CREATING DATA VISUALISATIONS FOR DASHBOARDS USING PARTICIPATORY DESIGN AND LOW-FIDELITY PROTOTYPING

by

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DECLARATION

I, JS van der Merwe, hereby declare that

- The dissertation titled "CREATING DATA VISUALISATIONS FOR DASHBOARDS USING PARTICIPATORY DESIGN AND LOW-FIDELITY PROTOTYPING" is my own work,
- I have made reference to all the sources that I have used,
- I have not submitted this dissertation, in part or in whole, to any other university for the purpose of assessment.

JS van der Merwe 19 October 2018

ABSTRACT

As the business world becomes more data-driven, it is becoming increasingly important to gain insights into organisational data to gain understanding and thus gain competitive advantages. Business intelligence is the term used for the methods and tools used by organisations to gain this understanding. One of these methods is data visualisation, which presents insights into the data in a supposedly easy-to-digest format to the information consumers. A common tool used for data visualisation in organisations is a dashboard, which is a collection of informative visualised data pieces. There are, however, some problems with data visualisation and dashboarding within organisations. Visualising data is a complex task, as the creator of the visualisation needs an understanding of how the human visual perception system works. There is also the matter of the visualisation being open to interpretation, and some users might not understand the visualisation as intended. In addition, there are issues directly related to dashboards. Creating dashboards can seem like an intimidating task, and some users might feel that dashboards attempt to oversimplify the intricacies of their organisation. Adding to these problems is the perception from management that their inputs into deciding which metrics to display on the dashboard was not requested.

This study proposes making use of participatory design and low-fidelity prototyping to get around these problems. Making use of participatory design will help give a voice to the users, as they are active in the design of the dashboard. Low-fidelity prototyping is a low-cost and practical way to create the prototypes, as it makes use of inexpensive items, can easily be discarded when a mistake has been made, requires less time than a high-fidelity prototype, and stimulates creativity. By making use of design science and case study research, participants were tasked with creating a data visualisation based on a company problem. A single design iteration was used. The observations, and post-session interviews were used to create a method, the artefact of the design science research. This model can now be tested and refined further.

Keywords: Business intelligence, participatory design, data visualisation, dashboards, low-fidelity prototyping

DEDICATION

This dissertation is dedicated to the memory of prof. Helene Gelderblom (1963 – 2018). She sparked my interest in academics, and guided me with great determination and humility throughout most of the journey. Her kindness and wisdom, and love for academics, will always be remembered fondly.

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1 INTRODUCTION

1.1 BACKGROUND INFORMATION

Understanding what is happening within a business is a vital part of the management of a successful business, as it helps the business maintain a competitive advantage over the competition (Yigitbasioglu & Velcu, 2012; Jaklič, Grublješič, & Popovič, 2018). Over the past decades, information systems have been developed to help businesses take a closer look at what is happening, not only within the business, but also in the competitive landscape. These information systems equip businesses with certain tools and processes to deepen management's understanding of and insight into their business. Business intelligence and analysis can help improve this understanding, as well as aid in making decisions within the necessary timeframe (Chen, Chiang, & Storey, 2012). At the core, business intelligence is a concept that refers to certain tools and data sources (Ranjan, 2008), used to provide stakeholders with relevant information to make business decisions (Negash, 2004).

The way business intelligence systems present information is an aspect well worth considering. Some business intelligence tools provide users with a visual representation of data to aid with decision-making. If there are simply rows of numbers, without any context to aid with the understanding of these numbers, there is very little purpose in taking them into account (Datig & Whiting, 2018). To provide numbers in a way which allows for insights to be gained from them, data visualisation is used (Datig & Whiting, 2018). Visualising data gives business intelligence analysts the opportunity to use their visual abilities to decide where action is needed (Negash, 2004). Data visualisation has been the focus of research for a long time; from discussing the advantages of making use of circles and bar charts for the illustration of statistics (Eells, 1926) to discussing the visualisation of big data (Bikakis & Sellis, 2016). Data visualisation is omnipresent in the modern and not-so-modern world, even if it might not seem evident at first, for example in weather instruments and music visualisations found in computer music players (Hohl, 2011).

Data visualisations are often organised in a specific way to aid in understanding them. Dashboards are popular tools used for the organisation of data visualisations. A dashboard is a combination of textual information and graphics, and contains the most important information necessary for specific objectives (Few, 2005). Designing dashboards, however, is not a simple task. There are many mistakes that designers must watch out for when designing dashboards. These mistakes include issues such as displaying more information than will comfortably fit on a single screen (Few, 2005) or using unnecessary decoration on the dashboard (Few, 2006). Perceptions can also hamper the development of dashboards, as the amount of work required to build dashboards can seem quite intimidating (Palpanas, Chowdhary, Mihaila, & Pinel, 2007). It is also difficult to get buy-in from management, as they feel that their opinions are not considered when deciding on dashboards measures (Allio, 2012). To counter this issue, the design of these dashboards needs to include consultation with some of the potential users of the dashboards. This means that the dashboards need to be designed in a user-centred fashion.

A user-centred approach to product development is used by most accomplished organisations (Smith, Smith, & Chen, 2013). User-centred design involves processes where the focus is placed on the artefact being designed, and the continual evaluation of whether it meets the needs of the user (Sanders, 2002). The aim of user-centred design is to put the users in a central position, to improve how users interact with the system (Teka, Dittrich, & Kifle, 2018). However, this does not quite solve the problem of management not being involved. This is where participatory design comes into play, with the aim to increase user involvement with the design (Sanders, 2002). Today, system developers are aware that users should be involved to make systems that are usable and whose worth is known by users (Pilemalm, Lindell, Hallberg, & Eriksson, 2007). It is especially important to involve the users at the beginning of the dashboard design phase to ensure that the dashboard will be successful (Chiang, 2009).

For the design of a data visualisation tool such as a dashboard, a low-fidelity prototype may be used. According to Rudd, Stern, and Isensee (1996), low-fidelity prototypes can be constructed quickly, without the need for a large investment of time or money. These factors will help to sell the concept of a low-fidelity prototyping method to management, as low-fidelity prototyping can be positioned as a time-saving and inexpensive method of design. This study investigated the use of low-fidelity prototyping for the design of dashboards to be used at management level in a business consulting firm, as resistance from management who use these dashboards can lead to the dashboard implementation being unsuccessful (Allio, 2012).

1.2 PROBLEM STATEMENT

Measuring performance within a company, for example return on investment, is an activity in which many businesses participate to stay competitive (Allio, 2012). Dashboards are popular tools used for this purpose, although their creation is sometimes fraught with difficulties. Dashboard creation is sometimes seen as an intimidating task and dashboards may require a substantial amount of time to develop (Palpanas et al., 2007). This perception is supported by the vast number of different available dashboard design options. These options can hinder an organisation's effective use of dashboards, as ample consideration needs to be given to the purpose of the dashboard (Yigitbasioglu & Velcu, 2012). This adds to the amount of time and effort needed to create a dashboard. Another factor that negatively impacts the design of dashboards is stakeholders being of the opinion that dashboards oversimplify the complex business world. This is problematic, as a principle of good dashboard design is to 'keep it simple' (Morton-Owens & Hanson, 2012). Another contributing factor is managerial resistance against dashboards. Some managers do not understand the data displayed by the dashboard as their input towards metrics used, such as performance measures, was never requested (Allio, 2012). In order to use dashboards to their full potential, better methods must be put in place across the organisation for guiding the design and rolling out dashboards (Allio, 2012).

1.3 PURPOSE OF THE STUDY

The purpose of this study was to create a new method for designing data visualisations meant to be used for management decision-making. The method made use of low-fidelity prototyping. It was developed by involving the potential users (i.e., management) in a process of participatory design of dashboards using low-fidelity prototyping techniques. Low-fidelity prototyping was used in this study due to its low cost and simplicity. Another reason for making use of low-fidelity prototyping was that it gave management a chance to be involved 'hands-on' in the design of the dashboards. This is a novel way of putting together a design team, as managers are often not included in design teams. This hands-on design, aided by participatory design, attempts to assist with the issue of managers not understanding the value of dashboards, as their input forms an integral part of the dashboards' design. By observing their design behaviour and how they used the prototyping material, and then analysing the prototypes that they came up with, suggestions were made regarding the best way to conduct such a participatory design exercise. The suggestions were evaluated and refined into a workable design method.

The research question addressed in this study is: How can low-fidelity prototyping in conjunction with participatory design be used in a design method for data visualisations?

1.4 RESEARCH OBJECTIVES

The objective of this research was to create a new methodology for data visualisation by incorporating participatory design and low-fidelity prototypes as a way to design dashboards. Practically, this research aimed to conduct a design session with managers in a consulting firm and create a method for data visualisation creation based upon the observations made during the session and the feedback received from participants afterwards. The purpose of the session was to observe how management created a dashboard with use of low-fidelity prototyping, and to gain insights from the participants afterwards by conducting interviews.

1.5 DELINEATIONS AND LIMITATIONS

This study only involved management in the creation of dashboards, as part of the problem addressed was to gain managerial support for the design of dashboards. Furthermore, this study did not take any demographic information into consideration, as the method was not applicable or tailored to suit only a specific group of people. Due to time constraints and availability issues, only one design session was held. This prevents comparisons to be made between different groups designing dashboards for the same scenario or the same group designing dashboards for more than one scenario.

1.6 ASSUMPTIONS

The study was conducted at an organisation where management make use of dashboards for budgeting and strategic planning purposes. As such, it was assumed that the participants would have knowledge about what dashboards are and what they are used for. It was further assumed that low-fidelity prototyping is an efficient way of conducting participatory design.

1.7 EXPECTED CONTRIBUTION

This research will provide a method to create dashboards in a way that will involve end users of the dashboards and not overwhelm the designers and developers creating the dashboard, as well as yield dashboards with enough detailed information to ensure that management do not feel that it undermines the complexities of their organisation.

1.8 DEFINITIONS

The following terms are important to understanding the research presented in this dissertation:

Human-computer interaction: The study of the interaction that takes place between computers and the users (Ritter, Baxter, & Churchill, 2014).

Business intelligence: Business intelligence indicates ideas and methods that utilise fact-based systems to enhance decision-making in businesses. The term also refers to the technology used to accomplish the enhanced decision-making (Lim, Chen, & Chen, 2013).

Dashboard: A dashboard is a screen containing various information-laden elements that aids information monitoring (Few, 2005).

Participatory design: Participatory design is a design process where end users of the system are involved in the design of the system (Unger, Nunnally, & Willis, 2013).

Low-fidelity prototype: A low-fidelity prototype is a low-cost prototype that is intended to illustrate look and feel, but has limited further functionality (Rudd et al., 1996).

User-centred design: An iterative design process of placing emphasis on what the user requires, conducting a task analysis, and conducting early testing and evaluation activities (Ritter et al., 2014).

1.9 ABBREVIATIONS

The following terms are used in abbreviated form in this document:

IT – Information technology

FBC – Freedom Business Consulting

1.10 CHAPTER OVERVIEW

This dissertation is divided into five chapters, the first being this introductory chapter. The aim of the introductory chapter was to provide the reader with knowledge of what is presented in the rest of this dissertation. The second chapter is the literature review, in which the literature relevant to the research question is discussed. The literature review in this dissertation focuses on business intelligence, data visualisation, dashboarding, user-centred design, participatory design and low-fidelity prototyping. The third chapter provides a discussion on the methods used to carry out the study. In this chapter, the methods used for gathering and analysing the data are discussed. This chapter also explains the ethical considerations relevant to this study.

The fourth chapter provides the reader with the details of the study carried out, and an analysis and the findings of the study. These findings include a thematic analysis of the observations made during the study, as well as a derived method for creating data visualisations using low-fidelity prototypes and participatory design. This chapter also maps the different parts of the derived method to the different stages of participatory design. The final chapter provides an explanation of how the different parts of the research described in this dissertation line up to the different components of design science, the conclusion drawn from the findings of the study, and areas for further research.

2 LITERATURE REVIEW

2.1 INTRODUCTION

This literature review consists of sections on business intelligence, an overview of data visualisation, the rationale behind data visualisation, and the limitations of data visualisation. This is followed by a discussion on what dashboards are, how they are used within businesses, and a brief overview of what is considered best practice when designing dashboards. An explanation of participatory design as well as its advantages and disadvantages then follows. Finally, an explanation is presented of low-fidelity prototyping, its advantages, disadvantages and applications.

2.2 BUSINESS INTELLIGENCE

This study originates from the concept of business intelligence. An early use of the concept of business intelligence was by Luhn (1958), in a paper describing an automated information distribution system. The concept of business intelligence as it is known today appeared in the 1980s (Davenport, 2006), rose to prominence during the 1990s (Chen et al., 2012), and continues to be a popular topic within the field of information systems. Determining how large amounts of data flowing into a business can be united and decoded is becoming an integral part of having a successful business (Gangadharan & Swami, 2004). The importance of business intelligence is increasing and is evolving to include not only technology, but also other components such as the infrastructure, applications and best practice necessary to make informed decisions (Lycett, 2013). Business intelligence should be understood to properly contextualise the study.

2.2.1 Business intelligence explained

Negash (2004, p. 177) states that “BI [business intelligence] systems combine data gathering, data storage, and knowledge management with analytical tools to present complex internal and competitive information to planners and decision makers.”

Business intelligence systems are tasked with providing certain functionalities to stakeholders. These functions are the creation of forecasts based on historical data, impact analysis, and on-demand access to data when answers to non-routine questions are needed (Negash, 2004). Popular business intelligence tools include ad hoc queries, analytical tools and predefined reports (Nelson, Todd, & Wixom, 2005). According to Tyson (as cited by Hannula & Pirttimaki, 2003), business intelligence consists of various data sources. These sources are customer intelligence, competitor intelligence, market intelligence, technological intelligence, product intelligence and environment intelligence. Hannula and Pirttimaki (2003) found that businesses do not see business intelligence as just some passing concept, but rather as a means to become more knowledgeable about their business environment and its development to provide support to operative actions. Gangadharan and Swami (2004, p. 140) describe business intelligence as “the result of in-depth analysis of detailed business data, including database and application technologies, as well as analysis practices”, and as using technology to gather and use information effectively to increase the impact of the business. Gangadharan and Swami (2004) also state that business intelligence assists with looking at all aspects of the business under the proverbial magnifying glass in order to find new streams of revenue and further reduce business costs. Business intelligence can thus be seen combining a holistic view of varied data with technology to evaluate all aspects of business in a continuous effort to gain insights into a business.

2.2.2 The business intelligence cycle

Business intelligence can be considered as cyclical (Rouibah & Ould-ali, 2002). Rouibah and Ould-ali (2002) discuss five phases of business intelligence: targeting, tracking, routing, interpreting and action. Targeting is concerned with keeping an eye on the environment of an organisation in order to determine the priorities for the following phase, tracking. Tracking is the selection and monitoring of critical weak signs. A weak sign (or signal) is simply one whose effect cannot be judged (Ansoff, as cited by Thorleuchter, Scheja, & Van den Poel, 2014). These weak signs, which are usually external, are then routed to inside the organisation. After this, information that the organisation has accumulated is interpreted into ‘actionable intelligence’, followed by action being taken if the interpretation points to something major. If this is not the case, the process moves back to the second phase where the information is refined if it is not precise enough. If the problem with the information is a boundary that is too large, the boundary must be changed, with the process going back to the first phase (Rouibah & Ould-ali, 2002).

2.2.3 Benefits of business intelligence

To rationalise the study of business intelligence, the benefits of business intelligence should be considered. These benefits, as discussed by Watson and Wixom (2007), are: cost savings due to the consolidation of data marts, time savings for both data suppliers and end users, large amounts of higher quality data, better decision-making, improved business processes, and the support of strategic business objective accomplishment. According to Gangadharan and Swami (2004), business intelligence is an important component of a long-term strategy to ensure that a business sustains success. Business intelligence improves the consistency of decisions and shifts the foundation of decision-making from making use of intuition to making use of data (Rubin & Rubin, 2013).

Petrini and Pozzebon (2009) found that business intelligence systems play a big role as channels for communication and information distribution. These business intelligence systems can improve the interaction that takes place between groups whose view is focused on established objectives by lending support to monitoring and evaluating results within a business. Furthermore, Petrini and Pozzebon (2009) found that business intelligence systems serve as a collaboration tool for knowledge discovery and sharing. Business intelligence tools enable businesses to gain an understanding of both their external and internal systems through the acquisition, organisation, analysis and use of information (Chung, Chen, & Nunamaker, 2005).

2.2.4 Business intelligence considerations

When implementing business intelligence solutions, an organisation has to consider the following (Gangadharan & Swami, 2004):

- The goals and priority for using information.
- Who the information users are.
- The information requirement differences between different groups of users.
- Whether the organisational culture allows for the use of information as a strategic asset.

- The corporate goals for the implementation of business intelligence.
- How decisions are made in the organisation, and whether business intelligence supports and facilitates the collaboration around data.

Isik, Jones, and Sidorova (2013) found that the quality of user access, flexibility of the business intelligence system, and integration with other systems are factors that contribute to better business intelligence system success. They also found that due attention must be given to providing users with access to business intelligence resources, and organisations must ensure that these systems integrate without hindrance with other systems. Finally, Isik et al. (2013) found that organisations must ensure that the process of decision-making is flexible, including the process of structured operational decisions. Business intelligence is an important channel for communication and spreading knowledge, and should ideally be permanent, trustworthy, accessible, as well as unambiguous (Petrini & Pozzebon, 2009).

2.2.5 Business intelligence components

Ranjan (2008) discusses four components of business intelligence, namely, data warehouse, data source, data mart, and query and reporting tools. The data warehouse component serves to support data cleaning and data aggregation, as well as containing operational data (Ranjan, 2008). Data warehousing is a core technique of business intelligence (Wang, 2015). The data source is where the data originates, and can consist of external data, historical data and/or operational databases (Ranjan, 2008). The data mart component refers to the container of strategic information set up per department, and supports a specific data unit, data function or data process (Ranjan, 2008). The last component is query and reporting tools, which refer to the systems that are used to query data and perform data analysis (Ranjan, 2008). These components are summarised in Table 1 below.

Table 1: Business intelligence components

Component	Description
Data warehouse	Supports a variety of data-related tasks, including cleaning and aggregation of data. It contains the operational data as well.
Data source	Data can come from a variety of different sources, including operational databases, external data, and historical data.
Data mart	Contains strategic information and is set up per department, as data needs differ between different departments. A data mart supports a specific data function, process or unit.
Query and reporting tools	Systems used to query the data, analyse important components and identify trends within the data. Data visualisation, in particular dashboards, falls into this category.

Adapted from Ranjan (2008)

2.2.6 Issues with business intelligence

Calculating the economic value of business intelligence systems using the usual avenues is a difficult task (Rubin & Rubin, 2013). Isik et al. (2013) found that organisations tend to place too much emphasis on the quality of business intelligence system data and that other considerations are forgotten about, which leads to a less successful system. Isik et al. (2013) concluded that, while data quality is a necessary capability, it is not the sole requirement for business intelligence success.

In many companies, business intelligence is managed on a departmental level, with inter-departmental variances in the use of analytics tools and personnel training, leading to discrepancies in key indicators within the organisation (Davenport, 2006). Another issue discussed by Davenport (2006) is that 20% to 40% of spreadsheets, which make up part of a traditional company's business intelligence, contain errors. Another issue is that the sharing of certain types of information with the use of business intelligence is a complicated task (Dong, Huang, Sinha, & Xu, 2014). It might also be difficult to gauge the performance of a business intelligence system, as the 'critical success factors' of the implementation of business intelligence systems are not well envisaged (Yeoh & Popovic, 2016).

2.3 DATA VISUALISATION

Presenting complicated information in a way that is understandable to users is known as information design (Black, Luna, Lund, & Walker, 2017). While information design as discussed in many sources (Black et al., 2017; Pettersson, 2014) is concerned with the visual representation of data, there are also other types of information design, such as auditory information design – for example, displaying social media feeds in an auditory fashion (Winters, Joshi, Cutrell, & Morris, 2019). In this dissertation, however, the focus is on visual data design. In the literature, data visualisation is frequently discussed alongside information design (Black et al., 2017; Noël, Joy, & Dyck, 2017). Data visualisation is used to assist stakeholders with making business decisions. Data visualisation is not something new. It is an established tool used, for example, in libraries to display information regarding budgets, use statistics, as well as the books that are available in the library (Shreedar & Naik, 2017). Representing data visually can facilitate finding solutions to problems, due to the efficient structure it furnishes users with (Lohse, Biolsi, Walker, & Reuter, 1994). Keim (2001) states that the amount of cognitive effort required to carry out certain activities is lessened by visually representing data. Figure 1 below shows a visual representation of headcount data.

Datig and Whiting (2018)

Figure 1: Headcount data

2.3.1 Visualisation explained

Business operations can generate massive amounts of data that need to be interpreted to aid in decision-making. Data visualisation can help with the exploration of these data and ensure that the data serve a useful purpose (Keim, 2001). The aim of data visualisation is to make humans part of the process of exploring data, by making them apply their perceptual abilities (Keim, 2001).

Data visualisation can be divided into two main categories, namely, scientific visualisation and information visualisation (Telea, 2015). Information visualisation is the utilisation of visual representations of abstract data, supported by computers, to enhance understanding, while scientific visualisation is the visualisation of (usually physical) scientific data (Card, Mackinlay, & Shneiderman, 1999). Chen (2005) describes information visualisation as not usually being concerned with numbers or spatial data, but rather with higher dimensional data. Chen (2005) also states that scientific visualisation makes use of supercomputers as a main source of data, as well as advanced computing techniques. This is not the case for information visualisation. For this study, information visualisation was used.

According to Chung et al. (2005, p. 62), "visualization is the process of displaying encoded data in a visual format that can be perceived by human eyes." Bendoly (2016) describes data visualisation, in the context of data analytics, as a specific category of 'informational picture' that effectively shows data and possible relationships. Individual types of graphics, including graphs, plots, and network diagrams, are referred to as 'idioms' (Bendoly, 2016). When these idioms are integrated successfully into a dashboard (discussed later in this dissertation), designers can carry across messages that are more complex (Bendoly, 2016).

2.3.2 The history of data visualisation

Data visualisation is nothing new and can be traced back more than half a millennium. Friendly (2006) divides data visualisation into eight distinct periods, namely, early maps and diagrams, measurement and theory, new graphic forms, early modern period, golden age, modern dark ages, rebirth, and high-D, interactive and dynamic data visualisation. These periods are discussed in Table 2 below.

Table 2: Timeline of data visualisation

Year	Period	Description
Pre-1600s	Early maps and diagrams	Geometric diagrams, e.g., to indicate the position of celestial bodies.
1600s	Measurement and theory	Physical measurements of time, space and distance. This included astronomy, maps, territories and navigation.
1700s	New graphics	Invention of maps with isoclines and contours. First attempts to map economic, geologic and medical data were made later in this century.
1800-1850	Early modern period	Thematic mappings and statistical graphics were growing very rapidly. This period also saw the beginning of geological cartography.
1850-1900	Golden age of statistical graphics	Divided circle diagrams, semi-logarithmic graphs and statistical atlases are just some of the many visualisations that were developed during this period.
1900-1950	Modern dark ages	Few innovations were made in this period. Data visualisations did, however, start to become more mainstream and were used as an important part of sciences such as physics.
1950-1975	Rebirth	Collaboration between computer science research, data analysis developments, and display and input technology led to a rapid growth in new visualisation techniques and methods.
1975-present	High-D, interactive and dynamic data visualisation	Data visualisation matured and has become an exciting and active multidisciplinary field.

Adapted from Friendly (2006)

2.3.3 Data visualisation criteria

The proposed method of data visualisation must satisfy several criteria in order to be considered successful. These criteria, as discussed by Tufte (2001), are:

- The data must be displayed.
- When viewing the data, the user should think about the content rather than about how the content is displayed.
- Big sets of data must be well articulated to aid understanding.
- Display space should not be cluttered with too many numbers.
- The user’s visual cognition system should be encouraged to make comparisons between data.
- Data should be displayed at several different detail levels.
- The display of the data should serve a definite purpose.

- There must be a high level of cohesion between the display of the data, the statistical description of the data set and the verbal description of the data set.

Chen (2005) discusses two types of prior knowledge necessary for understanding the data visualisation, namely, knowledge regarding the operation of the visualisation device and domain knowledge necessary to decode the content. Chen (2005) also states that, if abstract data are visualised, mutual ground must exist between the information visualisation and the user.

Wolfe (2015) argues that data visualisation is not just concerned with the representation of collections of numbers, but also with the selection and the thought that goes into the selection of the numbers to visualise.

2.3.4 Advantages of data visualisation

Visualising data holds several benefits that make it a worthy research area. According to Ware (2004), data visualisation is advantageous for the following reasons:

- Large amounts of data can be comprehended quickly.
- Properties that might not have been expected emerge during the visualisation of data.
- Problems with the actual data quickly become apparent when visualised.
- Large- and small-scale properties of data can be better understood when visualised.

According to Gardner Archambault, Helouvry, Strohl, and Williams (2015), if data visualisations are done correctly, they help with the recognition of patterns and relationships within the data, to communicate the data in a more interesting way. This in turn leads to the data being easier to understand. Making use of data visualisation tools provides several benefits, including: better decision-making, improved information exchanged, a lower IT (information technology) workload, less time wasting, better on-the-fly analysis of data, a high return on investment, and empowering end users (Wang, Wang, & Alexander, 2015). Along with the abovementioned benefits, data visualisation is a good way to present both abstract and concrete ideas (Shreedar & Naik, 2017).

2.3.5 Complexities of data visualisation

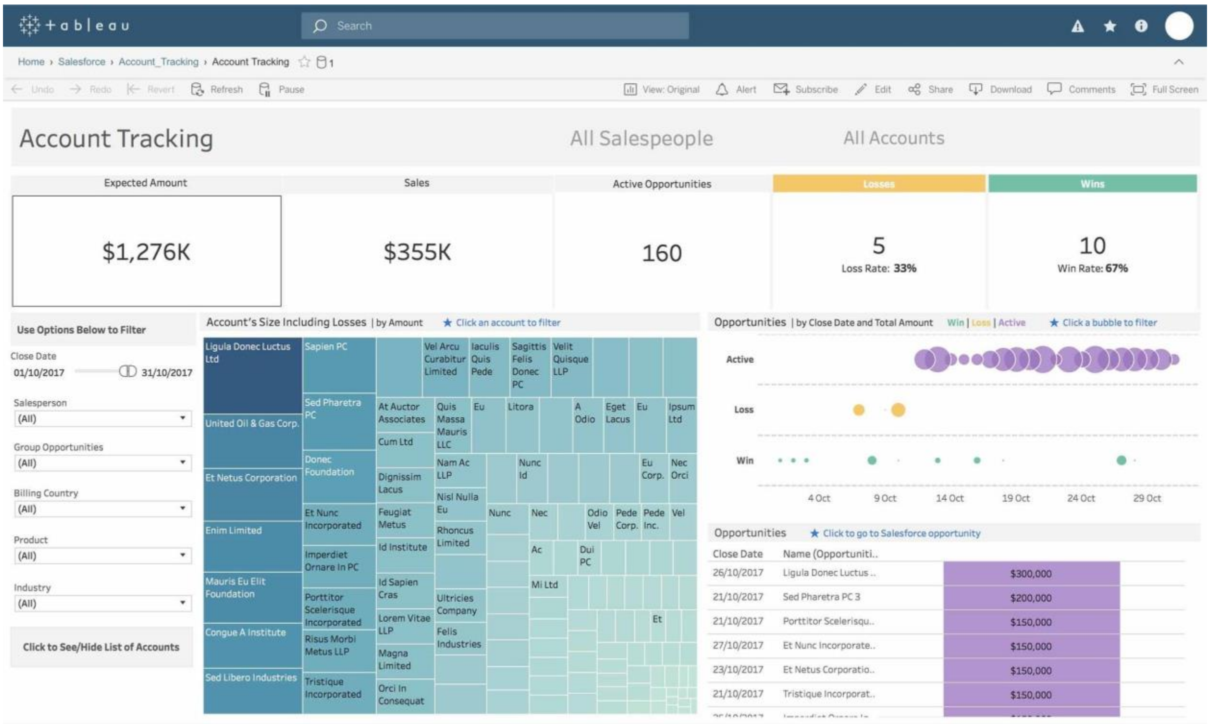
Visualising data effectively can be quite a complex task because, according to Few (2009), a good understanding of how humans perceive things visually is needed in order to depict data effectively. Another issue that adds to the complexity is the fact that individuals take away meanings from artefacts that differ from those intended by the creator (Hohl, 2011). Certain everyday examples of data visualisation, such as the visualisation of music pitch when a song is played through a computer music player, takes away user understanding of the workings of data visualisations, as the application can be seen as a 'black-box' (Hohl, 2011).

Adding to the complexity of creating a data visualisation is the fact that the human brain is predisposed to process certain things immediately, without the individual even noticing. These processing tasks are called 'pre-attentive attributes', and are influenced by colour intensity and hue, as well as size, orientation, length and width (Gardner Archambault et al., 2015).

Chen (2005) divides data visualisation challenges into three categories: challenges arising when viewing data visualisation from a user-centred perspective, technical challenges and challenges that need to be addressed on a disciplinary basis. In addition to the user-related issues discussed earlier in this section, user-centred challenges can arise from things such as the user's eyes not having the adequate capacity to interpret big data sets (Agrawal, Kadadi, Dai, & Andres, 2015). Technical challenges are especially prevalent when working with large amounts of diverse data, as bottlenecks can occur in terms of bandwidth as well as power consumption (Wang et al., 2015). This study focuses on challenges in the first category.

2.4 DASHBOARDS

Dashboards are popular tools for data visualisation. A dashboard is a screen on which information imperative to achieving objectives is combined and arranged to enable the monitoring of information by just having a brief look at the dashboard (Few, 2005). A dashboard may contain various types of display media, including graphs, geographic maps, tables and icons (Santiago Rivera & Shanks, 2015). Figure 2 provides an example of a dashboard displaying account tracking data.



Li (2018)

Figure 2: Account tracking dashboard

2.4.1 Characteristics of effective dashboards

Few (2005) states that dashboards should be well-organised, clear and to the point, and the information should be tailored specifically to the objective at hand. Furthermore, according to Guni (2014), dashboards need to be coherent, relevant, timely and efficient. A dashboard should allow the user to view the data in raw format to enable them to apply their own formulas for their own data analysis (Chiang, 2009). A dashboard should align with the processes and targets within a business to be successful (Cahyadi & Prananto, 2015). Dashboards should be consistent, and help the user to understand the context of metrics and the dashboard in general; a good way to achieve this context is to use dashboards alongside the organisation's portfolio management tools (Allio, 2012).

2.4.2 Stakeholders involved with dashboards

Different people work together to create dashboards. This collaboration is important for the design of a successful dashboard. According to Chiang (2009), collaborating with stakeholders at the beginning of the dashboard design process is a successful approach to take. Chiang (2009) discusses the following individuals and groups who are typically involved with the creation of a successful dashboard:

- *End users*: They will make frequent use of the dashboard.
- *Business analysts*: They will have to link up the needs to be satisfied with the technology employed by the solution.
- *Database team*: They are in charge of the identification and structuration of data sources.
- *IT team*: The actual dashboard and the infrastructure required by the dashboard will be provided by the IT team.
- *Project manager*: The project manager will ensure that all stakeholders are working together and staying within the allocated timeframe.

2.4.3 Common dashboard design mistakes

According to Few (2006), there are 13 common mistakes made when designing a dashboard, namely:

- going beyond a single screen's boundaries;
- giving the user insufficient context about the data;
- displaying more detail or precision than necessary;
- choosing a measure that is not sufficient;
- choosing inappropriate display media;
- introducing variety that is of no meaning;
- using poorly-designed display media;
- inaccurately encoding quantitative data;
- arranging the data in an unsatisfactory manner;
- not emphasising important data efficiently or not emphasising them at all;
- filling the screen up with decoration;
- not using colour correctly (see figure 3); and
- designing a display that is visually unappealing (see figure 4).

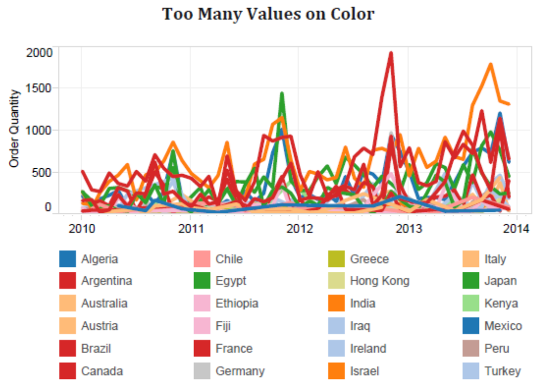
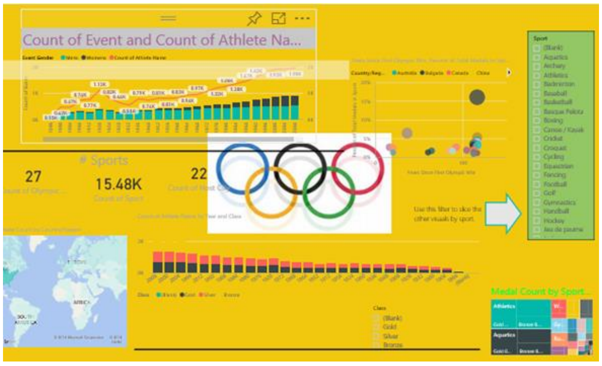


Tableau Software (n.d.)

Figure 3: Visualisation with too many colours used



Hart, Blythe, and Casey (2018)

Figure 4: Cluttered dashboard

According to Allio (2012), many dashboard issues do not arise from poor indicators being used, but rather from the dashboards not being properly linked up to the strategy.

The abovementioned factors were used as a guideline to gauge the success of the dashboard design when implementing the dashboard design method.

2.4.4 Dashboard design components

To design a method for dashboard development, the components of a dashboard need to be understood. Cahyadi and Prananto (2015) list dashboard components, including data, technologies, user, organisation, features, and graphs and metrics. The data component of dashboards revolves around where the data are stored (data warehouses), as well as the quality of the data and the systems that serve up data (Cahyadi & Prananto, 2015). These factors tie in with some of the common dashboard mistakes by Few (2006) discussed earlier in this section, which include not emphasising important data enough. The next element is technology, which includes how the information system landscape is set up (Cahyadi & Prananto, 2015). Following this is the person actually making use of the dashboard, where the design elements include the full profile of the user (Cahyadi & Prananto, 2015). The user, combined with the data component, is another element in which Few (2006) identifies a common dashboard mistake, namely, providing users with less context than is necessary to fully understand the data. The collection of the dashboard's users contributes to the next component, the organisation. This includes which roles the users play within the organisation (Cahyadi & Prananto, 2015). Features of dashboards, referring to what the dashboard can do, are another design component (Cahyadi & Prananto, 2015). Finally, Cahyadi and Prananto (2015) discuss graphs and metrics, which refer to what the user actually sees. This component requires careful consideration, as many of the typical mistakes when designing dashboards (Few, 2006) surround the graphs and metrics, for example, choosing the incorrect measure.

Table 3: Dashboard design elements

Component	**Design elements**
Data	Data warehouse, quality of data and database systems
Technologies	System architecture, platform, software and information systems
User	User characteristics, including their profile, background, experience and preferences
Organisation	Roles of users, culture, organisational requirements, style of decision-making and the definitions of the organisation's business rules
Features	Functionality of the dashboard
Graphs and metrics	User interface and selection of measurements

Adapted from Cahyadi and Prananto (2015)

2.5 USER-CENTRED DESIGN

The goal of designing data visualisations is ultimately to allow users to gain insight into the data presented by the visualisation. As such, the user should be kept in mind when designing the data visualisations. There are two concepts that come into play here: human-centred design and user-centred design. Human-centred design focuses on creating systems with increased usability by taking human factors into account, as described by ISO standard 9241-210:2010 (Shivers-McNair et al., 2018). User-centred design is a term that refers to a process of design where the development of the design is influenced by end users (Abras, Maloney-Krichmar, & Preece, 2004). User-centred design includes the evaluation of designs within a real-world context (Vilpola, 2008). The areas of research of user-centred design are far-reaching, and include medical science (Kübler et al., 2014), hospital care (Witteman et al., 2014), education (Grudniewicz, Bhattacharya, McKibbon, & Straus, 2016), criminology and geography (Roth, Ross, & MacEachren, 2015). The study described in this dissertation focused specifically on users being part of the design process, rather than just taking human factors in general into account. As such, user-centred design was relevant to this study.

2.5.1 Overview of user-centred design

User-centred design is also known as a 'European design approach'. This stands in contrast to the 'American design approach', which focuses on the functional view of systems and revolves around the designer (Garrity, 2001). Originally, user-centred design was conceived as a way to design computer systems requiring user interaction. User-centred design involves users in the design process, which might seem similar to participatory design. The big difference between the two is that user-centred design can be non-participatory, as users can be involved as subjects whose attributes and contexts contribute toward design, but who are not completely involved in the process (Carroll, 1996). User-centred design should provide guidance on system development and testing by providing insight into real-world system use by users (Vilpola, 2008).

2.5.2 User-centred design methodologies and implementation

User-centred design methodologies include model-based, story-based and scenario-based design (Vredenburg, Isensee, & Righi, 2002). Story-based design aims to create a persona for the anticipated user, which is then enhanced with tasks the persona will carry out, as well as the flow of these tasks (Vredenburg, Isensee et al., 2002).

The involvement of users is an imperative part of user-centred design, and can be achieved when a designer meets with users in their area of system use or by bringing users onboard the design process

(Vilpola, 2008). Actively involving users refers to contacting the users directly, and having design sessions or other elicitation sessions with the users (Vilpola, 2008). There are four principles of user-centred design, described in ISO standard 13407 1999, as discussed by Vilpola (2008):

1. User is actively involved.
2. User's tasks and technological function must be distinguished.
3. The design should be iterative.
4. The design should be multidisciplinary.

2.5.3 Advantages of user-centred design

User-centred design has been found to improve product usefulness and usability (Rocha et al., 2017; Vredenburg, Mao, Smith, & Carey, 2002). It is viewed as an imperative part of creating products providing usefulness to users, and allows the creation of systems that satisfy users requirements (Vilpola, 2008). Another big advantage of user-centred design is that the principles are specified in standards literature, for instance in ISO standard 13407 1999, as discussed previously (Vilpola, 2008). User-centred design is versatile, as its application is not limited merely to information systems, but can be applied to the design of any type of system (Lanter & Essinger, 2017). As systems designed with a user-centred approach are designed with the goal of aligning with the user's abilities, they should require more basic documentation, as well as less time spent on user training (Lanter & Essinger, 2017).

2.5.4 Issues with user-centred design

There is a lack of effectiveness measures for user-centred design (Vredenburg, Mao et al., 2002), which will make it difficult to gauge the success of a user-centred design effort. Employing user-centred design where there is wide user culture variety can be difficult (Putnam, Rose, Johnson, & Kolko, 2009). User-centred design is limited by timelines, available budget and available resources (Vilpola, 2008). The perception of user-centred design might also be a reason for concern, as user-centred design is sometimes perceived to have a high cost and to be cumbersome (Teka et al., 2018). Another hurdle to cross when considering the implementation of user-centred design is the fact that user-centred design potentially requires a large amount of the user's time (McKenna, Staheli, & Meyer, 2015), which aligns with the abovementioned issue of resource constraints. User-centred design is also not a method suited to a diverse environment, as it does not pay sufficient regard to nuances caused by intricate socioeconomic contexts (Teka et al., 2018).

2.5.5 Difference between user-centred design and participatory design

In literature, participatory design is often mentioned when discussing user-centred design, and the difference between user-centred design and participatory design has become quite unclear (Bannon, Bardzell, & Bodker, 2018). However, not all literature regards participatory design and user-centred design as two similar, yet discrete approaches. Participatory design is sometimes discussed alongside user-centred design, as a user-centred approach (Leng, Norowi, Atan, Jantan, & Rahmat, 2018). Participatory design has been suggested as a practice supporting user-centred design (Patwardhan et al., 2015). This, however, deviates from the original idea of participatory design, which aims to involve users in design, as well as help alleviate situations of differing ideas by putting democratic processes in place (Bannon et al., 2018).

2.6 PARTICIPATORY DESIGN

Actively involving end users in the system development process is an important aspect of developing useful and usable systems, and one that system designers are aware of, but that is still put on the back burner by software engineering practices (Pilemalm et al., 2007). One approach taken to achieve this is participatory design, a key part of the study described in this dissertation.

Pilemalm et al. (2007, p. 267) describe participatory design as:

> …a rather loosely connected set of philosophies, principles and techniques belonging, to the socio-technical system view.

Participatory design was first used in Scandinavia in the 1970s, motivated by empowering employees in a democratic fashion and to help incubate workplace democracy (Spinuzzi, 2005). There are two important reasons why participation in design came to the forefront: as a way to mitigate the issue of conventional approaches not working; and due to ethical issues, with the argument that end users should have some influence over the environment in which they work (Dearnley & Mayhew, 1983).

Participatory design is a process where systems are designed based on knowledge shared between users and designers, and enforces the idea that users' skills and working practices need to be taken into account when systems are designed (Schuler & Namioka, 1993). Participatory design is, in essence, the involvement of the users of the system in the design process (Unger et al., 2013). According to Hartson and Pyla (2012), participatory design brings user and customer knowledge and the skills of system designers together. However, it must be noted that participatory design is not purely about giving a voice to more stakeholders. It has multiple facets, including different approaches, relevant proponents, assumptions and areas of design that are focused on, as discussed by Törpel (2005). In addition to this, other aspects of participatory design include politics, users, methods, context, and products (Halskov & Hansen, 2015). In this dissertation, the term participatory design is used; however, it is also known as cooperative design (Bødker & Kyng, 2018; Holmlid, 2009).

2.6.1 Purpose and result of participatory design

The purpose of participatory design is to bring together stakeholders and give them the opportunity to learn more about other stakeholders' views (Hecht & Maass, 2008), as well as to create a more democratic and empowering workplace of greater quality (Bossen, Dindler, & Iversen, 2016). Clement and Van den Besselaar (1993) found that participatory design results in workers who are more aware of the fact that technology is not neutral or free of value, and users who have more confidence in taking initiative with technology. Participatory design uses various techniques that are expected to be relatively simple to learn, and that do not require users to have a great deal of prior knowledge (Pilemalm et al., 2007). There are three goals that participatory design aims to accomplish: research, political involvement and design (Bannon et al., 2018). An area in which participatory design has a large amount of value, although it is outside the scope of the research presented in this dissertation, is in empowering marginalised groups who have little common ground with designers and researchers (Frauenberger, Makhaeva, & Spiel, 2017). There are multiple techniques for participatory design, including the creation of low-fidelity prototyping, paper-prototyping, and storyboarding (Walsh, Foss, Yip, & Druin, 2012). Cooperative prototyping and workshops are also ways in which participatory design can be put into practice (Kang, Choo, & Watters, 2015). In the study described in this dissertation, low-fidelity prototyping was used. The rationale behind this, as well as a discussion on low-fidelity prototyping, can be found later in this chapter.

2.6.2 Participatory design issues

In early research conducted, Hirschheim (1985) found that participatory design, at least in the context of a system, was not nearly as simple as the literature at the time suggested. Participatory design also suffers from dependencies on context, and generates knowledge that is difficult to share, leading to repeated efforts (Frauenberger, Good, Fizpatrick, & Iversen, 2015). Further issues found by Hirschheim (1985) were that there were discrepancies between organisations utilising participatory design, the applications used and the people who were involved; that the results of participatory design did not go through a formal evaluation process; and that, despite positive feelings toward participatory design, the rate of organisations making subsequent use of participatory design after using it initially was very low. Control is another point of concern, as there are parties such as researchers and designers who might influence the outcome of the participatory design process (Frauenberger et al., 2015). Another issue which may arise is that the base argument for participatory design, which is to create systems that users find useful, will not necessarily allow for the successful inclusion of every single stakeholder.

2.6.3 Stages of participatory design

Spinuzzi (2005) discusses the underlying paradigm, methodology, research design and methods of participatory design. Spinuzzi (2005) argues that the design paradigm of participatory design is constructivism, as it assumes that knowledge exists in a certain context, not just in a person's mind. The methodology of participatory design, as discussed by Spinuzzi (2005), is based on participatory action research, as research-designers liaise with users in order to make conclusions. Spinuzzi (2005) identified three stages of participatory design research, namely, initial exploration of work, discovery processes and prototyping. The first stage is initial exploration of work, which is where users and designers meet with each other initially to become familiar with one another in terms of working together (Spinuzzi, 2005). Methods for this stage include observations, interviews, visits to the organisation, as well as other ethnographic methods (Spinuzzi, 2005). This is followed by discovery, where games such as organisational games and roleplay are used to enhance the participants' understanding and decide on how the work is to be prioritised (Spinuzzi, 2005). The final stage is the prototyping stage where users and designers make use of mock-ups, paper prototypes and cooperative prototyping to create an artefact (Spinuzzi, 2005). These stages are summarised in Table 4 below.

Table 4: Three stages of participatory design

Stage	**Research design**	**Methods**
Stage 1: Initial exploration of work	Users and designers meet during this stage to become familiar with how users work alongside one another.	Ethnographic methods, including observations, interviews and visits to the organisation.
Stage 2: Discovery process	Users and designers make use of different techniques to improve their understanding and to prioritise how the work is organised. They also come up with a future vision for the workplace.	Organisational games, role-play games, organisational toolkits, future workshops, storyboarding, and workflow models and interpretation sessions.
Stage 3: Prototyping	Users and designers form technological artefacts iteratively, to fit in with the future vision created during stage 2.	Mock-ups, paper prototyping, and cooperative prototyping.

Adapted from Spinuzzi (2005)

2.6.4 Participatory design in data visualisation

Prestopnik (2013) discusses three advantages of groups creating data visualisations. These advantages include cognitive advantages, an increase in cooperation and information-sharing capacity, and the ability to create and detect new patterns in data sets. Prestopnik (2013) found that groups visualising data lead to seemingly abstract complex data being understood. Arcia et al. (2015) undertook a study where participatory design sessions were held to create health information visualisations with members of the community. The authors found that working with the community directly could help create health visualisations that have meaning to the community, rather than creating visualisations based on assumptions that could potentially be a waste of time and even mislead community members.

2.7 PROTOTYPING

According to Lim, Stolterman, and Tenenberg (2008), designers make use of prototypes to learn, create and improve ideas in a way that is natural and develops over time. A prototype is an artefact that gives stakeholders the opportunity to interact with a proposed product, in order to experience what it is like to use the product in a realistic environment, as well as to explore various possible uses (Preece, Sharp, & Rogers, 2001). Prototyping early in the development process is necessary, as it makes it more difficult to create poor designs (Wiethoff, Schneider, Rohs, Butz, & Greenberg, 2012).

Thus, prototypes are exploratory tools used to provide designers with insight into how people interact with their ideas. This helps to foster good ideas.

2.7.1 Why prototype

Windsor and Storrs (1992) state that prototypes help to create a specification that a user will be able to understand, and that the evaluation of prototypes helps to elicit the details of the task at hand. Prototyping differs from the traditional systems development lifecycle in a key area: prototyping does not have concise design specification documents (Janson & Smith, 1985). Prototyping is also suitable in situations where users cannot specify what their information needs are, and when system analysts struggle to get a grasp on the users' environment (Janson & Smith, 1985). The main goal of prototyping is to facilitate system development, resulting in a system that meets all requirements from a user's perspective (Dearnley & Mayhew, 1983). Prototyping can also be used as a participatory exercise. Cooperative prototyping is seen as a way to reconcile designers and users in the design process by involving them actively and creatively, with an end-goal of generating ideas and exploring ideas, or of evaluating the prototypes in a work-like way (Bodker & Gronbaek, 1991).

2.7.2 Considerations when creating a prototype

According to Windsor and Storrs (1992), it is important to critique prototypes, as this helps to tear down communication barriers. These barriers include communicating abstract ideas, representing a system as a whole and helping along imagination. Windsor and Storrs (1992) are of the opinion that the scope of the prototype must be managed actively to ensure that it falls within the barriers of the available resources and allocated timeframe. They also emphasise the importance of realising that prototyping will not lead to designs that are flawless. When making use of prototypes, users who are not sold on the idea might rely on early prototypes to dismiss what the system represents, and as such efforts must be made to ensure that this does not happen (Dearnley & Mayhew, 1983). Furthermore, it is important to do research and determine an appropriate time to build a prototype, lest time and financial resources be wasted (Dearnley & Mayhew, 1983).

2.7.3 Low-fidelity vs. high-fidelity prototyping

Two types of commonly used prototypes are low-fidelity prototypes and high-fidelity prototypes. The fidelity of the prototype has an impact on how real the representation appears, the different types of usability testing methods that can be applied, as well as the ability of the users to take part in the design process (Walker, Takayama, & Landay, 2002). The fidelity of a prototype describes the level of ease with which it can be distinguished from the actual product it represents, as well as how it can be changed to highlight certain design aspects (Walker et al., 2002). A low-fidelity prototype is a prototype with limited functionality and interaction that is not intended to show detail but to illustrate look and feel, while a high-fidelity prototype is completely interactive and represents the most important functionality of a specific product's user interface (Rudd et al., 1996). According to Atladottir, Hvannberg, and Gunnarsdottir (2012), users find high-fidelity prototypes to be an obstacle, as they get so caught up in details about the working of the system that they do not think about new or enhanced features that might aid the design.

2.7.4 Advantages of low-fidelity prototyping

Utilising low-fidelity prototypes has several advantages. First and foremost, low-fidelity prototypes are low-cost prototypes and will not consume a large part of the development budget (Rudd et al., 1996). In addition to this, low-fidelity prototypes do not require a large amount of development time, as stated by Rudd et al. (1996) and Sefelin, Tscheligi, and Giller (2003). Low-fidelity prototypes also make iteration less difficult (Walker et al., 2002). Holzinger (2004) found that low-fidelity prototypes are easy to change and thus encourage participants to make suggestions. Walker et al. (2002) state that using low-fidelity prototyping makes participatory design easier. Holzinger (2004) furthermore found that low-fidelity prototypes allow elements to be crossed out if they are suspected to be elements that cause issues, which helps to explain why the element does not work if someone else suggests it in future. Atladottir et al. (2012) found that low-fidelity prototyping leads to more new or improved features when compared to making use of high-fidelity prototypes.

2.7.5 Disadvantages of low-fidelity prototyping

Rudd et al. (1996) discuss numerous disadvantages of low-fidelity prototypes, including limited error checking, the inability to provide a platform for proper evaluation by users, and the effort required to convert them into final products. There are issues that only high-fidelity or computer-based low-fidelity prototypes bring to light, including physical interaction, making comments on the concept, comparing the prototype with similar products, as well as determining issues relating to performance (Lim, Pangam, Periyasami, & Aneja, 2006). Holzinger (2004) found that certain literature overstates the ease of use of paper-based prototypes, due to the amount of time the entire process can consume. Holzinger (2004) also found that paper-based prototypes do not have apparent validity, causing certain users to not pay sufficient attention to them.

2.7.6 When low-fidelity prototypes are appropriate

Sefelin et al. (2003) discuss scenarios in which paper-based prototypes might be the preferred prototyping method to use. These include occasions when available prototyping tools have a limited feature set that is insufficient to implement the design, when members who lack the necessary skills to use available software are included in the design process, and when testing will generate a large amount of drawings that need to be discussed. Low-fidelity prototypes are recommended when the aim is to determine what requirements users have or what requirements exist in the market (Rudd et al., 1996). It is, however, not a good idea to make use of low-fidelity prototypes when requirements have been agreed upon (Rudd et al., 1996). In order to design a high-level view of the system early in the design process, low-fidelity prototypes are employed (Wood & Romero, 2010).

2.7.7 Rationale behind making use of low-fidelity prototypes in this study

The aim of the study discussed in this dissertation was to create a new method, rather than concrete visualisations. As such, details were not a great concern, but rather ideas and general thought processes. This idea, of focusing on the bigger picture rather than in-depth details, made low-fidelity prototyping the more suitable approach to take. The quick creation times of low-fidelity prototypes made them very appealing, as the managers who participated in the study had very little available time. As this study aimed to create a method where managers are more involved with the process, low-fidelity prototyping was once again a good approach to take because it encourages participation.

2.8 THE RESEARCH QUESTION IN LITERATURE

The research question, as stated in Chapter 1, is: "Can low-fidelity prototyping in conjunction with participatory design be used in a design method for data visualisations?" This question has not been covered sufficiently in the literature. In this section, existing research that has been done on certain elements of the research question is discussed.

2.8.1 Collaborative data visualisation

Mahyar, Sarvghad, and Tory (2009) discuss the role of note taking during collaborative data analysis, with a focus on note taking rather than collaborative design. There are similarities with the proposed study as they share the domain of collaboration during data visualisation. Where the main difference comes in, however, is in the research aims (note taking during collaborative visualisation vs. making use of collaboration to create a new visualisation method).

Prestopnik (2013) studied collaboration in visualisation in order to determine whether it holds benefits. One benefit identified by Prestopnik (2013) is that collaborative visualisation helped participants change their tacit knowledge into explicit knowledge. Thus, collaboration and the design of data visualisation are the two main factors shared by Prestopnik's paper and the research question posed in Chapter 1. However, where Prestopnik's paper aimed to determine the benefits and advantages of collaborative data visualisation, the study discussed in this dissertation used collaboration as a tool instead of focusing on research on collaboration.

2.8.2 Low-fidelity prototyping in the information systems field

Lim et al. (2006) explore the differences in high-fidelity and low-fidelity prototyping when researching the usability of mobile devices. This research shares the use of low-fidelity prototyping as a tool to gather data within the field with the research question posed in Chapter 1. However, the research by Lim et al. (2006) focused on usability, while the research discussed in this dissertation aimed to develop a new method.

2.9 CONCLUSION

Business intelligence, data visualisation, dashboards, user-centred design, participatory design and low-fidelity prototyping have now been expanded on. With these concepts cleared up, they can be contextualised in the next chapter. This chapter has shown that business intelligence is an important part of managing a modern business, and that business intelligence systems require a good understanding of more than just data. Data visualisation has been discussed to gain insights into businesses, and the importance of data visualisation as a method of enhancing users' understanding of data within a business has been discussed. Dashboards have been discussed as a method to present visualised information to users, along with the considerations and components of dashboards. User-centred design and participatory design have been discussed, and the importance of actively including users in the design of systems has been emphasised. Finally, low-fidelity prototyping has been positioned as a low-cost way to include users in the design of the interactive component of systems. The literature discussed in this chapter should lay a good foundation for the understanding of the rest of the chapters in this dissertation.

3 RESEARCH DESIGN

3.1 INTRODUCTION

This chapter explains how the study to create a new method for creating data visualisations making use of low-fidelity prototypes and participatory design, was designed. The chapter provides an overview of how the research was designed, the methodology that was used, the limitations of the study, as well as the ethical aspects that had to be considered for the study.

3.2 RESEARCH DESIGN

In this section, the research paradigm, approach and methodological framework are discussed.

3.2.1 Research paradigm

To determine the research paradigm best suited to answer the research question, three paradigms that are widely used in the information systems field were considered. The paradigms are positivist, interpretivist and critical. Orlikowski and Baroudi (1991) discuss these paradigms by giving an explanation of each paradigm's beliefs about physical and social reality, knowledge, and the relationship between theory and practice.

These beliefs are explained by Orlikowski and Baroudi (1991) as follows:

1. *Physical and social reality*: Beliefs regarding ontology, rationality of humans and social relations. Ontology is used to explain the relationship between humans and the world they live in, whether the social and physical realms are dependent on human action or not. Human rationality refers to the degree to which actions carried out by humans influence their intent. Social relations consider whether social relations are stable or dynamic.
2. *Knowledge*: Beliefs regarding epistemology and methodology.
3. *Relationship between theory and practice*: This describes what purpose knowledge serves in practice.

The three research paradigms are compared in terms of these beliefs in Table 5 below.

Table 5: A comparison of research paradigms

Paradigm	**Beliefs about physical and social reality**	**Beliefs about knowledge**	**Relationship between theory and practice**
Positivist	Physical and social world is objective and exists independently of humans. A one-to-one correspondence exists between the structures of the model and events. The researcher is neutral and does not interfere with the phenomenon. Human interaction happens in a consistent way.	Theories should be empirically testable, and should thus be able to be verified or falsified. An appropriate methodology must be strictly followed to gather valid knowledge. Surveys and controlled experiments are the primary method for data collection.	The relationship is mostly technical. Researchers are impartial observers who cannot morally judge or give subjective opinions. They can, however, evaluate and make predictions objectively. Researchers are separated from the phenomenon being researched.
Interpretivist	How people have social interactions with their world gives meaning to what is investigated. Social reality can be interpreted, and the social world is not a given. As things in the world change, so interpretations of reality can change.	The language used by people to describe social practices makes up part of those social practices being described. Researchers wish to understand actors' views about their social world and their role in it. Field studies are commonly used, as they look at people in their social setting. Phenomena should not be classified according to externally defined categories.	Researchers cannot view themselves as neutral. Researchers' assumptions, values, beliefs and interests will have an impact on their research.
Critical	Everything has potential that has not yet been fulfilled and causes people to make changes to their social circumstances when they discover the potential. Things never exist in isolation, but in the context of the relationships of which they are a part. Social reality is produced by humans, but contains objective characteristics that dominate human experience. There are contradictions in social forms, which will lead to new social forms.	Long-term history and ethnographic studies of the process and structures are used as research methods. Material states of domination must be understood and critiqued. Researchers need to understand people's language, in addition to understanding people's relationship with phenomena, even though the language might only be temporary and specific to a certain space.	Researchers want to raise awareness about how the status quo can restrict the social world. Social theory and social research are viewed as social critique. Researchers are more part of the analysis of the research, but can still have an impact on the participants' social reality.

Adapted from Orlikowski and Baroudi (1991)

The interpretivist paradigm was chosen for this study. The rationale for choosing this paradigm is discussed next.

3.2.2 Rationale for using the interpretivist approach

The interpretivist paradigm was considered to be best suited for answering the research question. This was due to the fact that the interpretivist paradigm observes people within their social context, and for this study, people were to be observed within their workplace. Furthermore, part of the problem was that managers did not realise or did not believe what value data visualisation could hold. To develop a successful method, the beliefs and views of the managers might have had an influence on whether they saw value in data visualisation. These issues with how the managers viewed data visualisation and the beliefs that the managers held regarding data visualisation aligned with the characteristics of interpretivism, as this paradigm does not attempt to separate individuals from their context. Lastly, as the research requirement to develop a new method included a guided participatory design session led by the researcher, the researcher could not be viewed as a wholly neutral party, which aligns with the interpretivism where the researcher is not considered a neutral party.

Although interpretive research was the best-suited paradigm for this research, there are some reservations and concerns surrounding its use. Garrick (1999) states that interpretivism is subjective by nature and lacks depth when it comes to the explanation of historical, structural, social, environmental and economic influences on what a person experiences. However, as participatory design and the perception of data visualisation are very subjective in nature, the areas of critique were deemed to not be of consequence to this study.

3.3 RESEARCH APPROACH

In this section, quantitative research is compared with qualitative research to justify the research approach that was used in this study.

3.3.1 Quantitative vs. qualitative research

According to Oates (2006), quantitative research is based on numbers, while qualitative research is based on all other data, including words, sounds and images. Due to the fact that qualitative research is usually about data other than numerical data, it does not lend itself to statistical analysis (Muijs, 2011). Qualitative research also deals with the participant's point of view, and focuses on routine practices (Flick, 2007). The aim of qualitative research is not necessarily limited to creating knowledge or scientific insights, but can also include creating knowledge that can be applied practically (Flick, 2007).

The advantages of quantitative research, according to Oates (2006), include the fact that it commands more scientific respect, it is based on established techniques, it is based on measurements and these are not subjective, and if there are large quantitative data sets to analyse, a computer can take care of the task quite quickly. The disadvantages of quantitative research discussed by Oates (2006) are that a researcher can do advanced statistical tests without having the background to properly understand the data, and that subjectivity can still creep in when deciding on group sizes and scales of graph axes.

According to Oates (2006), qualitative analysis is advantageous due to the fact that it provides diverse and rich data, and caters for the possibility of various explanations instead of just one. The disadvantages of qualitative analysis discussed by Oates (2006) are that the amount of data can overwhelm the researcher, that the researcher interprets the data more subjectively, and that it is difficult to fit data other than textual data into academic writing.

3.3.2 Rationale for using qualitative research

Quantitative research is typically for the following: questions demanding a quantitative answer, questions regarding the change of a numerical value, explanation of phenomena (e.g., finding factors influencing phenomena), and hypothesis testing (Muijs, 2011). As the research in this dissertation aimed to develop a method, the research question to be answered did not comfortably fit into any of these four categories.

The aim of the study was to create a new visualisation method by interacting with people and determining the processes they go through when given the opportunity to create a visualisation prototype. For this reason, opinions of the participants, as well as voice recordings, images of prototypes and observation notes, were used. This fell under qualitative research as it was a rich and diverse non-numerical data set.

3.4 RESEARCH METHODOLOGY FRAMEWORK

The research framework used in this study was design science, in conjunction with case study research.

3.4.1 Design science research

Design science is a process that aims to solve problems, focused on creating new artefacts (Hevner, March, & Park, 2004). As the aim of this research was to create a new design method. This new method was the artefact produced by this research, and as such design science research was appropriate.

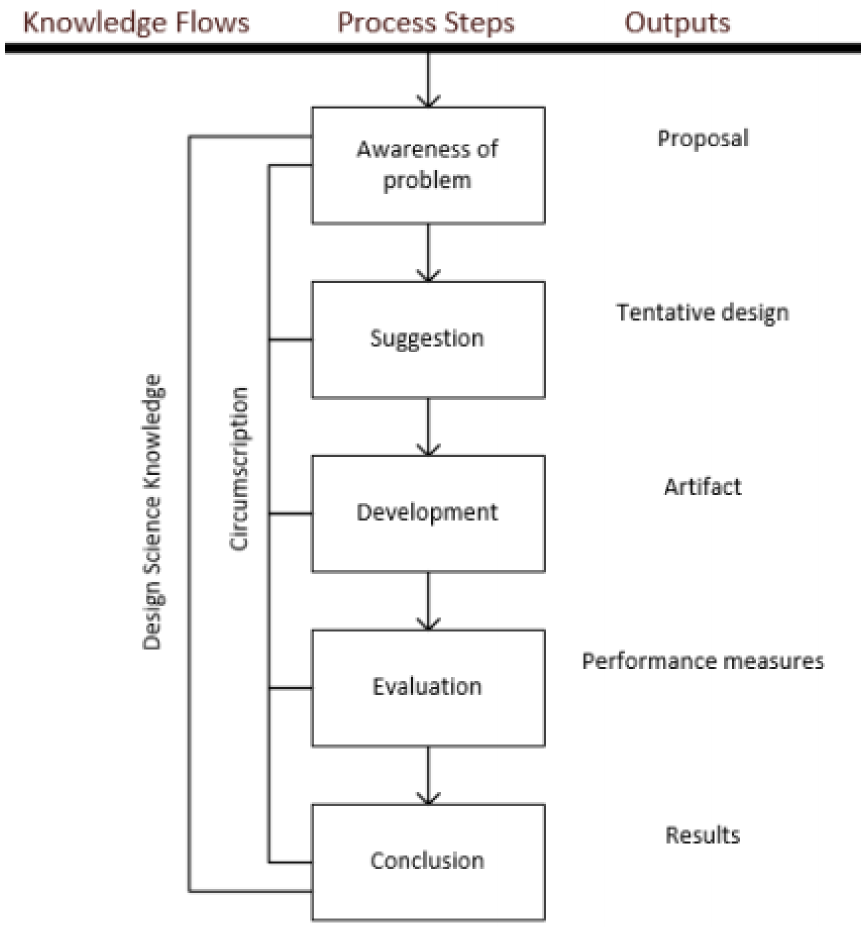
Hevner et al. (2004) discuss seven guidelines for design science research in information systems research, namely, design as an artefact, problem relevance, design evaluation, research contributions, research rigour, design as a search process and communication of research. These guidelines are discussed in detail in Table 6 below.

Table 6: Guidelines for design science research

Guideline	Description
1. Design as an artefact	The result of design science research should be an IT artefact that addresses an important problem within organisations. It should be described in such a way that it can be implemented and applied successfully within an organisation. These artefacts are usually not complete information systems, but rather innovations that define things such as ideas and practices that act as conduits for the successful use of information systems.
2. Problem relevance	In order to be considered relevant, the research must address problems faced by the information systems community, as well as opportunities related to the interaction between people, IT and organisations. The research must also aim to solve a problem within the community that has not yet been addressed.
3. Design evaluation	Effective evaluation methods must be used to demonstrate the artefact's utility, efficacy and quality. Appropriate measures must be defined against which to measure the artefact. Evaluation happens iteratively, and provides insight during the design process and when the design product is being developed. An artefact can only be considered to be complete and to have achieved its goals when it satisfies both the requirements and constraints of the problem it is supposed to solve. The different types of evaluation methods available are observational, analytical, experimental, testing and descriptive.
4. Research contributions	The contribution of the research should be clearly visible in the areas of the design artefact, the foundations of the design and the methodologies of the design. Three types of research contributions can be provided: novel, general and significant contributions. The research should make at least one such type of contribution. The contribution of the research will be measured against the accuracy of its depiction of its business and technological environments, as well how easily it can be implemented.
5. Research rigour	Rigorous methods must be used when conducting the research. These methods should be applied when designing and evaluating the artefact. Rigour is derived from both the theoretical base of the research and the research methodologies used. In order to further develop new artefacts, it is important that the evaluation methods are rigorously carried out to understand the reason why a specific artefact is or is not working.
6. Design as a search process	Design science is an iterative process that involves searching for good solutions to problems. When carrying out the design-related work, heuristic search strategies are created, utilised and assessed.
7. Communication of research	The design research will be communicated not only to technically-minded people, but also to people in management roles. Thus, it is important to provide enough detail on both the implementation and use of the artefact, as well as to provide the detail management require to decide whether resources should be allocated to the implementation and use of the artefact within their organisation.

Adapted from Hevner et al. (2004)

The process of design science is depicted in Figure 1 below, as adapted from Vaishnavi and Keuchler (2004).



Adapted from Vaishnavi and Keuchler (2004)

Figure 5 : Design science research process

The process illustrated in Figure 1 depicts the iterative design science process, including the data that flow between iterations, as well as the outputs of the various process steps. In the study presented in this dissertation, the process presented by Vaishnavi and Keuchler (2004) was followed. Each of the process steps suggested in the above diagram can be mapped to a specific section of the dissertation, as explained in Table 7 below.

Table 7: Research processes, inputs and outputs

Process step	Input	Output
Awareness of problem	Literature review	Proposal forming part of literature review conclusion
Suggestion	Data collection and analysis	Proposed solution after carrying out research
Development	Proposed solution after carrying out research	Complete description of the created method
Evaluation	Literature review, analysed data	Guidelines to determine the success of the method
Conclusion	Success guidelines	The adjusted method after it has been evaluated against the guidelines

3.4.2 Case study research

Case study research was used as part of the research carried out. According to Yin (2014), case study research is widely used when research revolves around phenomena surrounding individuals, groups, organisations and politics. More specifically, a single case was used in this study. A main assumption of case study research is that context and other complex conditions related to the case study are imperative to the understanding of the case (Yin, 2012).

According to Darke, Shanks, and Broadbent (1998), there are five considerations when deciding on whether to use case study research, namely, the type of research that can be addressed by making use of the case study, how the case study project can be designed in such a way that the research question can satisfactorily be answered, how it will be possible to convince organisations to participate in the case study research, how data can effectively be collected from the participants, and how rigour can be applied to ensure that the case study is up to an academically publishable standard.

The considerations outlined by Darke et al. (1998) above were taken into account with the design of the study as follows:

1. *Type of research to be addressed with the case study*: Qualitative research, where a combination of participant observation and feedback was used to create a new method for designing data visualisation dashboards utilising participatory design and low-fidelity prototyping.

2. *How the case study project can be designed to answer the research question satisfactorily*: Principles and guidelines from qualitative research and design science were applied to the research design, and ethical considerations were adhered to, to ensure that the end result was a clear answer to the research question stated in Chapter 1.
3. *How it will be possible to convince an organisation to participate in the research*: The benefits of participatory design and low-fidelity prototyping were explained to the organisation. The research can also be a good starting point to facilitate conversations regarding business intelligence in the organisation, and having participants build something together can act as a team-building activity.
4. *How data can be effectively collected from participants*: Voice recordings and written responses to questions were used.
5. *How rigour can be applied to ensure that the case study is up to an academically publishable standard*: The study was guided by literature available in respect of the subject matter and research approach taken, to ensure that the study was aligned with the body of work already existing within the academic realms of the research presented in this dissertation.

3.5 RESEARCH METHODS

In this section, the instruments to be used for data gathering, the data to be gathered, and how the data were analysed are discussed.

3.5.1 The case study

Freedom Business Consulting (a pseudonym for the actual business where the study was conducted), hereafter referred to as FBC, is a business consulting organisation that employs around 120 people. FBC provides analytics, business intelligence, enterprise architecture, application development and various business management solutions to clients. FBC's consultants are divided into three groups:

- financial services industry, specialising in providing consulting to banks and other financial institutions;

- resources and utilities industries, providing services to organisations such as mines; and
- business development, providing services such as business intelligence development to banks and manufacturing industries.

At the top of the FBC organisational structure are four directors: a managing director, a director of new business, an operations director and a business development director. Reporting to the directors are three general managers, one for each of the aforementioned FBC groups. Reporting to the general managers are operations managers, each with their own team of consultants reporting to them. The organisational structure of FBC can be seen in the organogram in Appendix D.

As FBC provides consultancy services to a wide client base, and as the projects differ in scope, length and required input, it is important for management to have an overview of how consultants are performing, how many projects they are on, how much capacity they have available and when they will be free to take on new projects.

3.5.2 The scenario

At FBC, a need was identified for a resource pipeline planning dashboard to be used by management. The requirements for this dashboard were not clearly defined, but the purpose was clear. A dashboard was required that would allow management plan how to allocate resources, determine where resource issues will have completed a project, and see some information regarding the different projects at FBC. This scenario was written up and given to the participants during the study.

3.5.3 The participants

A total of six participants were part of the study. The participants were three of FBC’s directors: the managing director, the operations director and the director for business development. The other three participants were FBC’s three general managers. They were identified as the best-suited participants as some of the issues regarding dashboard design were a lack of management buy-in and the fact that there was a genuine business case for which they could design a dashboard prototype.

3.5.4 Data gathering process and participants

In order to develop a new design method, a participatory design session was held. This design session involved the stakeholders who actually make use of data visualisation within the organisation. Six individuals participated in the design session.

To ensure that the process ran as smoothly as possible, a pilot study was conducted. Problems that arose during this session were taken into consideration and adjustments were made to the setup of the actual design session. The participants involved in the pilot study were also employees of FBC and included junior and senior consultants, as well as a member from IT support.

The participants were divided into two groups of three people. The groups were given the same scenario, see Appendix A, for which to create a dashboard. The participants were also provided with a low-fidelity prototyping kit, consisting of various parts representing various kinds of data, not only typical elements found in dashboards. The groups were given an hour to complete their dashboards and to explain their dashboards to the researcher and the other group. The whole process was voice recorded and photographs of the dashboards were taken. Finally, interviews were conducted with each participant individually to gather auxiliary data.

3.5.5 Instruments used for data gathering

Table 8 provides an overview of the instruments that were used, as well as each instrument's description, purpose, and reliability and validity.

Table 8: Instruments used for recording data

Instrument	Description	Application	Reliability and validity
Voice recorder	A device used to record what participants said.	During the session with participants, voice recorders were used in to keep a record of what was said.	Very reliable and valid, as the participants' exact words were recorded.
Camera	The camera was used to capture images.	Photographs of the prototypes designed by the participants were taken during the session.	Very reliable and valid, as it provides an exact representation of the developed prototype.
Notebook and pen	Notes were written down as necessary.	During sessions with the participants.	Moderately reliable and valid – not used as the primary data source but rather as a complementary data source.
Created prototypes	The prototype dashboards created by the participants.	Created during the design sessions and used for reference after the design sessions.	Very reliable, as these prototypes will be available after the study has been conducted for referral, and are static in nature. As such, the prototypes will not change.

Besides the recording equipment, the prototyping kit was an important part of the data gathering process. The kit comprised large plastic poster boards, coloured paper and pens, glue, coloured insulation tape, various shapes of stickers (including smiley faces), pipe cleaners, round polystyrene disks, and other things such as googly eyes and board game pieces.

3.5.6 The pilot study

The pilot study was conducted with six non-management staff members. They were provided with a case study and a prototyping kit with various items, including coloured paper, stickers, coloured insulation tape, felt-tip pens and large project boards. The sessions proceeded as follows: The participants were greeted and thanked for their time. They were then given printed-out copies of the case study and the expectation of them for the session was explained. They were then given 45 minutes to create dashboards based on the given case study. After the allocated time had elapsed, they were asked to present their dashboards. Finally, they were thanked for their time. After the session, interviews were conducted with three of the six participants. The dashboards designed by the participants of the pilot study are shown in Figures 2 to 4 below.

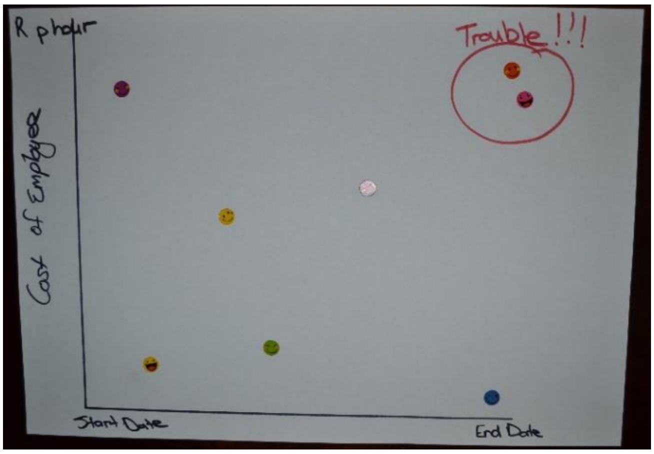


Figure 6: Employee cost dashboard

Figure 7: Resource pipeline planning dashboard

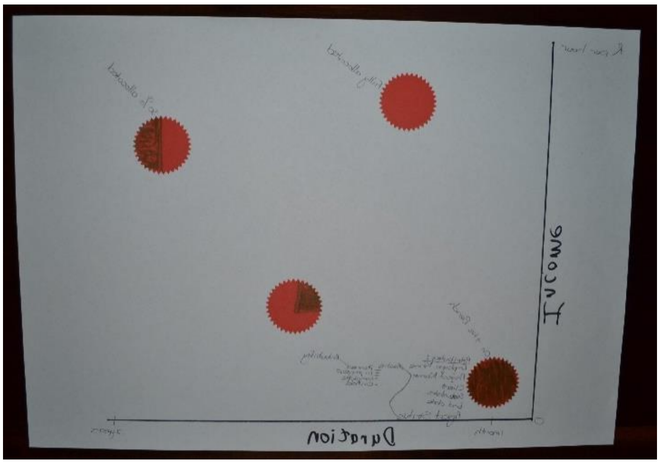


Figure 8: Projected resource allocation – duration and income

An initial concern was that the session would not be well-accepted by the participants and that they would view it as a slightly juvenile exercise. This was not, however, the case, and all participants partook eagerly in the activity. During the session, the groups worked well together and produced dashboards. Some problems were, however, noted. These were:

- Some participants had urgent work to do and were thus not fully focused on the session.
- The prototyping kit was laid out in the middle of a large table around which the two groups of participants sat. This made it difficult for them to not interact with each other and caused them to get in each other's way, as they had to make use of a communal pool of sources.
- There was some confusion regarding the case study, as the participants did not want to extrapolate and make any assumptions.
- The participants focused a great deal of time referring to and making notes on the case study, instead of focusing on designing their dashboards.

Based on the problems encountered during the pilot study, the formal study was adjusted accordingly. The adjustments were:

- Scheduling the sessions at the end of the day to ensure that the participants were not distracted by upcoming work.
- Splitting the tables and prototyping kits to separate the groups from another.
- Not handing the participants the formal case study, and instead discussing the situation with them.

The case study used was an existing case within FBC, and as such management needed little explanation of the case.

3.6 FORMAL DESIGN SESSION SETUP

The formal design session was structured in much the same way as the pilot study, aside from the few issues with the pilot study that brought about changes to the design of the session. There were three boardroom tables next to each other, with three chairs at either end. The prototyping kit provided is shown in Figure 5 below.

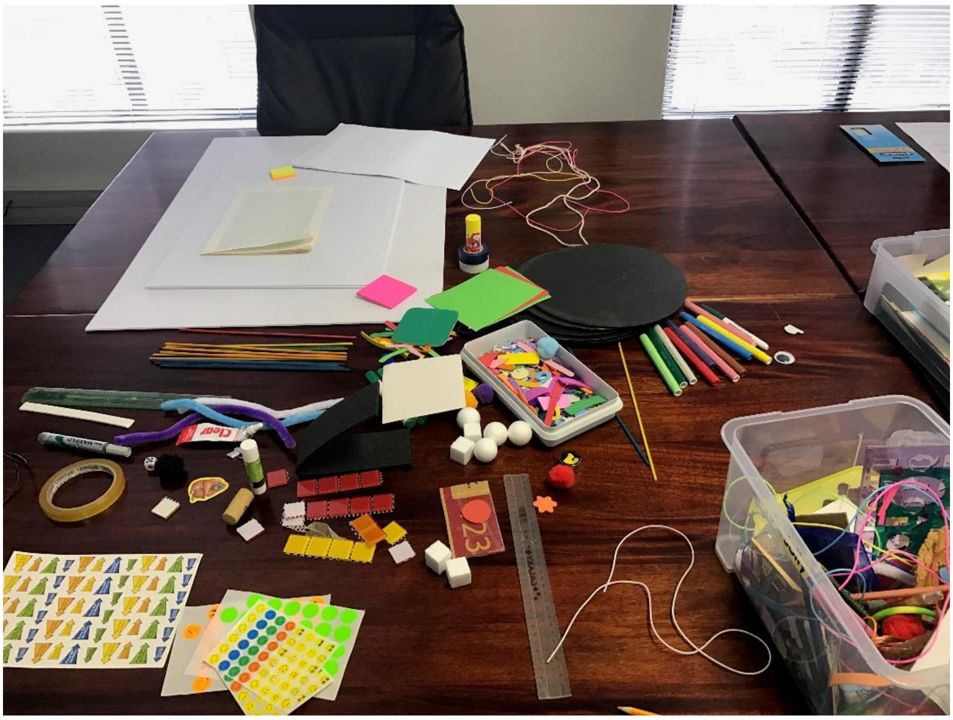


Figure 9: Prototyping kit

Unfortunately, due to the packed schedules of the participants, it was not possible to conduct interviews with them directly after the session. As such, the questions were sent to the participants via email. Four out of the six participants, two from each group, provided feedback.

3.7 ANALYSIS

Thematic analysis was carried out on the data, following the process for interpretive data analysis by Terre Blanche, Durrheim, and Painter (2006). The process set out by the authors is as follows:

1. *Familiarisation and immersion*: After collecting the data, the researcher should have a basic understanding of the content. This should be followed by immersion in the data, which involves going over the data in depth and making notes about the data. In this study, the design session was recorded using voice recorders. These recordings were then transcribed by the researcher. This was a long and tedious process, due to a number of factors: there was background noise, the recorders for each team picked up the voices of the other team, and in

some cases the participants spoke quietly or spoke simultaneously. Due to these reasons, the researcher had to listen to parts of the recordings numerous times, and go back to some areas where there was too much interference and slow down the recordings. The upside of the laborious process was that the researcher became very familiar with the content, and gained a better understanding of the flow of the sessions and what happened. The combination of listening and writing down what was said immersed the researcher in the content.

2. *Induction of themes*: The researcher should attempt to isolate the overarching themes that are present within the data. In the case of this research, it meant reading through the transcripts and emails and making notes about where certain themes arose and where there was a clear separation between different parts of the design, i.e., discussing the case study, designing the dashboard and creating the actual dashboard.
3. *Coding*: Coding of the data happens in conjunction with the induction of themes. During the coding process, pieces of the actual data are marked to indicate which theme or themes are applicable to this specific piece of data. This process is dynamic, and the codes applied to parts of the data might change during the coding process. In the case of this research, coding was done in parallel with the theme induction. Different words in the transcripts and email responses were marked with colours matching different code words.
4. *Elaboration*: During elaboration, the individual themes are inspected in isolation to determine whether any new issues and sub-themes come to the forefront.
5. *Interpretation and checking*: The situation investigated should be written down, often making use of the themes induced. This interpretation should then be re-evaluated to determine whether there are problems or issues, and repetition. This was done in conjunction with elaboration in this study.

3.8 LIMITATIONS

This study focused solely on making use of low-fidelity prototyping to create a new data visualisation method. Thus, any value that might have been added by also making use of a high-fidelity prototype has been lost. Furthermore, only one organisation was used for this study. Thus, there are no comparable results from a different organisation.

Participatory design was used, so the ideas of individual participants might have been lost. An attempt was made to mitigate this by conducting post-session interviews with the individual users.

The method created was evaluated by data visualisation experts. However, no evaluation on the final method was done by the participants.

3.9 ETHICAL CONSIDERATIONS

To ensure that this research put the participants first, a number of steps were taken to ensure that the participants were protected:

1. All participants were given a consent form to sign. They were not pressured into signing this form, and should they choose to, they could revoke their participation. Without a signed consent form, individuals were not able to participate in the study. Refer to Appendix B for the consent form given to the participants.
2. No photographs or videos were taken of the participants. The only photographs taken were those of the prototyping kits and produced prototypes.
3. In transcriptions of the recordings and in all reports on the research, care was taken to ensure that no names were used. The voice recordings will not be distributed outside of the relevant parties at the university.
4. The participants were informed before the session started that they could leave the session at any time without having to provide a reason.
5. Contact details for the researcher's supervisor were provided for any complaints or concerns to be directed to the supervisor, should the participant wish to not relay these to the researcher.
6. No personal or ethnographic details about the participants were needed.

Before any user participation was requested, an application for ethical clearance was submitted to the University of Pretoria Engineering, Built Environment and IT Research Ethics Committee. The documentation that was submitted included confirmation from the postgraduate coordinator that the proposal for this dissertation had been accepted, a copy of the interview questions to be asked after the design sessions, a declaration by the researcher, the informed consent form used, and a permission letter from FBC which stated that the researcher was permitted to carry out the proposed research at the organisation. This clearance was granted – refer to Appendix C for the approval letter.

3.10 CONCLUSION

A study focusing on observing people within their contexts has been discussed in this chapter and was used as the rationale behind following an interpretivist approach, as well as carrying out a qualitative study. As the study discussed in this chapter involved observing a group of people creating low-fidelity dashboards and then creating a model for creating data visualisations from the observations made during this study and from feedback received after the study, design science was chosen as the research framework to be used. This was because design science is a method with a process that results in an artefact. The artefact, in the case of this study, is a new method. Case study research was chosen to be used in conjunction with design science. An initial design for a dashboard design session was laid out. A pilot study was carried out, and alterations were made to the design session setup based on observations made during the pilot study. Finally, this chapter has detailed the steps taken to ensure that the study carried out remained within ethical boundaries, as prescribed by the University of Pretoria.

4 DATA GATHERING AND ANALYSIS

4.1 INTRODUCTION

The study's design has been described in detail in the previous chapter. This chapter provides information regarding the execution and the results of the participatory design session. Firstly, the design participatory design session's structure and sequence of events are explained. This is followed by an analysis of the results of the session, including audio recordings of the session, observations made during the session, and the answers to interview questions posed to the participants afterwards. The analysis steps taken were immersion, theme induction and codification, and finally elaboration, interpretation and checking. The results of this analysis are then used to describe a proposed method for data visualisation using low-fidelity dashboard prototypes and participatory design.

4.2 THE DESIGN SESSION

The design session started off by an explanation of the case study. As all the participants were part of strategic and resource management of the company in question, they all had knowledge about the problem to be solved, as well as preconceived ideas about how to do it. Initially, the prototyping kits laid out in front of them caused some confusion as to what exactly they would have to do with the kit, but also piqued their interest. Two of the participants started to fiddle and play around with some of the string and furry balls during the explanation of the case. The participants divided themselves into two groups, one group consisting of directors and the other group consisting of general managers. The two groups sat at opposite sides of three large tables, with a clear separation between the two groups. Each group was supplied with their own prototyping kit.

During the session, participants from both teams took time to explain and illustrate their ideas, making liberal use of the materials at hand. Eventually the dashboards were created and both teams seemed satisfied with what they had created.

There were some similarities between the dashboards: both teams made extensive use of a few colours and used a wide variety of materials. However, the difference between the two dashboards was quite striking: The first dashboard was ordered, neat and simple, with clear labelling. The second dashboard was more conceptual, and had a large variety of visualisations. Figures 6 and 7 below show the dashboards created during the session. These dashboards were used to develop the artefact of this research (a new method), and are not the design science artefacts themselves.

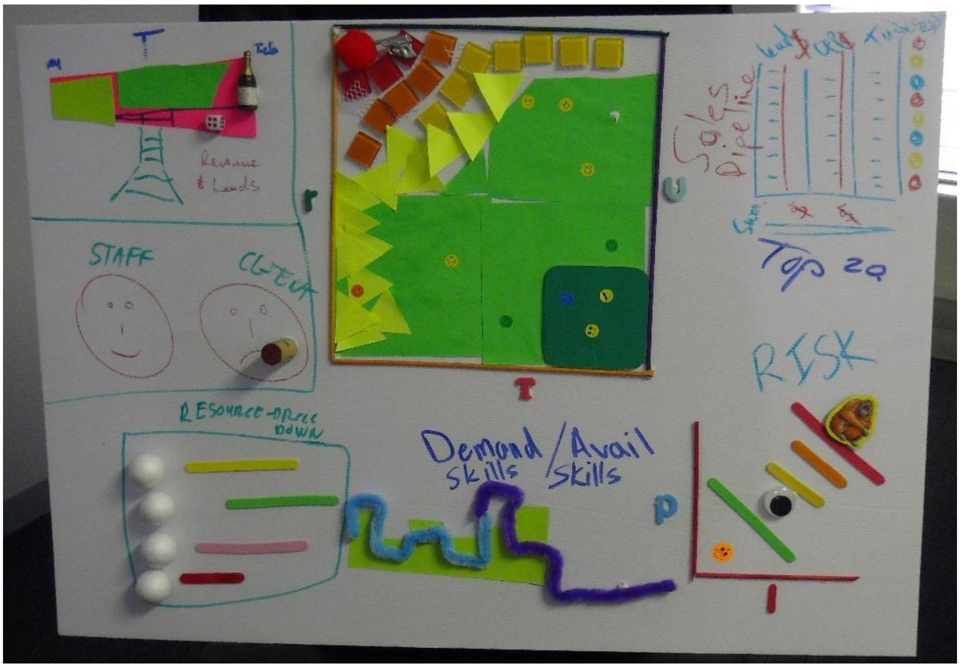


Figure 10: Dashboard created by the team of directors

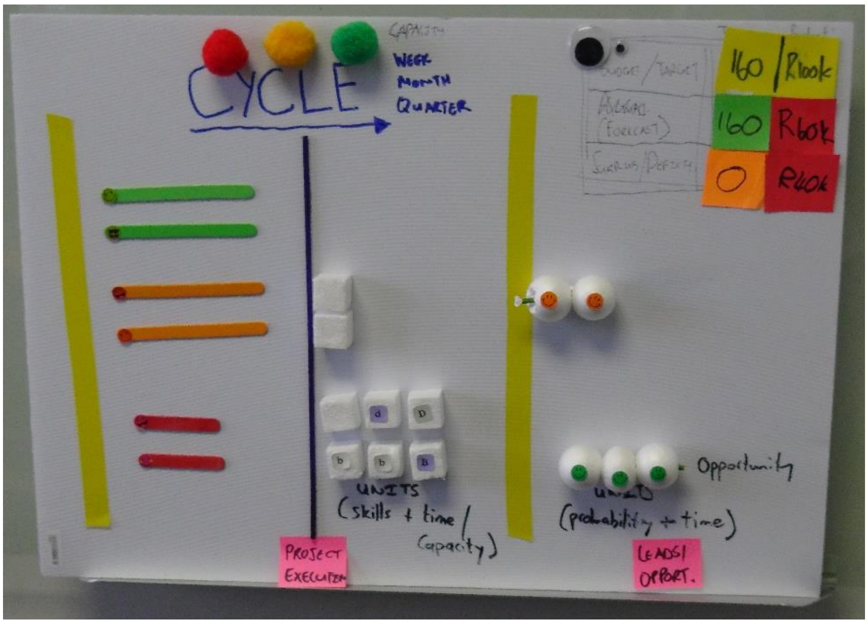


Figure 11: Dashboard created by the team of general managers

4.3 ANALYSIS

In this section, thematic analysis as discussed by Terre Blanche et al. (2006) is carried out. This includes immersion, theme induction and codification, and elaboration, interpretation and checking. This analysis is supplemented by observations made during the session.

4.3.1 Immersion

4.3.1.1 Observations during the session

The sessions started off relatively tense, as the participants were unsure of what exactly to expect. The prototyping kits on the tables in front of both teams did elicit some curiosity, but also some confusion. Two participants immediately started fiddling around with parts of the prototyping kit, including the woolly pipe cleaners. After the initial introduction and explanation, the participants were initially a bit hesitant, but quickly started to participate with a great deal of interest. The participants spoke to each other as if they were taking part in a typical company brainstorming session and appeared to be comfortable with making use of the prototyping kits. There was a certain air of playfulness, as the participants joked around with some of the items, such as an orangutan sticker, furry pipe cleaners and googly eyes. The participants took the prototype design very seriously and produced detailed dashboard prototypes. The team of directors even came up with a novel graph, which they named the ‘Sunrise model’ (see Figure 8). The teams spent a substantial amount of their time searching for items in the prototyping kit, but they did not spend much time just browsing what was available.

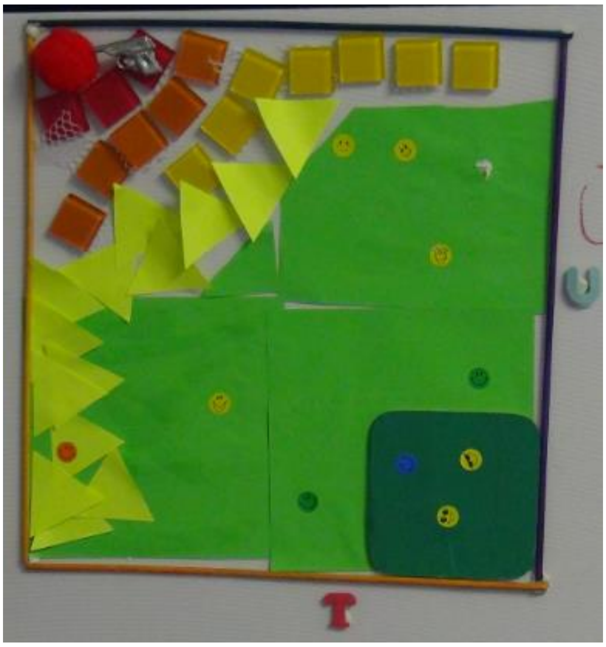


Figure 12: Sunrise model

4.3.1.2 Analysis of the session transcriptions

Both teams immediately started off by considering the scenario and what data they wanted to see. This is a good starting point, as one of the criteria of data visualisation is that the data in question should be displayed (Tufte, 2001). The group of general managers immediately discussed what they wanted to see from a time perspective, by discussing timelines for projects and hour allocations, while the directors went on to discuss what they would like to see from an overall company perspective. The director of the financial services industry brought up the idea of a formula to calculate priority, thus moving away from a pure design mindset. This is a point where care needs to be taken to provide an explanation of the calculation on the dashboard, as a complexity of data visualisation is the fact that a data visualisation can hide the underlying mechanics (the calculation in this case) from the user (Hohl, 2011). The team of directors also discussed the time aspect of the case shortly after starting.

There was a clear split between the participants discussing the scenario and starting with the design of the dashboards, although the team of directors started with the design of their dashboard sooner than the team of general managers. Both teams also referred to their current infrastructure, processes and tools throughout the sessions, attempting to align the dashboards with what was in place within the business at that stage. This included references to programs such as their internal information management system, Excel, and Tableau, their process for assigning resources to projects and their management meetings. This means that the dashboard was given one of the characteristics of an effective dashboard, using dashboards alongside the organisation's portfolio management tools (Allio, 2012).

The business development director referred to their previous experience at companies at one stage during the process, as they were busy designing the dashboard. Throughout the session, the managing director kept the team of directors focused on the specific part of the dashboard they were working on and pointed out when they strayed from that specific view. The managing director also played the role of a timekeeper, reminding the team of directors of the fact that they had limited time throughout the session. The team of directors focused on the types of work performed within the organisation, for instance referring to the role of business analysts multiple times. The team of general managers also referred to specific positions within the company, but to a lesser extent.

Both teams often referred to quantitative aspects such as percentages. Another aspect that was noticeable was that both teams seemed to refer to colour often, especially colours indicating statuses such as red, amber and green. This use of colour to indicate statuses, with red meaning a bad status and green meaning a good status, means that the participants avoided one of the common dashboard mistakes, incorrect use of colour (Few, 2006). Furthermore, both teams referred to which shapes to use on the dashboard, for instance dots, circles, cubes and arrows.

When labelling the axes of the graphs on the dashboards, the directors were interested in using the letter shapes available in the prototyping kit, rather than just writing down the axis labels. It seems that the teams gravitated towards creating dashboards that convey information, while also avoiding a common dashboard design mistake: creating a visually unappealing dashboard (Few, 2006).

The team of directors also searched for places to add some of the more unique items in the prototyping kit, using a big googly eye to indicate a place on the dashboard where they should keep an eye out, using a model champagne bottle to indicate where things on the dashboard were positive, and using an orangutan sticker and small plastic gun to indicate where an employee's performance was less than desirable. The general managers used smiley face stickers to indicate resources and, similarly to the directors, used a googly eye to indicate something they should keep an eye on – in this case, the budget and target. Throughout, the directors were also communicating and explaining their ideas to one another. This means that the participants fulfilled one of the purposes of participatory design, namely, bringing together the views of stakeholders and allowing stakeholders to learn more about the views of the other stakeholders (Hecht & Maass, 2008).

During the presentations, colour played an important role in the explanation of the directors' dashboard. The general managers also referred to colours in their presentation, but to a far lesser extent than the general managers. The quantitative aspects of the dashboards played a big role in both the directors' and general managers' presentations. They referred to timelines and dates throughout their presentation. The directors also referred to 'top N' aspects on their dashboards: top 20 strategies and top 10 priorities.

4.3.1.3 Analysis of the interview question responses

All the participants who answered the interview questions had positive feelings towards working with other people. However, one participant warned that, if one team member has a stronger personality than other team members, the design might be biased towards that one person's input. All the participants were of the opinion that working with others in the design session had an influence on their creativity, with three of the participants explicitly stating that the impact of working with others had a positive impact on their creativity.

The feedback on the prototyping kit varied, with one participant feeling that there needed to be more order to the prototyping kit, although the participant did comment on liking the prototyping kit itself. One participant was of the opinion that the prototyping kit was sufficient, while another participant was sceptical about the kit but surprised at how well it seemed to work. Another response was that the prototyping kit made them think differently about reporting, and a suggestion was made that there needs to be a facilitator who plays a bigger role in situations where the team lacks some initial momentum.

When asked about which elements caught their eyes, two of the participants said that the colour of the elements grabbed their attention. Two of the participants felt that the shapes were attention-grabbing. This is a point where caution should be applied, lest the dashboard become cluttered with decoration, a common dashboard design mistake (Few, 2006). One participant was drawn by what the participant referred to as ‘mini-toys’, which included the small plastic gun and the champagne bottle.

The participants had different answers to the question about which elements they thought are the most important when designing a dashboard. One participant mentioned that the most important element when designing a dashboard is a good understanding of the organisation, which will allow the dashboard designer to use anything (a very ambiguous term) to build something which represents the organisation’s key performance indicators. Another participant stated that the most important element is the information and what it represents. This participant also mentioned that the purpose of using dashboards is to make informed choices, and using the correct data and information and looking at the correct things can lead someone to make good decisions. The opinion of this participant aligns with a benefit of business intelligence systems: providing users with information to aid in better decision-making (Watson & Wixom, 2007). Another participant stated that visual grouping is the most important part of dashboard design. There was only one participant who referred to the actual prototyping kit when answering the question. This participant felt that the most important elements are things like smiley faces, which convey a sense of emotion, and any elements which can indicate trends.

Three of the participants said that there were no elements in the kit that could not be used. One participant said that they could not remember, but thought that the usefulness would depend on the requirements and specific data. Only one participant said that there were things that could be added to the prototyping kit. This participant suggested that the addition of Lego building blocks could be useful.

The question regarding comments and suggestions elicited the most feedback from the participants. A participant suggested that an exercise must be undertaken before the design session to get the designers away from the normal way of thinking when it comes to dashboard design, lest they use elements that produce dashboards most closely resembling the dashboards they are used to, for example paper and pipe cleaners. One participant thought that the design session was long enough to get down to the point, yet short enough to avoid, as the participant put it, ‘analysis paralysis’. This indicates that the session avoided a disadvantage of low-fidelity prototyping: the amount of time the process can take (Holzinger, 2004). Another participant felt that the exercise was unique and refreshing. The last participant stated that care must be taken with the facilitation and assistance during the session, to ensure there is enough initial input from the person facilitating the session so that the teams gain momentum.

4.3.2 Theme induction and codification

The themes discussed here were identified across the observations, transcriptions and interview responses. The themes that arose and the elements that formed part of the themes are discussed in this section.

Theme 1 – Colour: During the design sessions, and in the interviews afterwards, colour was an element that played a big role. The participants referred to the colours red, amber and green often while discussing project statuses and risks (see Figure 9). The participants also referred to specific colours during the presentations to direct the audience’s attention to the part of the dashboard that they were explaining at that moment. The ‘sunrise model’ (see Figure 8), which was a graph designed by the group of directors was so called due to the use of red and yellow within the graph, had a small red area on top of a larger yellow area, with a big green area being the most desirable. The participants made use of only a few colours without any instruction to do so – this came naturally.

Figure 13: Red, amber and green used in prototype

Theme 2 – Shapes: The shape of certain items within the prototyping kit caught the eye and stimulated the imagination of the participants. The participants joked around with items, including a toy gun, champagne bottle and orangutan. One participant referred to these items as ‘mini toys’ in response to the interview question, and stated that they were drawn by these items. The participants also made use of googly eyes to indicates areas to keep an eye on. Shapes were also used when communicating ideas to one another, as the participants would refer to specific shapes, for example spheres and cubes, when explaining which items they would like to place on the dashboard. The smiley faces were another shape that played a role in the session. These were used to indicate individual resources on the dashboard, and one participant felt that something like smiley faces, which can help to convey emotion, is important. The use of shapes is shown in Figure 10 below.

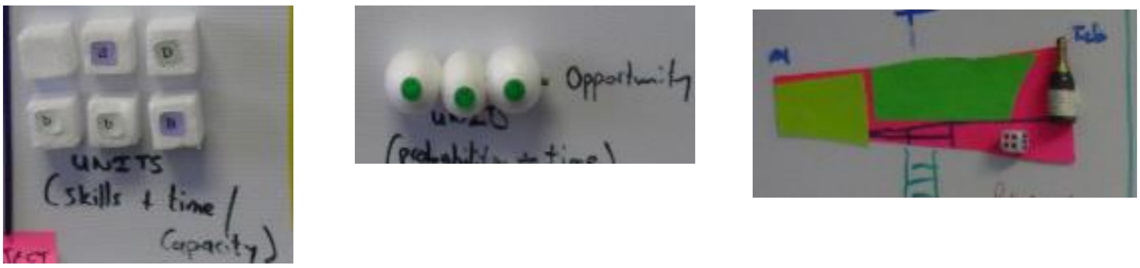


Figure 14: Some of the different shapes that were used

Theme 3 – Texture: The first items the participants interacted with were the woolly pipe cleaners, as these immediately played with the woolly pipe cleaners when the sessions started. A participant also stated that they liked the woolly balls that were in the kit during the session. The use of texture, specifically woolly pipe cleaners, is shown in Figure 11 below.

Figure 15: Woolly pipe cleaners used

Theme 4 – Facilitation: Facilitation of the session seems to be an aspect that should be an important consideration. The beginning of the session saw participants who did not know exactly what was expected of them, and only after some explanation and questions did they start hesitantly. This is an issue that can be resolved by improved facilitation. A participant stated in their interview that they felt the facilitator needs to play a bigger role during the session, especially at the beginning of the session, to ensure that the teams get moving.

Theme 5 – Order: The prototyping kits were not ordered. One of the participants felt that the kits should be ordered in some way. This was substantiated by the relative frequency with which participants rummaged through it. It was also the case that the participants searched for specific items within the prototyping kit instead of perusing its contents.

Theme 6 – Frame of reference: Both teams seemed to put the design they were carrying out into context within their own organisation and experiences. They treated the design session with the same kind of attitude that would typically be reserved for company meetings. There were many references to current tools and structures in place within their organisation, as they would often refer back to their existing software and processes, as well as resources roles and even specific names of people. The fact that the participants made liberal use of their current frame of reference was supported by a participant who felt that understanding the organisation is a very important element of the dashboard design session being successful.

Theme 7 – Session timeline and timekeeping: The division between discussion and working on the prototype was clear with both teams. The team of directors were also conscious of the amount of time they were being afforded, as the managing director kept on reminding them that they had limited time and that they needed to get through everything. This time-consciousness was also reflected in the managing director's interview, where they felt that the session length was just the right amount of time.

Theme 8 – Quantitative aspects: The quantitative aspects of a dashboard, including the data to be displayed, timelines on data, calculations to be used and top N analysis played an important role in the design of the dashboards, as these quantitative aspects were points of discussion throughout the design session and were also referred to in the interview questions, where one participant felt that the correct data and information are an important aspect of informed decision-making (see Figure 12).

Figure 16: Top N being used in dashboard

Theme 9 – Communication and team dynamics: Throughout the sessions, the team members were constantly communicating with each other, and no decisions were made without a consensus. In some cases, where further explanation was needed, this was simply given without the team member being upset or frustrated about having to explain something. The importance of good communication and team dynamics also came to the forefront in the interviews, where one participant warned that a team where one member has a strong personality may lead to a biased dashboard. Another factor that came to light was that some of the participants felt that the other participants had a positive impact on their own creativity.

Theme 10 – Requirements: The scenario provided was deliberately general and not very detailed. During the design session, several requirements, for instance the requirement to display top priorities on the dashboard, was revealed. As such, the session was also a requirement elicitation session, as the requirements were discussed and visually communicated, first in the two groups separately, and afterwards to both groups during the dashboard presentations.

4.3.3 Elaboration, interpretation and checking

The themes identified in the previous section were all revisited to ensure that all elements were covered. What arose from this further inspection was how closely related some of these identified themes were. These related themes were then grouped together, to create a smaller set of broader themes. The overarching themes identified were:

Overarching theme 1 – Sensory elements: What became apparent when reviewing the identified themes, was that visuals and haptics made an impression on the participants. Thus, themes 1 to 3 can be combined, as colour, shapes and texture have to do with sensory elements.

Overarching theme 2 – Session guidance: The way that the session was presented and ordered was a noticeable aspect of the study. Upon further inspection, it became apparent that theme 7 (session timeline and timekeeping), could be broken up into two sub-themes: the actual division of the phases of the prototype development, namely, discussion and development, and the time-consciousness and timekeeping of the participants. Facilitation, timekeeping and communication, and team dynamics are included as part of the overarching theme of management. The reason for this inclusion is that all of these themes deal with a certain aspect of guiding the session. The facilitator will guide the team towards an end objective, the timekeeper will ensure that the team arrives at a finished prototype within the allotted time, and good interaction and communication between team members will help create a smoother and more inclusive prototyping sessions.

Overarching theme 3 – Individual train of thought: Three themes had to do with how the participants thought when building the prototype. These were themes 5, 6 and 8: order, frame of reference and quantitative elements. The unordered array of items to create prototypes with got the proverbial ‘creative juices’ of the participants flowing, while the participants relied on some prior knowledge to help with the creation of the prototype, as well as on quantitative measures to determine how to structure their visualisations.

4.4 PROPOSED METHOD

The culmination of the research put forth so far is a method for creating data visualisations by utilising low-fidelity prototyping and participatory design. In this section, aspects identified earlier in this chapter that constitute the steps of the method are discussed and then ordered logically to create the proposed method.

4.4.1 Method steps

The following steps are to be carried out to create a visualisation with participatory design and low-fidelity prototyping, as identified earlier in this chapter.

Step 1 – Put together a prototyping kit: The prototyping kit is an important part of the method for two reasons: firstly, the participants will work with it quite a lot to get the required parts, and secondly, it is used to stimulate creativity as the participants look through various objects, which might trigger uses and ideas in the participants. The participants in this study spent some time going through the contents to find something they already had in mind, and one participant expressed a desire for a more ordered kit.

To this end, it is proposed that the kit be semi-ordered, with the kit's items ordered by the sensory element that was most prevalent during the research: colour. This means that the participants can decide on a colour of item and not waste time looking for a specific colour within a monolithic pile of items; instead, they can go straight to the desired colour and then look through. By sorting the items in this way, participants will still need to look through some items they may not have thought of, but they will get a sense that the prototyping kit is more ordered. The party setting up the prototyping kit can decide to rather organise the kit by shape, or even textures (woods, smooth items, fuzzy items and so forth), depending on their specific case. The prototyping kit should be comprehensive. In the design session held as part of this study, it was evident that the participants were amused by some of the more juvenile elements of the prototyping kit, which lifted the mood of the session. Thus, the prototyping kit should not be limited to business-related objects or restricted colours.

Step 2 – Deciding on participants: Many parties should be considered when creating dashboards. These parties, discussed in the literature review of this dissertation in more detail, include business analysts, end users, the database team, the IT team and the project manager (Chiang, 2009). In this study, the end users (management) were chosen. In this study, the participants knew each other and shared similar backgrounds, which meant that they were able to communicate easily with each other. This worked out well, as there was no need for introductions or sessions to establish context. If this had not been the case, more time might have been needed.

Step 3 – Creating context: The context referred to here is twofold: context about the participatory design, low-fidelity prototyping and the purpose of the sessions, and context with regard to what needs to be designed. In the case of this study, the participants were given context of the situation by means of a printed case study. However, it might be necessary to give more in-depth information about the case. This is an area for further exploration but is outside the scope of this dissertation.

Step 4 – Keeping time: The study was time-sensitive, and it is anticipated that this will usually be the case. For the study, the time limit was decided on beforehand and communicated to the participants. A dedicated timekeeper should be appointed per group, if the sessions are to be divided into groups, to remind all other participants in that group to work in a timely fashion. In this study, one participant took on this role without being asked to. However, in the other group this was not the case, and thus it is recommended that this be done from the start of the session.

Step 5 – Creating the prototype: The purpose of the design session is to actually let participants work together to create a prototype data visualisation with a low-fidelity prototyping kit.

Step 6 – Post-session feedback: In the study, participants were asked to provide feedback in the form of some interview questions. Although not all the participants answered, this feedback still provided some valuable insight into the session, and generated some new ideas, for instance the inclusion of Lego blocks in the prototyping kit. As this will help to evolve and refine these sessions, it is recommended that post-session feedback be requested. The specifics of the structure of how the feedback is requested are not discussed in this dissertation, but might be an area for further research.

Step 7 – Prototype presentations: After the prototypes have been developed, participants should be given an opportunity to present their prototype to the other involved participants and stakeholders. In the case of this study, the presentations were only done for other participants, but in a real-life scenario it might be useful to allow other stakeholders, not involved in the prototyping process, to critique the prototype and ask questions, to stimulate creativity. Whether this will be a good idea remains to be seen, and it might be a research avenue worth exploring in future.

Step 8 – Deciding on scenario for design session: The design session should have a scenario for which the participants are to design the prototype. In the case of the study carried out for this dissertation, an existing case within the business was used. This case was based on an actual need for information within the company and facilitated the exchange of different solutions to the same problem. For this reason, it is advised that a need for information within the organisation, or an information solution for which a consensus cannot be reached, be formalised and used for a study. The characteristics of a good scenario for participatory design sessions are outside the boundaries of this dissertation, and are an opportunity for future research.

4.4.2 Logical method

The individual steps in the method were discussed above. In this section, the steps are grouped according to the three stages of participatory design discussed in the literature review chapter, namely, initial exploration of work, discovery process and prototyping (Spinuzzi, 2005), and logically ordered.

The following steps lay the foundation for the design session and should be done first. These are thus a part of stage 1, the initial exploration of work:

1. Deciding on a scenario.
2. Deciding on participants and inviting them to partake.
3. Putting together a prototyping kit.
4. Creating context.

5. Post-session feedback – in the method proposed here, post-session feedback can be used for additional exploration of work and can be used as the input to a new discovery and prototyping process. This leads to the possibility of iterative participatory design, which is not within the scope of this research.

The following steps are part of stage 2, the discovery process:

1. Creating context.
2. Prototype presentations – this part of the discovery process will only be carried out after the prototyping stage, and thus opens up the possibility of an iterative participatory design process, which is not within the scope of this research.

The following steps deal with the actual creation of prototypes, and are thus part of stage 3, the prototyping phase:

1. Creating the prototype.
2. Keeping time.

4.5 CONCLUSION

After holding the participatory design session and analysing the results, three overarching themes came to light. These themes were sensory elements, session guidance and individual train of thought. These themes, along with their respective sub-themes, were used as an input to develop a method for data visualisation creation using low-fidelity dashboard prototypes and participatory design. The method comprises several steps, grouped into the three stages of participatory design (Spinuzzi, 2005). The first stage, initial exploration of work, consists of deciding on a scenario and participants, putting together a prototyping kit, creating context, and post-session feedback (this step feeds into the first stage of the next iteration of visualisation design). The second stage, discovery, consists of prototype creation and presentations. The third stage, prototyping, consists of the prototype creation and timekeeping. With this model, a method has been developed for creating data visualisations using low-fidelity dashboard prototypes and participatory design.

5 CONCLUSION

In this dissertation, context was given about a problem of creating data visualisations, as well as the importance of data visualisation as a part of business intelligence and the management of business. This was backed up by a literature review detailing research done in the domains of business intelligence, participatory design, user-centred design, low-fidelity prototyping and dashboarding.

After the problem had been identified and described, and research into the related areas had been done, a method was developed to create a possible solution to the problem. Design science was chosen as the way to conduct the study, as a new method (which is seen as an artefact in this dissertation) was developed. It was decided to conduct a design session where managers from a business with a need for data visualisation would create low-fidelity prototypes by working together. The ethical considerations and the process to ensure that the research would be ethically sound were also described. This session was received well, as the post-design session feedback seemed positive. Observations about the process, as well as participant comments, were taken into account and a method for creating data visualisation using low-fidelity prototypes was developed. In this conclusion chapter, the dissertation's use of design science is explained, the dissertation is summarised and areas for further study are described.

5.1 DESIGN SCIENCE USE

In Chapter 3, the processes in design science were described as awareness of problem, suggestion, development, evaluation and conclusion (Vaishnavi & Keuchler, 2004). The design science process is iterative, but for the purpose of this dissertation only one iteration was carried out.

5.1.1 Awareness of the problem

In Chapter 1, the problem was identified and explained, and a problem statement was formulated by reviewing literature and identifying issues. The problem identified was that users, especially management, are not involved enough during the development of data visualisations, and that data visualisation might appear to be an arduous task.

5.1.2 Suggestion

In Chapter 1, a solution to the abovementioned problem was suggested. The suggested solution was a method for creating data visualisations by making use of participatory design and low-fidelity prototypes.

5.1.3 Development

While Chapter 1 set the stage for the research to be carried out, Chapter 2 formed a basis to give the reader context about five key areas of this dissertation: business intelligence, participatory design, user-centred design, low-fidelity prototyping and dashboarding. Chapter 3, the methodology chapter, described how the actual method would be developed. The final part of the development of the artefact was part of Chapter 4, where the execution of the method was detailed.

5.1.4 Evaluation

After the method to gather data was developed and executed, the data gathered were evaluated and used as input to refine the rudimentary method proposed in Chapter 1. The initial method consisted of identifying participants, putting together a prototyping kit, assembling a scenario, conducting a design session and conducting post-design session interviews. These stages were enhanced, and steps were added to the method for future use.

5.1.5 Conclusion

The conclusion of this research is the proposed method, which can now be refined further and evaluated in an iterative fashion. The scope for further research, found later in this chapter, can provide guidance on how to refine the developed method, and can go towards creating a more rigorous method.

5.2 THE RESEARCH QUESTION ANSWERED

The research question was: How can low-fidelity prototyping in conjunction with participatory design be used in a design method for data visualisations? The answer to this question is the model proposed in Chapter 4 (see Figure 13). This model has been created after analysing the results from a design session. The participants reacted positively to the design session where participatory design and low-fidelity prototypes were created, and the result of their efforts were two distinctly different dashboards addressing the same issue. The design session even resulted in a novel visualisation, which the participants themselves named the ‘sunrise model’.

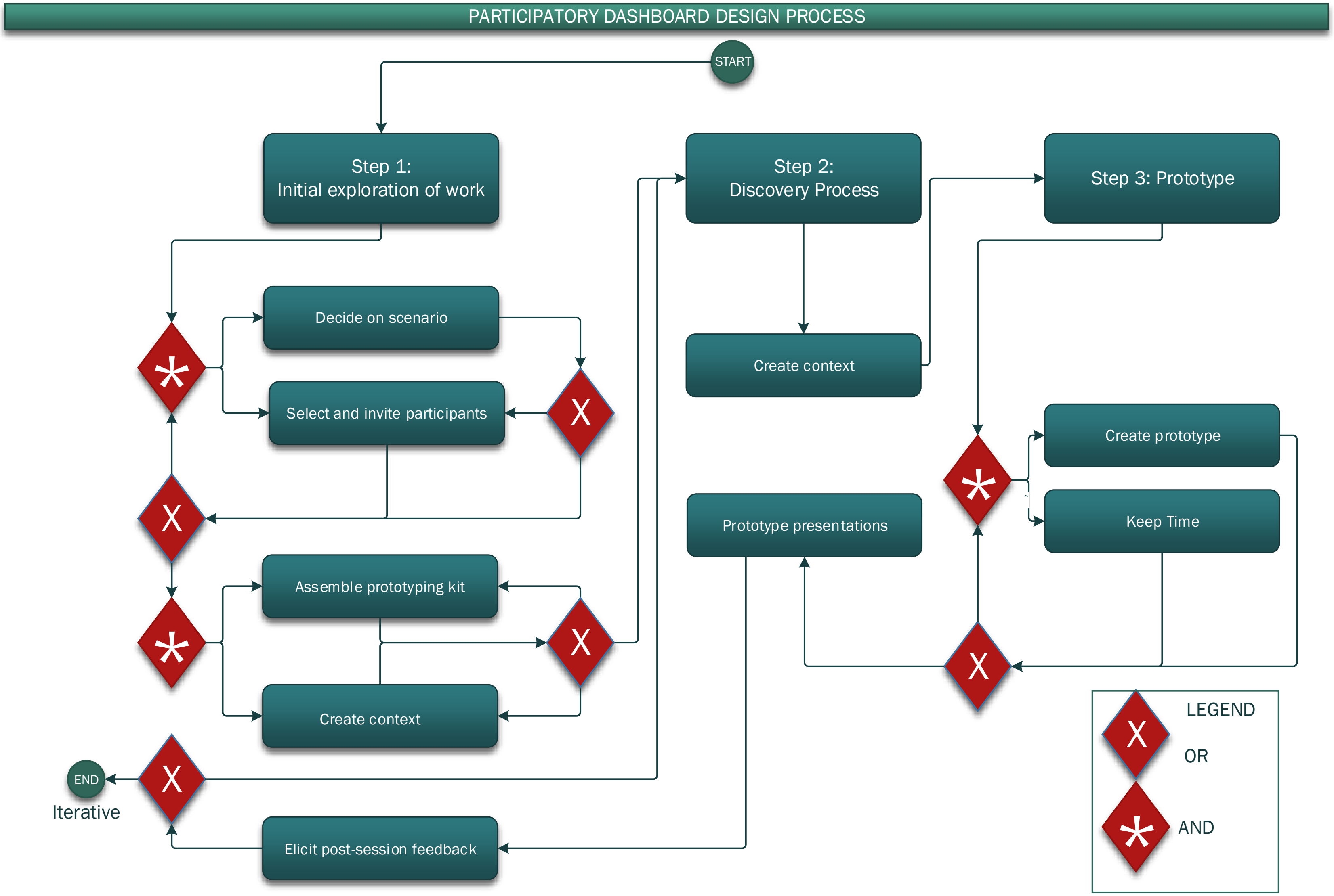


Figure 17: Participatory design process

5.3 SCOPE FOR FURTHER RESEARCH

This dissertation suggests a new method for creating data visualisations using participatory design, and can be seen as one iteration of the design science process. Further iterations should be conducted to refine this method. The following items were identified as areas to be researched, in order to enhance and expand the research contained within this dissertation:

1. A comparison between participatory design sessions where the participants know each other and situations where the participants do not know each other.
2. A comparison of approaches to provide participants in participatory design with context regarding the purpose of the session.
3. An investigation into what constitutes a successful scenario for a participatory design session.
4. An exploration of whether the stages of participatory design, as discussed by Spinuzzi (2005) (initial exploration of work, discovery and prototyping), can be used as an iterative process, where prototyping can again lead to exploration and discovery.

5.4 CONTRIBUTION OF THIS STUDY

The study presented in this dissertation makes both theoretical and practical contributions.

5.4.1 Theoretical contributions

The literature reviewed for this study brings together data visualisation, participatory design, dashboarding and low-fidelity prototyping. It has affirmed various parts of the existing body of literature by adding practical examples to the theory.

5.4.2 Practical contributions

A method for creating visualisations using low-fidelity dashboard prototypes and participatory design has been developed by observing two groups of managers within an organisation. The results and analysis illustrate how managers worked together to create a visualisation from a business case in their organisation, and detail how they interacted with a low-fidelity prototyping kit.

5.5 CONCLUSION

This dissertation, and the study carried out as part of the dissertation, has led to a new method to follow for creating data visualisations. The method has been created by going through one iteration of the design science process, and lays a foundation for further iterations and refinements to be made to the method, as well as providing scope for related future research to be carried out.

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APPENDIX A: SCENARIO

An important task of operations management within a firm is resource pipeline planning. Management needs to be aware of which employees are allocated to which projects, for what period of time they are allocated to the project, how many hours they are allocated to the project, as well as when they finish with a project. Other aspects which managements might consider include the performance of specific divisions, revenue per client and resources per project. The task is to design a dashboard which showcases all the above information to management.

The following is relevant to the management:

1. Employee name
2. Project client
3. Project name
4. Project status e.g. planned
5. Project probability e.g. how certain is the company that this project will happen if the project is still being planned
6. Start date
7. End date
8. Hours allocated each month

APPENDIX B: INFORMED CONSENT FORM

INFORMED CONSENT AGREEMENT

Name of study: MIT(Information Systems): Creating data visualisations for dashboards using participatory design and low-fidelity prototyping

Researcher: Mr Stefan van der Merwe

Supervisor: Prof JH Gelderblom

Purpose of study: Developing a data visualisation methodology by making use of participatory design and low-fidelity prototyping.

Description of study: Participants will be divided into groups and be provided with a scenario and a low-fidelity prototyping kit. The participants will then be asked to create a dashboard for the scenario by making use of the low-fidelity prototyping kit.

Data which will be gathered: Photographs of the developed dashboards, voice recordings of the session, and voice recordings of post-session interviews.

Research conditions:

- Participants will be taking part as a group.
- No ethnographic or personal data of the participants are recorded or taken into consideration
- Participants can withdraw from the study at any time, without any questions being asked
- The photographs of the dashboards will not contain any part of a participant or a participant's information
- Voice recordings and transcriptions of the voice recording will be dealt with as strictly confidential
- No names will be used to report on the findings of the study
- The results of the study will form part of a written document, and to develop a methodology. No personal information of any participant will be revealed within this document, however.
- Participant privacy and confidentiality is important and will be preserved at every step of the study

Time required: The participatory design session will last a maximum of 40 minutes, and the interview afterwards will last a maximum of 10 minutes.

Contact details:

Stefan van der Merwe

Email: u12005569@tuks.co.za

Cell phone number: +27 72 870 0076

Your participation in this study is greatly appreciated.

I (full name)____

hereby declare that I am aware of the above information and that I am willingly participating in this study.

Signature____________________ Place __________________ Date _____________________

APPENDIX C: ETHICAL CLEARANCE

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

Faculty of Engineering,
Built Environment and Information Technology

1956 – 2016
60
years of
Engineering Education

Reference number: EBIT/64/2016 17 October 2016

Mr JS van der Merwe
Department of Informatics
University of Pretoria
Pretoria
0028

Dear Mr Van der Merwe,

FACULTY COMMITTEE FOR RESEARCH ETHICS AND INTEGRITY

Your recent application to the EBIT Research Ethics Committee refers.

Approval is granted for the application with reference number that appears above.

1. This means that the research project entitled "Creating data visualisations for dashboards using participatory design and low-fidelity prototyping" has been approved as submitted. It is important to note what approval implies. This is expanded on in the points that follow.

2. This approval does not imply that the researcher, student or lecturer is relieved of any accountability in terms of the Code of Ethics for Scholarly Activities of the University of Pretoria, or the Policy and Procedures for Responsible Research of the University of Pretoria. These documents are available on the website of the EBIT Research Ethics Committee.

3. If action is taken beyond the approved application, approval is withdrawn automatically.

4. According to the regulations, any relevant problem arising from the study or research methodology as well as any amendments or changes, must be brought to the attention of the EBIT Research Ethics Office.

5. The Committee must be notified on completion of the project.

The Committee wishes you every success with the research project.

Prof JJ Hanekom
Chair: Faculty Committee for Research Ethics and Integrity
FACULTY OF ENGINEERING, BUILT ENVIRONMENT AND INFORMATION TECHNOLOGY

Fakulteit Ingenieurswese, Bou-omgewing en Inligtingtegnologie
Lefapha la Boetšenere, Tikologo ya Kago le Theknolotši ya Tshedimošo

APPENDIX D: INTERVIEW QUESTIONS

Interview guide for participatory design session

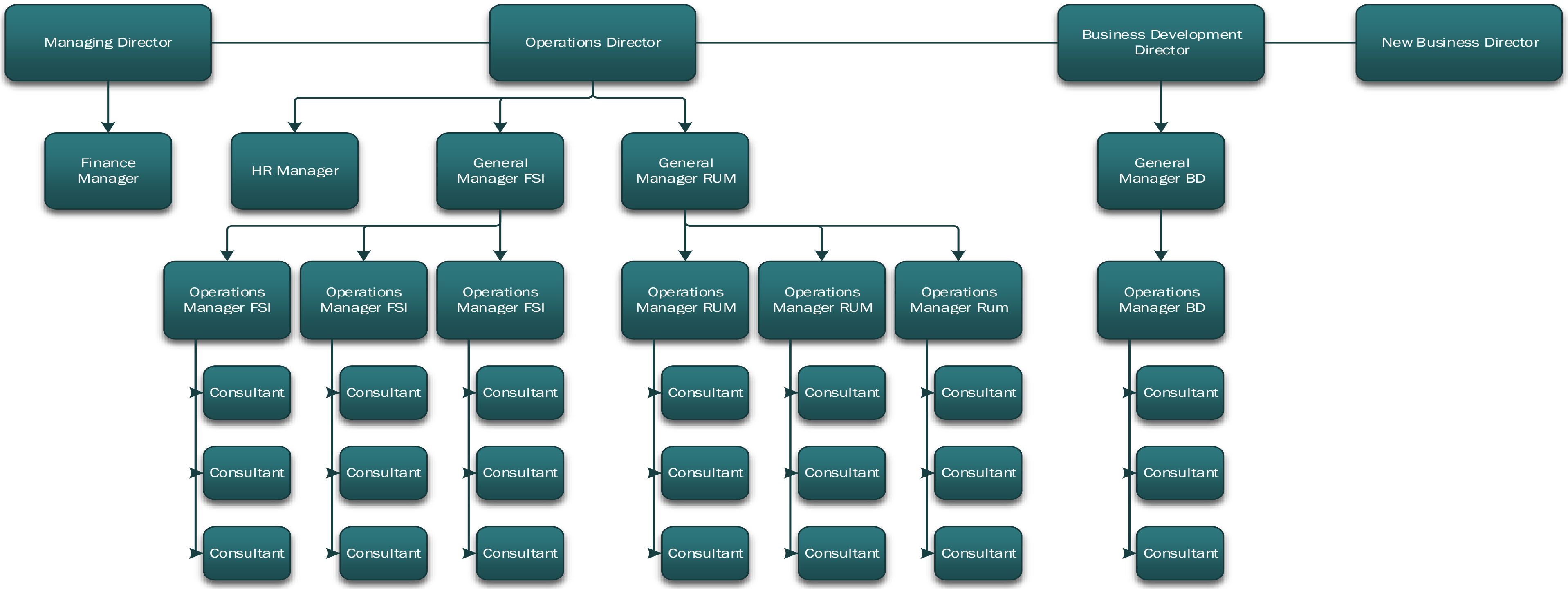
1. Introduction
    - Thank participant for taking part in participatory design session earlier
    - Explain that the interview is to get individual perspectives of participants
    - Explain to the participant that they can stop the interview at any time
    - Explain to the participant that the interview will be recorded, as indicated in participation agreement form
    - Explain to the participant that their names will not be used at any time during any time when reporting on the interview
    - Explain to the participant that the recording of the participant during the interview will be kept strictly confidential, and the only other parties who will have access to the recording beside myself will be my supervisor, and a transcriptionist, should one be used
    - Explain to the participant that nothing said in the interview will be held against them in any way
    - Briefly explain the case study again
2. Questions

- The questions will be open-ended, and no background or demographic questions will be asked

    - What did you think of the prototyping kit used?
    - Which elements in the kit caught your attention and why?
    - Which elements did you consider most important when creating the dashboard and why?
    - Which elements in the prototyping kit would you not use when creating a dashboard and why?
    - Which elements would you like to add to the prototyping kit and why?
    - How did you feel about working on the design with other people?
    - How did you feel your creativity was influenced by the other people in you group?
    - Are there any other comments or suggestions you have regarding the session?

3. Conclusion
    - Inform the participant that the results of the study can be obtained from me once finished
    - Thank the participant for their time

APPENDIX D: FBC ORGANOGRAM



APPENDIX E: LANGUAGE EDITING DECLARATION

Susanna Elizabeth Louw
Phone 076 588 8561
Email anzelle@wordfix.co.za
SATI membership number 1002866

EDITING DECLARATION

DATE: 19/10/2018

I, SE Louw, hereby declare that the dissertation titled ***CREATING DATA VISUALISATIONS FOR DASHBOARDS USING PARTICIPATORY DESIGN AND LOW-FIDELITY PROTOTYPING***, with the exception of verbatim quotes, has been professionally language edited by me.

If further information is required, please contact me.

SE Louw	2018-10-19
Susanna Elizabeth Louw	Date