spend Visibility,D:/BI/Materials/Published Cubes/General Spend Visibility.mdc
2010/02/26	Beatrice de Carvalho	2010-02-26:10:05:08.041	2010-02-26:10:05:08.041	/Materials/General Spend Visibility,D:/BI/Materials/Published Cubes/General Spend Visibility.mdc
2010/02/26	Beatrice de Carvalho	2010-02-26:10:05:11.025	2010-02-26:10:05:11.025	/Materials/General Spend Visibility,D:/BI/Materials/Published Cubes/General Spend Visibility.mdc
2010/02/26	Beatrice de Carvalho	2010-02-26:10:03:31.463	2010-02-26:10:03:31.463	/Materials/General Spend Visibility,D:/BI/Materials/Published Cubes/General Spend Visibility.mdc
2010/02/26	Beatrice de Carvalho	2010-02-26:10:03:55.103	2010-02-26:10:03:55.103	/Materials/General Spend Visibility,D:/BI/Materials/Published Cubes/General Spend Visibility.mdc
2010/02/26	Chrisna Jooste	2010-02-26:11:59:28.294	2010-02-26:11:59:28.294	/Materials/General Spend Visibility,D:/BI/Materials/Published Cubes/General Spend Visibility.mdc
2010/02/26	Chrisna Jooste	2010-02-26:11:59:36.029	2010-02-26:11:59:36.029	/Materials/General Spend Visibility,D:/BI/Materials/Published Cubes/General Spend Visibility.mdc
2010/02/26	Chrisna Jooste	2010-02-26:11:59:40.669	2010-02-26:11:59:40.669	/Materials/General Spend Visibility,D:/BI/Materials/Published Cubes/General Spend Visibility.mdc
2010/02/26	Chrisna Jooste	2010-02-26:11:59:46.497	2010-02-26:11:59:46.497	/Materials/General Spend Visibility,D:/BI/Materials/Published Cubes/General Spend Visibility.mdc
2010/02/26	Chrisna Jooste	2010-02-26:11:59:50.107	2010-02-26:11:59:50.107	/Materials/General Spend Visibility,D:/BI/Materials/Published Cubes/General Spend Visibility.mdc
2010/02/26	Chrisna Jooste	2010-02-26:11:59:59.075	2010-02-26:11:59:59.075	/Materials/General Spend Visibility,D:/BI/Materials/Published Cubes/General Spend Visibility.mdc
2010/02/26	Chrisna Jooste	2010-02-26:12:00:05.904	2010-02-26:12:00:05.904	/Materials/General Spend Visibility,D:/BI/Materials/Published Cubes/General Spend Visibility.mdc
2010/02/26	Chrisna Jooste	2010-02-26:12:00:27.247	2010-02-26:12:00:27.247	/Materials/General Spend Visibility,D:/BI/Materials/Published Cubes/General Spend Visibility.mdc
2010/02/26	Chrisna Jooste	2010-02-	2010-02-	/Materials/General Spend Visibility,D:/BI/Materials/Published Cubes/General Spend Visibility.mdc

		26:12:03:42.529	26:12:03:42.529	
2010/02/26	Beatrice de Carvalho	2010-02-26:09:55:38.416	2010-02-26:09:55:38.416	/Materials/General Spend Visibility,D:/BI/Materials/Published Cubes/General Spend Visibility.mdc
2010/02/26	Beatrice de Carvalho	2010-02-26:09:56:27.416	2010-02-26:09:56:27.416	/Materials/General Spend Visibility,D:/BI/Materials/Published Cubes/General Spend Visibility.mdc
2010/02/26	Beatrice de Carvalho	2010-02-26:10:03:10.275	2010-02-26:10:03:10.275	/Materials/General Spend Visibility,D:/BI/Materials/Published Cubes/General Spend Visibility.mdc
2010/02/26	Beatrice de Carvalho	2010-02-26:09:53:37.291	2010-02-26:09:53:37.291	/Materials/General Spend Visibility,D:/BI/Materials/Published Cubes/General Spend Visibility.mdc
2010/02/26	Beatrice de Carvalho	2010-02-26:09:56:58.572	2010-02-26:09:56:58.572	/Materials/General Spend Visibility,D:/BI/Materials/Published Cubes/General Spend Visibility.mdc
2010/02/26	Beatrice de Carvalho	2010-02-26:10:05:00.259	2010-02-26:10:05:00.259	/Materials/General Spend Visibility,D:/BI/Materials/Published Cubes/General Spend Visibility.mdc
2010/02/09	Gillian Radingwana	2010-02-09:12:20:57.252	2010-02-09:12:20:57.252	/Materials/General Spend Visibility,The request has been redispatched.
2010/02/09	Gillian Radingwana	2010-02-09:12:21:16.299	2010-02-09:12:21:16.299	/Materials/General Spend Visibility,The request has been redispatched.
2010/02/22	Chrisna Jooste	2010-02-22:12:30:04.101	2010-02-22:12:30:04.101	/Materials/GHP/ghp origin types,D:/BI/Materials/Published Cubes/GHP/ghp origin types.mdc
2010/02/02	Quintin Wiese	2010-02-02:12:13:33.091	2010-02-02:12:13:33.091	/Materials/Inventory Availability & Error,D:/BI/Materials/Published Cubes/Inventory/Inventory Availability & Error.mdc
2010/02/02	Quintin Wiese	2010-02-02:12:15:22.684	2010-02-02:12:15:22.684	/Materials/Inventory Availability & Error,D:/BI/Materials/Published Cubes/Inventory/Inventory Availability & Error.mdc
2010/02/02	Hanri Smit	2010-02-02:12:38:13.825	2010-02-02:12:38:13.825	/Materials/orders statistics time to create purchase order,D:/BI/Materials/Published Cubes/Procurement/orders statistics time to create purchase order.mdc
2010/02/03	Hanri Smit	2010-02-03:07:20:38.558	2010-02-03:07:20:38.558	/Materials/orders statistics time to create purchase order,D:/BI/Materials/Published Cubes/Procurement/orders statistics time to create purchase order.mdc
2010/02/03	Hanri Smit	2010-02-03:07:20:18.292	2010-02-03:07:20:18.292	/Materials/orders statistics time to create purchase order,D:/BI/Materials/Published Cubes/Procurement/orders statistics time to create purchase order.mdc
2010/02/04	Gillian Radingwana	2010-02-04:15:06:38.440	2010-02-04:15:06:38.440	/Materials/orders statistics time to create purchase order,D:/BI/Materials/Published Cubes/Procurement/orders statistics time to create purchase order.mdc
2010/02/04	Gillian Radingwana	2010-02-04:15:19:57.956	2010-02-04:15:19:57.956	/Materials/orders statistics time to create purchase order,D:/BI/Materials/Published Cubes/Procurement/orders statistics time to create purchase order.mdc
2010/02/04	Gillian Radingwana	2010-02-04:15:21:44.315	2010-02-04:15:21:44.315	/Materials/orders statistics time to create purchase order,D:/BI/Materials/Published Cubes/Procurement/orders statistics time to create purchase order.mdc
2010/02/04	Gillian Radingwana	2010-02-04:15:07:15.331	2010-02-04:15:07:15.331	/Materials/orders statistics time to create purchase order,D:/BI/Materials/Published Cubes/Procurement/orders statistics time to create purchase order.mdc
2010/02/04	Hanri Smit	2010-02-04:15:24:29.893	2010-02-04:15:24:29.893	/Materials/orders statistics time to create purchase order,D:/BI/Materials/Published Cubes/Procurement/orders statistics time to create purchase order.mdc
2010/02/04	Hanri Smit	2010-02-04:12:38:56.690	2010-02-04:12:38:56.690	/Materials/orders statistics time to create purchase order,D:/BI/Materials/Published Cubes/Procurement/orders statistics time to create purchase order.mdc
2010/02/04	Gillian Radingwana	2010-02-04:15:09:14.315	2010-02-04:15:09:14.315	/Materials/orders statistics time to create purchase order,D:/BI/Materials/Published Cubes/Procurement/orders statistics time to create purchase order.mdc
2010/02/04	Hanri Smit	2010-02-	2010-02-	/Materials/orders statistics time to create purchase order,D:/BI/Materials/Published Cubes/Procurement/orders

		04:12:38:50.503	04:12:38:50.503	statistics time to create purchase order.mdc
2010/02/04	Gillian Radingwana	2010-02-04:15:06:14.175	2010-02-04:15:06:14.175	/Materials/orders statistics time to create purchase order,D:/BI/Materials/Published Cubes/Procurement/orders statistics time to create purchase order.mdc
2010/02/04	Hanri Smit	2010-02-04:15:23:58.206	2010-02-04:15:23:58.206	/Materials/orders statistics time to create purchase order,D:/BI/Materials/Published Cubes/Procurement/orders statistics time to create purchase order.mdc
2010/02/04	Hanri Smit	2010-02-04:15:24:40.300	2010-02-04:15:24:40.300	/Materials/orders statistics time to create purchase order,D:/BI/Materials/Published Cubes/Procurement/orders statistics time to create purchase order.mdc
2010/02/04	Hanri Smit	2010-02-04:15:24:50.893	2010-02-04:15:24:50.893	/Materials/orders statistics time to create purchase order,D:/BI/Materials/Published Cubes/Procurement/orders statistics time to create purchase order.mdc
2010/02/04	Gillian Radingwana	2010-02-04:15:09:45.753	2010-02-04:15:09:45.753	/Materials/orders statistics time to create purchase order,D:/BI/Materials/Published Cubes/Procurement/orders statistics time to create purchase order.mdc
2010/02/04	Hanri Smit	2010-02-04:12:38:05.847	2010-02-04:12:38:05.847	/Materials/orders statistics time to create purchase order,D:/BI/Materials/Published Cubes/Procurement/orders statistics time to create purchase order.mdc
2010/02/04	Gillian Radingwana	2010-02-04:15:19:08.972	2010-02-04:15:19:08.972	/Materials/orders statistics time to create purchase order,D:/BI/Materials/Published Cubes/Procurement/orders statistics time to create purchase order.mdc
2010/02/04	Hanri Smit	2010-02-04:12:38:54.581	2010-02-04:12:38:54.581	/Materials/orders statistics time to create purchase order,D:/BI/Materials/Published Cubes/Procurement/orders statistics time to create purchase order.mdc
2010/02/22	Chrisna Jooste	2010-02-22:12:27:08.976	2010-02-22:12:27:08.976	/Materials/orders statistics time to create purchase order,D:/BI/Materials/Published Cubes/Procurement/orders statistics time to create purchase order.mdc
2010/02/23	Hanri Smit	2010-02-23:08:33:59.901	2010-02-23:08:33:59.901	/Materials/orders statistics time to create purchase order,D:/BI/Materials/Published Cubes/Procurement/orders statistics time to create purchase order.mdc
2010/02/23	Hanri Smit	2010-02-23:08:33:32.276	2010-02-23:08:33:32.276	/Materials/orders statistics time to create purchase order,D:/BI/Materials/Published Cubes/Procurement/orders statistics time to create purchase order.mdc
2010/02/23	Hanri Smit	2010-02-23:08:33:57.510	2010-02-23:08:33:57.510	/Materials/orders statistics time to create purchase order,D:/BI/Materials/Published Cubes/Procurement/orders statistics time to create purchase order.mdc
2010/02/23	Hanri Smit	2010-02-23:08:34:02.260	2010-02-23:08:34:02.260	/Materials/orders statistics time to create purchase order,D:/BI/Materials/Published Cubes/Procurement/orders statistics time to create purchase order.mdc

ANNEXURE I: Heuristic evaluation of the BI system, Cognos7 - Upfront

The criteria for the evaluation will be based on the Heuristic framework as discussed in Chapter 3, and user observations discussed in Chapter 4,5, the evaluation will comprise two sections, section A will address general interface design heuristics, and section B will explore expert evaluator intuition and general usability.

The evaluation will be conducted on the following Business Intelligence System:

- Cognos7 Upfront

Procedure

1. The evaluation facilitator will log into the system.
2. The facilitator will give a quick tour of the system.
3. Take about 15 minutes browsing the site to familiarise yourself with the system.
4. User Task: perform the activity listed below to get a feel for the use of the system. Your evaluation will be based on this activity and all other parts of the system. The evaluation will take place in a "Heuristic Evaluation" test folder with duplicate cubes found in the default user newsbox directory.
    a. Find and open the current user's NewsBox
    b. Find and open the "*Cognos Upfront Heuristic Evaluation"* folder
    c. *Open the "On Contract Spend"* cube.
5. List any violations of the heuristics that you identify in the system, i.e. problems that occur. Please be specific in describing the problem by explaining why it is a problem with respect to the heuristic(s) violated. Each problem should be written out separately. The number in the first column of the table of the heuristics may be used to refer to a particular criterion. You are free to explore any section of the site to identify and describe a problem, please take care not to save any changes outside the "*Cognos Upfront Heuristic Evaluation*" folder.

Thank you for participating in this evaluation exercise.

ANNEXURE J: HEURISTIC EVALUATION SCREEN SHOTS– COGNOS7 UPFRONT

Evaluation of the Business Intelligence Information System

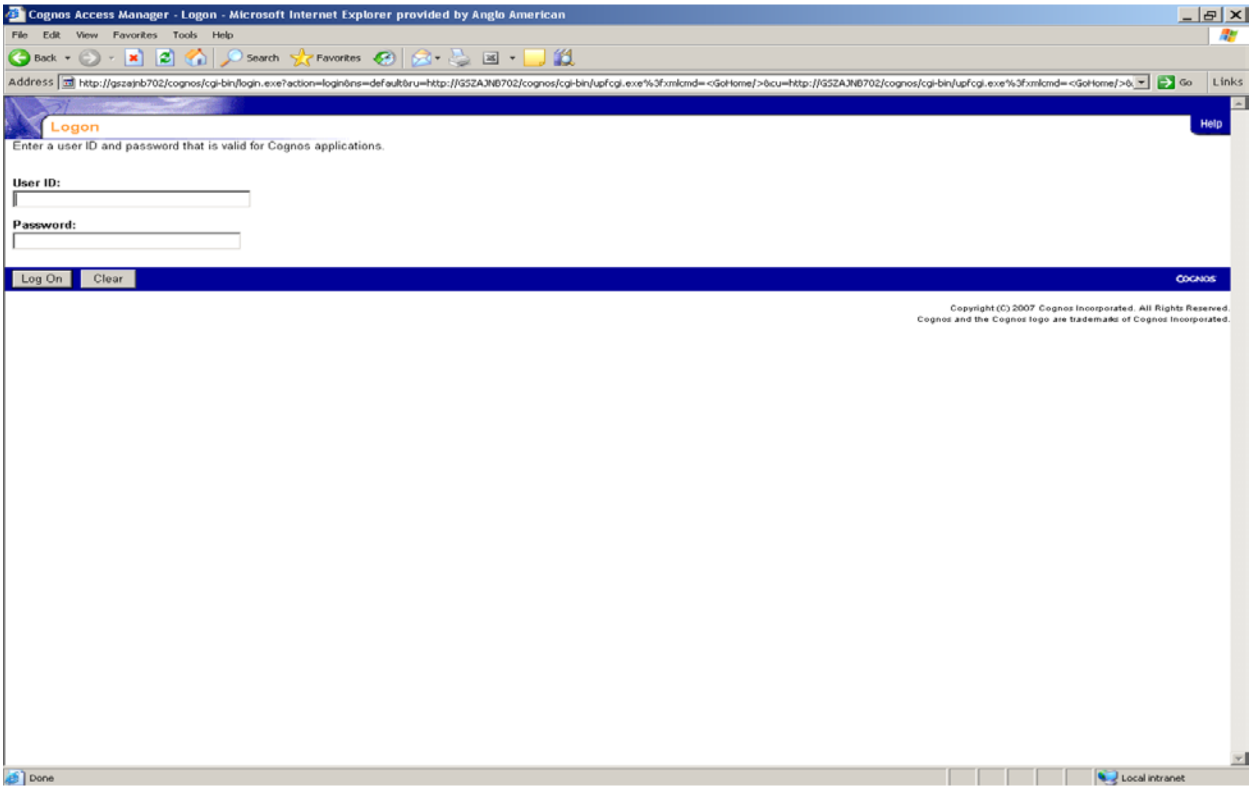
Expert evaluation

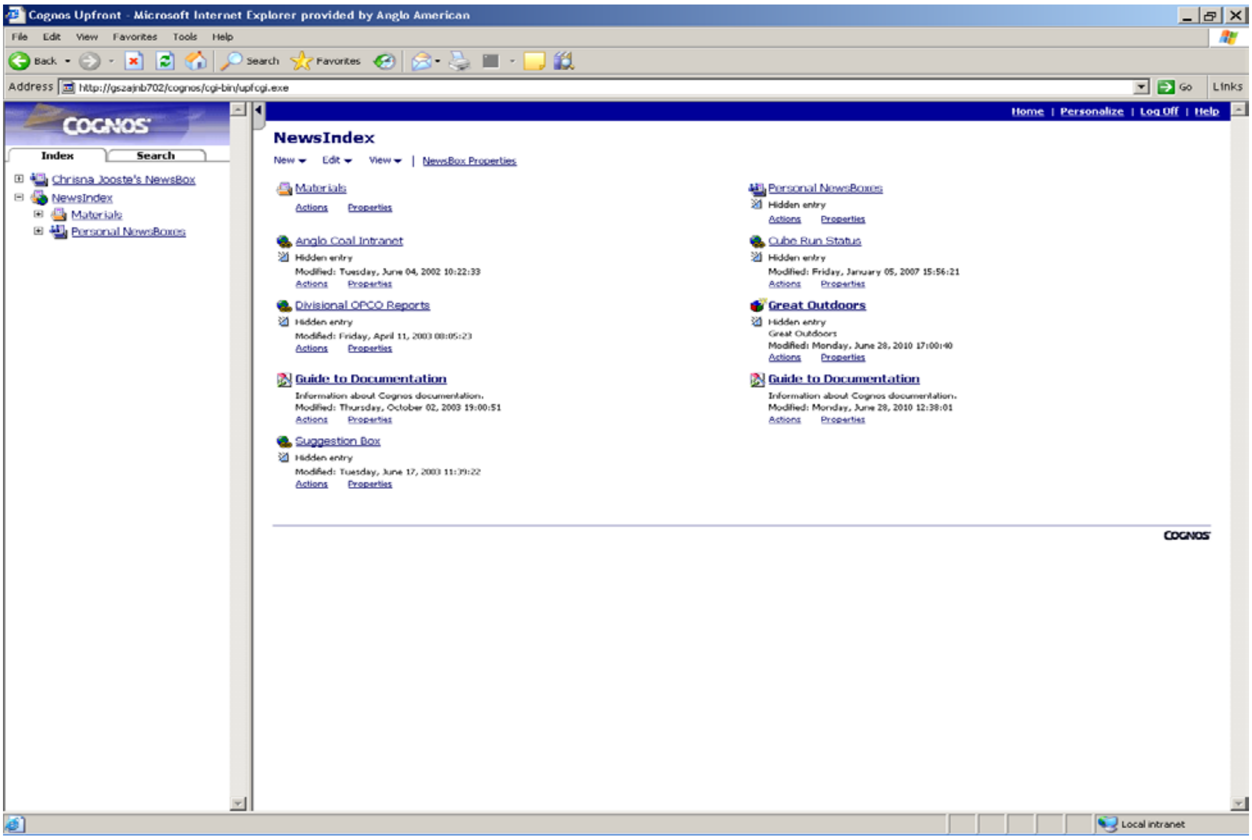
Consent form

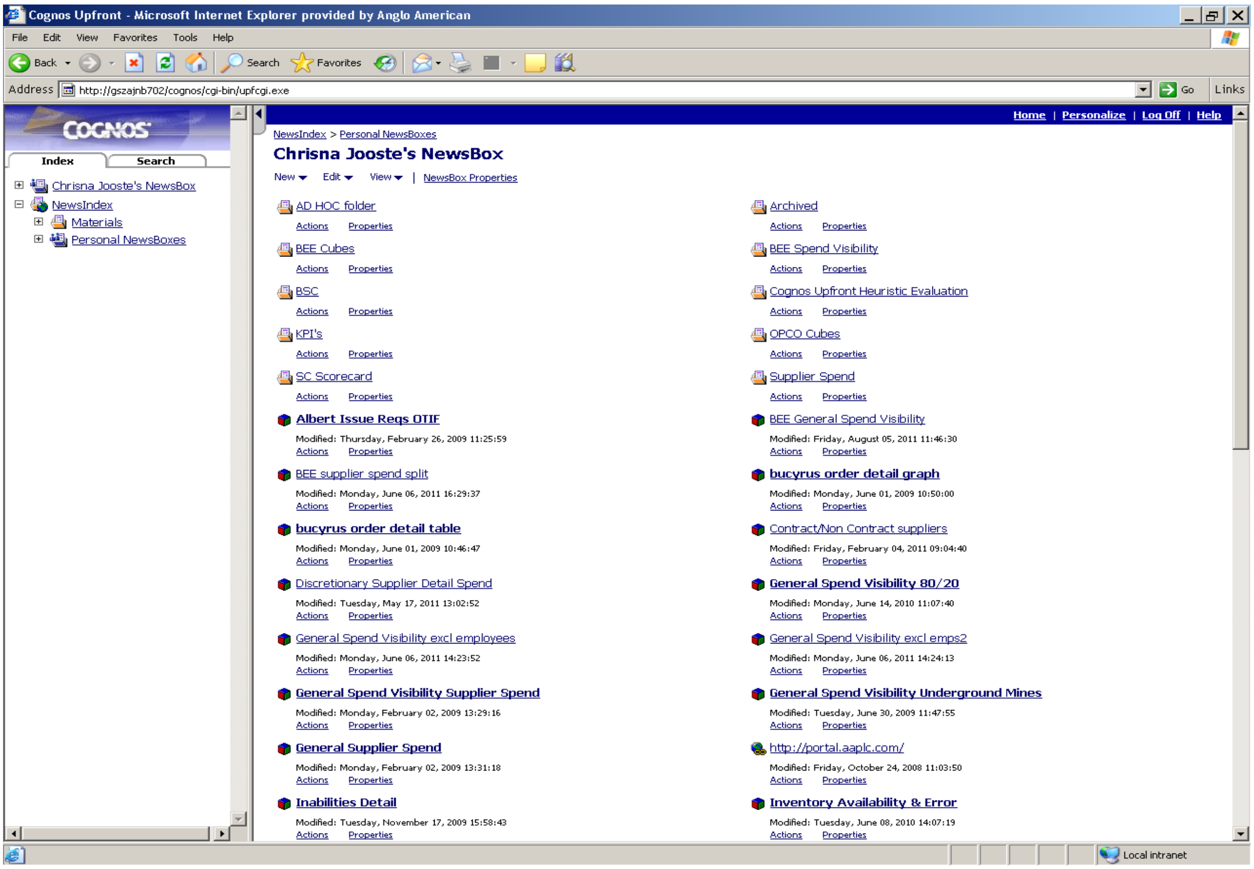
I, ___________________________________ working as ___________________________________ at ______________________________________ in the department/division of ____________________________________ state that I am willingly participating in this heuristic evaluation exercise as an expert evaluator.

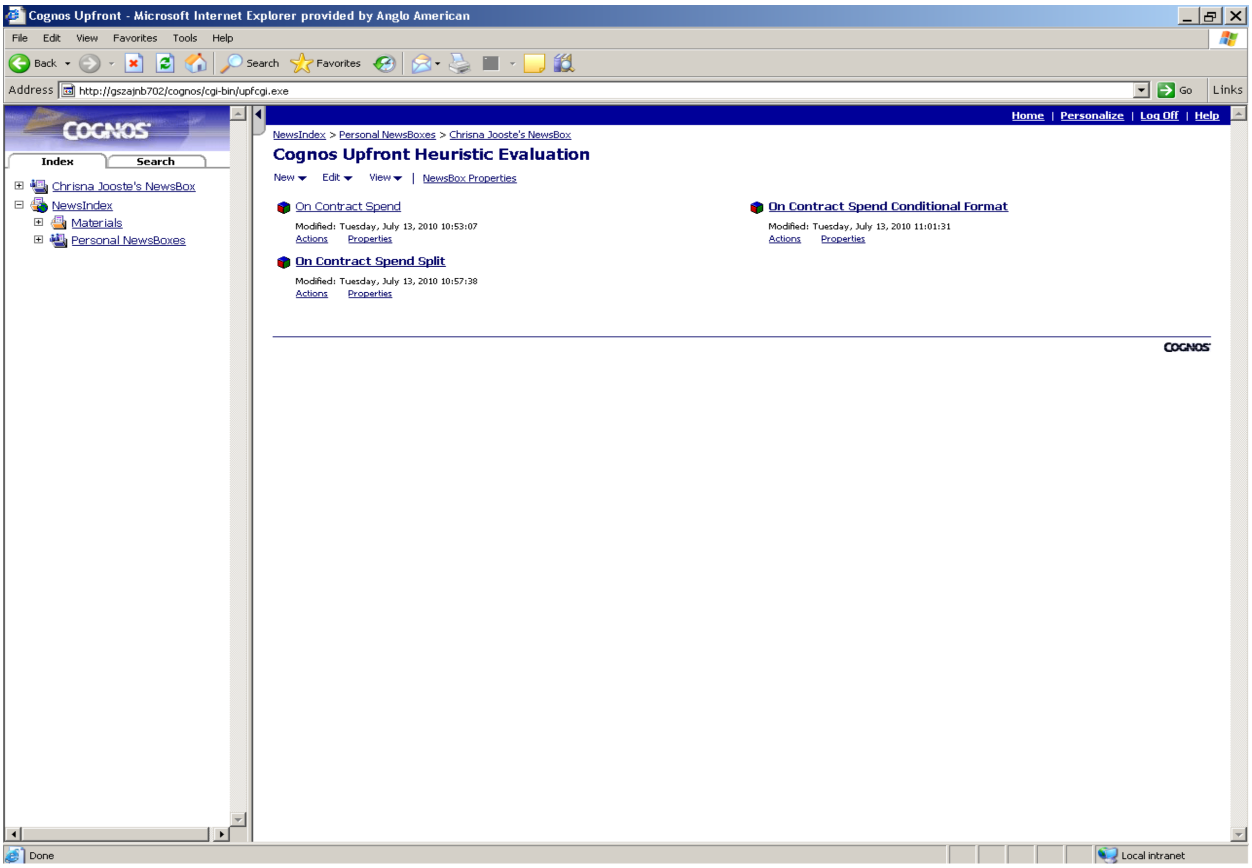
I realise that the findings of the evaluation will be used for research purposes and that the findings will be published.

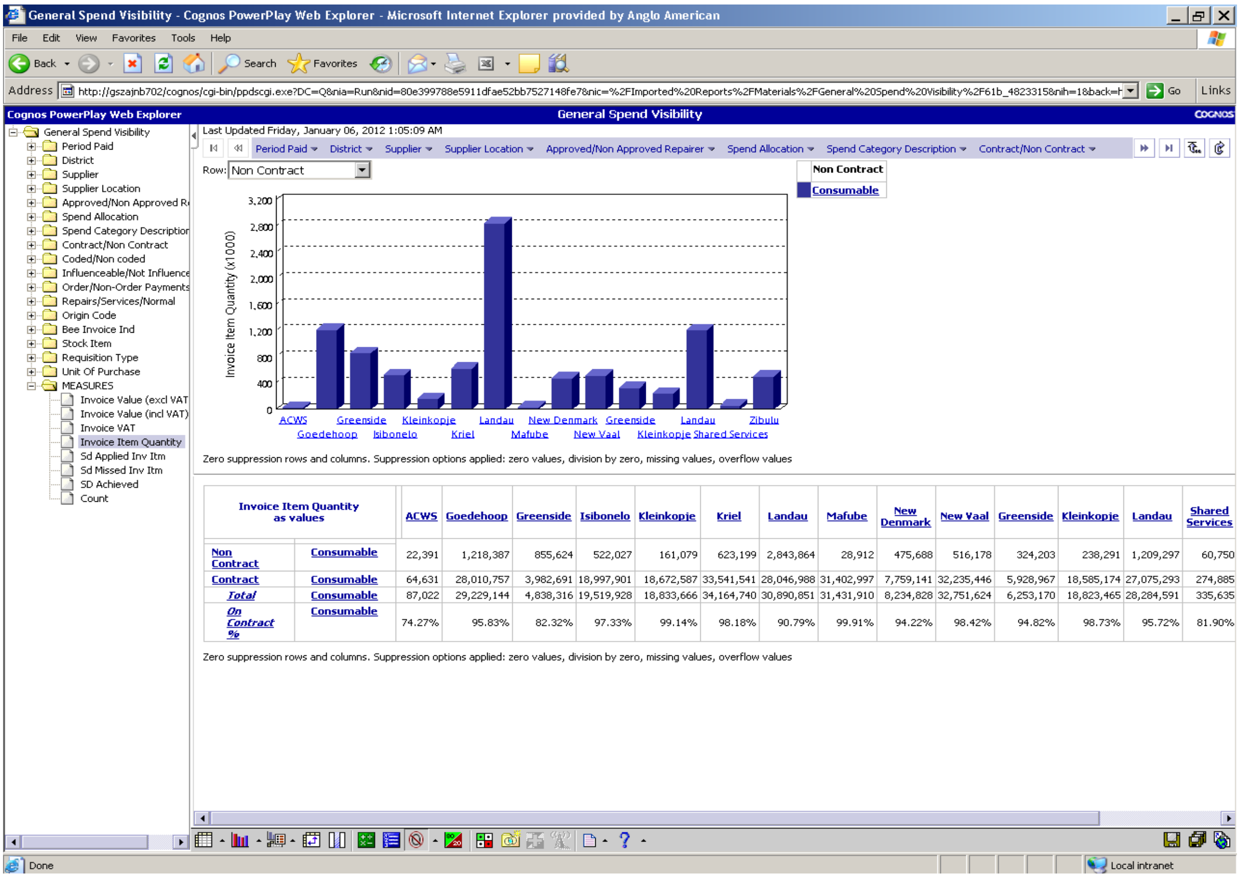
Signed _____________________________ date ________________________________

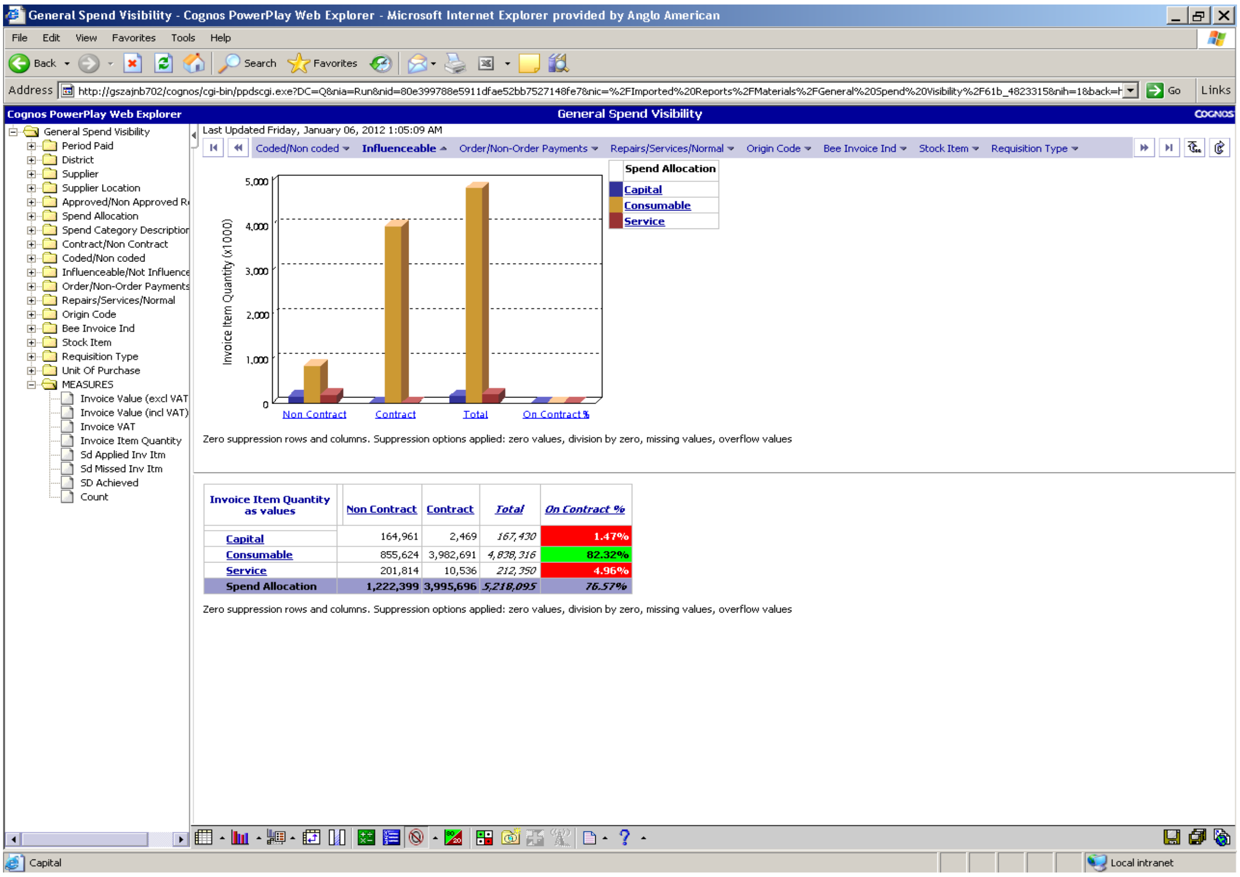

Cognos Access Manager - Logon - Microsoft Internet Explorer provided by Anglo American
Logon
Help
Enter a user ID and password that is valid for Cognos applications.
User ID:
Password:
Log On
Clear
Copyright (C) 2007 Cognos Incorporated. All Rights Reserved.
Cognos and the Cognos logo are trademarks of Cognos Incorporated.
Done
Local intranet


Cognos Upfront - Microsoft Internet Explorer provided by Anglo American
Home | Personalize | Log Off | Help
Index
Search
Chrisna Jooste's NewsBox
NewsIndex
Materials
Personal NewsBoxes
NewsIndex
New
Edit
View
NewsBox Properties
Materials
Personal NewsBoxes
Anglo Coal Intranet
Cube Run Status
Divisional OPCO Reports
Great Outdoors
Guide to Documentation
Guide to Documentation
Suggestion Box
Local intranet


Cognos Upfront - Microsoft Internet Explorer provided by Anglo American
File Edit View Favorites Tools Help
Address http://gszajnb702/cognos/cgi-bin/upfcgi.exe
Home | Personalize | Log Off | Help
Index Search
Chrisna Jooste's NewsBox
NewsIndex
Materials
Personal NewsBoxes
NewsIndex > Personal NewsBoxes
Chrisna Jooste's NewsBox
New Edit View | NewsBox Properties
AD HOC folder
Archived
BEE Cubes
BEE Spend Visibility
BSC
Cognos Upfront Heuristic Evaluation
KPI's
OPCO Cubes
SC Scorecard
Supplier Spend
Albert Issue Reqs OTIF
BEE General Spend Visibility
BEE supplier spend split
bucyrus order detail graph
bucyrus order detail table
Contract/Non Contract suppliers
Discretionary Supplier Detail Spend
General Spend Visibility 80/20
General Spend Visibility excl employees
General Spend Visibility excl emps2
General Spend Visibility Supplier Spend
General Spend Visibility Underground Mines
General Supplier Spend
http://portal.aaplc.com/
Inabilities Detail
Inventory Availability & Error
Actions Properties
Local intranet


Cognos Upfront - Microsoft Internet Explorer provided by Anglo American
File Edit View Favorites Tools Help
Address http://gszajnb702/cognos/cgi-bin/upfcgi.exe
Home | Personalize | Log Off | Help
Index Search
Chrisna Jooste's NewsBox
NewsIndex
Materials
Personal NewsBoxes
NewsIndex > Personal NewsBoxes > Chrisna Jooste's NewsBox
Cognos Upfront Heuristic Evaluation
New Edit View | NewsBox Properties
On Contract Spend
Modified: Tuesday, July 13, 2010 10:53:07
On Contract Spend Conditional Format
Modified: Tuesday, July 13, 2010 11:01:31
On Contract Spend Split
Modified: Tuesday, July 13, 2010 10:57:38
Actions Properties
COGNOS
Done
Local intranet


General Spend Visibility - Cognos PowerPlay Web Explorer - Microsoft Internet Explorer provided by Anglo American
Cognos PowerPlay Web Explorer
General Spend Visibility
Last Updated Friday, January 06, 2012 1:05:09 AM
Row: Non Contract
Non Contract
Consumable
Invoice Item Quantity (x1000)
ACWS Goedehoop Greenside Isibonelo Kleinkopje Kriel Landau Mafube New Denmark New Vaal Greenside Kleinkopje Landau Shared Services Zibulu
Zero suppression rows and columns. Suppression options applied: zero values, division by zero, missing values, overflow values
Invoice Item Quantity as values | ACWS | Goedehoop | Greenside | Isibonelo | Kleinkopje | Kriel | Landau | Mafube | New Denmark | New Vaal | Greenside | Kleinkopje | Landau | Shared Services
Non Contract | Consumable | 22,391 | 1,218,387 | 855,624 | 522,027 | 161,079 | 623,199 | 2,843,864 | 28,912 | 475,688 | 516,178 | 324,203 | 238,291 | 1,209,297 | 60,750
Contract | Consumable | 64,631 | 28,010,757 | 3,982,691 | 18,997,901 | 18,672,587 | 33,541,541 | 28,046,988 | 31,402,997 | 7,759,141 | 32,235,446 | 5,928,967 | 18,585,174 | 27,075,293 | 274,885
Total | Consumable | 87,022 | 29,229,144 | 4,838,316 | 19,519,928 | 18,833,666 | 34,164,740 | 30,890,851 | 31,431,910 | 8,234,828 | 32,751,624 | 6,253,170 | 18,823,465 | 28,284,591 | 335,635
On Contract % | Consumable | 74.27% | 95.83% | 82.32% | 97.33% | 99.14% | 98.18% | 90.79% | 99.91% | 94.22% | 98.42% | 94.82% | 98.73% | 95.72% | 81.90%
Zero suppression rows and columns. Suppression options applied: zero values, division by zero, missing values, overflow values


General Spend Visibility - Cognos PowerPlay Web Explorer - Microsoft Internet Explorer provided by Anglo American
Cognos PowerPlay Web Explorer
General Spend Visibility
Last Updated Friday, January 06, 2012 1:05:09 AM
Spend Allocation
Capital
Consumable
Service
Invoice Item Quantity (x1000)
Non Contract Contract Total On Contract %
Zero suppression rows and columns. Suppression options applied: zero values, division by zero, missing values, overflow values
Invoice Item Quantity as values | Non Contract | Contract | Total | On Contract %
Capital | 164,961 | 2,469 | 167,430 | 1.47%
Consumable | 855,624 | 3,982,691 | 4,838,316 | 82.32%
Service | 201,814 | 10,536 | 212,350 | 4.96%
Spend Allocation | 1,222,399 | 3,995,696 | 5,218,095 | 76.57%
Zero suppression rows and columns. Suppression options applied: zero values, division by zero, missing values, overflow values

ANNEXURE K: INSTRUMENT 2 - BUSINESS INTELLIGENCE HEURISTIC EVALUATION QUESTIONNAIRE

Usability Evaluation - usability design heuristics

System name: Cognos7 Upfront

Section A

SUMI:

- Efficiency – E
- Control – C
- Learnability – L
- Helpfulness – H

	Criteria	Severity Rating					Heuristic Evaluation	SUMI
1	**Hierarchical Display**							
	1.1 The highest level of information is displayed.	Strongly disagree				Strongly Agree		E
		1	2	3	4	5		
	1.2 The system displays a hierarchical map to determine level of data granularity.	Strongly disagree				Strongly Agree		E
		1	2	3	4	5		
2	**Page display, layout and structure**							
	2.1 The page is displayed in a clear and uncluttered fashion.	Strongly disagree				Strongly Agree		A
		1	2	3	4	5		
	2.2 The page presents data in a well structured manner.	Strongly disagree				Strongly Agree		E
		1	2	3	4	5		
	2.3 The navigational buttons are easily identifiable.	Strongly disagree				Strongly Agree		E
		1	2	3	4	5		

	2.4 Task icons are easily and logically identifiable.	Strongly disagree				Strongly Agree		H
		1	2	3	4	5		
	2.5 Cube name is displayed clearly.	Strongly disagree				Strongly Agree		E/A/H
		1	2	3	4	5		
	2.6 Dimensions are displayed clearly.	Strongly disagree				Strongly Agree		E/A/H
		1	2	3	4	5		
3	**Cube Navigation**							
	3.1 It is possible to explore cube dimensions without getting lost.	Strongly disagree				Strongly Agree		H/E/C
		1	2	3	4	5		
	3.2 It is possible to view cube measures easily.	Strongly disagree				Strongly Agree		E/H
		1	2	3	4	5		
	3.3 The cube dimensions or measures are easily selected.	Strongly disagree				Strongly Agree		E/C
		1	2	3	4	5		
4	**Data**							
	4.1 Data is easily accessed.	Strongly disagree				Strongly Agree		E/C
		1	2	3	4	5		
	4.2 The data has recently been updated.	Strongly disagree				Strongly Agree		E
		1	2	3	4	5		

	4.3 It is easy to export data to another format.	Strongly disagree				Strongly Agree		C/E
		1	2	3	4	5		
	4.4 There are adequate choices of export formats available.	Strongly disagree				Strongly Agree		C/E
		1	2	3	4	5		
5	**Presentation of information**							
	5.1 Data is easy to read.	Strongly disagree				Strongly Agree		A/E
		1	2	3	4	5		
	5.2 Data dimensions are clearly visible.	Strongly disagree				Strongly Agree		A/E
		1	2	3	4	5		
	5.3 Data measures are formatted clearly.	Strongly disagree				Strongly Agree		A
		1	2	3	4	5		
	5.4 The display of data as a graph is useful.	Strongly disagree				Strongly Agree		E
		1	2	3	4	5		
	5.5 The system enables good analysis.	Strongly disagree				Strongly Agree		E
		1	2	3	4	5		
	5.6 The system prevents information overload.	Strongly disagree				Strongly Agree		E/A
		1	2	3	4	5		

	5.7 The system is useful to reveal trends and patterns that would otherwise not be visible	Strongly disagree				Strongly Agree		E
		1	2	3	4	5		
6	**Language**							
	6.1 The system uses terminology applicable to its intended audience.	Strongly disagree				Strongly Agree		A
		1	2	3	4	5		
7	**Value of information provided**							
	7.1 Sufficient information is provided to help users make a decision.	Strongly disagree				Strongly Agree		E
		1	2	3	4	5		
	7.2 There is functionality (comparison charts etc) to assist in the decision making.	Strongly disagree				Strongly Agree		E
		1	2	3	4	5		
8	**Utility**							
	8.1 The website provides a sufficient set of functions that enable users to carry out all their tasks effectively.	Strongly disagree				Strongly Agree		E/C/H
		1	2	3	4	5		
	8.2 The site provides a 'save' functionality for future use.	Strongly disagree				Strongly Agree		C/H/E
		1	2	3	4	5		

	8.3 The site provides a knowledge sharing functionality.	Strongly disagree				Strongly Agree		C/E
		1	2	3	4	5		
9	**Effectiveness**							
	9.1 The website aids users in being effective, i.e. supports users in learning, in conducting their task efficiently, in accessing the information they need, and viewing the data they want.	Strongly disagree				Strongly Agree		L/E/C
		1	2	3	4	5		
10	**Efficiency**							
	10.1 Once users have learned how to use a system, they can sustain a high level of productivity to carry out their tasks.	Strongly disagree				Strongly Agree		L/E
		1	2	3	4	5		
11	**Learnability**							
	11.1 It is easy for the user to work out how to use the system by exploring the interface and trying out certain actions.	Strongly disagree				Strongly Agree		L
		1	2	3	4	5		
12	**Memorability**							
	12.1 The interface provides support to assist users in remembering how to carry out tasks.	Strongly disagree				Strongly Agree		L/H
		1	2	3	4	5		

13	Security						
	13.1 The system asks for a sign-on and password and automatically locks after the user has been inactive for a period of time.	Strongly disagree				Strongly Agree		C
		1	2	3	4	5		
	13.2 The user is restricted to only view data that is applicable to his/her profile.	Strongly disagree				Strongly Agree		C
		1	2	3	4	5		
14	Satisfaction							
	Rate the system based on the following: 1 – very poor 2 - average 3 - above average 4 - good 5 – excellent	1	2	3	4	5		A/E/H/C/L

Please write any additional comments or elaborations you may have in the space below.

____
____
____
____
____
____
____
____
____
____
____

<u>Section B</u>: Post-test - User experience design heuristics questionnaire

System name: ___________________________________

1. Please select from the list of positive and negative emotions that you may have experienced while using the system.

Positive experience		**Negative experience**	
Easy to use		Cluttered	
Enjoyable		Frustrating	
Appealing		Overwhelming	
Useful		Time consuming	
Comprehensive		Annoying/irritating	
Logical			
Other:		Other:	

2. Rate the system based on aesthetics.

	Bad		Average		Good	
Use of colour	-3	-2	-1	1	2	3
Use of graphs	-3	-2	-1	1	2	3
Clear and easy to read	-3	-2	-1	1	2	3
Visual load – (How much on page)	-3	-2	-1	1	2	3
Text size	-3	-2	-1	1	2	3
Text colour	-3	-2	-1	1	2	3
Overall visual appeal	-3	-2	-1	1	2	3
Compared to other BI systems you have seen and used	-3	-2	-1	1	2	3

3. Rate the system based on your overall experience.

Thank you for your participation

Questionnaire: Usability Testing Evaluation of Business Intelligence system

Note: all the information you provide in this questionnaire is confidential and will only be used for research purposes.

Background questionnaire

1.1 Please indicate your age

18-24	***25-34***	***35-44***	***45 +***

1.2 Please indicate your gender

Male	Female

1.3 What is your home language

English	Afrikaans	Zulu	Xhosa	Sotho	Other

If other, please specify ____________________

1.4 For how long have you been an business intelligence user?

0-3 months	3-12 months	12-24 months	24-48 months	48+ months

1.5 Indicate if you have experience with any of the following business intelligence areas.

OLAP cubes	Data mining	Catalogs	Reports	Dashboards

2. Pre-test questionnaire

2.1 Have you ever used a Business Intelligence system?

Yes	***No***

If you answered "Yes" in question 2.1 above, please complete questions 2.2 - 2.5, otherwise proceed to question 2.6.

2.2 How often do you use Business Intelligence systems?

Number of times	***(Please circle applicable option)*** ***(per) day / week / month / year***

2.3 If you answered "Yes" in question 2.1 above, which features do you use most often?

a ____

b ____

c ____

2.4 If you answered “Yes” in question 1 above, which features do you least often use?

a ____________________

b ____________________

c ____________________

2.5 If you answered “Yes” in question 2.1 above, is there anything you specifically like or dislike about Business Intelligence systems?

Like ____________________

____

Dislike ____________________

____

2.6 Please describe what is important to you in the design of Business Intelligence systems in order to create a good user experience.

____

____

____

3. Post test performance questionnaire

3.1 Cognos7 Upfront

Please rate the website on the following:					
1.1 I would like to use this system frequently next time I require data.	Strongly disagree			strongly agree	
	1	2	3	4	5
1.2 I found the system unnecessarily complex.	strongly agree			strongly disagree	
	1	2	3	4	5
1.3 I thought the system was easy to use.	strongly disagree			strongly agree	
	1	2	3	4	5
1.4 I think that I would need the support of a technical person to be able to use this system.	strongly agree			strongly disagree	
	1	2	3	4	5
1.5 I found the various functions in this system were well integrated.	strongly disagree			strongly agree	
	1	2	3	4	5
1.6 I found the various functions in this system were easily identifiable.	strongly disagree			strongly agree	
	1	2	3	4	5
1.7 I thought there was too much inconsistency in this system.	strongly agree			strongly disagree	
	1	2	3	4	5
1.8 I Believe that most people would learn to use this system very quickly.	strongly agree			strongly disagree	
	1	2	3	4	5
1.9 I found the system cumbersome to use.	strongly agree			strongly disagree	

	1	2	3	4	5
1.10 I felt confident using the system.	strongly disagree				strongly agree
	1	2	3	4	5
1.11 I needed to learn a lot of things before I could get going with this system.	strongly agree				strongly disagree
	1	2	3	4	5

3.2 What is your overall impression of the system?

____

____

____

____

____

____

3.3 Please write two things you liked BEST about the system.

____

____

____

____

____

____

3.4 Please write two things you liked LEAST about the system.

3.5 If you could make 1 change to this system, what change would you make?

3.6 Would you recommend this system to a friend or colleague?

Yes	***No***

Why?

3.7 Do you trust this system? Please motivate your answer

____

____

____

____

____

____

3.8 Please rate the system on a scale of 0 to 10.

0	1	2	3	4	5	6	7	8	9	10

Overall comment

Please write any additional comments or elaborations you may have in the space below.

____

____

____

Comments continued:

____

____

____

____

____

____

Thank you very much for your valuable input.

ANNEXURE L: HEURISTIC EVALUATION DATA SHEET

	Heuristic Evaluation - Data coding						Usability Principle	
	Section A							
	Question	Participant A	Participant B	Participant C	Participant D			
1.1	1	4	3	2	3		E	
1.2	2	2	3	2	1		E	
2.1	3	2	2	2	1		A	
2.2	4	3	2	3	2		E	
2.3	5	1	3	2	1		E	
2.4	6	2	2	2	1		H	
2.5	7	2	2	2	1		H	
2.6	8	4	3	3	3		H	
3.1	9	3	3	3	3		E	
3.2	10	2	2	2	1		E	
3.3	11	3	2	3	3		C	
4.1	12	4	2	3	3		E	
4.2	13	2	2	3	1		E	
4.3	14	4	2	3	2		C	
4.4	15	2	3	3	2		C	
5.1	16	3	2	2	2		E	
5.2	17	3	2	3	2		E	
5.3	18	3	2	3	2		A	
5.4	19	3	2	3	2		E	
5.5	20	2	3	3	2		E	
5.6	21	4	3	3	3		E	
5.7	22	4	3	4	3		E	
6.1	23	4	3	3	3		A	
7.1	24	3	3	4	3		E	
7.2	25	3	2	2	2		E	
8.1	26	3	2	3	2		C	
8.2	27	3	2	2	2		C	
8.3	28	4	3	3	3		E	
9.1	29	4	3	3	3		E	
10.1	30	4	3	3	3		L	
11.1	31	3	2	2	2		L	
12.1	32	1	3	2	1		L	
13.1	33	3	2	2	2		C	
13.2	34	3	2	2	2		C	
	35	3	2	2	3			0.5
		2.942857143	2.428571429	2.628571429	2.142857143	2.535714		
		59%	49%	53%	43%	51%		

Emotions Experienced			
Positive Experience	**(Count)**	**Negative Experience**	(Count)
Easy to use	2	**Cluttered**	1
Enjoyable	1	**Frustrating**	2
Appealing	0	**Overwhelming**	3
Useful	3	**Time consuming**	2
Comprehensive	1	**Annoying/Irritating**	2
Logical	1		
Other			

Aesthetics Coding						
Aesthetics	**Worst**		**Average**			**Best**
Use of colour	0	1	2	3	4	5
Use of graphs	0	1	2	3	4	5
Clear and easy to read	0	1	2	3	4	5
Visual load	0	1	2	3	4	5
Text size	0	1	2	3	4	5
Text colour	0	1	2	3	4	5
Overall visual appeal	0	1	2	3	4	5
Compared to other BI systems you have seen/used	0	1	2	3	4	5

Aesthetics Data						
Aesthetics	**Worst**		**Average**			**Best**
Use of colour	0	2	1	1	0	0
Use of graphs	0	0	1	1	2	0
Clear and easy to read	0	1	1	1	1	0
Visual load	0	0	0	2	2	0
Text size	0	1	2	1	0	0
Text colour	0	2	2	0	0	0
Overall visual appeal	0	0	1	2	1	0
Compared to other BI systems you have seen/used		0	2	2	0	0

Aesthetics Scores						
Aesthetics	**Worst**		**Average**			**Best**
Use of colour	0	2	2	3	0	0
Use of graphs	0	0	2	3	8	0
Clear and easy to read	0	1	2	3	4	0
Visual load	0	0	0	6	8	0
Text size	0	1	4	3	0	0
Text colour	0	2	4	0	0	0
Overall visual appeal	0	0	2	6	4	0
Compared to other BI systems you have seen/used	0	0	4	6	0	0

User Experience Coding						
User Experience	**Worst**		**Average**			**Best**
Features & functionality	0	1	2	3	4	5
Structure of information	0	1	2	3	4	5
Structure of navigation	0	1	2	3	4	5
Root page layout	0	1	2	3	4	5
Other page layout	0	1	2	3	4	5
Customisation	0	1	2	3	4	5
Use of graphs	0	1	2	3	4	5
Ease of use	0	1	2	3	4	5
Level of relevance to user	0	1	2	3	4	5

User Experience Data						
User Experience	**Worst**		**Average**			**Best**
Features & functionality			1	2	1	
Structure of information			1	2		1
Structure of navigation		1	2	1		
Root page layout		1	1	1	1	
Other page layout			1	3		
Customisation			1	3		
Use of graphs		1	1	1	1	
Ease of use		1	1	2		
Level of relevance to user			2	1	1	

User Experience Scores						
User Experience	**Worst**		**Average**			**Best**
Features & functionality	0	0	2	6	4	0
Structure of information	0	0	2	6	0	5
Structure of navigation	0	1	4	3	0	0
Root page layout	0	1	2	3	4	0
Other page layout	0	0	2	9	0	0
Customisation	0	0	2	9	0	0
Use of graphs	0	1	2	3	4	0
Ease of use	0	1	2	6	0	0
Level of relevance to user	0	0	4	3	4	0

Heuristic Evaluation Post Test - Data coding

Section C - Participant answers

Question	Prticpnt A	Prticpnt B	Prticpnt C	Participant D
1	4	3	2	3
2	4	2	3	3
3	4	3	3	3
4	4	3	4	3
5	3	2	2	3
6	4	3	2	2
7	4	3	3	3
8	3	2	3	2
9	4	3	3	2
10	3	2	3	3
11	3	2	2	2

Section C - Participant data coding

Question	Prticpnt A	Prticpnt B	Prticpnt C	Participant D		
1	3	2	2	2	5	0.45
2	3	2	2	2	5	0.45
3	4	2	2	3	5	0.55
4	4	3	3	3	5	0.65
5	3	2	2	3	5	0.5
6	3	3	2	2	5	0.5
7	4	3	3	3	5	0.65
8	3	2	3	2	5	0.5
9	4	3	2	2	5	0.55
10	3	2	2	1	5	0.4
11	3	2	2	2	5	0.45
						0.513636

ANNEXURE M: SUMI STATISTICS VARIABLES

Frequencies of attribute variables

		Eff		
< 20	5	10.00	5	10.00
20-29	5	10.00	10	20.00
30-39	10	20.00	20	40.00
40-49	6	12.00	26	52.00
50-59	10	20.00	36	72.00
60-80	14	28.00	50	100.00
		Contr		
< 20	3	6.00	3	6.00
20-29	7	14.00	10	20.00
30-39	9	18.00	19	38.00
40-49	5	10.00	24	48.00
50-59	14	28.00	38	76.00
60-80	12	24.00	50	100.00
		Learna		
< 20	5	10.00	5	10.00
20-29	3	6.00	8	16.00
30-39	12	24.00	20	40.00
40-49	6	12.00	26	52.00
50-59	6	12.00	32	64.00
60-80	18	36.00	50	100.00

Frequencies of attribute variables condensed into categories with sufficient frequencies: Chose the score value of 37 as category boundary

		Global		
Global	**Frequency**	**Percent**	**Cumulative Frequency**	**Cumulative Percent**
<37	15	30.00	15	30.00
>36	35	70.00	50	100.00
		Eff		
<37	19	38.00	19	38.00
>36	31	62.00	50	100.00
		Aff		
<37	11	22.00	11	22.00
>36	39	78.00	50	100.00
		Helpf		
<37	13	26.00	13	26.00
>36	37	74.00	50	100.00
		Contr		
<37	18	36.00	18	36.00
>36	32	64.00	50	100.00
		Learna		
<37	17	34.00	17	34.00
>36	33	66.00	50	100.00

ANNEXURE N: E-MAIL FROM DR. KIRAKOWSKI - HARDWARE FAILURE

Jooste, Chrisna

From:	Kirakowski, Jurek [jzk@ucc.ie]
Sent:	02 August 2011 03:45 PM
To:	Jooste, Chrisna
Subject:	RE: SUMI request
Follow Up Flag:	Follow up
Flag Status:	Completed

Hi Chrisna

It looks very much as if the last seven replies were lost in a crash that occurred half way through 2010: my hard disk developed a black hole exactly where the SUMI records were being kept so that it was not until some months later that I discovered that file size for some of these archives was zero. I was able to restore the system as of 16th April which is where the data set I sent you comes from.

Apologies: I just had another look around in various odd places but that's the best I can do :-(#

I think it's still worth doing the reliability analysis though - usually adding data makes things better so you'd be able to say the reliability was 'at least' at this standard (now I'm getting curious!)

I shall be away sporadically during August.

Best wishes

jk

-----Original Message-----
From: Jooste, Chrisna [mailto:Cjooste@anglocoal.co.za]
Sent: 01 August 2011 10:29
To: Kirakowski, Jurek
Cc: van Biljon, Judy
Subject: FW: SUMI request

Dear Dr. Kirakowski,

Many thanks for the quick response, the raw data sent through and the explanation of the composition of SUMI. It's much appreciated!

Please confirm the data set sent with your previous mail as the correct one, according to your mail (please see attached) dated 29 April, we received 50 completed responses?

Many thanks,
Chrisna

-----Original Message-----
From: Kirakowski, Jurek [mailto:jzk@ucc.ie]
Sent: 29 July 2011 03:34 PM
To: Jooste, Chrisna
Subject: RE: SUMI request

Hi Chrisna

1

Please find a copy of the raw data file. I note the sample size is 43 which is a little small for reliability analysis, and since it all comes from one product there is not as much variation between the responses as one might want (ie there may be a 'truncated range' effect) - but we have to do what we can.

The identification of which items belong to which scale is as follows:

For the subscales Efficiency, Affect, Helpfulness, Control and Learnability, item 1 is Efficiency, 2 is Affect... 5 is Learnability, 6 is Efficiency again and so on cyclically so that item 50 at the end is Learnability.

For the Global subscale the following 25 items contribute:

7, 8, 15, 18, 19, 21, 23, 24, 26, 27, 28, 31, 35, 36, 37, 38, 39, 41, 42, 43, 44, 45, 46, 48, 49

It's ages since I did a reliability analysis on SUMI data: would you be so kind as to return the favour and give me a result of your analysis? I presume your statistician will be using something like Cronbach's Alpha coefficient and item-whole correlations?

In general I would expect Alphas of .8 or more for the subscales and somewhat higher for the Global because there are more questions in it.

Good luck with the analysis.

Best wishes

jk

PS I enclose some data gathered by my colleague Nigel Claridge on a variety of business systems with SUMI. He's away on vacation at present but I can ask him to send you the powerpoints of a talk he gives on the basis of this data - which is absolutely fascinating!

-----Original Message-----
From: Jooste, Chrisna [mailto:Cjooste@anglocoal.co.za]
Sent: 29 July 2011 12:55
To: Kirakowski, Jurek
Cc: van Biljon, Judy; Muller, Helene
Subject: SUMI request

Dear Dr. Kirakowski

I made use of the SUMI questionnaire during April 2010 in order to test the usability of a Business Intelligence system (Cognos7 - Upfront) as part of my MSc studies at the University of South Africa. You also provides us with the test analysis and a very helpful explanation.

Would it be possible to provide us with the individual scores of the sample? The statistician that is assisting us would like to perform scale reliability testing to ensure consistency.

We would also like to know which SUMI questions map to which usability principle (i.e. questionnaire parameters) addressed by SUMI?

Your assistance will be greatly appreciated.

Kind Regards

Chrisna Jooste

Business Intelligence & Process Coordinator

logo_signature

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ANNEXURE O: QUIS

Q.U.I.S Generic Use Interface Questionnaire

OVERALL REACTIONS TO THE SOFTWARE	
terrible *wonderful* 0 1 2 3 4 5 6 7 8 9	*inadequate power* *adequate power* 0 1 2 3 4 5 6 7 8 9
difficult *easy* 0 1 2 3 4 5 6 7 8 9	*dull* *stimulating* 0 1 2 3 4 5 6 7 8 9
frustrating *satisfying* 0 1 2 3 4 5 6 7 8 9	*rigid* *flexible* 0 1 2 3 4 5 6 7 8 9

SCREEN	
Characters on the computer screen hard to read easy to read 0 1 2 3 4 5 6 7 8 9	*Sequence of screens* confusing very clear 0 1 2 3 4 5 6 7 8 9
Highlighting on the screen simplifies task not at all very much 0 1 2 3 4 5 6 7 8 9	*Organization of information on screen* confusing very clear 0 1 2 3 4 5 6 7 8 9

· LEARNING	
Learning to operate the system difficult easy 0 1 2 3 4 5 6 7 8 9	*Tasks can be performed in a straight-forward manner* never always 0 1 2 3 4 5 6 7 8 9
Exploring new features by trial and error difficult easy 0 1 2 3 4 5 6 7 8 9	*Remembering navigation / use of commands* difficult easy 0 1 2 3 4 5 6 7 8 9

· SYSTEM CAPABILITIES	
System speed slow fast enough 0 1 2 3 4 5 6 7 8 9	*Correcting your mistakes* difficult easy 0 1 2 3 4 5 6 7 8 9
System reliability unreliable reliable '0 1 2 3 4 5 6 7 8 9	*Experienced and inexperienced users' needs are taken into consideration* never always 0 1 2 3 4 5 6 7 8 9

ANNEXURE P: SUS

System Usability Scale

	Strongly disagree 1	2	3	4	Strongly agree 5
1. I think that I would like to use this system frequently					
2. I found the system unnecessarily complex					
3. I thought the system was easy to use					
4. I think that I would need the support of a technical person to be able to use this system					
5. I found the various functions in this system were well integrated					
6. I thought there was too much inconsistency in this system					
7. I would imagine that most people would learn to use this system very quickly					
8. I found the system very cumbersome to use					
9. I felt very confident using the system					
10. I needed to learn a lot of things before I could get going with this system					