Cape Peninsula
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THE DESIGN OF A HANDS-FREE SPEECH RECOGNITION APPLICATION DURING THE INTRAPARTUM STAGE

by

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DECLARATION

I, Forchu Midou Melo, declare that the contents of this thesis represent my own unaided work, and that the thesis has not previously been submitted for academic examination towards any qualification. Furthermore, it represents my own opinions and not necessarily those of the Cape Peninsula University of Technology.

Signed **Date**

ABSTRACT

Unlike the developed nations, the health sector within the developing countries is faced with the triple challenges of human, financial and technological scarcity of resources. This insufficiency of resources results into amongst other intrapartum mishaps. To ameliorate some of these conditions, the World Health Organization (1994) promoted the use of the pathogram as an informative and data capturing tool that could help reduce intrapartum mishaps. The usage of the partogram within the intrapartum environment also introduced a dilemma as birth attendants spent quite a good amount of time using their eyes and hands (in pen and paper) capturing medical data onto the partogram instead of investing these resources onto the expectant mother and or fetus.

This study adopted Design Science Research as a suitable research approach, strengthened by a pragmatic philosophical standpoint.

This study involved the following methods;

- A review of literature in the intrapartum environment, along with topics from relevant reference disciplines including speech recognition
- A series of semi-structured contextual interviews with birth attendants, student nurses and senior midwives
- A design science research study using the knowledge from the reference disciplines to design a hands-free voice driven epartogram
- A simulation of the capturing of intrapartum data to evaluate and refine the prototype (epartogram) by applying anonymized intrapartum data driven by natural speech
- An evaluation of the artifact (epartogram) based on a number of published guidelines recommended by scholars to demonstrate its potential utility as well as to establish if the solution is generic to the contextual environment.

Although the introduction of ICT into the problem domain abetted the process of data capturing (specifically the referral process), the fundamental aspect of using the prototype to free the hands and eyes of the birth attendants proved challenging due to issues with the recognition of natural speech by speech recognition systems and background noise. Monitoring of MOU and the referral process from a lower MOU to a higher one could benefit a great deal from this study as the prototype thrived well in that regard.

Natural speech recognition by machines in an uncontrolled environment is still at its infancy (some of the most powerful engines can not differentiate between background noise and direct instruction). Not withsatnding the challenges posed by the infancy of speech recognition, the

artifact showed potential as a manual epartogram providing spatial access to multiple participating MOU via the cloud.

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my family and friends for believing in me

DEDICATION

To the gentle souls that took me in and raised me as theirs.

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Glossary

Terms/Acronyms/Abbreviations	Definition/Explanation
MOU	Midwifery obstetrics unit
HI	Health Informatics
IT	Information Technology
HIS	Health Information System
DSR	Design Science Research
IS	Information Systems

Ethnography

According to Reeves (2008), ethnography is the study of social interactions, behaviors, and perceptions that occur within groups, teams, organizations, and communities. However, in this study, it is used quite lightly to refer to the observation of simulation as well as contextual structured and semi-structured carried out to understand certain missing aspects from the literature review.

Keywords: Design Science, Utility, MOU, Speech recognition, Information Quality

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CHAPTER ONE

INTRODUCTION

1.1 Introduction

In this chapter, the background to the study is described to serve as a basis for the proposed solution. The problem statement follows from the background description. This is followed by the research questions that are used in this study to investigate the design of the proposed solution. The aim of the study is given followed by the scope of the study. The research methodology used for the design research process is briefly outlined according to the intended audience and anticipated outcomes. This chapter is concluded with the structure of the thesis.

1.2 Background

This research topic came about as a result of a study that was carried out by Van Zyl (2011) within the HBHC (Home-based Healthcare) environment. He looked into the "Mutual Isolation and the Fight for Care; An Ethnography of South African Home- based Healthcare Contexts". The study elucidated some of the social and cultural factors that are pertinent within the HBHC, explored the needs and desires of caregivers (particularly informational and educational) and ultimately laid the early foundation for possible communication technology-based solutions. Most important, this research is a subset of a much broader research being conducted by lecturer in midwifery at the University of Stellenbosch within a community health centre (CHC) which is a level one intrapartum facility (Midwifery Obstetrics Unit). The main research focuses on the "Development of a sustainable information communication framework that contributes to the effective management of the intrapartum period". This research focuses on how the complexities of the information communication can be improved to enhance the management of the intrapartum period. In essence, both of the afore-mentioned researchers concluded that the capturing of data within their respective environment was a labour intensive endeavour and was prone to data quality difficulties. Inaccurate medical records could easily result into fatalities. A further perusing of literature on the subject it was found that this data capturing somehow affects the quality of care provided to the respective environments.

Pen and paper are generally used for the capturing of data and this is still particularly true within the medical environment. The usage of pen and paper as a data capturing tool is even more pronounced in the third world countries and specifically within the less affluent areas. Naturally, with pen and paper, the user's eyes and hands are used during the capturing process. One of the biggest challenges with pen and paper is the time and physical resources (eye sight and hands) it takes and the need to possibly re-enter the data from the paper again into some computerised system as demonstrated by Boldt and Raasch (2008).

According to the The Association of Commonwealth Universities (2011), the process of birth is a critical one as the lives of the mother and baby hangs precariously on a balance. This is even more so in the developing countries (rural areas) where resources are few and far between. According to Van Zyl (2011), the use of pen and paper to capture health data within the low income setting by the home-based health caregivers poses a number of challenges namely: recording, transmitting and storing of data. Although Van Zyl (2011) focused on the home-based care (HBHC), I argue that the challenges Van Zyl (2011) identified resonate with the intrapartum environment as they are both governed by the information theory as promulgated by Shannon (1948) in his seminal work, "*A Mathematical Theory of Communication*". Shannon contends that the fundamental problem of communication is that of reproducing at one point, either exactly or approximately, a message selected at another point. Entropy is a major component of information theory. It essentially measures how much information that a piece of data contains or in this case, how much intrapartum information that a birth attendant could hold in memory over a given time frame. As well, Chiba et al. (2012) concur with Van Zyl (2011)'s contention that most often, some of this data is inaccurately captured, misplaced or damaged as well as being illegible, incorrectly coded, inappropriate and unrecognisable. According to Martin (1992), quality medical data is of utmost importance as it provides documentation of appropriate treatment, auditing, saves lives, cost and increases the quality care to patient. It also is used to evaluate practitioner performance as well as monitor resource use.

The paper form on which intrapartum records are captured is called a partogram and was initially introduced by Friedman (1954) and further developed by Philport (1972). The World Health Organization (1994) conducted a study of 35,484 participants in South East Asia which indicated that the partogram, when used effectively, reduced prolonged labour (from 6.4% to3.4%); labours requiring augmentation (20.7% to 9.1%);emergency C/S; reduced (9.9% to 8.3%) and stillbirths (from 0.5% to 0.3%). Following this study, the World Health Organization (1994) recognized its importance and recommended its adaptation to be promulgated universally. A partogram is a graphical representation of the observations of the mother, foetus and labour progress enabling the identification of any deviation from the normal.

There are insufficient skilled birth attendants within these midwifery obstetric units (MOU) and most often, only about 50% of women have birth attendants at the time of labour and this figure does not indicate quality of care (Intrapartum Care In South Africa, 2005,Farrell, 2007), Kigenyi et al.2013,&Gaunt, 2010). Due to the scarcity of human resources, birth attendants are expected to do a lot of multitasking. As observed by Van Zyl (2011) in the community based health care scenario, I argue that the birth attendants within the MOU intrapartum environment is also faced with the triple challenges delineated above. Further, Hübner et al. (2011) suggest that the use of pen and paper approach at data capturing within the intrapartum environment introduces cross infection as pen, paper, patients and birth attendants cross each other's path.

Based on numerous materials that I have scanned through, I concur with Wager et al. (2009) when they state amongst others, that the fundamental issues affecting the capturing of data with pen and paper are erroneous data, inconsistent data, handwriting issues and incomplete data. The issue of handwriting is exacerbated after a shift change, as the current shift often seems to have difficulties deciphering the convoluted handwriting.

Due to the bloodied nature of the intrapartum environment, birth attendants have a tendency to memorize intrapartum data with the objective of capturing it onto the partogram when they eventually take off their gloves. However, according to the information processing framework and cognitive psychology (dealing with the concept of chunking and the limited capacity of short term memory) proposed by Miller (1994) and further promulgated by Johnson (2008), this approach of data capturing overloads the birth attendant's short term memory which is vulnerable to interruption or interference, thus engendering the occurrence of numerous data capturing inconsistencies. Further, according to M'Rithaa (2014), some birth attendants scribble on pieces of tissues in order to circumvent the short term memory problem. However, this does not answer the question of data quality, data integrity and data consistency.

The need for quality intrapartum data for child birth register and quality care has unequivocally been demonstrated by Chiba et al. (2012) in their work in two rural district hospitals in Kenya.

According to Lawn & Zupan (2005), 97% and 98% of reported stillbirths and neonatal deaths occur in developing countries respectively, resulting in a 1-in-22 chance of mothers dying during childbirth compared to 1-in-8000 mishaps in the developed countries World Health Organization (2007). The fundamental cause of these mishaps has been noted as being delay in recognizing complications in childbirth due to strain on limited resources.

Information communication technologies have been used extensively in many fields and have been known to drastically reduce inefficiencies, data inconsistencies, automate processes, increases productivity, etc.

Given the situation above, it can be reasonably asserted that all ICT avenues should be explored to ameliorate the situation and one of these ways is to make full use of the expertise of the birth attendant's skills by providing a suitable data capturing mechanism that will hopefully relegate the capturing of intrapartum data to a secondary role by possibly freeing their eyes and hands to concentrate on giving care.

1.3 Problem Statement

The simultaneous manual capturing of intrapartum (vital registration) data and the delivery of care to mother and baby within a level one health facility poses a dilemma, as the birth attendant's full attention is not with/on the mother and or the baby. Much needed attention is thus taken away from the mother and child as the birth attendant uses her/his hands and eyes to capture required intrapartum data. Inadequate data collection further compounds the situation as an inaccurate medical record can easily result and most often results into mishaps.

1.4 Research question

The main research question for this study is:

What are the characteristics of hands-free speech driven partogram used by birth attendants within the intrapartum environment?

The table (table1.1) below delineates the research sub questions, the research methods by which to answer the specific question and finally the objectives for which the questions are asked. It is important to understand the objective of each question because necessarily each question should aim at contributing to the answering of the main research question.

Table 1: *Research sub questions*

Research sub-questions	Research method(s)	Objectives
What are the contextual implications for designing a hands free data capturing system for the intrapartum environment?	Stimulatory-Observation of the data capturing modus operandi by birth attendants and literature review	Observation will provide an additional insight into the level one health facility and also an understanding of how the intrapartum environment impacts design and development and possibly what form the solution to the problem might take Literature review will provide the necessary design requirements to successfully create a system that can be used within the afore-mentioned environment.
What unique design issues are necessary to consider for an ICT intervention	Stimulatory-Observation Interview	Understand the unique conditions that may exist within the intrapartum environment
How can the appropriate design considerations for a hands free data capturing tool be identified within a research process?	Literature review, Design and Development based research.	Literature review will provide an understanding of the best way to use the design process as a means of research. Will provide an understanding of how possible design knowledge and innovative thinking can be captured.
How could birth attendants use a hands-free possibly speech driven or other variations of partogram during the intrapartum stage?	Simulation of artefact (prototype)	To better understand and quantify the utility of the artefact.

1.5 Aim of the research

The main aim of this study is to understand what needs to be considered during the design process to design a suitable artefact by using relevant and rigorous methods to produce an artefact that attempts to answer the data capturing question as demanded by the needs of the level one (MOU) health facility. Further, looking at the design considerations that go into the development of such an artefact and to a lesser extent, considering how a DSR methodology can be utilised in research by providing a practical example of design science research in practice.

Finally, it is also the aim of this research to gain as much as possible an in-depth understanding of the intrapartum environment within a level one MOU within the Cape Metro.

1.6 Scope of Study

This research study aims at designing and developing a software-based artefact using an iterative agile development methodology. For the artefact to be implemented at an MOU, some basic technological infrastructure such as electricity, access to the internet, hardware in the forms of earpiece, computers etc. will be required. The overall research itself only focuses on the first few iterations of the development process (due to resource constraint) and the objective is only to produce a proof of concept. In essence, the ex-post evaluation is not entertained for this study as it is out of scope. As well, the human computer interaction (HCI) elements of the solution are only entertained in as much as usability is concerned and the aesthetical aspect is not considered at this time due to time constraint as well as the fact that HCI implication could become an independent study on its own. That said, a limited aspect of information architecture (IA) principles such as grouping of similar elements, metaphors and labelling, navigation, search functionality and HCI design recommendation from the father of user interface (Jacob Nielsen) such as inter alia userability were incorporated in the layout and design of the user interface (Nielsen, 1999; Norman & Nielsen, 2010). The focus of the study is on MOU within the Cape Metropole region of the Western Cape Province.

1.7 Research Methodology

This research study will be broken up into two different parts, the all-encompassing research and the underlying design and build phase that will produce the artefact.

This research uses a qualitative-pragmatic approach following a design science research paradigm (Hill, 2009). The overarching research relies on the development component to produce data and research results. The pragmatic approach involves using the method which appears best suited to the research problem and not getting caught up in philosophical debates about which is the best approach. With pragmatic approach, the researchers grant themselves the freedom to use any of the methods, techniques and procedures typically associated with quantitative or qualitative research. The research recognises that every method has its limitations and that the different approaches can be complementary. Different techniques maybe used at the same time or one after the other. For example, the researcher might start with face-to-face interviews with several people or have a focus group and then use the findings to construct a questionnaire to measure attitudes in a large scale sample with the aim of carrying out statistical analysis. The practical component of the research is based on the design and development of an artefact, namely a software based system. The practical component of the research follows a pragmatic approach because certain aspects of both qualitative and quantitative approaches have been used. (Creswell, 2007; Creswell & Plano Clark, 2007 and Tashakkori & Teddlie (1998,2003) support this position.

After considering the work of authors such as Hevner et al. (2004), Hevner (2007), Peffers et al.(2006), Van der Watt (2012) etc., the overall Design Science Research (DSR) methodology involves the following seven steps:

I. Problem identification, understanding and motivation
II. Identifying the objectives/focus of the research and solution
III. Concept design
IV. DSR artefact design and development
V. Artefact evaluation
VI. Research contribution
VII. Communication

1.8 Significance of the research

As indicated by the literature review in the next chapter and contextual interview, there exists an absence of a robust data capturing mechanism within the level one MOU within the Cape Metro. Such a mechanism can allow the birth attendant to focus more on providing care to mother and or baby than on the capturing of necessary intrapartum data. This research provides a practical example as well, it clearly lists and discusses the design and design considerations that were required within the development of a hands-free data capturing mechanism. These design considerations are presented in such a way that the context is clear and can be applied to similar projects.

1.9 Delineation of Research

This research is focused primarily on the MOU within the Cape Metro. The research does not focus on the mother and or feotus. The focus is on the birth attendants and their interaction with the capturing of intrapartum data and therefore no mother or child will be involved in the study and the data used will not be about a specific patient but rather that of a typical patient (anonymized).

Speech was discovered to be the best means with which data could be captured naturally. However, the complexity of speech recognition was such a limiting factor. Although great strides have been made by proprietary speech recognition engines, using it meaningfully is still a challenge. It is therefore far too ambitious and cumbersome to attempt to cover all aspects involved in designing and developing a dynamic hands free data capturing application.

The research is design and development-based, thus the research looks primarily at the technical aspects involved in the development of the system, with attention only being paid to the human related aspects where needed as part of the design and development process. The design considerations addressed by the research are those design considerations closely related to the technical aspects of the system and not the usability aspects.

1.10 Intended Audience

The research considers the intrapartum environment within a MOU context within the Cape Metro area. Particularly, the prototype will be of great interest to birth attendants. Thus, the primary intended audience are those working in a similar environment. Due to the design nature of this study a secondary audience might be software developers and speech recognition experts who may be interested in critiquing, implementing or extending the artefact.

1.11 Expected Outputs and Outcomes

The primary output of the research is a thesis detailing the process and consideration that goes into designing a hands free data capturing application targeting a MOU intrapartum environment within the Cape Metro

A secondary output is the actual prototyped data capturing application, intended to be used within an MOU intrapartum environment and contributions to the academic body of knowledge relating to Design Science Research and a deeper understanding of the capturing of data within the afore-mentioned environment.

The outcome is the insights gained through designing the proposed solution.

1.12 Structure of the thesis

This research study consists of a total of ten chapters in its entirety. The layout is based on a fairly rudimentary structure namely: the first chapter provides an introduction to the thesis, the second chapter details the literature review, the third chapter details the research methodology utilised to conduct the research, from the fourth chapter onwards the research process is detailed and finally chapter ten details the research findings and contributions.

The chapters representing the research process were based on the implemented research methodology, with each chapter representing at least one step in the methodology.

Although a number of researchers, both in and outside of IS, have sought to provide some guidance to define design science research as suggested by Hevner et al. (2004) and to document the appropriate reference literature (Vaishnavi et al. 2005), so far no IS research has explicitly focused on the development of a conceptual process and mental model for carrying it out and presenting it (Peffer et al. (2006)). In their quest to resolve this issue stated above, they went ahead and designed a process for DSR. They thought that this process is consistent with design science processes in other disciplines, provides a nominal process for conducting the research, and finally provides a mental model for what DS research output should look like. Figure 1.2 below encapsulates their findings and recommendations. The eventual thesis layout depicted in figure 1.2 below is based on inter alia Peffer et al. (2006)'s primary recommendations.

Objectives for a design science research process model	Archer (1984)	(Takeda et al. 1990)	Eekels and Roozenburg (1991)	Nunamaker et al (1991)	Walls et al (1992)	(Rossi et al. 2003)	(Hevner et al. 2004)
1. Problem identification and motivation	Programming Data collection	Problem enumeration	Analysis	Construct a conceptual framework	Meta-requirements Kernel theories	Identify a need	Important and relevant problems
2. Objectives of a solution			Requirements				Implicit in "relevance"
3. Design and development	Analysis Synthesis Development	Suggestion Development	Synthesis, Tentative design proposals	Develop a system architecture Analyze and design the system. Build the system	Design method Meta design	Build	Iterative search process Artifact
4. Demonstration			Simulation, Conditional prediction	Experiment, observe, and evaluate the system			
5. Evaluation		Confirmatory evaluation	Evaluation, Decision, Definite design		Testable design process/product hypotheses	Evaluate	Evaluate
6. Communication	Communication						Communication

Figure 1.1: *A Design science process Peffer et al. (2006)*

Appropriating from Peffer et al. (2006) amongst others, figure 1.2 below visually demonstrates the layout chapters of the thesis and how they correspond to the implemented research methodology.

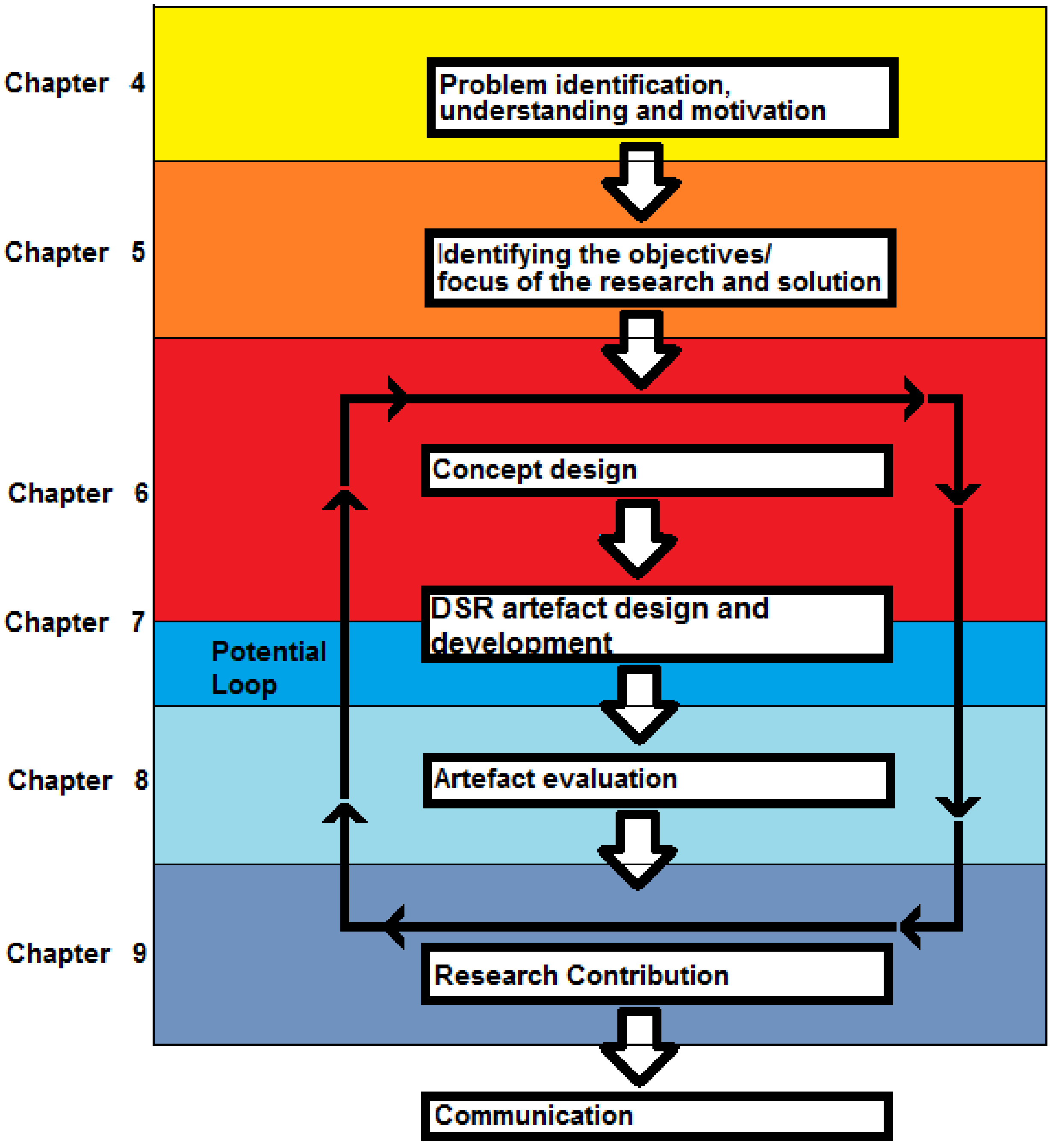


Figure 1.2: *Thesis layout adapted from Van der Watt (2012)*

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

The literature review presents an overview of the maternal health care setting globally but more focus is given to the low resource settings including the fatalities that occur within the intrapartum environment in the two types of regions, namely developed and developing contexts. Quite some amount of effort is given to understanding the partogram and its underlying components in detail as it is at the core of this study (the actual data to be captured). The capturing of intrapartum data is described within two types of settings namely, the affluent environment (sparingly as they are not the paper's unit of analysis but merely as a comparison tool) as well as the under-resourced settings. Although very important, health informatics is duly but briefly looked at as this research study itself is only a subset of health informatics. A look at data mining within the intrapartum context is also evaluated, although at a high level as it is out of the direct scope of this study. Because of the need to understand how and where captured data ends up, the standards for healthcare records are scrutinized in relation to our main question. This paper looks at harnessing the power of speech recognition. The mechanics and complexity of speech recognition is presented even though at a very high level with the hope that in so doing, the complexity of this technology will be appreciated within the intrapartum context. Finally, I present a review of design science research and its justification for this study.

2.2 The state of maternal healthcare

More than a million stillbirths and over eight hundred thousand neonatal deaths occur annually. The majority of these intrapartum mishaps occur in developing countries, where there is scarcity of quality perinatal care (Lawn et al., 2009).

About sixty million births occur outside of health facilities annually, and most of these childbirths take place without a skilled birth attendant. It is within these low resource settings that intrapartum fatalities and mishaps are prevalent. According to Bryce et al. (2010), task shifting to increase access to caesarean delivery, simplified neonatal resuscitation training and usage of partogram by frontline health workers linked to emergency obstetrical care services could ameliorate the status quo.

According to Goldenberg et al. (2007) and Charts Bin Statistics Collector Team (2011), the developed countries had lower total stillbirth rates (6.0 versus 21.3/1,000 births, p 0.0002) as well as a lower fraction of stillbirths that were intrapartum (0.16 versus 0.31, p 0.0019).

Developed countries' antepartum stillbirth rates were 5.2 versus 25 to 35.0/1,000 births in southern Africa and Asia. Intrapartum stillbirth rates averaged 0.9/1,000 births for developed countries compared to 20-25/1,000 births for some countries in southern Africa and Asia (Lawn et al. 2010).

Continuing from the previous paragraph, they observed that the relationship between intrapartum stillbirths and the various measures of care were inversely proportional. For each 1% increase in the percentage of women with at least 4 antenatal visits, the intrapartum stillbirth rate decreased by 0.16 per 1,000 births. As well, Goldenberg et al. (2007) contends that as Caesarean section rates increased from 0 to 8%, for each 1% increase, there was a decrease of 1.61 intrapartum stillbirths per 1,000 births.

According to McCarthy (2002) and a study that was carried out by Charts Bin Statistics Collector Team (2011), close to five hundred thousand women die due to complications arising from pregnancy from a total of two hundred million that fall pregnant annually. The WHO initiated the Safe Motherhood programme in 1987 and its ultimate objective was to reduce by 50 % the maternal mortality and morbidity by the year two thousand. This initiative failed woefully (Maine & Rosenfield 1999). However, the current initiative (MDG, millennium development goal 4 and 5) from the WHO is to reduce to 75% the 1990 level of child and maternal mortality by 2015 (McCarthy, 2002). Bryce et al. (2013) bemoans the fact that although there are known and efficacious interventions to address most of the major causes of these deaths, important gaps remain and the biggest challenge being to ensure that all women and children have access to life-saving interventions. Lessons learned from the previous initiative should therefore be scrutinized carefully to avoid repeating the same mistakes.

Woods (2009) contends that the most common primary cause of death of foetuses and neonates over 1000g in South Africa is intrapartum hypoxia. Prolonged and obstructed labour is associated with feotal hypoxia, birth trauma and infection resulting in intrapartum or early new-born deaths and perinatal morbidity. Therefore, prevention of obstructed labour is an important intervention towards reducing maternal and perinatal mortality and morbidity, and in achieving the Millennium Development Goals 4 and 5.

Goldenberg et al. (2007) demonstrated by using data obtained from a longitudinal study from developed countries that the rate of intrapartum stillbirths is inversely proportional to the increasing intrapartum care. It is therefore of interest to this study to understand the relationship between increasing care and the impact on the mother and child. They therefore concluded that intrapartum death rates could be used as an indicator of quality of care. They further stated that because of a proportional relationship between the rate of intrapartum stillbirths and the availability of intrapartum care, a significant majority of intrapartum stillbirths occur more in low and middle-income than in high-income countries (31% vs. 16% of stillbirths, respectively). The Western Cape Department of Health (2011) indicated that infant mortality rate for this region is about 2.6 % of live births while the South African national estimate stands at 4.8% of live births.

2.3 Health Informatics

This study is a subset of health informatics as it uses computer hardware and software amongst others to capture, transfer and store medical data (Mettler & Raptis 2012). Health informatics refers to the utilization of resources, devices, methods and communication systems to ameliorate the health sector. These resources, devices, methods etc. might include information science, computer science, social science, behavioural science, management science and others Borycki (2011). The health sector amongst others includes the following;

- Clinical Informatics
- Public Health Informatics
- Nursing Informatics
- Medical Informatics
- Community Health Informatics

According to Hayes and Barnett (2008), health informatics is well grounded in the developed countries such as Canada, United States, United Kingdom etc. Reinhold (2010) concludes the opposite for developing countries, that health informatics is still at its infancy. An example of health informatics could include a Wireless Health Outcomes Monitoring System (WHOMS), developed by Bielli et al. (2004). It allows physicians to assess cancer patients' conditions in a remote setting. Vincent et al. (2006) carried out a study in Quebec, Canada in which they proposed a public tele-surveillance service for elderly HBHC patients especially those with disabilities. The patients wore a wireless transmitter in the form of a medallion or bracelet. This transmitter had the capability for two-way audio communication with health professionals at the service centre. The transmitter provided a lot of functionalities inter alia voice reminder for medications, prescribed exercises, medical appointments. Although the study concluded that the service did not provide a drastic improvement in the quality of life for patients, it did have a significant positive impact on the caregivers (e.g. patients' relatives, friends) psychologically. The review of literature on health informatics seems to suggest a well-entrenched practice in the developed countries as opposed to the developing ones (Luna et al. 2004). They contend that inter alia, this could be attributed to lack of trained workforce, structural deficits in the physical networks, high costs, geographic dispersion, and high percentages of the people living in rural areas or informal settlements

The Health Systems Trust (HST), being a member of a consortium of organisations working with the Department of Health whose objective is that of stemming the tide of unnecessary pregnancy related death in South Africa, bemoans the fact that the Western Cape's Groote Schuur hospital (a level 3 facility), for example, treats 500,000 outpatients, and admits another 40,000 into its wards each year and only uses cardboard folders to save patients` medical notes with none of the clinical data being captured on the hospital's computer systems, which are used mainly for administrative tasks such as billing (Khan, 2013).

Patient records and management systems range from state-of-the-art computerised operations to simple pen and paper. So far, the 849-bed Inkosi Albert Luthuli Central Hospital in KwaZulu-Natal is the only paperless public hospital (as far as patient’s record is concerned) in SA, while most of the country's clinics still rely almost entirely on paper systems (Mostert-Phipps 2013; Khan 2013).

The Western Cape Provincial Administration eventually installed a patient administration system called Clinicom in its larger hospitals, including Groote Schuur, Khayelitsha District Hospital, Tygerberg and the Red Cross Children's Hospital. This infrastructure was installed by JAC (Pharmacy Information System) in conjunction with their South African distributor, Health System Technologies (HST), but the hospitals are still not linked to each other due to the lack of available bandwidth (Khan, 2013).

2.4 Standards for Healthcare Records

Health Records (HRs) focus on the total health of the patient—going beyond standard clinical data collected in the provider’s office and inclusive of a broader view on a patient’s care (Gunter & Terry 2005). While Medical records (MRs) are a digital version of the paper charts in the clinician’s office, MRs contains the medical and treatment history of the patients in one practice. However, for the purpose of this study, both terms will be used interchangeably to refer to a systematic collection of electronic health information about an individual patient or population (Gunter & Terry 2005).

The standard of health records is important to consider at this point as the artefact that will ultimately be produced as one of the outputs of this study will be steeped in data, data handling, data capturing and possibly data transmission. Medical records contain sensitive data and standards should exist that govern its collection, sharing, storing and retrieval. These electronic health records are expected to produce benefits (such as ease of tracking data over time, monitoring and improving of overall quality of care, as well as an easy way of identifying which patients are due for preventive screenings or check-ups) for patients, professionals, organisations, and the population as a whole. Health informatics standards such as Health Level 7 (HL7), CEN, GEHR (Good European Health Record) all address the structure of medical data to ease exchange, integration, retrieval or storage (Van Ginneken, 2003). A number of important issues arise when electronic records are considered namely: security of the data (e.g. hacking to alter, delete or update records), rights of access (e.g. government or corporate intrusion into private health care matters etc.) (MacAfee, 2010). Health Level 7 (HL7) version 2 and upward versions of the standards, which support clinical practice and the management, delivery, and evaluation of health services, are the most commonly used in the world (Dave, 2014). CEN, GEHR handles data structure but HL7 (described above) is more in line with this study as it deals specifically with this research target which is under resourced environment where there are issues with inter alia data capturing, storage, retrieval etc.

2.5 Intrapartum data capturing in maternal care settings

The primary labour monitoring tool within the low resourced setting is the partogram. The usage of the partogram is premised on inter alia the limitation of resources such as human, financial, technological, experience etc. This premise doesn’t seem to exist within the developed countries. The birth attendant’s / patient ratio is very low in the developed countries and because of this, Walraven (1994) questioned its effectiveness in the developed or high-income countries and has suggested that the use of the partogram can be an unnecessary interference in clinical work. Also, Lavender and Malcolmson (1999) have argued that the partogram may restrict clinical practice, reducing midwives' autonomy and limiting their flexibility to treat each woman as an individual. The capturing of data within the developed countries as surmised by these immediate authors above does not seem to present the dilemma that it does in the under-resourced settings. Fatusi et al. (2008) carried out a study whose objective was to assess the impact of training on use of the partogram for labour monitoring among various categories of primary health care workers and eventually they concluded that lower cadres of primary health care workers can be effectively trained to use the partogram with satisfactory results, and thus contribute towards improved maternal outcomes in developing countries with scarcity of skilled attendants.

Traditionally, most hospitals in the developing countries and specifically within the less affluent areas generally use pen and paper for data capturing onto the partogram as demonstrated by Yisma et al. (2013) in a study they carried out titled “Completion of the modified World Health Organization (WHO) partograph during labour in public health institutions of Addis Ababa, Ethiopia”. They realized that there was a poor completion of the partogram during labour in public health institutions of Addis Ababa and attributed it to poor management of labour or simply inappropriate completion of the instrument. This intrapartum data captured on the partogram is at best entered into some computerized system at a later stage or merely archived in some store room .This type of manual storage makes retrieval difficult. As already mentioned above, this approach of data capturing with pen and paper while providing care in a highly under resourced environment divides the birth attendant's focus (M'Rithaa et al. 2015).

Certain hospitals use digital pens and computer readable forms such as the IALCH (Inkosi Albert Luthuli Central Hospital) in Durban, South Africa where the data captured on the forms are directly stored onto a computer out of sight. Another data capturing apparatus being used to capture intrapartum data is the Partopen digital pen. The Partopen digital pen hardware and software system supports partogram use by providing audio instructions for measuring and recording labour progress indicators, real-time decision support based on recorded measurements, and time-based patient-specific reminders for taking measurements. A study carried out in Kenya to examine the impact of digital pen technology on partogram completion by less experienced birth attendants showed an improved completion rate (Underwood et al. 2013).

The digital pen writes like a normal ballpoint pen, but has a tiny infrared camera at its tip. Any paper can be used with a digital pen if a dot pattern is added to the layout at the time of printing. The dot pattern consists of a number of barely visible dots that can be read by the digital pen. The pen reads the pattern and registers what and where the user writes. Boldt and Raasch (2008) carried out a pilot study in Germany that compared a variety of electronic data capture (EDC) methods and unravelled the fact that digital pen and paper are significantly more user friendly, quicker and more accurate compared with using a keyboard, tablet PC or PDA to capture data. They further suggest that by not having to re-key and then double- or triple-check medical notes, healthcare staff are more productive and provide better care to a greater number of patients.

In 2011 Jhpiego (An international non-profit organization affiliated with The Johns Hopkins University) and its partners (Johns Hopkins University Center for Bioengineering Innovation and Design and Laerdal Global Health) proposed to rapidly develop and conduct initial field-testing for an "E-Partogram," an affordable, easy-to-use, handheld electronic decision-making tool for preventing or managing complications during labor as demonstrated in figure 2.1. The fundamental objective for digitizing the partogram was to simplify intrapartum data capturing as well as ensure that quality data is captured.

Figure 2.1: *A digitised partogram (epartogram) developed by Jhpiego*

The same study identified the main draw backs of the paper partogram, namely:

- The partogram was seen as a recording device rather than a decision making tool
- It was tedious to fill out
- It was difficult to interpret even if trained, especially in real time
- Obtaining all the measurements required is incredibly time consuming

Despont-Gros et al. (2005) looked at the use of digital pen and paper technology within an already computerized environment. They took great pain at delineating the advantages of digital pen and paper over the traditional method of manual pen and paper and eventually concluded that the digital pen proved successful in data acquisition within a stressful clinical environment. However, they also cautioned that, although cost is involved, for an increase success, the acquisition forms must be designed specifically for the use of digital pens. Lind and Karlsson (2004) as well looked at the use of digital pen and paper within a home based health care environment where captured data is fed directly into a central database and immediately accessed by an authorized medical practitioner. Although they focused on palliative home based healthcare, their approach with regards to the sharing and centralization of data is of great interest to this study and it will be interesting to examine this modus operandi of data capturing and transmission to determine its value regarding the intrapartum environment. Data captured can be accessed remotely and instantly by authorized health personnel, this could then engender the possibility of remote diagnosis (telemedicine) and or treatment suggestions.

The use of digital pen and paper ensures that data is only captured once (Despont-Gros et al. 2005). However, it does not solve the fundamental problem of freeing the hands and eyes of the birth attendant to fully concentrate on providing care to the mother and or child. Although the capturing of intrapartum data is vital, Hübner et al. (2011) are of the opinion that the usage of pen and paper within this environment poses a dilemma as it also engenders the possibility of reinfection through the sharing and exchange of pen and or paper. The question of reinfection through data capturing mechanism is out of scope for this study but remains relevant to the study. However, a hands-free data capturing mechanism if properly tested and validated could be a mitigating factor to the reinfection question.

Frøen et al. (2005) identified and expounded on other types of data that needed to be captured within the intrapartum environment. They further emphasised the necessity of appropriately capturing high quality data and surmised that such data would go a long way to identify causes of fatalities if they occur and may lead to improved classification systems, effective registration, reporting systems and ultimately be of huge advantage to the safety of the mother and child.

Fayyad and Uthurasamy (1996) encourage the storage of large sets of data and I find that this is of interest as most often intrapartum data is not referenced dynamically because it is not stored at the onset with dynamic retrieval in mind. The continual storage of records over time will eventually result in large data sets that can eventually be considered under the concepts of big data. Big data refers mostly to the storage, search, sharing, transfer, analysis and visualization of data. Pareek (2007) recommends that to visualize big data, it could be sliced and diced to generate business forecast. As well, the study of big data, its inner machinery (such as data warehousing) and its limitations are out of the scope of this project. The extraction of information from stored data and generation of forecast give businesses a competitive advantage. Although it may appear to be too optimistic, it is well worth thinking that perhaps using the corporate approach to some extent within the intrapartum environment might increase quality of care such as forecasting, anticipating and avoiding intrapartum mishaps.

2.6 The impact of the usage of technology for data capturing

It seems that there is limited literature on the impact of IT system on mother and child within the intrapartum environment. However, there has been some clamour about the usage of mobile phones generally. Mobile phones as well as other communication network devices use electromagnetic radiation in the microwave range. The International Agency for Research on Cancer (IARC) as recently as 2011 indicated that mobile phones were in group 2B (meaning therefore that there could be some risk as opposed to outright group 2A out- right risk) (Moynihan, 2014). It is of importance to note that the radiofrequency exposure to a user falls off rapidly with increasing distance from the handset. It turns out that a person using a “hands free” device, will therefore have a much lower exposure to radiofrequency fields than someone holding the handset against their head. To understand if there could be a negative impact on the mother and or child by the usage of IT systems within the intrapartum environment, the only article I could find was that of Divan et al. (2008). They looked at the possible effects of radio frequency fields on children. They also examined the association between prenatal and post-natal exposure to cell phones and behavioural problems in young children. They concluded that exposure to cell phones prenatally and, to a lesser degree, post-natally was associated with behavioural difficulties such as emotional and hyperactivity problems around the age of school entry. At the same time, they cautioned that these associations could be non-causal and may be due to unmeasured confounding factors. This aspect will therefore not be specifically considered in this study.

2.7 The case for Partogram

Friedman (1954) was the first to propose and utilize a realistic tool for the study of human labour. He did this by graphically depicting the dilation of the cervix during labor. He divided the labour process into a latent and active phase. The "action" and "alert" lines were later added to the graph by Philpott and Castle (1972) thus converting it into a tool for monitoring labour. The current partogram is designed to monitor not only the progress of labour, but also the condition of the mother and the fetus during labour and has been advocated by the WHO (1994) as a necessary tool in the management of labour and recommends its universal use during labour.

A partogram is therefore a chart on which the salient information about the fetal well-being, maternal well-being and the progress of labour are recorded agaist time. It is practically a managerial tool used to record all observations made on the mother and fetus during labour on one chart. It helps to identify at an early stage those women whose labour is slow and is also used to assess the progress of labour and to identify at an early stage when intervention is required. This chart has proven to be able to reduce intrapartum mishap (Lavender et al. 2012). It is composed of the following sections namely: mother’s information, fetal well-being, labor progress, medication and maternal well-being as demonstrated on figure 2.2.

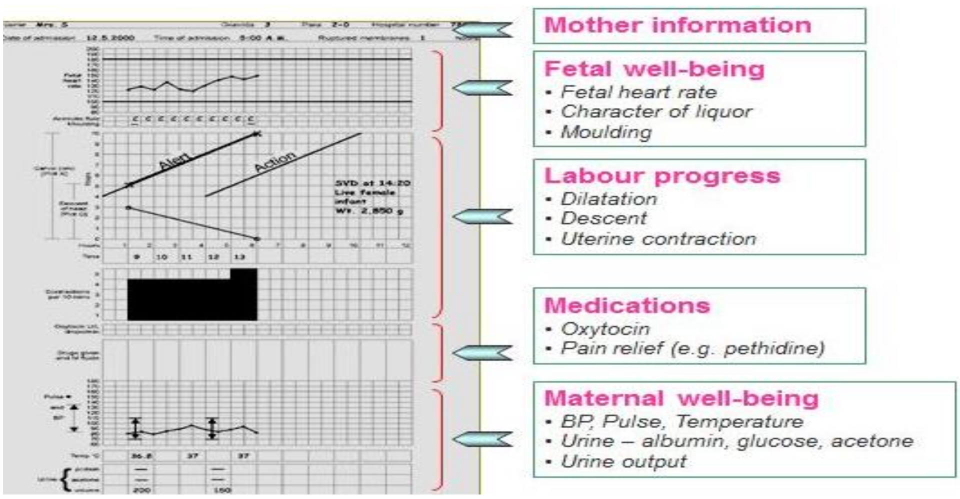


Figure 2.2: *A partogram’s overview with its various subsections WHO (1994)*

Groof et al. (1995) carried out a study in Niger to assess the impact of the partogram on maternal and perinatal mortality. This study involved about 3000 women in labour and in essence, their result showed that the partogram indeed can reduce the labour to delivery time, improves decision making as well as follow up care. Fatusi et al. (2008)'s study in Nigeria concurs with the previous study.

In his quest to assess the progress of labour and identify when intervention is necessary, Dangal (2006) discovered that using the partogram proved effective and efficient in reducing complication from prolonged labour. Javed et al. (2007) carried out an extensive study on about a thousand women to determine amongst others the effect of partogram on the frequency of prolonged labour and whether intervention based on the partogram guidelines can actually significantly reduce intrapartum complications. Results showed a commendable decrease in the maternal and perinatal morbidity. However, some health-care practitioners, especially in high-income countries, have questioned its effectiveness. For example, Walraven (1994) suggests that the use of the partogram can be an unnecessary interference in clinical work. Also, Lavender and Malcolmson (1999) argue that the partogram may restrict clinical practice, reducing midwives' autonomy and limiting their flexibility to treat each woman as an individual. The present Cochrane Review (a study conducted in six settings, namely: Mexico, South Africa and Pakistan) as demonstrated in Lavender et al. (2012) has two objectives, namely: to determine the effect of use of the partogram on perinatal and maternal morbidity and mortality and to determine the effect of partogram design on perinatal and maternal morbidity and mortality. The study concluded that although they could not recommend routine use of the partogram as part of standard labour management and care within highly resourced environments, the partogram could serve as a simple and inexpensive tool to monitor labour in a cost-effective way in under-resourced areas.

In under-resourced settings, prolonged labour and delay in decision-making are important causes of adverse obstetric outcomes (Ibid). Owing to resource constraints in such settings, it is usually not possible to monitor each expectant woman continuously throughout the duration of labour. In such settings, the partogram serves a simple and inexpensive tool to monitor labour in a cost-effective way. One case–control study from Pakistan found the partogram to reduce the frequency of prolonged labour, augmented labour, postpartum haemorrhage, ruptured uterus, puerperal sepsis perinatal and maternal morbidity and mortality (Ibid). The present review does not provide conclusive evidence to change established practices in under-resourced settings.

The partogram displays the progress in cervical dilatation as a continuous graph, while at the same time; displaying as many other features of the state of the mother, the foetus and the labour as possible in graphic form. It is this combination of features which makes the partogram useful.

The objective of this study is to use scientific design methods to develop an electronic artefact (e-partogram) and evaluate its efficacy during the intrapartum domain. It is therefore paramount that the nature and components of the partogram be detailed and the necessary data and metadata, that would be captured, delineated. As already stated above, the partogram consists of the expectant mother's information, foetal well-being, labour progress, medications and maternal well-being and these different types of information are discussed next. The information in the following section about the partogram and intrapartum data specifics, all comes from (WHO 2004; Rowe & Vyta 2007; and Levin & LaSala 2014).

2.6.1 The woman's information

The information relating to the pregnant woman needed for the partogram is presented in Table 2.1.

Table 2.1: *A list of information capture*

Information	Brief Rational
Name	For identification
Age	All of these have fundamental medical implications and each has to be captured.
Gravidity	
Parity	
Gestation	
Pelvis	
Risk factors	
Spontaneous labour	
Induced labour	
Time of ROM	
Duration of labour	
Date/time of admission	
Time of rupture of membrane	
Short ante natal history	

2.7.1 Fetal information

The fetal information captured for the partogram includes the foetus's heart rate, amniotic fluid, moulding, etc. This section captures information about the status of the foetus and detects any abnormalities. The foetal well-being is monitored by measuring the feotal heart rate, amniotic fluid, moulding of the fetal skull bones and formation of the caput. The foetal heart rate provides a safe and reliable way of knowing whether the foetus is well. This is determined by listening after each contraction for one minute and the figure `+-` is recorded ½ hourly (each square is ½ hour) to one hourly and covers the range from 100 to 200 beats per minute (WHO 2004; Rowe & Vyta 2007 and Levin & LaSala 2014).

The amniotic fluid gives a relative indication of the status of the membranes. The membrane could either be intact and denoted by (i) or ruptured. If ruptured, the amniotic fluid could either be clear (C), meconium stained (M), blood stained (B) or absent (A). Moulding gives a relative indication if the pelvis can accommodate the foetal head and is measured as shown in table 2.2 below.

Table 2.2: *Fetal information*

Symbols	Meaning
0	→ bones separated
+	→ bones touching but can be separated
++	→ bone over lapping
+++	→ bones over lapping severely

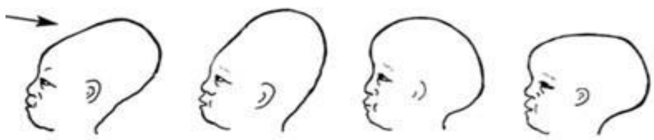
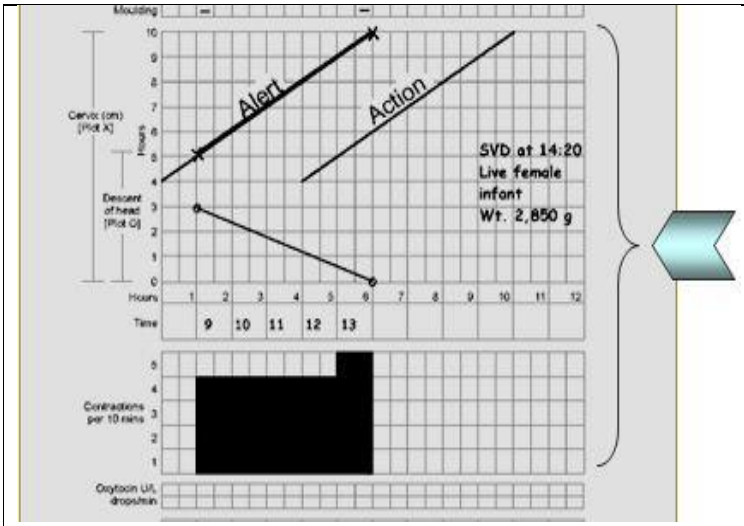


Figure 2.3: *Normal variations in molding of the newborn skull, which usually disappears within 1–3 days after the birth*

2.7.2 Labour progress

Information within this domain includes cervical dilatation, descent and uterine contraction dilatation and descent. Figure 2.3 - 2.10 illustrates the information used for monitoring the different labour stages.



Dilatation and Descent

Latent (0-3 cm) and Active (3-10 cm) phase.

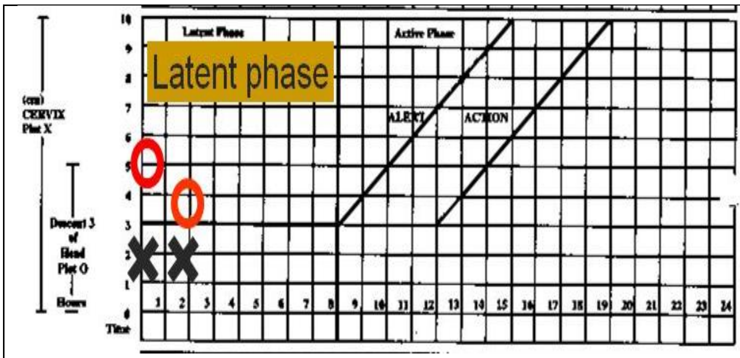
Dilatation of cervix plotted as "X" axis and Descent plotted as "O" axis.

First vaginal examination done on admission is recorded.

Subsequent vaginal examination is done every 2-4 hourly.

Transfer from latent to active phase.

Figure 2.4: *Measurement of dilation and descent*



Plot dilatation as "**X**"
Plot descent as "**O**"

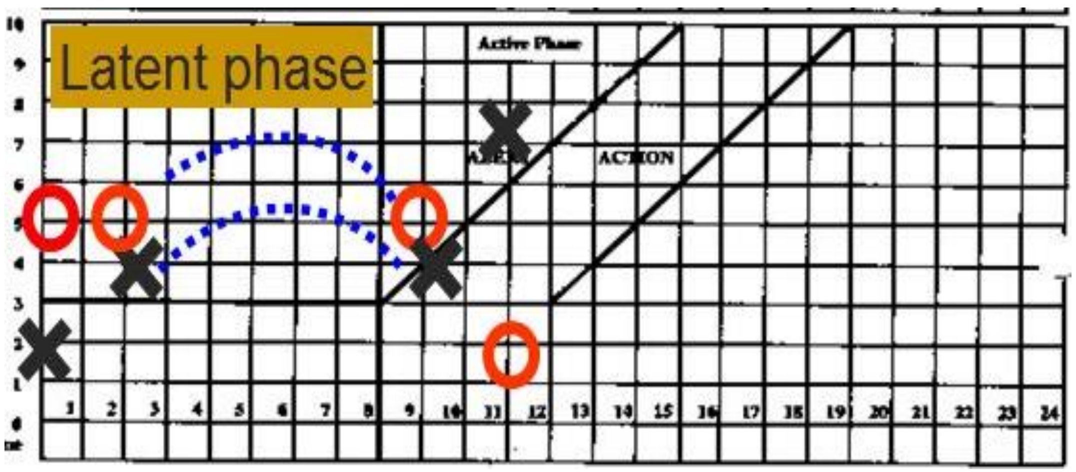
At admission:
- Dilatation → 2 cm
- Descent → -2

2 hours after admission:
- Dilatation → 2 cm
- Descent → -1

As the dilatation is only 2 cm therefore the labour progress is in the latent phase

Figure 2.5: *Progress in the latent phase*

Labour progress recording in the active phase



Legend
Plot dilatation as "**X**"
Plot descent as "**O**"

Latent phase ↑ · Active phase ↑

	0 hours (admission)	2 hours	4 hours
Dilatation "O"	2 cm	4 cm	7 cm
Descent "X"	-2	-1	+1

Figure 2.6: *Progress in the active phase*

Cervical dilatation (diameter of the mother's cervix in centimetres), descent and uterine contractions are the main activities that are monitored during this stage. This stage consists of the latent and active phases. Usually the woman is in the latent phase on admission and dilatation is at maximum of

3 cm which should last a maximum of 8 hours. If she exceeds 8 hours she will be managed for prolonged latent phase of labour. The woman's status is transferred to active on the partogram when the dilatation exceeds 3 cm within the 8 hours that means she is progressing well. There is a direct proportional relationship between the dilatation and the descent of the head as demonstrated on figure 2.6 above. If labour progresses well, plotting of cervical dilatation should always remain on an alert line or towards the left of the alert line. If it crosses to the right of the alert line towards the action line, this could be an indication that labour may be prolonged. The expectant mother is then transferred to the referral hospital for further management and action is taken.

As demonstrated by figure 2.7, uterine contraction is observed ½ hourly. Each square represents 1 contraction felt in 10 minutes.

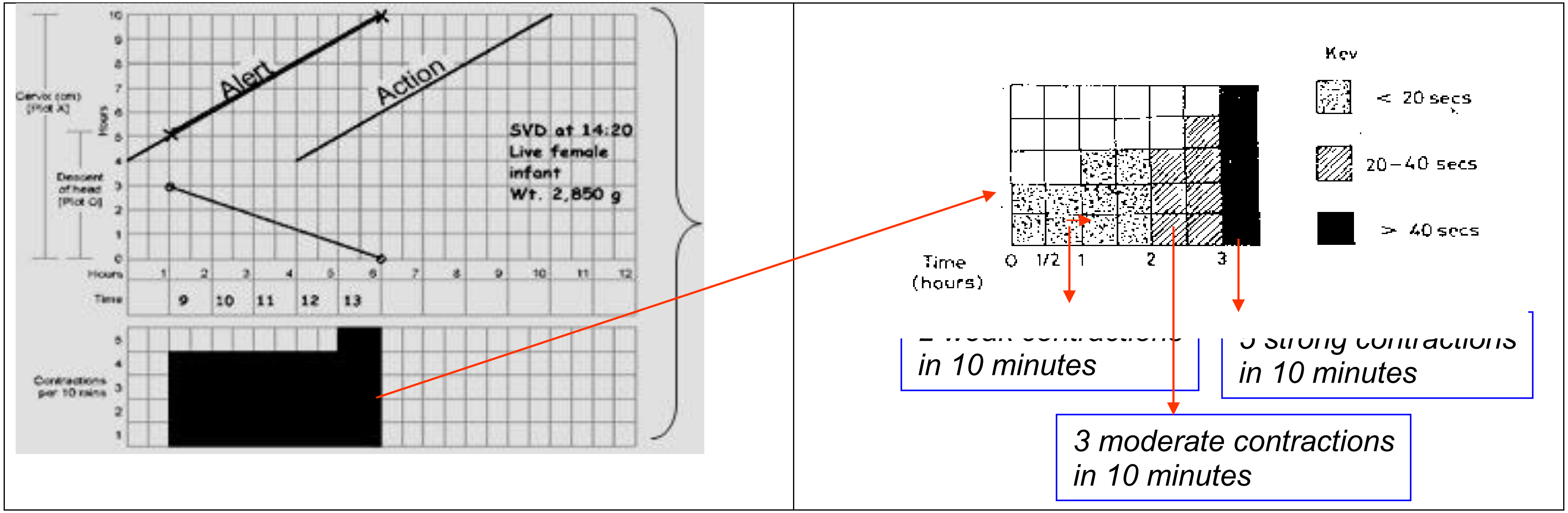


Figure 2.7: Observation and monitoring uterine contraction

2.7.3 Maternal Condition

As depicted in figure 2.8, the maternal condition captured within the intrapartum stage is indicated by the vital signs – BP, pulse, temperature (ºC), urine analysis (acetone, albumin, glucose etc.), urine volume, medications or drug given.

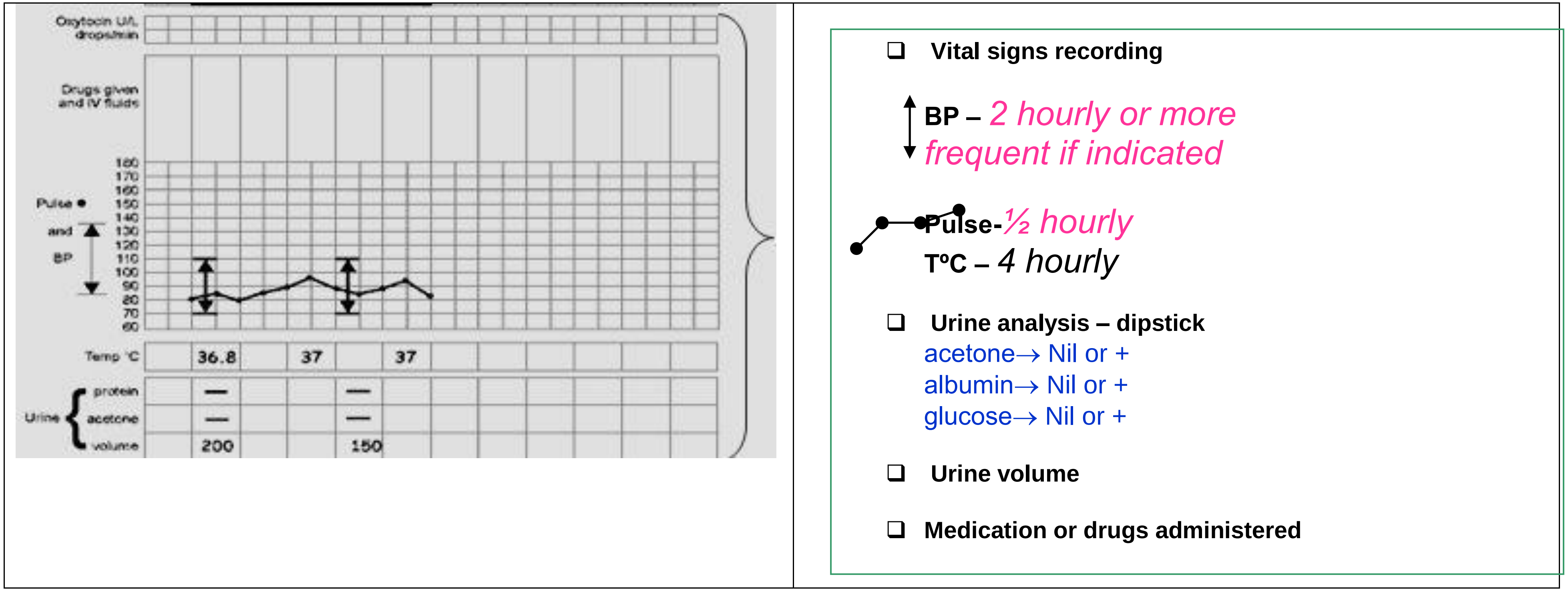


Figure 2.8: *Monitoring of maternal vital*

It is always important to seek the patient's consent before taking vital signs; this is in accordance with the Nursing and Midwifery Council (NMC, 2004). The blood pressure is recorded as two readings; a high systolic pressure, which occurs during the maximal contraction of the heart, and the lower diastolic or resting pressure. A normal blood pressure would be 120 (systolic) over 80 (diastolic). Usually the blood pressure is read from the left arm unless there is some damage to the arm. The difference between the systolic and diastolic pressure is called the pulse pressure.

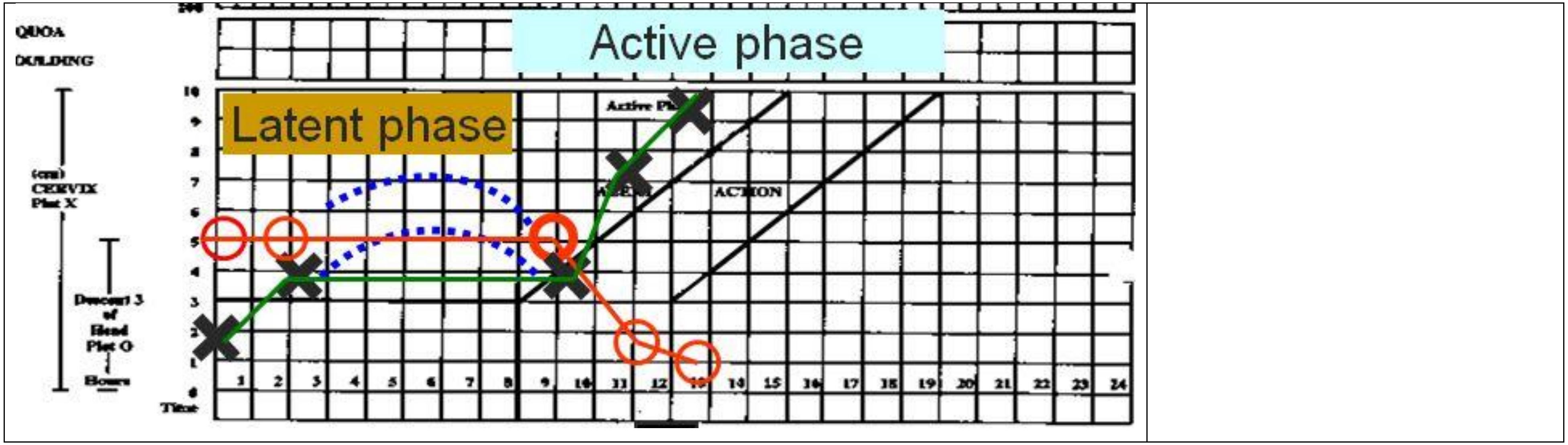


Figure 2.9: *Analysing the progress of labour from the partogram*

If progress is satisfactory the plotting will remain on or to the left of the alert line. If labour is not progressing normally the plotting will be to the right of the alert line.

2.7.4 Labour patterns

Figure 2.10 below depicts the various types of labour, their progress and the types of problems that can occur in both phases.

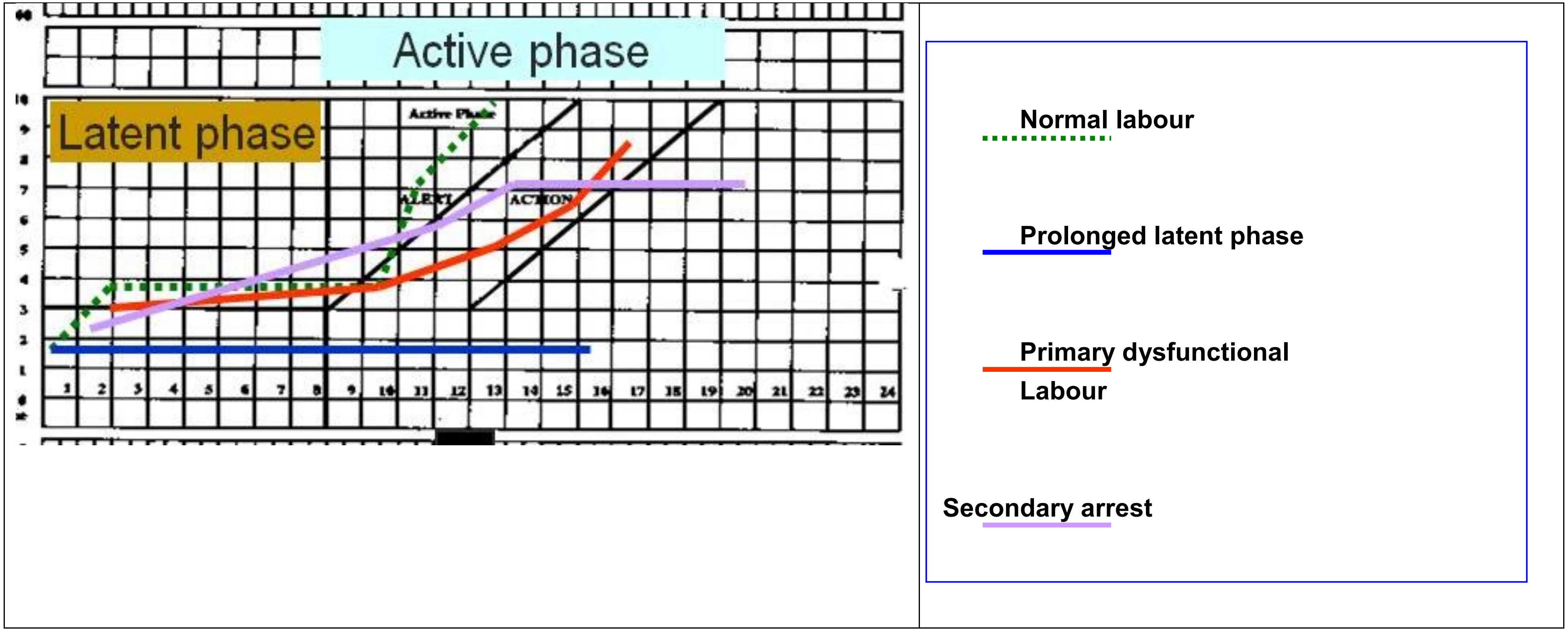
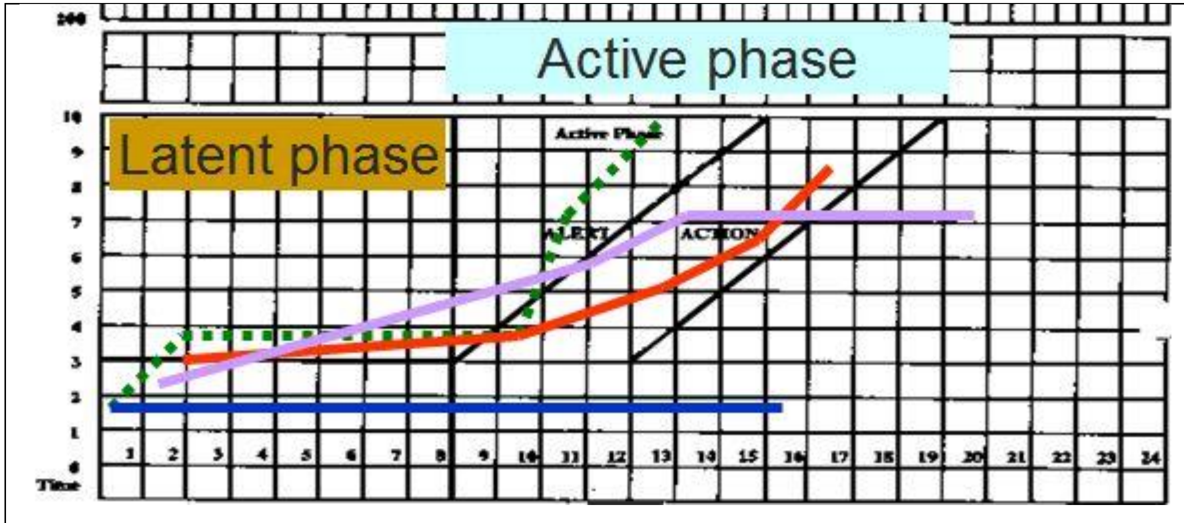


Figure 2.10: Various types of labour



Right of Alert Line

- This means warning
- Transfer to higher level facility
- Reaching the action line
- This means possible danger

Decision needed on future management (usually by obstetrician)

Figure 2.11: *Types of labour, interpretation and possible action to take*

2.7.4 Characteristic of caregivers

The term “caregiver” encompasses a wide range of experiences and situations. Caregiving may include caring for a loved one in the caregiver’s home, the care recipient’s home or in an institutional setting (Greenlee & Scharlach 2015). For all intent and purposes, this study will be looking at care within an institutional setting and specifically at the role of the midwife as a healthcare professional during the labour process. Although Neal et al. (1997) contend that most caregivers are female; the number of male midwives is gradually increasing (Pilkenton & Schorn 2008). Male midwives also offer unique attributes to the childbearing family’s experience precisely because they are males (Ibid). Midwives are specialists in childbirth, postpartum, and well-woman health care. They have varying levels of education, training and experience. Generally, midwives are trained to recognize the variations of normal progress of labor and deal with deviations from normal to discern and intervene in high risk situations (WHO, 2000). In many developing countries, where it is available, midwifery is the front-line of maternal health services and provides necessary care in a safe and cost effective manner (WHO, 2013).

Midwives refer women to specialists such as obstetricians (found in better equipped and higher level MOU’s) in complications related to pregnancy and birth when a pregnant woman requires care beyond the midwives' scope of practice. In many parts of the world, these professions work in tandem to provide care to childbearing women. In others, only the midwife is available to provide care. Midwives are trained to handle certain more difficult deliveries, including breech births, twin births and births where the baby is in a posterior position, using non-invasive techniques (Renfrewet al. 2014).

2.8 Data capturing hardware and software in the clinical environment

There are wide varieties of data capturing devices ranging from bar codes, RFID, biometrics such as facial recognition applications or finger print reader and many more. These technologies are readily available in the market and are used in the capturing of data for a specific environment. However, it is not clear how and if they could be used within the intrapartum environment. Some of these are discussed next.

2.8.1 Barcode Readers

A barcode reader is a device that reads pre-printed barcodes. Barcodes are encoded with information that is then read by the barcode readers. Barcode readers contain decoder circuitry analysing the barcode's image data provided by the sensor and sending the barcode's content to the scanner's output port (Pei et al. 2008).

2.8.2 RFID

Radio-frequency identification (RFID) makes use of radio-frequency to transfer data between the source object with a tag that contains the data and a central base or reader. Unlike a bar code, the tag does not necessarily need to be within line of sight of the reader, and is most often embedded in the tracked object.

Since RFID tags can be attached to cash, clothing, everyday possessions, or even implanted within people, the possibility of reading personally-linked information without consent has raised serious privacy concerns (Angell & Kietzmann 2006).

2.8.3 Biometrics

This refers to a case whereby the source of data is human physiological characteristics and traits such as fingerprint, face recognition, palm print, iris retina etc. Thus data capturing from biometrics are more reliable in verifying. However, the collection of biometric identifiers raises privacy concerns about the ultimate use of this information (Delac & Grgic 2004).

2.9 Speech recognition

A number of commercial applications inter alia systems for name-dialling (Gao et al. 2001), travel reservations (Chen, 2001), getting weather information (Zue, 2000), accessing financial accounts (Davies, 1999); automated directory assistance (Jan et al. 2003), use of speech to complete clinical digital forms (Suominen et al. 2015), Garrett (2007)'s use of speech recognition to increase the writing skills of individuals with disabilities etc. are all in current use. The fact that these systems work for thousands of people on a daily basis is a testimony to technological advance in speech recognition.

From observation and first-hand experience, smart phones have become quite powerful and most have speech recognition functionalities. Speech is used mostly as a part of a user interface and for custom speech commands. Giants in this field are Google, Microsoft Corporation (Microsoft Voice Command), Digital Syphon (Sonic Extractor), LumenVox, Nuance Communications (Nuance Voice Control), VoiceBox Technology, Speech Technology Center, Vito Technologies (VITO Voice2Go), Speereo Software (Speereo Voice Translator), Verbyx VRX , SVOX etc.

Much has been said about the capturing of intrapartum data onto the partogram using various modus operandi, amongst other, digitizing the partogram, using a touch screen interface, using an electronic pen and digital paper. As already noted, there is a scarcity of resources within the MOU. The fundamental problem has been that of freeing the eyes and hands of the birth attendant so that she/he can increase the level of care given to the mother and child. Using speech to drive the data capturing process seems to be at this moment a plausible solution to the research problem.

Voice recognition is the process of taking the spoken word as an input to a computer program. Adams (1990) describes it as the technology by which sounds, words or phrases spoken by humans are converted into electrical signals, and these signals are transformed into coding patterns to which meaning has been assigned.

Speech is a highly complex biological process and its vocalizations vary widely in terms of accent, pronunciation, articulation, roughness, nasality, pitch, volume, and speed. Moreover, during transmission, background noise and echoes, as well as electrical characteristics can further distort our irregular speech patterns if telephones or other electronic equipment are used). All these sources of variability make speech recognition, even more than speech generation, a very complex problem (Liauw Kie Fa, 2006).

Figure 2.12: *An overview of speech recognition process.* AT&T Speech API

Figure 2.12 above demonstrates how AT&T speech recognition works. In effect, the speech uttered is digitized routed to the clouds housing a speech recognition application program interface (API). This API processes the speech and hopefully makes sense of it.

From its onset in the early 1950’s, researchers have looked at rule-based methods for voice recognition. These systems could recognize digit and isolated words, but performed poorly because of co-articulation effects and inflexibility of rule based hard decisions (Kaufmann, 2009).

Speech recognition is most often divided into two classes namely: "template matching" and "feature analysis" (Gaudard et al. 2007). Template matching seems to be the most widely used technique as its accuracy rate is much higher than that of feature analysis. However, Juang and Rabiner (2004) argue that it also suffers from most limitations (only isolated word recognition, mishandling of variability in the speech signal) and that accuracy is dependent on it being used properly.

As with any approach to voice recognition, the first step is for the user to speak a word or phrase into a microphone. The electrical signal from the microphone is digitized by an "analog-to-digital (A/D) converter", and is stored in memory (Juang & Rabiner 2004).

2.9.1 Template Matching

When researchers began using computers to recognize speech, template matching was the logical route to take (Dharun & Karnan 2012). Template matching uses the Dynamic Time Warping (DTW) algorithm (Ibid) to determine the "meaning" of this voice input. The computer creates an acoustic image of the input then attempts to match the input with a digitized voice sample (template) by using conditional statements.

Because of the uniqueness of each individual's voice, it is impossible for the program to contain a template for all potential users, so the program must first be "trained" with each new user's voice before the user can be recognized by the program. During training, the program computes a statistical average of the multiple samples of the same word and stores the averaged sample as a template in a program data structure. Because of this, template matching is referred to as speaker dependent recognition system and its user base is limited to those users whose voice have been trained or registered in the program Lee (1989).

Template matching functions well under two conditions namely: the number of words must be limited and the user must speak in a consistent manner and interject pauses between words (Ibid). Discrete, or isolated, speaker dependent recognition systems generally recognize up to 1,000 words, has an accuracy rate of about 98% and are useful in very specific busy-hands, busy-eyes environments (Gaudard et al. 2007).

2.9.2 Feature Analysis

Feature analysis is a "speaker-independent" speech recognition approach (Laface & DeMori 2012). Unlike template matching which looks for a possible match between input voice and a saved template, this approach uses Fourier-transforms or linear-predictive-coding (encodes speech at a low bit rate and provides extremely accurate estimates of speech parameters) to process the voice input, then tries to discover distinguishing similarities between the expected inputs and the actual digitized voice input (Ibid). With this approach, the system does not have to be trained by each new user because the similarities will exist for a wide range of speakers. Some of the limitations of pattern matching such as accents, varying speed of delivery, pitch, volume, and inflection can be handled by feature analysis. However, over the years, speaker-independent speech recognition has proven to be extremely challenging, with some of the greatest hurdles being the variety of accents and inflections used by speakers of different nationalities (Uma Maheswari, 2008). Recognition accuracy for speaker-independent systems appears to be less than for speaker-dependent systems, which is usually between 90% and 95% (Uma Maheswari, 2008).

To distinguish between the speech recognition systems, one could determine if they can handle only discrete words, connected words, or continuous speech (Laface & DeMori, 2012). The majority of voice recognition systems are discrete word systems, and these are fairly easy to implement ibid. For this type of system, the speaker must pause between words. This could be useful for situations where only one word responses or commands are required as an input to drive system processes, but it is unnatural for multiple word inputs (Madisett, 2009). The resultant artefact of this study will likely be a discrete word system because of its high accuracy rate and the fact that single words could be used fairly easily and hopefully effortlessly to drive the capturing process within a level one MOU intrapartum environment.

In a connected word speech recognition system, multiple word phrases are allowed, but the user must be extremely careful to articulate each word clearly and not slur the end of one word into the beginning of the next word. Totally natural, continuous speech includes a great deal of "co-articulation", where adjacent words run together without pauses or any other apparent division between words. A speech recognition system that handles continuous speech is the most difficult to implement. Figure 2.13 presents a brief history and evolution of voice recognition.

Overall, background noise is one of the main factors that influence the performance of a speech recognition system. These systems usually work best under laboratory conditions such as a quiet room with only one person speaking into a microphone. In reality this is often not the case (other people talking in the background, music, motor noises etc.) therefore presents a major challenge for speech recognition systems (Meyer et al. 2013).

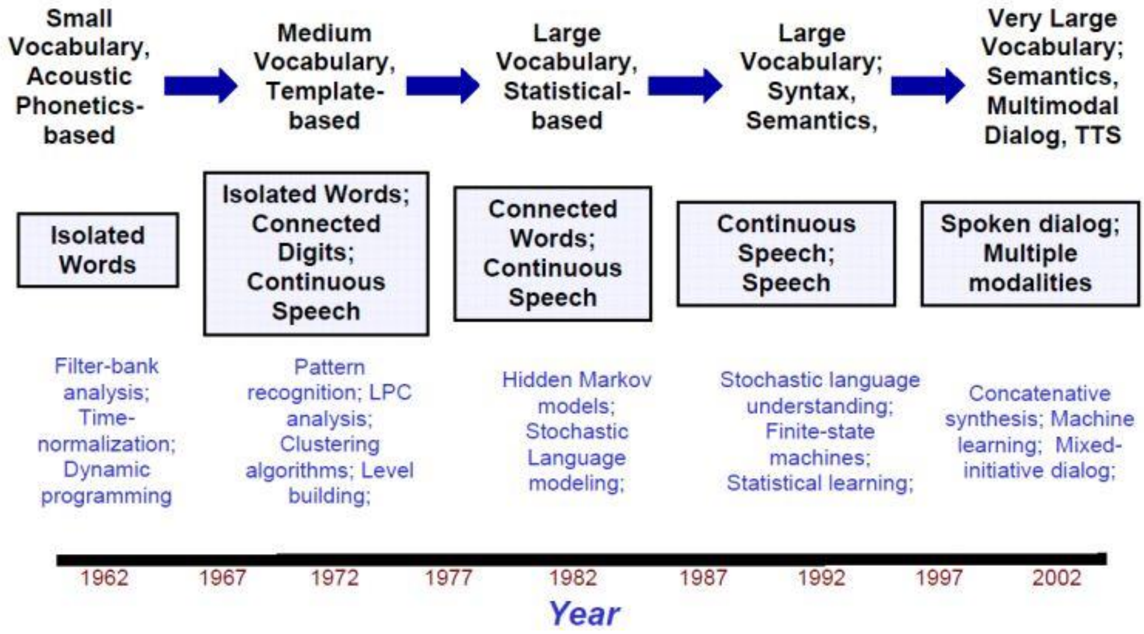


Figure 2.13: *Stages in the evolution of speech recognition. Adapted from Juang & Rabiner (2004)*

2.9.3 A comparison of speech recognition software

For the purpose of verifying the efficacy of speech recognition software (most common and available ones), Table 2.3 below shows a relative comparison. As productive as they may seem, they all seem to possess a fundamental flaw. With about 90% accuracy rate the following problems could be experienced, namely: word mistakes, failing to accept some words at times and finally difficulties picking up hyperlinks on complicated websites with numerous links.

Table 2.3: *Speech recognition software*

Make of software	Attributes
Dragon NaturallySpeaking	Dictation, text-to-speech and command input. The user is able to dictate and have speech transcribed as written text, have a document synthesized as an audio stream, or issue commands that are recognized as such by the program. Requires training.
iListen/ Dictate	Mostly for Mac machines. Uses the same speech-recognition engine as Dragon NaturallySpeaking and thus has all the same benefits and flaws.

Windows Speech Recognition	Relies on Microsoft SAPI(speech API) Requires extensive training. User is able to dictate, issue commands
Siri	Also relies on the same speech-recognition engine as Dragon NaturallySpeaking .It answers questions, makes recommendations, and performs actions by delegating requests to a set of Web services.
Google now	Intelligent personal assistant available within the Google Search mobile application for the Android and iOS operating systems. Answers user-initiated queries.

2.9.4 Evaluation of Headphones

Headphones either have wires for connection to a signal source such as an audio amplifier, radio, portable media player, mobile phone, electronic musical instrument, or have a wireless device (Bluetooth), which is used to pick up signals without using a cable. For the purpose of the study, I will be looking at hands free and cordless head phones. The driving factor here is providing an uncluttered headpiece that is durable enough and capable of carrying user specific commands even with background noise.

Bluetooth is a wireless technology standard for exchanging data over short distances (using short-wavelength UHF radio waves in the ISM band from 2.4 to 2.485 GHz) from fixed and mobile devices. A comparison of Bluetooth headset is listed on Table 2.4.

Table 2.4: *Bluetooth wireless headsets McEvoy (2012) & Top Ten REVIEWS (2015)*

Mark /Image	**Attributes**
	• Up to 30 feet away from your PC or mobile phone • Wind Stop technology to minimize wind noise. Great for use outside • Talk time: 7 hours • Standby time: 300 hours
	Advanced technologies in Echo cancellation & Noise reduction ensure the good sound quality.
Plantronics Marque 2 M165 	• Dual microphones help reduce noise and wind • giving you better sound quality. • Deep Sleep power-saving mode. • Built-in rechargeable battery. • Operating range of up to 33-feet away. • Up to 7 hours/11 days battery power.
	• Black reversible ear hook • Noise Reduction (acoustically tuned) • Up to 14 days standby • Up to 9 hours talk time • Operating range: Up to 33 feet • Built-in rechargeable li-on polymer battery
	• Clip type Headset • Headset with a retractable earpiece • Incoming call alert • Out of range alert • Multi-point technology • Clear sound quality • Easy secure pairing • Lower power consumption • Talk Hour: Up to 7 hrs • Standby Hour: Up to 240 hrs • Charging Hour: 1.5-2.0 hrs • Product Range: 10 meters with no obstructions

2.10 Design science justification

Because of the design nature of the study, this study uses Design Science Research (DRS) as a suitable and relevant methodology. This section thus explores academic literature on DSR, its concepts and central themes as well as reasons to justify its use of DSR for this study. The next section below looks at the origin, history and nature of DSR as provided by diverse academic literature.

2.10.1 What is Design Science Research?

Cross (2001) surmises that humans in general for thousands of years are known to have undertaken design related researches. Such design activities might inter alia include the pyramids, the tower of Pisa (Cross, 2001). One can only imagine the chief architect Imhotep (ca. 2650-2600 BCE) asking fundamental questions about the design and construction of the pyramid for his great King Djoser. This design related research spans various disciplines including architecture, engineering, education, psychology and the fine arts.

Eminent authors within the information system milieu such as Hevner et al. (2004) and March and Storey (2008) give credit to Herbert Simon as the father of design science because of his work on the Sciences of the Artificial (Simon, 1969). Simon argues that, unlike the natural science, a fundamental knowledge could be sourced in the world of the artificial constructed by humans. Hill (2009) contends that unlike the natural sciences (with main objective being truth and necessity), the artificial sciences are more in favour of on utility and contingency (possibility). I observe that the most common theme amongst these disparate fields is the notion of an artefact.

Simon's (1969) view is contrary to the notion that the role of IT artefact in information systems (IS) research is controversial (Weber 1987; Orlikowski & Iacono 2001; Benbasat & Zmud 2003) as well as the notion that there is an absence of professional relevance of IS research (Benbasat & Zmud 1999; Hirschheim & Klein 2003).

The period around the Second World War saw the validity of DSR taking second place to the natural sciences. As a consequence, the notion of artefact was pushed to the background Hill (2009). The work that Simon did as a matter of fact forms the basis for researchers and academics to take these artificial sciences more seriously and particularly elevate design as a means for undertaking research. Following Simon's cry, authors such as (Hevner et al. 2004; Gregor 2006; Gregor & Jones 2007; Jörg et al. 2007; Peffers et al. 2007) examined Design Science Research as a research method within the Information Systems field as well as used for conducting research on IS topics (Arnott, 2006).

Over the years in the modern era, quite a range of nomenclature has arisen to denote research carried out using design-based approaches. Gregor (2002) portrays that it has been called inter alia engineering type research, design science, system development approach, constructive type research and prototyping within the nineties (1990's). Simon (1969) contends that irrespective of what name it's been called, it has always been a means of generating knowledge by using design. Hevner et al. (2004) has a major impact on DSR as we know it today.

Here, I will attempt to understand DSR as portrayed by the academic literature as well demonstrate how it is used within and to support this study. According to March and Smith (1995), information technology (IT) and IS research is orientated towards the study of artefacts and artificial phenomena. This is because of the complexity and artificial nature of the resultant artefact (Hevner et al. 2004). DSR focuses more on artefacts that are used in human-machine systems (Gregor, 2002).

As previously touched on, there are two major paradigms for research within the IS and IT field namely: design-based research and behavioural-based research (Hevner et al. 2004). DSR within the IS and IT paradigm seeks to solve IT related problems by using and applying knowledge generated from behavioural-science research (Behavioural-science research attempts to understand reality or a given research problem (March & Smith 1995; March & Storey 2008) as well as the kernel-theories (knowledge originating outside the IT and IS field (Hevner et al. 2004 & Niehaves 2007).

DSR seeks to address the so called "wicked problems", problems which exist or arise from the complex interaction where the problem constraints and environment are ill-defined and multiple different solutions exist, each of which depends heavily on human creativity and teamwork (Hevner et al. 2004). They further noted that these so called wicked problems make it challenging to describe the processes and laws relevant to the solution and problem. March & Smith (1995) proposes that DSR should produce innovative artefacts that respond appropriately to the needs of humanity. Wang and Wang (2010) concur that the limits of creativity and innovation should be pushed and further declare that standard applications in standard environments are no longer of interest to the design-science discipline.

DSR is fundamentally a problem solving process (Hevner et al. 2004) as its focus is on creating of an artefact to respond to the problem at hand. The process of creating this artefact involves the presentation of a design related problem and the subsequent generation and evaluation of a design-based solution (March & Storey 2008). Thus in a nutshell, DSR considers how things ought to be to attain a desired outcome while behavioural science research considers how things are used by humans (Hasan, 2004).

The creation and evaluation of research artefacts are intrinsic parts of DSR. These artefacts are generally considered to be knowledge containing objects. They are thought of to be containing ideas, assumptions technical capacities, concepts and practices. Because of their knowledge containing attributes, they can be deployed effectively within the IS discipline to handle the processes of analysis, design, implementation and management (Hevner et al. 2004).

March and Storey (2008) concur with March and Smith (1995) when they state that artefact construction is carried out inter alia to attaining a predefined goal, in order to address a design issue or extend the boundaries of known application within the IT and IS domain. Hevner (2007) contends that artefact construction and evaluation are and should always be a twin activity as it is the evaluation phase that produces the desired research findings and provides the necessary proof that the designed artefacts are able to address the research problem. For the research to be rigorous, he proposed that the build and evaluate phases should be an iterative process spanning the entire length of the research process. Hevner et al. (2004) is of the opinion that the evaluation phase further enhances the understanding of the problem at hand as well as allowing the quality of the artefact and the process used to create the artefact to be evaluated and improved.

Artefacts are purposely designed and created, with the intent of performing a specific purpose. These artefacts inherently contain and represent the underlying design considerations and assumptions. Hasan (2004) refers to DSR as a “disciplined investigation" which is conducted within the development process and is aimed at improving the "thing" being developed. The "thing" in this case could be the artefact, the developer, development process or even the research methodology.

According to Hasan (2004), some of the issues that reviewer has with DSR is the absence of behavioural science research entities like hypotheses, experimental design or data analysis. However, according to Gregor (2002), instead of hypotheses, DSR strives to create artefacts that are innovative, valuable and speak to the problem.

Because of the possibly long and complex processes involved in creating the artefact, Hevner et al. (2004), suggest that DSR allows room for the research process to be simplified by perhaps decomposing the problem into smaller components. This miniaturization of the problem could then be used to look at a relevant means, end or law that is in play (Van der Watt, 2012). The artefact can thus be used to look at one specific aspect of the research.

The attempt of DSR is to bridge the gap between theories and practice (Ellis & Levy 2010). The researcher within DSR does not only produce theoretical knowledge but applies practical knowledge of a situation or a task to create an artefact (March & Smith 1995). After applying knowledge to create the artefacts, the aim of DSR becomes to explain why the artefact (constructs, models, methods and initiations) works, or possibly why it doesn't work (Hasan, 2004) by means of evaluating the artefacts against criteria such as value and utility (March & Smith 1995).
According to Gregor and Jones (2007), the human researcher is regarded as the tool which interprets the instantiations and the theories and is also responsible for moving information between the two. Van der Watt (2012) further propounds that the human researcher finds and interprets the theories and uses it during the instantiation and development. Also, the researcher can gain new insight on the existing theories or create new ones during the iterative process of development.

DSR could be used for a fairly new, unknown or less obscured research area. When used for an initial research, the artefact is in the form of a prototype. Also, when used for a less obscured research area and to avoid duplication and enforce relevance, the researcher must identify and show that the existing IT artefacts, if present in any form, are not adequate to address a given problem (March & Storey 2008).

The above section considered relevant academic literature on the topic of DSR, in order to provide a better understanding of a possibly obscure research methodology. The following section considers the arguments in the literature that supported the idea of design as a means of research.

2.10.2 Design as Research

This section considers the justification found within the literature for using design as a credible form of research.

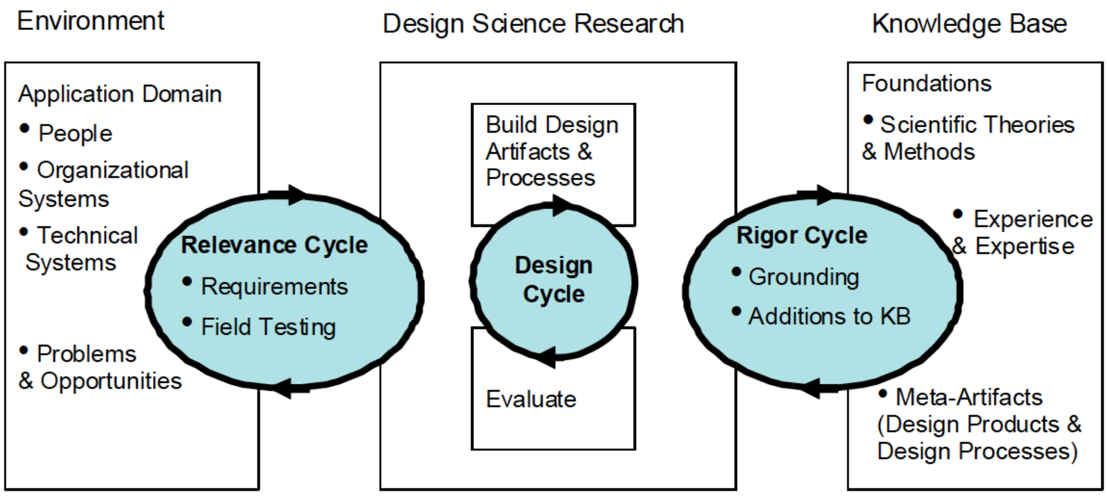


Figure 2.14: *DSR and its three closely r*elated cycles (Hevner, 2007)

Because of the number of citations and respect that they command, when it comes to DSR and its justification as a knowledge generating paradigm, the main contributing authors seem to be Hevner et al. 2004, Hasan (2004), Livari (2007) and Hevner (2007). Hevner (2007) was a response to Iivari (2007)'s essay on the key properties of DSR paradigm (ontology, epistemology, methods, and ethics) in attempting to address the perceived limitations of the views of Hevner et al. 2004. As depicted in figure 2.14 above, for DSR to be justified as a valuable form of research, Hevner (2007) puts it clearly that the research should contain three closely related cycles and that the design cycle (iterative artefact construction and evaluation) should be steeped in two fundamental aspects: relevance and rigour emanating from the environment and knowledge base respectively.

He states that "*The Relevance Cycle bridges the contextual environment of the research project with the design science activities. The Rigor Cycle connects the design science activities with the knowledge base of scientific foundations, experience, and expertise that inform the research project. The central Design Cycle iterates between the core activities of building and evaluating the design artefacts and processes of the research*" Hevner (2007:2).

The period around the Second World War saw the validity of natural sciences being given more credence than DSR and as a consequence, the notion of artefact was pushed into the background (Hill, 2009). Simon's (1969) work was in essence a call-to-arms for academics to embrace these artificial sciences and in particular, design as a means for undertaking research. Since then, Design Science has been examined within Information Systems as a research method (Gregor 2006; Gregor & Jones 2007; Hevner et al. 2004; Jörg et al. 2007 and Peffers et al. 2007) as well as used for conducting research on IS topics (Arnott, 2006).

Benbasat and Zmud (1999) were of the opinion that most often DS researchers do not duly give the necessary attention that both of these entities (relevance and rigor) deserve and are more inclined in gaining academic legitimacy by duelling only on rigors at the expense of relevance. Over emphasis on rigour results in practitioner legitimacy vacuum and vice versa.

Ellis and Levy (2010) and Hasan (2004) both agree that research involves: "addressing an acknowledged problem building upon existing literature and making an original contribution to the body of knowledge" and that its ultimate output is an addition to the body of knowledge of the discipline. It is also important to note at this point that there needs to be a clear conceptual link between the research itself and the process of knowledge discovery and or knowledge creation (Ellis & Levy 2010).

People who participate in the process of systematic analysis, design and production are in fact taking part in higher mental activities (creative and innovative thinking) which provide new insights and knowledge in relation to the problem being addressed. These activities can be seen as being a legitimate research method as knowledge is created during the development life cycle (Hasan, 2004).

The design and development of IT and IS solutions is itself a creative process based on application of systematic and diligent methods. IT and IS solutions are created in order to perform a specific function, to addressing a certain need or identified problem. If the process of design and development is based on and builds on current academic knowledge and effort is made to identify the research contribution and prove an acceptable amount of rigour throughout the development process, then it is possible for the process of design and development to be legitimate research (Van der Walt, 2012).

Research in natural and behavioural-science is based on discovery and justification; while research in DSR is based on build and evaluate (March & Smith 1995) with the eventual goal of DSR being the utility of knowledge generated through the build and the evaluation process (Hevner et al. 2004).

From the above definitions and discussions from diverse authors, it is therefore my submission that it is clear that DSR is a valid and justified form of research and optimal for this study. The following section looks at the literature on the artefacts produced by DSR in more detail.

2.10.3 Artefact in Design Science Research

DSR artefacts can be broadly defined as: models, methods, constructs, instantiations and theories. Artefacts can include social innovations, new or previously unknown properties of technical/social/informational resources (March & Storey 2008); new theories explaining the causes of a problem; new design and developments models; new methods and processes for implementing models or tools (Ellis & Levy 2010). Van der Walt (2012) duly noted that not all sources agree on the validity of theories as an acceptable type of DSR artefact. These artefacts not only help in the creation and analysis of data but also its presentation (March & Smith 1995; Gregor 2002; March & Storey 2008).

I will take a moment here to briefly go through some of the definitions of artefact as meticulously defined by Iivari (2007). A construct is the vocabulary and symbols of a domain, the conceptualisation of a problem with the domain. A model is a set of statements expressing the relationship amongst constructs, the abstraction and the representations.

A method is a set of steps (algorithm, guidelines or practices) used to perform a task although it's noteworthy that not all methods can constitute artefacts; a method is based on constructs (language) and a representation (model). An instantiation is the application of an artefact in its environment, the implemented and prototyped system (March & Smith 1995; Hevner et al. 2004).

According to Ellis and Levy (2010) there are three factors involved in the creation of a DSR artefact namely: the creation of a conceptual framework; creation of system architecture and the creation of a prototype to be tested and evaluated. For the purpose of this study, an artefact as a prototype to be tested and evaluated is more plausible.

Within DSR, artefacts are perceived as embodying knowledge and one of the primary sources of research data. Gregor (2002) notes that an artefact can reflect the tools and methodologies used in its construction, while certain design theories link the construction methods with the particular type of artefact.

Hevner et al. (2004) raised two fundamental issues that must be satisfied for the DSR to be able to provide credible research data. Firstly, the utility of the artefact must be demonstrated and secondly, the artefact must be able to address an identified problem. If the artefact successfully addresses a given problem, then the underlying knowledge can be assumed to be credible. The design cycle as depicted in figure 2.14 above and specifically the evaluation phase helps to show the utility of the artefact and also explains how the artefact addresses the identified problem as well as the underlying knowledge contribution.

Natural and behavioural-sciences can provide a meaningful contribution to the design-science field by providing knowledge and information relating to the natural world in which the artefact must function (March & Smith 1995). Due to Hevner (2007)'s insistence on relevance and rigour, design-science can use these knowledge provided by natural and behavioural science as inputs to the design cycle to produce an artefact. According to March and Smith (1995), these artefacts can in turn act as an input into the behavioural science domain (a phenomenon that can be studied, such as the requirements for a new IS solution to be accepted within a specific context). This falls outside the scope of this study.

Due to the evolutionary nature of society, problems and technology, artefacts themselves are not static and can evolve through human action or because of new technology that has been developed (Gregor, 2002).

2.11 Theoretical conceptual model

Figure 2.15 below encapsulates the theoretical conceptual model for this study based on the relevant literature reviewed. The unit of analysis is a level one Maternal Obstetric Unit (MOU). The model lists the characteristics of the intrapartum environment as well as that of the care givers. Further, the model demonstrates the current modus operandi of data capturing. In addition it also shows two desired states namely: a digitized data partogram with the keyboard used as the capturing tool and a case where human speech is used to directly capture data onto the digitized partogram. The use of speech to capture data is a cyclic one as it requires a lot of adjustment and fine tuning.

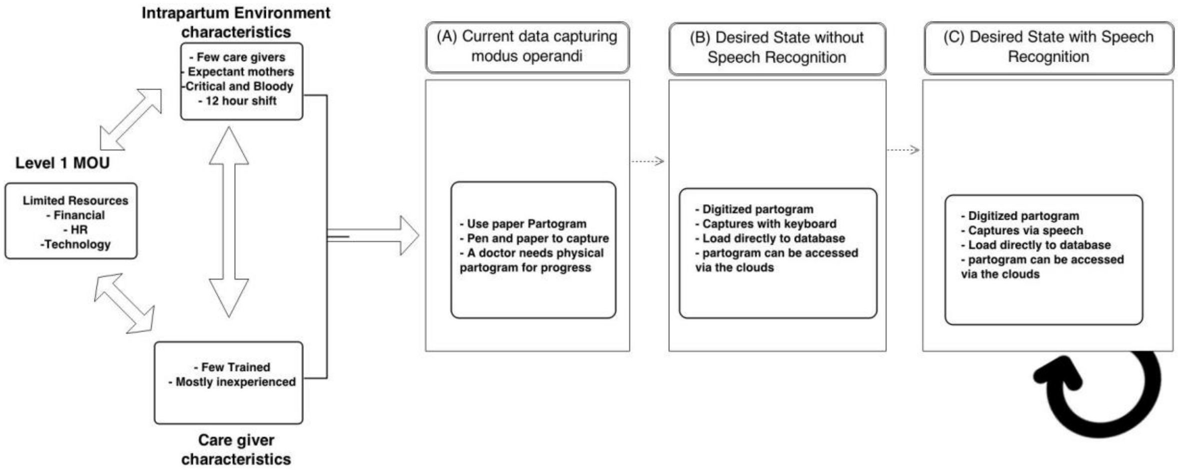


Figure 2.15: *Theoretical framework of this study*

2.12 Literature Review Conclusion

Initially the literature review focused on the academic literature that related to the primary context of the research, maternal health care. In order to provide an all-encompassing view on maternal health care, the research looked at literature on both the developed and developing world. However, the main focus was placed on highlighting the challenges faced by settings similar to developing countries especially those in low resource area. The literature showed that increasing access to resources such as amongst others financial, technological and human resources directly increased quality of care to patients and ultimately produced a best possible outcome.

The literature review also looked at the topic of health informatics, and the various advantages it brings to healthcare and its ability to influence the quality of care at remote facilities. The broader health informatics was only looked at briefly as it is somewhat out of the scope of this research project. Again, a huge disparity exists between the developed and developing nations. Literature bemoans the infancy at which health informatics is in developing natures.

The importance of standards of health care records was considered and Health Level 7 (HL7) version 2 and upward (which supports clinical practice and the management, delivery, and evaluation of health services) was considered a more apt standard in as much as this study is concerned.

The capturing of data within the intrapartum environment was considered in more detail. A comparison was drawn between data capturing in the developed world and developing countries. An evolutionary attempt at introducing technology into data capturing was looked at as well as capturing devices such as partopen, partogram etc. The advantages of electronic data capturing devices were presented. Over time, data captured can easily grow quite large. Thus, the dynamics of large data was looked at and recommendation on how to generate a competitive advantage from large data similar to the corporate environment was looked at.

The literature review also looked at the impact of the usage of technology within the intrapartum environment and found out that although some concerns have been raised, no evidence of substance seems to exist to support a negative impact.

The partogram, being the major data-capturing tool within the target research environment, was delved into with a certain degree of detail. The various sections such as the woman's/maternal information, foetal well-being, labour progress, medications, maternal well-being as well as their respective sub component were looked at. Overall, it presented a birds-eye view of the intrapartum data capturing.

The literature review also contained a reasonable amount of technological hardware and software (speech recognition engines). A basic comparison between the technologies was looked at with the intention of possibly selecting the most appropriate to use for this research project.

Finally, the literature on design science was scrutinized and a case for design science as a relevant methodology for this research (as supported by numerous authors) was considered.

In a nutshell, the literature review provided a better understanding of the problem domain as well as a reasonable expectation on the way forward.

CHAPTER THREE

STUDY DESIGN METHODS /RESEARCH METHODOLOGY INTRODUCTION

This research project utilized Design Science research as already demonstrated in the previous chapter where the related literature was reviewed to answer the research questions and ultimately respond to the fundamental research problem. Evidence exists to suggest that this research philosophy, although not called DSR as we know it today, has been used in the past (Simon, 1969). Although Hevner et al. (2004) published their paper in 2004 in which they contended that DSR was erroneously regarded as an approach that was fairly new within the realm of Information Systems, their contention is still as valid today as it was in 2004. For that reason, this chapter will seek to expound the chronological development of Design Science, its philosophical basis and ultimately demonstrate why its usage is justified for this research study. The following sections below will deal with the selection and justification of the particular data collection (empirical) and analysis phases of this research:

1. Literature review of relevant material
2. Interview (Semi-Structured)
3. Conceptual Study
4. Artefact Simulation
5. Research Evaluation

For this project, I have selected to employ a hybrid approach, that of qualitative and quantitative data collection, this is because a hybrid approach draws from both domains and Hill (2009) contends that it is a necessary consequence of building and evaluating an artefact, in this case involving the use of measurements parameters by birth attendants. The first section presents a general historical origin and evolution of DSR

3.1 Introduction To Design Science

Cross (2001) surmises that humanity has for thousands of years been known to have undertaken design related researches. This research spans various disciplines including architecture, engineering, education, psychology, and the fine arts. However, eminent authors within the information system milieu such as Hevner et al. (2004) and March and Storey (2008) give credit to Herbert Simon as the father of design science because of his work on the Sciences of the Artificial (Simon 1969). Simon argues that, unlike the natural science, a fundamental knowledge could be sourced in the world of the artificial constructed by humans. Hill (2009) contends that in contrast to the natural sciences (which are concerned with truth and necessity), these artificial sciences' area of focus are usefulness (utility) and contingency (possibility). The common theme that emerges throughout these various fields is the concept of an artefact.

Unbelievably, as far back as 1969, Simon (1969) definitely crushed the notion that the role of IT artefact in IS research was controversial as posited by these relatively newer authors (Weber 1987; Orlikowski & Iacono 2001; Benbasat & Zmud 2003) as well as the notion that there is an absence of professional relevance of IS research (Benbasat and Zmud 1999; Hirschheim and Klein 2003). As much as I admire these authors immediately cited above, I find Simon (1969)'s arguments more convincing as his argument is in agreement with other eminent authors cited in the proceeding paragraphs.

The period around the Second World War saw the validity of DSR succumbing to the primacy of the natural sciences. As a consequence, Hill (2009) surmises that the artefact relegated to an inferior position. Simon (1969), already about half a century ago, put forward a very strong view intimating that academics ought to wake up from their slumber and embrace these artificial sciences and particularly design as a modus operandi of conducting research.

From Simons' era, quite a number of researchers have arisen to champion his cause resulting in Design Science being used within Information Systems as a valued research method (Arnott 2006; Gregor 2006; Gregor & Jones 2007; Hevner et al. 2004; Jörg et al. 2007; Peffers et al. 2007).

3.2 Motivation

The background and context for the project is presented first and thereafter Takeda et al. (1990)'s five steps are used as a way to present the history of the development of the project as demonstrated in figure 3.1below.

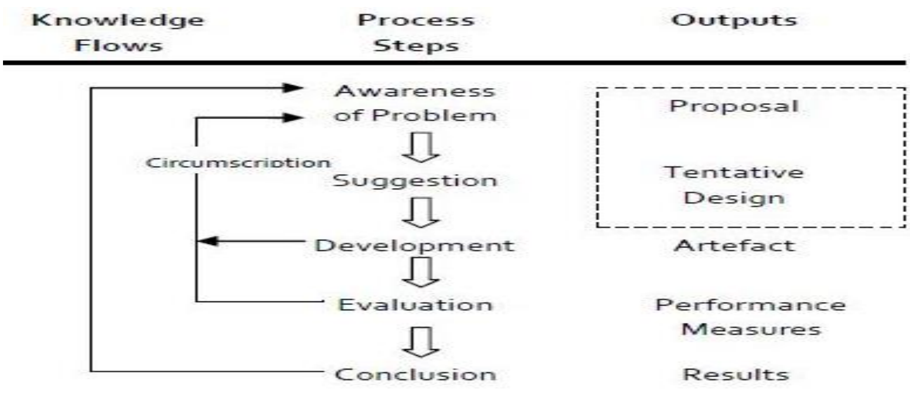


Figure 3.1: *Design cycle process adapted from Takeda (1990)*

As stated in section 3.1 above, awareness of the problem considered by this study came about through a study that was conducted by Van Zyl (2011) within the home-based health care as well as an on-going study by a senior intrapartum nurse at Stellenbosch University; investigating how the complexities of the information communication can be improved to enhance the management of the intrapartum period. The research identified that, while there are a number of data capturing modus operandi within the intrapartum environment, none specifically addressed the fundamental question of improving healthcare to mother and child by freeing the eyes and hands of birth attendants within the MOU so they can concentrate on the expectant mother. The question of using technology to determine if an ICT application could be used within the intrapartum environment for data capturing arose. The conclusion from this step was an acceptance by the Cape Peninsula University of Technology of my master's research project.

The suggestion step as depicted in figure 3.1 was the understanding that ideas from the Information Technology disciplines (e.g. theories, constructs and measures) and intrapartum medical data needs could be valuable in resolving this problem. These ideas from the relevant disciplines are neither readily nor easily transferable and thus require an understanding of the intrapartum data literature, practice within the Information Systems context, formalization into an artefact and evaluation against some (intrapartum context) criteria. The resultant yield from this step was a master's degree proposal, accepted by Cape Peninsula University of Technology.

The development of the artefact and its evaluation encompasses the crux of the empirical work carried out in this research, the rationale of which is outlined in this chapter. The development phase produced an intrapartum data capturing artefact while the evaluation phase assesses of the artefact against recommended criteria.

Finally, the thesis will comprise of analyses and conclusions which be inclusive of the descriptions of the research processes, the empirical stages, the artefact itself as well as the results of the evaluation.

3.3 Goals Of The Research Design

For the intrapartum data-capturing problem to be addressed, it is important to recognize two things. Namely, what form the solution to the problem might look like and how it might actually be utilized in real life. The most important aspect to consider at this juncture is utility. With that in mind, this research is largely focused on generating an outcome, which is of use to those in practice. Thus, the understanding and knowledge attained is of an applied nature.

It goes without saying that the artefact should satisfy two fundamental stipulations namely; rigour – to provide an input into the knowledge jar and relevance – be capable of being applied in the relevant environment (Hevner et al. 2004).

There have been discussions and debates within the IS community regarding the two fundamental qualities of an artefact (rigor and relevance). Hirschheim and Klein (2003) argue that the importance of relevance has been relegated to the research dust bin of mere acknowledgment and IS researchers were too preoccupied with gaining academic legitimacy by duelling too much on rigor alone and by so doing creating practitioner legitimacy vacuum (relevance). Benbasat & Zmud (1999) lay bare the supposed dichotomy that exists and eventually promulgated the need for an increased relevance in IS research. Noted scholars such as Applegate (1999) and Davenport & Markus (1999) concurred with Benbasat & Zmud (1999) and further argued that the only way Information Systems can successfully assimilate the rigor and relevance within DSR is by learning from disciplines like inter alia medicine, law and engineering. These disciplines achieve both goals by employing the two distinct approaches namely: develop/build and justify/evaluate.

Further, Burstein & Gregor (1999) also suggest that Design Science should also make use of an approach known as systems development methodology. For this study, the investigation is concerned with developing and evaluating an artefact. This evaluation was part of a useful information system and hopefully making an input to theory by providing a "proof-by-construction" as coined by Hill (2009). The main differences between the broader approach of Design Science and Information Systems Development are defined in table 3.1 below.

Table 3.1: *Difference between DS and IS development adapted from Hill (2009)*

Parameters	**Design Science**	**Information System**
Scope	Just one of the disciplines under IS	Extended scope and has a wide range of disciplines
Artefact	The term "artefact" accommodates a broader view for the purposes of research evaluation. Rather than just working instantiations, it also includes constructs, models, methods and frameworks.	

For this study, the artefact is a working instantiation for capturing of intrapartum data within a level one health facility by employing a hands-free and wireless system. Kock et al. (1997) and Hevner et al. (2004) define Action Research as being a case where “intervention is carried out in a way that may be beneficial to the organisation participating in the research study”. The act of intervening allows the researcher to study complex organisational phenomena that occur before, during and after the intervention and usually to study and characterize the benefits and difficulties of the intervention itself (Iivari & Venable 2009). Because this study does not intend to actually intervene in the health facility during this research safe for carrying out simulation, this study does not qualify as an action research especially since there is no aim of implementing the method within the health facility nor tracing the impact of the changes throughout the health facility – another aspect of action research (Burstein & Gregor 1999). The study is also not considering the use or adoption of the artefact with the focus on the construction of it with a proof-of-concept the only evaluation.

3.4 Employing Design Science In Research

The guideline for Design Science chosen for this study is Hevner et al. (2004) as well as a clarified version a few years later Hevner (2007). The clarification came about as a response to Iivary (2007)’s commentary on the previous guidelines.
Hevner et al. (2004) expounded on a framework that was originally propounded by March and Smith (1995). First they stated in a comparable way that two paradigms are important in IS research, behavioural science and design science; “The behavioural science paradigm seeks to develop and verify theories that explain or predict human or organizational behaviour. The design-science paradigm seeks to extend the boundaries of human and organizational capabilities by creating new and innovative artefacts.” (ibid., p. 75).

Hevner et al. (2004) in effect proposed a framework and guidelines to understand, execute and evaluate IS research. The framework (Figure 3.2) compares the two mentioned paradigms and positions them next to the problem space, referring to Simon (1969) resulting in the by-the-researcher perceived business-needs, and the knowledge-base on the other side, consisting of methodologies and foundations.

The knowledge of the knowledge-base can be applied in IS research or the knowledge base can be fed with new insights as a consequence of IS research. The instantiation as a result of the design science research efforts will influence and change the environment in which it is implemented (Figure 3.2 below).

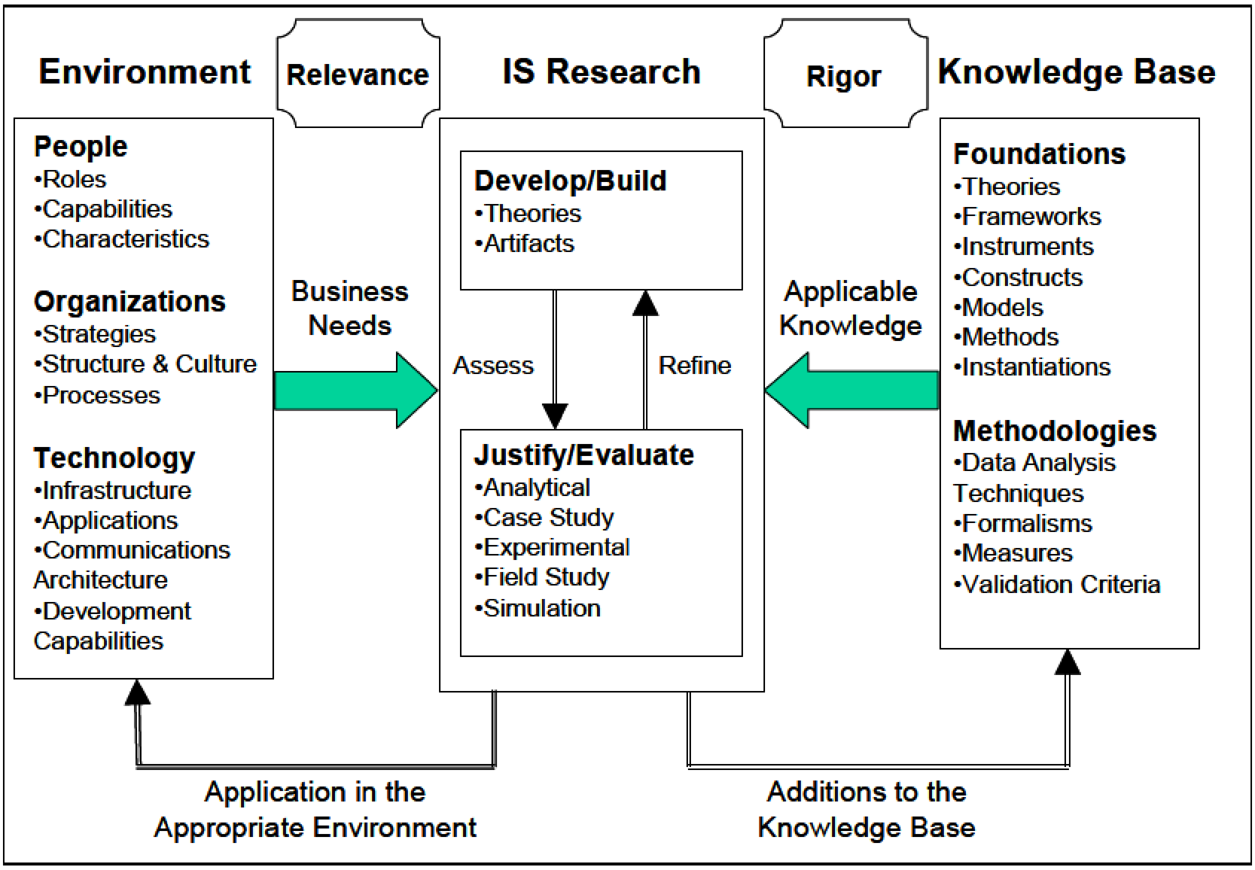


Figure 3.2 : *IS research framework Hevner et al. (2004)*

Below in Table 3.2, are the seven DSR guidelines that will be employed for this research project as suggested by Hevner et al. (2004).

Table 3.2: *DSR Guidelines Adapted from Hevner et al. (2004)*

Design-Science Research Guidelines	
Guideline:	**Description**
1. Design as an artefact	DSR must produce a valid artefact in the form of a construct, a model, a method or an instantiation.
2. Problem relevance	The objective of DSR is to develop technology based solutions to important and relevant business problems
3. Design evaluation	The utility, quality and efficacy of a design artefact must be rigorously demonstrated via a well-executed evaluation methods
4. Research contribution	Effective DSR must provide a clear and verifiable contribution in the area of design artefact, design foundations and or design methods.

5. Research rigour	DSR relies upon the application of rigorous methods in both the construction and evaluation of the design artefact.
6. Design as a search process	The search for an effective artefact requires using available means to reach desired ends while satisfying laws in the problem domain.
7. Communication of research	DSR must be presented effectively to both technology-oriented as well as management-oriented audiences.

As a response to Iivari (2007)'s essay on the key properties of DSR paradigm (ontology, epistemology, methods, and ethics), Hevner (2007) further describes design science research as an embodiment of three closely related cycles as already demonstrated on figure 2.13 above. He states that

> "*The Relevance Cycle bridges the contextual environment of the research project with the design science activities. The Rigor Cycle connects the design science activities with the knowledge base of scientific foundations, experience, and expertise that informs the research project. The central Design Cycle iterates between the core activities of building and evaluating the design artefacts and processes of the research*" (Hevner, 2007:2)

He recognises the need for constructive research methods, which allow disciplined, rigorous and transparent building of IT artefacts as outcomes of design science research and admonishes that these three cycles (depicted in figure 3.3 below.) should be present and clearly defined in any DSR project. Authors such as Stokes (1997) and Winter & Schelp (2006) posits that the objective of design science research is to achieve the elusive Pasteur quadrant; that of high rigour and relevance.

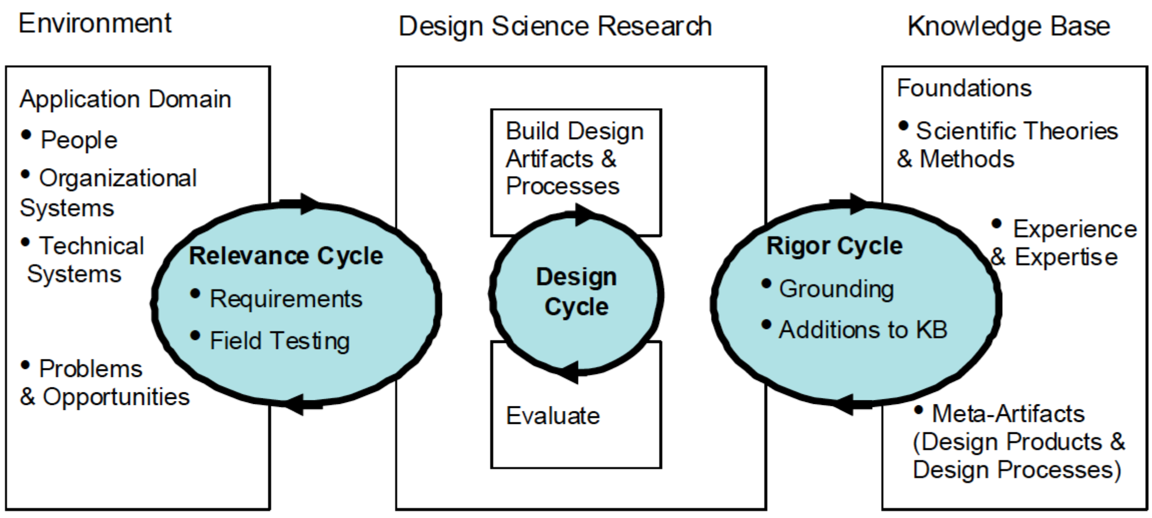


Figure 3.3: *DSR cycle adapted from Hevner (2007)*

The Relevance Cycle will input requirements from the intrapartum environment into the research and introduces the research artefacts into environment for field-testing. The Rigor Cycle will provide grounding theories and methods along with domain experience and expertise from the foundations knowledge base into the research and adds the new knowledge generated by the research to the growing knowledge base. The central Design Cycle where the actual research takes place will maintain a much more constricted iteration of research activity for the development and evaluation of the artefact and processes.

Firstly, the key elements from this generic model are identified and mapped to this specific project.

3.4.1 Business Needs

I begin with the industry requirements or needs extracted from the environment, to satisfy the research need of relevance. Hevner et al. (2004) contend that the industry requirements or needs should be “assessed within the context of organizational strategies, structures, culture and existing business processes”. Hence, to understand the business need for the hands free capturing of intrapartum data, I therefore have to examine these elements to ensure that if an artefact were developed it will actually be relevant to the target organization. This also requires a careful definition of the “target organizations” to ensure that the scope is specific to the problem at hand. When emphasising relevance, Mckay and Marshall (2008) recommend that the design task in information system be conceived as one that includes rather than strips away the social and organisational context of the artefact.

3.4.2 Processes

The research problem shows that the target organizations or health facilities have a data capturing mechanism going on. As demonstrated in the partogram, examples of intrapartum information include:

- Information about the mother, such as date of birth, parity, gravidity etc.
- Information about the baby (foetus) such as heart rate, caput etc.

This information is acquired either directly from the mother or from mother’s medical file (If it is available and found within reasonable amount of time). The uniqueness of medical needs also ensures that medical care is provided to each mother and or foetus based on their respective health conditions as opposed to one solution fitting all.

3.4.3 Infrastructure And Applications

According to literature as well as contextual interview, the mother’s information is captured on a paper form called the partogram and is ultimately stored in some storeroom. This capturing is done by birth attendants. All medical decisions regarding the mother and child are taken based on the data captured on the form. It is always a mission to retrieve this form as quite some time is spent searching for it and in some instances they are never found. Based on these key organizational considerations, one could argue that the data capturing process would be a labour intensive process.

An empirical phase is included with its objective being to try and understand the drivers of the organizational and technological needs in these target health facilities. This empirical phase will ensure that the design and use of the data capturing mechanism is relevant.

3.5.4 Applicable Knowledge

For Design Science to be rigorous, this research must be able to draw on existing knowledge from a number of domains.

> "The knowledge base provides the raw materials from and through which IS research is accomplished ... Prior IS research and results from reference disciplines provide [constructs] in the develop/build phase. Methodologies provide guidelines used in the justify/evaluate phase." (Hevner et al. 2004, p. 80).

I find it important to reiterate here that knowledge is sourced (in both phases) from prior Information Systems research as well as from the relevant reference disciplines. Design Science should also be able to make a contribution to what Hevner et al. (2004) calls the archival knowledge base of foundations and methodologies. Kock et al. (1997) and Hill (2009) contend that the primary focus is to be able to contribute to the Information Systems knowledge base and not worry too much about making contribution to the reference disciplines as it is not a requirement within Design Science.

The main features of the guidelines found within the DSR will be used to guide the design of the hands free data capturing mechanism. The research problem stated above suggest that this study will be dealing with what can be considered as sub-fields of Information Systems namely: the design of an artefact as part of a system and its usage.

A number of data capturing mechanisms have been designed, developed, proposed, evaluated and implemented by Jhpiego (2011). A solid understanding of such mechanisms is required to avoid redundancy, duplication and misunderstanding. Luckily enough, there exists a huge chunk of academic research as well as professional knowledge that has been developed over the last few years. Notably, this study stands some chance of being able to contribute to the knowledge base as the design and use of hands free speech driven data capturing device is still at its infancy (Kamneyanda et al.1997 & Wagner 2013).

The reference discipline is the part of the knowledge base that provides a new viewpoint to the problem that subsequently engenders the development of possibly a better way of doing things within the said domain. This study also includes Shannon (1948)'s Information Theory as one of the reference disciplines. These reference disciplines provide the foundational ideas for the "build phase" as well as provide somewhat clearer definitions of inter alia entropy and utility.

3.4.5 Develop/Build

For this study to count as being conducted using Design Science, it must satisfy rigor and relevance to this end by producing and evaluating a novel artefact (Hevner et al. 2004). While March and Smith (1995) argue that constructs, models and methods are valid artefacts, artefact as an instantiation will be the mantra for this study. With this in mind and supported by Hevner et al. (2004)'s guidelines as well as March and Smith (1995)'s admonishment, the develop/build phase involves:

- Going through a huge collection of knowledge (derived from sources such as IS research literature, foundation or reference disciplines etc.),
- Improving the understanding of the problem and the organization in their respective contextual environments.
- Assessing, synthesizing and analysing the acquired knowledge obtained from the respective domains.
- Developing a prototype embodying the contextual body of knowledge.

The next step is to subject the resulting artefact to the justify/evaluate phase.

3.4.6 Justify/Evaluate

The artefact will need to undergo through a stringent evaluation as well as justification to ensure that it satisfies two criteria namely: its usefulness to practitioners (practitioner relevance) as well as contributing to the Information Systems knowledge base. This evaluation is done as part of the proof-of-concept and not to consider its use in practice as an implementation.

Before I can justify/evaluate the artefact, it is essential to elucidate the assertions made about it. The artefact could be thought of as inter alia the following:

- that it is an improved way to value correctly data capturing within the intrapartum environment,
- that it may possibly be better in some way than existing approaches,
- that chances are high that it might be preferred by birth attendants over other approaches,
- that birth attendants may find it useful in certain circumstances,
- that academics from the related research area may find it as something of value.

These assertions has to be tackled and clearly stated during the develop/build phase vis-à-vis the existing approaches.

Although there is no way of stating the claims precisely before the develop/build phase, however, the research problem clearly indicates that the artefact must fulfil two goals:

- Internal validity.
- External validity.

For the artefact to be useful, Hill (2009) contends that its components such as scope, outputs, arguments and possibly calculations should be able to appeal to the intended users.

In other words, an artefact to aid birth attendants capture intrapartum data hands freely must allow the user to have some confidence in the outputs (such as correctly captured data, the mathematical logic that handles early warning triggers, reports etc.)and where they (such as triggers, numbers of reports etc.) came from. For the artefact to be considered as having been developed using rigorous processes and thus the likelihood of it contributing to the Information Systems research, both of the above stated goals must be met. I will now consider each of the evaluation methods prescribed by Hevner et al. (2004).

Table 3.3: *Possible evaluation methods in design science research, adapted from Hevner et al. (2004)*

Evaluation Method	Description	Discussion
Observational	Case Study: Study artefact in depth in business environment.	Simulation using birth attendants and nursing students will satisfy this condition
	Field Study: Monitor use of artefact in multiple health facility.	I argue that simulatory exercises carried out in multiple sittings by birth attendants and nursing students will give a fair observational understanding of the artefact
Analytical	To test for static qualities and examine the structure of artefact by using static analysis as an automated tool.	Not applicable as an external validity test.
	Architecture Analysis aims at constraining the architectural techniques to be used in the artefact development.	This method is also not appropriate for the development of this artefact
	Optimization: Determine integral ideal characteristics of the artefact.	Usage of test cases to demonstrate the behaviour of the artefact under certain conditions or when fed certain data types.
	Test for dynamic qualities such performance using dynamic Analysis.	Again, test artefact with sufficient test inputs to produce interesting behavior.

Experimental	Use controlled experimentto test for elements such as quality by observing the artefact(using a single independent variable such as inter alia usability).	This could be used to generate evidence to support or disprove the utility of the artefact and ultimately the result used further to improves the quality of the artefact.
	Simulation: Execute artefact with artificial data using either birth attendants and or nursing students	Using of simulation is a good candidate here as the issue of the privacy of mothers in labour will be mitigated while still providing useful information. The use of real world data will go a long way in vouching for external validity.
Testing	Using black box testing that examines the functionality of the artefactwithout peering into its internal structures.	Monitor the behaviour and output of the artefact as simulation takes place.
	Use structural or white box testing to measure the internal structures or workings of the artefact.	Feed in specific data such as extremely high fetal temperature into the artefact and trace its path, behavior and output.
Descriptive	Informed Argument: Use information from the knowledge base (e.g. relevant research) to build a convincing argument for the artefact's utility.	Derive a conclusion based on the analysis of the simulation(evaluation)

	Scenarios: Construct detailed scenarios around the artefact to demonstrate its utility.	Another promising avenue to pursue since a contrived scenario grounds specific context without relying on an indefensible generalization.

3.5 Overall Research Design

After going through the general Design Science approach vis-à-vis the needs of this research, the following sections will present the research design for this study. Preliminarily, the philosophical (reality and existence, modus operandi of acquiring knowledge and conducting research) stance taken will be presented. Further, it will be demonstrated how this research meets the expectation of Design Science by listing each of the five empirical phases of the research project and how these phases are subservient to Design Science. Finally, the proposed research design is discussed vis-à-vis the research guidelines advocated by Hevner et al. (2014) and Van der Walt (2012). This discussion argues that the research design for this project is well justified.

3.5.1 Philosophical Position

As part of the literature, this study considered "Critical Realism" as advocated by (Bhaskar 1975; Bhaskar 1979 & Bhaskar 1989) as its philosophical stand point. Authors such as Mingers (Mingers 2000; Mingers 2004a; Mingers 2004b), Dobson (2001), Smith (2006) and Carlsson (2003b, 2005a, 2005b), posit that this philosophical position bodes well with Design Science. Vaishnavi and Kuechler (2004) further posits that Design Science works best when its practitioners shift between pragmatic and critical realist perspectives, guided by a pragmatic assessment of progress in the design cycle. However, due to the limited scope of this study, a qualitative pragmatic philosophical position suits this study better.

The data capturing artefactcould be considered complex socio-technical phenomena as it falls within the realm of technology and society. On one hand, it is clearly a real object (composed of hardware components such as chip, plastic, metal etc.), whose characteristics are directed by laws of physics (such as the theory of electromagnetic proposed by Maxwell (1865) in his *'Dynamical Theory of the Electromagnetic Field*'). On the other hand, Hill (2009) contends that it has been designed to implement abstractions such as operating systems, databases, applications and work flows.

Because of the design-oriented objectives of this research, positivism (social positivism) is not an appropriate approach to take because its objective is hypothesis testing to discover causal relationships between dependent and independent variables. Kuechler and Vaishnavi (2008) posit that the objective of positivism is prediction, whereas design science is concerned with progress.

The knowledge generated by this research should be of a form that could be acceptable to the users within the intrapartum healthcare sector (MOU) as well as within the academic community. This means the data capturing application will require a quantitative component, at least to test acceptability by the birth attendants. Thus, philosophical paradigms that result only in qualitative models are not viable options for this study.

Layder (1993) states that the central feature of realism is the fact that it attempts to preserve a ‘scientific’ attitude towards social analysis at the same time as recognizing the importance of actors´ meanings and in some way incorporating them in research. As such, a key aspect of the realist project is a concern with causality and the identification of causal mechanisms in social phenomena in a manner quite unlike the traditional positivist search for causal generalizations.

The philosophical position of this project will now be presented.

3.5.1.1 Epistemology

This research project takes two epistemological positions; namely coherence during the build/develop phase and then pragmatic during the evaluation stage. This is common, as “*critical realists tend to opt for a pragmatic theory of truth even though some critical realists still think that their epistemology ought to be correspondence theory of truth. Other critical realists prefer to be more eclectic and argue for a three-stage epistemology using correspondence, coherence and pragmatic theory of truth.”* (Kaboub, 2001:1).

The pragmatic theory of truth is advocated during the justify / evaluate phase. It claims that what’s true is what works. At this juncture, this research is mainly inclined towards the significance and utility of knowledge. Pragmatism asks its usual question. "Grant an idea or beliefs to be true”. It says, “what concrete difference will its being true make in anyone's actual life? How will the truth be realised? What experiences will be different from those which would be obtained if the belief were false? What, in short, is the truth's cash-value in experiential terms?”. James (1907) contends that as soon as pragmatism poses such a question, it sees the answer instantly as true ideas being those that we can assimilate, validate, corroborate and verify while false ideas are those that we cannot.

Because of the goals of the evaluate/justify phase of Design Science, the emphasis is on utility and not truth. One of the objectives of this study is to contribute a validated and useful knowledge to the knowledge base. Thus, justified true beliefs are knowledge that will work.

3.5.1.2 Axiology

Carrying out research has an impact on all the stakeholders. With this in mind, the project is dedicated to showing and demonstrating and upholding ethical standards as demanded by the University regulations (Higher Degree Committee1.1,Higher Degree Committee1.1A and Higher Degree Committee1.2). This means the study must be ethical with how it deals research subjects and other stakeholders.

This research project shall seek to contribute to the knowledge base without consideration for its potential commercial value. Thus, the knowledge gathered shall be placed into public domain.

3.5.2 Build/Develop Framework

The outline of the phases involved in this research is listed. The reason for the existence of each phase is discussed. As well, the rationale for selecting a particular method over the others is established. The objective is to demonstrate coherence of the research design as well as it being subservient to Design Science of Hevner et al.(2004) and Hevner(2007).

3.5.2.1 Literature Review

Literature is reviewed with the objective of gathering, assessing and synthesising knowledge. For Design Science Research to be considered as having been carried out rigorously, it must be able to draw from the various knowledge bases such as the reference disciplines as well as from the accumulated knowledge within the Information System domain. Furthermore, the research project must be guided by the contemporary needs of the IS practitioners in order to be relevant. It is therefore imperative that literature from a broad array of sources be perused and analysed:

- Current data capturing research within the intrapartum environments, including related publications. The authors are typically academics writing for an audience of academics and "reflective practitioners". This constitutes an important source of knowledge around methodology (Design Science for IS), data capturing, hands free kits, voice recognition systems. This project will possibly be able to add to this knowledge base at its completion.
- Literature on Information Systems practitioner can be found in the following sources namely: white papers, practice-oriented journals, web sites, industry seminars etc. Authors in this milieu are usually senior practitioners and or consultants and most often are hired to write. Issues that concern them will be acquired from these sources. The people from this domain are some of the groups that will be interested in the outcome of this study, thus it is imperative to understand their needs.
- Authors from this reference disciplines are mostly academics and can be found in places such as textbooks. This also needs to be analysed. However, it is not all that important

to inquire intensely into this reference disciplines as with the IS research because it is has been distilled and codified and has literally become old news.

3.5.2.2 Interviews And Questionnaires

The second phase requires that a profound understanding of the business needs (the capturing of intrapartum data and definitions of intrapartum data)be developed. Here this project argues that this understanding could best be achieved through a series of semi-structured interviews with birth attendants, their managers and student nurses (due to their relative availability and propensity to co-operate) and eventually a questionnaire after the simulation to elicit quantitative data from them. This is because the business needs around intrapartum data can best be elicited from them and they are well placed in determining the utility of the prototype. They are also best placed to articulate the organizational data capturing modus operandi.

For this project, two alternative research strategies, namely: case study and survey, were considered. However, they were both eventually rejected because the research strategy most suitable for this study was indicated as DSR.

Case studies would not be unsuitable due to the few number of cases to which I would have access, combined with health privacy issues and legal sensitivities involved in a very detailed examination of private medical records. Case study as well, would limit the exposure to different stakeholders given the time, resource and access constraints. Case studies also are not typically associated with the design of an artefact.

Surveys were ruled out because it could not provide a deeper understanding of business needs required for this research. This research gives more weight to an unstructured interview as a data collection method since it can elicit greater detail than a simple form or even short written response. This weight is given to interviews because it allows the tailoring of questions to individual subjects. This individualisation draws out the experiences, knowledge and perspectives of the individual. Hill (2009) contends that this is something that cannot be done readily with survey instruments.

3.5.3 Justify/Evaluate Artefact

3.5.3.1 Simulation Study

For the artefact to be properly evaluated, it must be deployed and used to replicate the capturing process usually done by using the partogram. It is imperative to show that the artefact can actually be used and the results are intelligible.

Artificial data stands a better chance of producing these results. In this case, artificial or synthetic data (anonymized) refers to valid medical records from unknown persons. Background noises mimicking the birth environment shall also be factored in for a realistic simulation. These records should mimic real world scenario for evaluation purposes. The capturing of these data must then be attempted hands freely and speech driven by the participating birth attendants. The behaviour of the artefact can then be assessed and evaluated.

3.5.3.2 Evaluation By Argumentation

Finally, some criteria is defined and used to evaluate the research process including the artefact produced. It is not adequate to depend only on the statistical analysis (quantitative data from post evaluation questionnaire) of the simulation because the simulation alone will not be able to present a wider perspective of the performance of the artefact as well as the fact that it might not ensure the suitability of the artefact and thus ensure that the research is indeed “Design Science” and not just “Design”. It is important to note at this juncture that this stage depends largely on the selection of an appropriate array of guidelines. This research has borrowed heavily from and has elected to use the guidelines found in MIS Quarterly (Hevner et al. 2004). This is because it is heavily cited and seems to be an authority in this field. An initial discussion on how the proposed research design meets these guidelines follows next.

3.6 Assessment Of Research Design

Hevner et al. (2004) developed general guidelines for the assessment of Design Science. The guidelines and how the research design meets them are described and discussed in this section as demonstrated in table 3.4 below.

Table 3.4: *Guidelines for assessment of design science research adapted from Hevner et al. (2004)*

Guideline	Description	Discussion
Design as an Artefact	Design Science research must produce a viable artefact in the form of a construct, a model, a method, or an instantiation.	The artefact created during the development phase satisfy the benchmarks of an artefact, as it embodies an instantiation (in this case, a hands free voice driven application for the capturing of intrapartum data).
Problem Relevance	Providing solutions to relevant business problems using technology is the main objective of DSR	The amount of resources and time invested by companies and post graduate researchers in tackling the capturing of intrapartum data shows how highly they consider the problem as important and relevant. Also, the amount of intrapartum mishap occurring within the level one health facility makes this question (capturing of intrapartum data) amongst others a relevant one to ask.
Design Evaluation	Rigorous evaluation must take place to appropriate the utility of the artefact.	The artefact is evaluated by simulating the capturing of intrapartum data using real data and decision processes of unknown mothers and babies.
Research Contributions	The research should be able to contribute to the knowledge base. These contributions could be in the form of artefact, design foundations etc.	There exists a clear gap within the knowledge base vis-a-vis the hands free capturing of intrapartum data. This research proposes to resolve this problem by deploying the appropriate research method (Design Science).
Research Rigour	Rigorous methods are deployed in both the construction and evaluation of the design artefact as required by DSR.	Business needs from contextual interviews and the existing knowledge base guided the build/develop and evaluation phase
Design as Search	The search for an effective artefact requires utilising available means to reach desired ends while satisfying laws in the problem environment.	Here, the artefact is bounded by organisational norms, assumptions and cultures. As well, it also seeks to understand them and operate within them.
Communication of Research	Design Science research must be presented effectively both to technology-oriented as well as management-oriented audiences.	This finding will be communicated appropriately to the managers at the relevant health facilities.

3.7 Conclusion

The challenges faced by this research project is that of designing, developing and evaluating an artefact that could be considered as novel and the use of this instrument for the capturing of intrapartum data wirelessly, hands-freely and using human speech. Its novelty lies in the fact that it's never been tried before to capture intrapartum data hands-freely onto a digitized partogram. This research could be of value to practitioners because of its emphasis on the production of an artefact. As well, this research project finds Design Science to be suitable for its research design needs. The model of Design Science outlined by Hevner et al. (2004), Hevner (2007), Peffers et al. (2006) and Van der Walt (2012) is appropriate for the purposes of this research and so their terminology, guidelines as well as their assessment criteria is largely adopted here.

Literature from relevant academic and practitioner knowledge sources is deployed during the build / develop phase, a succession of semi-structured interviews with relevant health practitioners in target health facilities as well as observation of birth attendant's simulation of the capturing process of intrapartum data. The artefact itself is a product of a conceptual study steeped in intrapartum healthcare business needs.

A simulation study of the data capturing processes is carried out during the justification/evaluation phase using artificial or synthetic data. Thereafter, the artefact and simulation results are evaluated.

Without appearing to repeat myself but rather hoping to reiterate, this study uses a combined DSR framework coined by Van der Walt (2012) as depicted in figure 3.3 below. Van der Walt (2012) carried out what seems to be a comparative study among the existing DSR frameworks (Hevner et al. 2004; Hevner 2007; Iivari 2007; Hasan 2004 etc.) and realized that they were fundamentally similar except for some minor but relevant differences. This combined DSR framework succinctly satisfies the prerequisites for DS as a research methodology and suits the objective of this study.

This combined framework has five distinct phases that sequentially follow each other. However, the third phase is what Hevner (2007) calls the design cycle which in its own has three cyclic sub phases.

The following framework was created and used for this research:

1. Problem identification, understanding and motivation.
2. Identifying the objectives/focus of the research and solution.
3. Concept design.

4. DSR artefact design
5. Artefact evaluation
6. Research
7. Communication.

The above framework used in this research is a combination of the previous discussed DSR approaches sourced in the academic literature. Some of the phases of the various sourced approaches to DSR were similar and thus combined.

Figure 3.3 Adapted from Hevner (2007) and Van der Walt (2012)

Graphical representation of the research methodology.

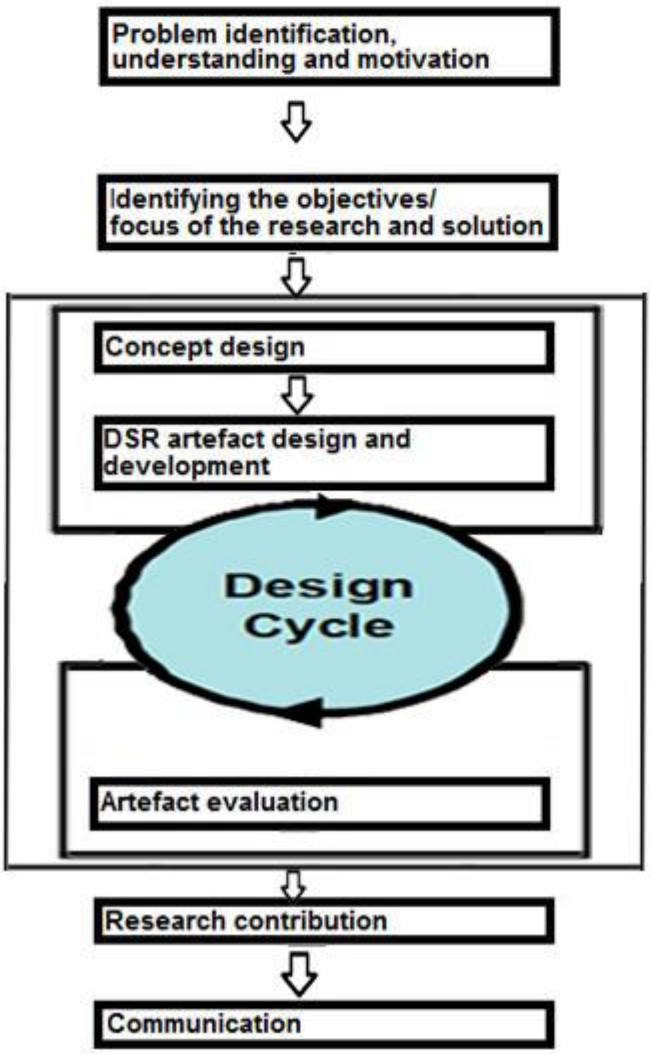


Figure 3.4: *Research methodology*

Figure 3.4 above graphically represents the research methodology used in this research. This figure is used throughout the remaining chapter to demonstrate where the content of the chapter falls in relation to the methodology, as certain chapters may contain information relevant to one or more steps.

In the graph a potential loop or iteration is shown (denoted by the square with arrows). These steps follow on each other and a high-level conceptualisation is created for the solution. These high level conceptualisations are then used to create more concrete designs which, are developed in the forms of artefacts and finally these artefacts are evaluated. This iteration can be done for the development of each artefact in the research but in the case of this research the development effort follows an agile-scrum approach consisting of a number of iterations in which iteration is focused on the development of a set of related functionality.

CHAPTER FOUR

CONCEPTUALIZATION

In the previous chapter the research problem was detailed and the objectives were given as part of the research methodology discussion. In this chapter the ethnographic understanding noted above is discussed as part of refining the research problem. The research objectives are discussed in the following chapter in order to align the chapter structure with the methodology used for this study.

4.1 Introduction

Further, this chapter touches on the first phases in the DSR methodology utilised in this research shown in Figure 4.1 below. These phases are: problem identification, understanding and motivation.

The identification and conceptualisation of the research problem relies heavily on literature review where evaluation and syntheis of key concepts takes place as well, the identification and conceptualisation also rely on the contextual interviews carried out at the MOU's where the requirements are understood.

4.2 Model / Artefact Development

This research is highly contextual and in order to obtain sufficient insight into the problem, data was collected with an extensive unstructured interview with a senior midwife, few visits to the facility, unstructured interview with student nurses from CPUT and a literature review to sufficiently understand the problem. These contextual interviews combined with the literature review depict an ethnographic understanding of the problem domain. Due to lack of enough time and the sensitive nature of the intrapartum environment, it was not possible to embed the researcher within the environment for observations that form part of a proper ethnographic study. In this research project, the word ethnography is used loosely to represent the contextual interviews and observation of simulation of intrapartum activities by birth attendants. The ethnographic understanding relating to this study is discussed next.

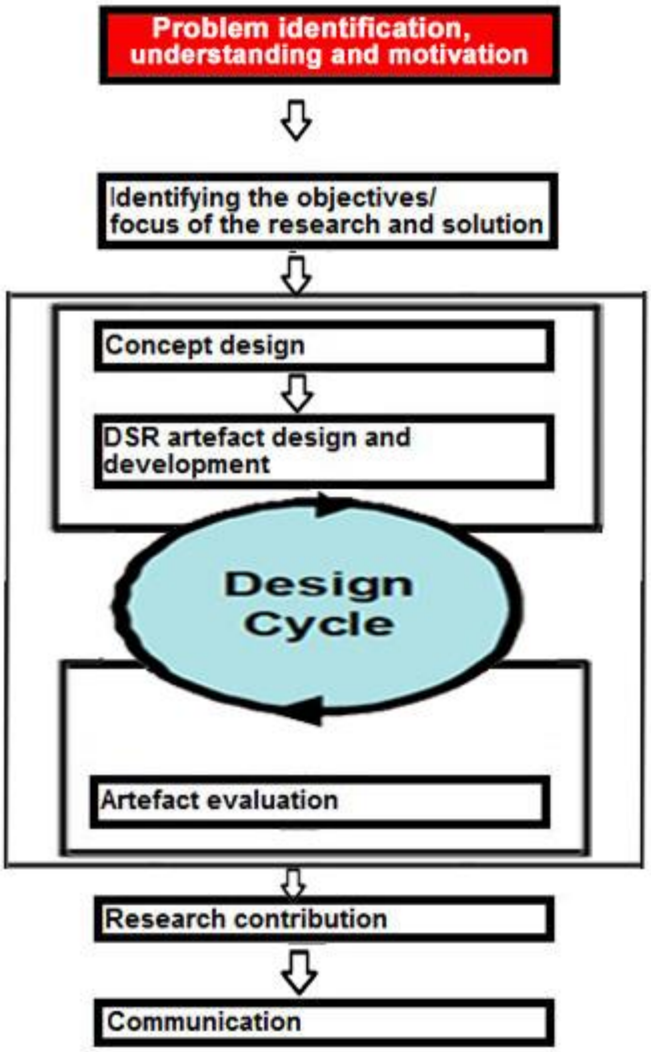


Figure 4.1: *Content of the Conceptualisation Chapter in relation to the research methodology*

4.3 Intrapartum Healthcare Contexts

The first section considers a general conceptualisation of the intrapartum healthcare context. The second section looks specifically at the Elsies River MOU and Vanguard community health (labour ward) Centre in the Cape Metropole of the Western Cape Province.

4.3.1 General Intrapartum Healthcare Context

This research looks at the design and use of a hands-free data capturing mechanism. Essentially the development and quest for the solution feeds into the research, providing the research data. The "research" and "development" attempt to address different but related problems and both are within the same context, that of a level one MOU within the Cape Metropole.

This section specifically considers the intrapartum healthcare context, in order to better understand the research area. The insights provided by the ethnographic understanding of the identified intrapartum domain from the various unstructured interviews, serve to guide the solution/development process, provides the problem, the objectives and requirements whilst this context also provides a lens for identifying and placing the research findings to a specific context. The general intrapartum healthcare context provided a good initial starting point for the research and the initial solution design / conceptualisation.

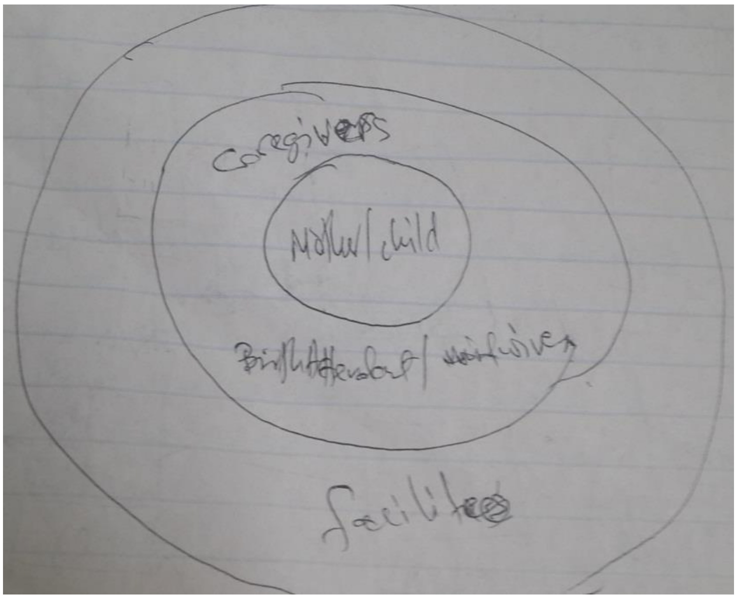


Figure 4.2: *Initial onion model of the intrapartum healthcare context as captured during contextual interviews*

From the initial ethnographic understanding developed from the contextual interviews and literature review, a simple onion model conceptualisation, above, of the interrelating layers involved in delivering intrapartum healthcare to mother and child was created. The onion diagram provides a general overview of the different levels involved in the provisioning of intrapartum healthcare within my unit of analysis. After reading related literature, and further interviews with midwives (this time, mostly at Elsies MOU) on the state and architecture of the obstetrics units within the Cape Metropole, another layer was added to the preliminary onion model depicted in figure 4.2. As depicted in figure 4.3 below, that far outer limit represented the sphere of the government. . Although this layer is out of the scope of this study, it is briefly described below to contextualise the proposed solution. Government in this case refers to the local government. Although regulations from the national government cascades down to the provinces and various regions, It is important to note that it might be implemented contextually and perhaps different in each locality. For the purpose of this study, the government in this case specifically refers to the local government of the Cape Metropole.

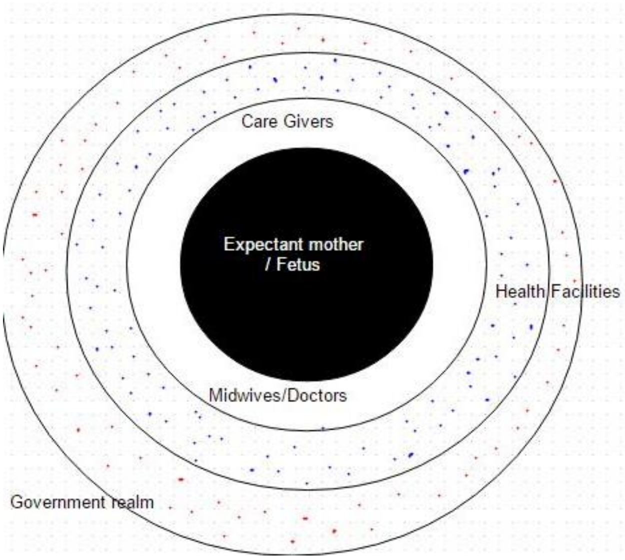


Figure 4.3: *Updated onion model of the intrapartum healthcare context including the government layer*

The onion diagram was useful to represent the different layers involved in the delivery of intrapartum care to mother and child because it provides for the conceptualisation of these levels. The mother/child are fundamental at the core of intrapartum healthcare and are where the need for intrapartum healthcare services arises. The intrapartum caregivers such as midwives are the primary care givers to woman during the intrapartum period; the various health facilities ranging from level one through to level three MOU provide different levels and types of care to the mother and child; while governmental bodies provide the rules, support, regulations etc. to the various facilities.

The expectant mother and foetus are said to be in the intrapartum period and thus require intrapartum care when the mother is in labour and subsequently few hours after labour. Although there is no exact science about what constitutes the beginning of labour, a general consensus exists that seems to agree that the signs of labour amongst others might include lightening, passing of the mucus plug, contractions, water breaking, effacement and dilation of the cervix. The health situation of the expectant mother and or foetus will be determined by the midwives in the MOU who will provide care to them. Cases of labour or birth involving risky situations are referred to an increasing higher level of care (from level 1 to 2 and finally to level 3 facilities).

A number of data or information is collected from and about the mother. In most cases, the mother’s information is available and already on the partogram. This will be for the mother who has had some form of prenatal check-up. Prenatal check-up usually involves amongst others physical examinations, collection of (mother's) medical history, checking her blood pressure, height and weight, pelvic exam, as well as blood and urine tests. Examinations are also performed on the child via the use of ultrasound to collect valuable data. This data might include the development of foetal body parts such as (e.g., heart, brain, liver, stomach, skull, other bones), nature of amniotic fluid, umbilical cord (for possible problems) and information about due date (based on measurements and relative developmental progress).

The caregivers within the intrapartum environment are generally midwives. Within the MOU, the majority of caregivers are birth attendants with varying degrees of experience. In this research project, there arose an understanding that the difference between a midwife and a general intrapartum caregiver relied on their qualification and experience. In a low resource environment as the one being investigated, student midwives or training midwives could be referred to as birth attendants not yet skilled. It is important to note at this point that all of the intrapartum data collected from and about the mother/child are for the most part captured manually onto the partogram by the birth attendant/midwife. The capturing of the intrapartum data discussed in the previous paragraph is done simultaneously while providing care to the mother and child. In an environment where resources are limited such as the MOU of this study, this capturing of data and provision of care proves to be a dilemma. This dilemma often results in the partogram not being properly completed (incomplete data, incorrect, inconsistent data) as well as sub optimal care being provided to the mother/child.

The intrapartum healthcare facilities as already noted range from level one to level three MOU. The level one MOU is for mothers with normal labour (low risk) with no history of difficulty giving birth. These MOU's are decentralized around the Cape Metropole to ensure maternal care is accessible. It is within these environments that there are scarcity of resources and a high ratio of experienced caregiver to mother care. There are 11 MOU's within the Cape Town metropole health district (MDHS) which include amongst others: Elsies River, Vanguard community health centre (labour ward), Michael Mapongwana (Khayelitsha), etc. The expectant mother and child are usually referred to a level two or level three hospital if the need for a higher level of care arises. Karl Bremer hospital is a level two hospital and provides a full range of high-level maternity services, spanning the three main stages of childbirth – Antenatal care; labour and delivery and postnatal care. This hospital boasts an array of experienced and highly trained teams of midwives and obstetricians and state-of–the-art facilities. Referral to this hospital is usually from Mitchell's Plain, Guguletu and Khayelitsha. Patients (expectant mother and or child) are ultimately referred to a level three facility such as Groote Schuur maternity centre. Patients referred to a level three facility are usually those with the highest risk pregnancies/deliveries. These risks amongst other might include heart-condition, asthma, diabetes, depression, high blood pressure, obesity, thyroid disease, or epilepsy etc. Although Karl Bremer also has a fully equipped operating theatre and very sophisticated neonatal ICU, it sometimes refers high risk women to Tygerberg Hospital which is a level three hospital Figure 4.4 below depicts intrapartum healthcare stakeholders.

When cases are referred to a higher level of care with the use of an ambulance, the partogram is often just bundled along with the expectant mother/child in its current state. While at the higher-level hospital on referral, the partogram is the only source of information about mother/child and if it is not a true reflection, then the health of the mother and child might be at risk. It is thus a tripartite data conundrum: data collection, data capturing and finally data transmission on cases involving referrals.

4.3.2 Specific Home-Based Healthcare Context

In order to improve the conceptualisation of the intrapartum healthcare context, the onion model above was replaced by a landscape model that was specific to my unit of analysis (Elsies River MOU) as shown in figure 4.4. Figure 4.4 was the initial understanding and was not entirely accurate. Referral from one MOU to another can only occur to MOU's within the region. An example would be a referral from Elsies MOU (Level 1) to Karl Bremmer (Level 2)and finally to Tygerberg Hospital (Level 3)in that same order. Further updates to the landscape model can be found on figure 4.5.

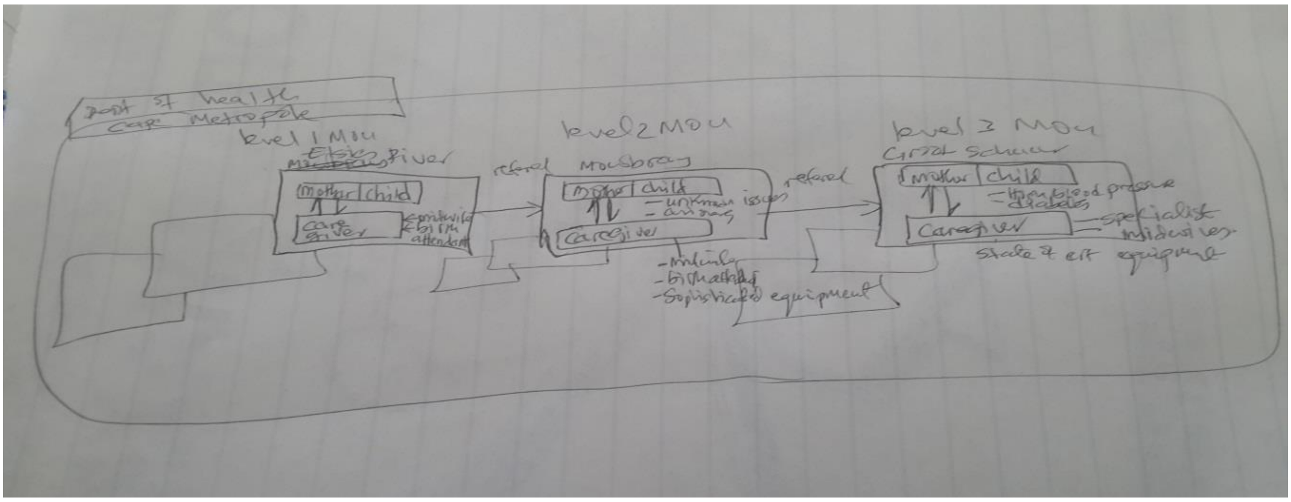


Figure 4.4: *An initial depiction of intrapartum care, care-givers and care facilities*

The reasons for replacing the onion model with the landscape model are: the landscape model provides a finer detail on the relationship between the different layers (mother/child, caregivers, MOU's); the landscape model also provides a deeper level of understanding of the data flows between the different layers; the different stakeholders and participants can be named.

Figure 4.4 shows the landscape model of the various levels of care. The primary focus is on the mother / child and the care they receive from the various care-givers. In cases where referral is needed, interaction between the various levels of care does take place. There are quite a number of private hospitals with maternity wards. However, it is important to note that this study is only concerned with public MOU's.

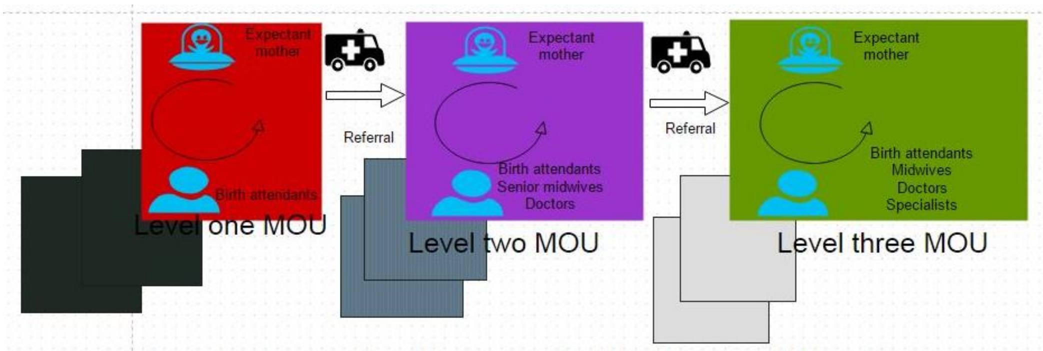


Figure 4.5: *An updated depiction of intrapartum care, care-givers and care facilities*

Figure 4.5 depicts an updated version of the landscape model. The colour coding does not mean anything specifically other than for clarity. It succinctly depicts the various MOU's and referral from one to another by means of the white arrow and the ambulance vehicle. It shows that the interaction within each MOU between care-givers and expectant mothers is cyclic. It is cyclic in the sense that the care giver measures / elicits information from the expectant mother and or child understanding that this elicitation and or measurement (e.g. temperatures, heart rate) will most often prompt a response and or question from the expectant mother. Referral is for high risk women moving from lower level MOU to a higher one. Also, the referral is from a situation of low care to that of higher care.

In DSR various artefacts are designed and developed as part of the research, but these previously mentioned unknowns (parameters or process flows) all play an important role in defining the characteristics of the DSR artefacts. However, because these are both unknown and very important it is necessary that they be known to assure the creation of successful artefacts (and thus successful research).

The Elsies River MOU and Gugulethu MOU are the ones under considerations. Few more visits to these facilities added a lot more understanding. There were simply not enough birth attendants to provide the needed quantity and quality of care that the mother and child require.

As already noted, the partogram contains detailed information about the progress of labour for mother and baby. This partogram is used by a number of different parties for different purposes including: department of health inspectors to ensure that care is being delivered, doctors, birth attendants etc. The referral process most often involves the calling of an ambulance and transferring of the patient alongside the partogram to a higher MOU for further care.

4.3.3 Intrapartum care Commonalities and Differences

Both MOU facilities discussed in the previous section have a number of commonalities (shown in table 4.1), since both deliver intrapartum health care to under-resourced environments around the Cap Metropole. These communities, however, also have a number of differences.

Table 4.1: *Differences and similarities between two MOU's*

MOU	Description	IT penetration	Commonalities	Differences
Gugulethu MOU	Provide intrapartum care at level one care/primary level of care.	A low penetration of IT-based solutions and corresponding prevalence of paper-based systems	Both suffer from a lack of resources including human, funding and infrastructure to provide quality of care.	The facility had fewer health workers and I witnessed only one computer system and a single telephone line.
Elsies River MOU	Provide intrapartum care at level one care/primary level of care.	Also low penetration of IT. Use of paper rampant.		This facility had more experienced care-givers. I was very impressed to witness a hired independent contractor on duty.

4.4 Current Systems

This section considers the current systems that are used within the MOU. The first section considers the paper-based systems that are predominately used. The issues with the current paper-based system are detailed in the following section. In light of these issues the importance of addressing the identified problems is shown.

4.4.1 Paper Systems

The paper-based system known as a partogram is used to capture and manage intrapartum data within Elsies River MOU and Gugulethu MOU. The paper-based system plays a key part in any attempt to understand how data is captured within these environments. Because of the low penetration of IT based solution within these level one MOU's, these paper systems are the primary means of data collection, storage, processing and transmitting.

The paper-based systems can thus give a good indication of which data is collected, how the data is structured, how it is collected and what meaning is assigned to data. The paper system forms an important communication tool between the various caregivers and other higher level MOU's in cases where referral is necessary. It also acts as a recording of observations and patient measurements for the institution.

There is little evidence of implemented and utilised IT-based solutions in terms of data management and acquisition within the MOU's. IT-based systems that were used were spread-sheet based and used as a storage means or for generating reporting statistics and had nothing to do with intrapartum data capturing.

The low resource nature of level one intrapartum health care engenders a situation whereby care givers have to simultaneously provide care while collecting vital data. This scenario throws in two things: poor data capturing and potentially poor quality of care given to mother and child. Often, data is illegible, incorrectly captured, incomplete due to these multitasking activities etc.

The partogram is also subjected to the wear and tear of constant use. This therefore means that it could get damaged, could easily get lost or stolen – this is an important ethical issue since confidential patient information can fall into the wrong hands.

4.4.2 Identified Problems

Part of the DSR methodology used in this research involves the identification, clarification and motivation of the research problem. This section attempts to identify the problems faced when capturing data within the intrapartum environment and will later motivate the need for the research and solution. Ideally the problem identification would also involve a component of literature review, although the literature relating to intrapartum data capturing and its challenges were already touched on in the previous chapters (Chapters 2 and Chapter 3).

A number of problems and issues were identified from my visits, contextual interviews and literature review which prevented the effective and efficient capturing of intrapartum data as well as providing optimum care to mother and baby.

Some of the problems which are experienced within the MOU in as much as data capturing is concerned are: high ratio of expectant mother to care-giver introduces error in capturing; the nature of immediate intrapartum environment is somewhat bloody and inhibits data capturing. With bloodied hands and incapable of recording vital data, the birth attendants resort to keeping vital mother/baby data in memory with the aim of channelling it later on to the partogram. This approach of delayed data capturing has been discredited and is prone to inconsistencies: issues with collecting and using quality, reliable information; low penetration and usage of IT-based solutions; lack of sufficient infrastructure to support care activities or IT based solution; and a lack of enough trained intrapartum professionals.

Two related problems are addressed during the research, the solution problem is addressed using design and development based research which creates the research data in order to address the research problem.

The following section motivates the above-mentioned problems and the need for the research.

4.5 Problem Relevance and Motivation

When following a DSR approach in conducting research it is necessary that the problem be identified and qualified so that it can be addressed using a design-based approach. The reason for motivating the usage of DSR approach is that it provides additional validity to the research and the research findings.

The development component of the research considers developing a simple tool for trying to capture (hands-freely with the help of Windows speech engine) and understand this intrapartum data. The literature and interview noted issues around efficient data capturing while providing care to mother and child. My visits and contextual interviews at the MOU's supported the literature findings by showing that even though data is being captured with pen and paper (partogram), the process was taking away the time they could have used differently especially during peak hours.

4.6 Research Problem Revisited

This section will consider the problem being addressed by the research and the underlying development effort.

This research follows a DSR methodology which as discussed in Chapter 3, involves the creation of research artefact with the intent that this artefact can act as both a means for solving a given practical problem, but also can serve as a tool for conducting the research.

The development effort, which produced the research artefacts, involved the creation of a hands free data capturing mechanism to be used within the intrapartum environment. The development was undertaken as part of a project conducted at CPUT in Cape Town in the Western Cape of South Africa. The project's overall focus was to consider how ICT could be used to address the data capturing issues within a level one MOU within the less affluent communities in the Cape Metro. By watching academic YouTube videos as well as nursing students and midwives performing a simulation of intrapartum care, the dilemma became apparent. There is therefore a need for an encumbered data capturing tool that will free the hands and eyes of the birth attendant but also allow them to capture the vital data none the less. There is a need for more ICT solutions within the level one MOU intrapartum environment to ameliorate the situation, although the current lack of resources remains a problem.

A number of reasons existed for the low IT penetration as detailed in the literature review: an overall lack of funds; a misconception of the advantages and uses of IT; low literacy rates and thus a fear of IT solutions amongst caregivers and limited infrastructure. These reasons need to be considered when designing the IT solution to aim for a more useful solution in the intrapartum environment.

A large strain is placed on the level one intrapartum facilities (MOU's) and subsequently the birth attendants. The high ratio of birth attendants/ expectant mother and the need to collect and preserve birth information thus necessitates that an IT-based solution should be considered with the hope that it will ameliorate the status quo.

IS and IT artefacts and instantiations however do not function in a vacuum, the performance of an IT-based solution is related to the environment that it operates in. This is because the environment surrounding the solution defines how the solution will be used, by whom the solution will be used, where the solution will be used and the constraints under which the solution must function (Van der Watt, 2012). Thus a clear understanding of the environment and the context of the intended solution is important for successful development of intended artefacts (March & Smith 1995).

The context thus also provides the problem domain, or the opportunity domain depending on one's perspective, which gave rise to the need or desire to develop a solution in the first place. Furthermore beyond identifying the problem and the problem domain, looking at the context provides some of the underlying justification and motivation for creating the solution.

Conceptualising the context not only provides important clarification around the solution artefact produced by the development, but also provides important clarification for the intended research. As the research considers design considerations first, understanding the context in which a solution must function also helps to inform a researcher or developer about the issues and considerations that need to be taken into account such as the constraints or liberties.

CHAPTER FIVE

CONCEPTUALIZATION OF THE PROBLEM AND POSSIBLE SOLUTIONS (OBJECTIVES)

This chapter represents the second phase in the chosen research methodology and takes a closer look at the objectives of the research and the solutions. This chapter logically follows on from the previous chapter which looked at the identification and conceptualisation of the research problem relying primarily on literature review and contextual interviews carried out at the MOU's.

5.1 Introduction

Identifying the objectives of the solution artefactforms an important part of the overall design and development process involved in creating any particular type of solution (Van der Watt, 2012). As detailed in Chapter 3 the fundamental research tool used to examine some aspect of the research area/problem within the DSR is the creation of artefacts. These DSR artefacts may have two purposes, namely: that they could be a research tool only and secondly that they could be part of the design and development of software intended to be used apart from the research. The objectives of this study is determined by the problem domain as the domain acts as a storehouse of the issues that need addressing. As already demonstrated in the previous chapters, research is a knowledge generating process or an attempt at understanding the problem domain in a different dimension. In contrast, the development of a solution is a process that produces tools intended to achieve a number of possible usages beyond creating knowledge and insight (Hevner, 2007). In DSR, the objective of the artefacts could be twofold, that of guiding the research undertaking, as well as guiding the development process of the solution. This research will pull these two objectives together as much as possible to simplify the overall research and the research process .

The first section within this chapter considers the objectives of the designed and developed solution; the second section focuses on the research objectives and attempts to unify these with the development objectives. The final section of this chapter discusses these two sets of objectives and the justification for the research.

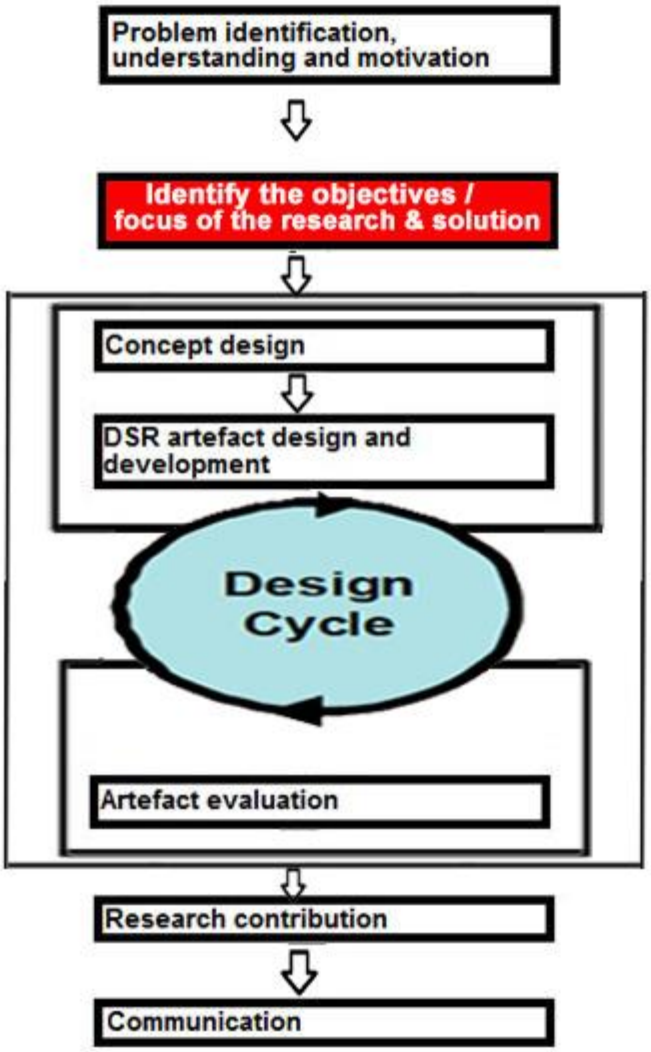


Figure 5.1: *Focus of chapter 5 in relation to the methodology*

5.2 Objectives of the design and development

This section will look at the objectives of the solution artefacts in order to provide a better understanding of the underlying design and development process which was used to generate the research artefacts which in turn were used to identify the research findings and contributions.

To meet the objectives, it is necessary to define in detail the required functionality, the overall characteristics of the solution and to take into consideration the limitations and advantages of the intended context of use in which the solution must function. Specifying the objectives thus provides focus and guides additional analysis, design and development efforts which are undertaken in order to achieve the specified objectives.

These objectives were created by combining the findings of the literature review and the ethnographic understanding derived from the contextual interviewing and observing a simulation of intrapartum duties by student nurses, as detailed in the previous chapter.

The design and development objectives for the underlying design and development originated in the identified problems specifically: the lack of an unfetted intrapartum data capturing mechanism within the MOU level one (and between different levels in cases of referrals); high ratio of patient to health care provider, quality of data captured, risk of losing the partogram.

The specific objectives of the solution artefactare:

- To be used as a data capturing tool. Ideally this objective would be achieved by digitizing the partogram thus allowing the birth attendants to capture intrapartum data directly onto a computerized system.
- To be able to capture data wirelesly and hands freely. This will mean doing away with the pen/paper and thus freeing the birth attendant's hands.
- The solution should be able to allow speech recognition so that birth attendants can use speech to drive the data capturing.
- Human-computer interaction does not form a major part of this research, thus only birth attendants/student nurses with enough technical competencies will be involved in the evaluation of the solution during the evaluation phase.

These higher-level objectives provide clear requirements and guidance for the design and development. However, some refinement might take place durring the iterative development processes.The following section considers the objectives of the research and attempts to align the research and development objectives.

5.3 Objectives of the Research

The objective of the research has previously been discussed in Chapter 3 Section 3.4. This section attempts to join the development and research objectives.

The development objectives are technologically focused, with the primary purposing relating to what the system is intended to accomplish, or what a person using the system is intended to be able to accomplish. The research objectives however are more focused toward understanding and explaining, and thus aim to guide how this understanding and explanation can come about. According to Benbasat & Zmud (1999), the research objectives within the DSR in a nutshell, are ultimately to provide academic and practitioner legitimacy to answering the research questions and according to Hevner (2007), by injecting rigour and relevance along the lengh of the study.

So where the development objectives attempt to guide the creation of the solution artefact, the research objectives attempt to understand what is required to create the solution artefact as well as why the IT artefact could solve the problem. By gaining this fundamental understanding of the "what" and "why" allows for a prescriptive knowledge to be developed. A further objective of the research is thus to provide some framework or guidelines by which further developments of similar solution artefacts (or artefacts in a similar context) can be undertaken with a potentially higher level of success (Hill, 2009; Ven der Watt, 2012).

The following section considers and discusses briefly the two separate sets of objectives at play during the research.

5.4 Separate solution and Research objectives

At the start of the research only a single set of objectives was in place. As the research got underway it became clear that the research objectives which looked at the design consideration were not sufficient on their own and that there existed clear objectives for the design and development (the 'carpentry') component of the research which played an important role in the research as well which is the development of an actual IT artefact.

To prove research rigour and relevance within the software solution and not having to take it to the field for testing for a considerable amount of time, evaluation by birth attendants and student nurses was the next best thing to do. The aim of this research study was to create a proof-of-concept of the IT artefact design and not a fully functional solution. Also, a huge focus was also laid on a subset of the overall development, specifically looking at the design considerations. Although the solution's objectives were the same as that of the research, having two sets of objectives did thus prove useful in preventing researcher's bias and ultimately ensuring the validity of the overall research as demonstrated in figure 5.2 below.

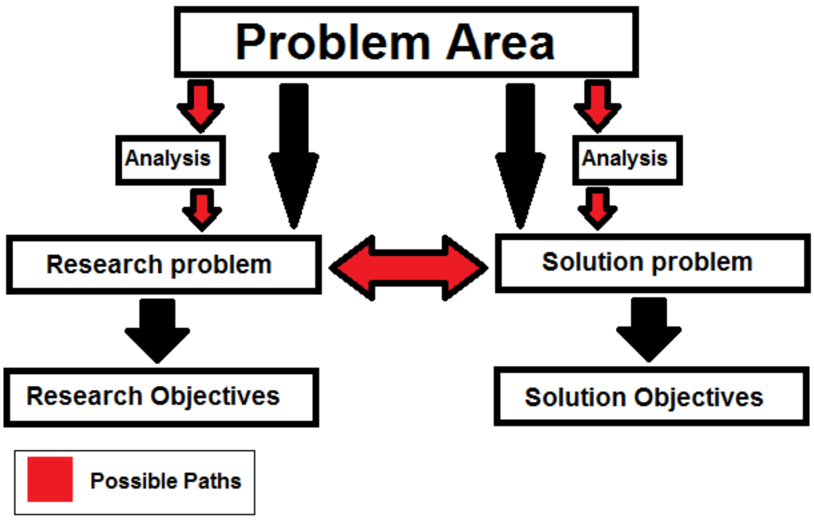


Figure 5.2: *Conceptualisation of the process from problem to objective (Van der Watt, 2012)*

Figure 5.2 shows that both objectives originate from the problem area (context) via the research problem. Although it is possible for the problem to come directly out of the problem area, for this researcha certain amount of initial exploratory research was conducted before identifying the problem within the problem area.

The Research problem may result in a solution problem and vice versa. For example if a software project is underway then research can spring from a given area of the software project and the opposite is also true, a given research undertaking can give rise to the creation of a software solution. Irrespective of the source of the derived problem, the link between the problem area must be maintained at all times.

This chapter looked at the objectives of the solution artefact and sparingly touched on the topic of the research objectives since these have already been discussed in a previous chapter. The research objectives being of high importance to the research was dealt with in great detail. Conversely, the solution objectives were also looked at, but this time only to ensure the validity of the overall research.

CHAPTER SIX

DESIGN AND DEVELOPMENT

This chapter focuses on the concept design as well as the solution design and development phases of the chosen DSR methodology, specifically the third and fourth step in the chosen research methodology defined in Chapter 3. Within this chapter an overview of the design and development phases are provided as well as several of the design diagrams. Effort is also made to detail some of the design and development choices made as well as the factors that gave rise to these choices and thus the underlying logic behind the given chosen choices.

6.1 Introduction

DSR is based around the concepts of “build” and “evaluate” and rapid iteration between the two phases through the research process (Kuechler & Vaishnavi, 2008). Normally, during the DSR process, a number of research artefacts are created which act as tools for examining a given research problem. The artefacts are evaluated in order to generate the research data and findings thus providing some insight into a given research problem. Chapter 3 provided a more detailed discussion on the topic of design-based research.

The first section of this chapter focuses on the design of the solution concepts, providing the reasoning for the chosen design choices. The second section considers the design and creation of the solution architecture, the solution functionality and the creation of the data structures. These are indicated on the diagram of the chosen methodology in Figure 6.1.

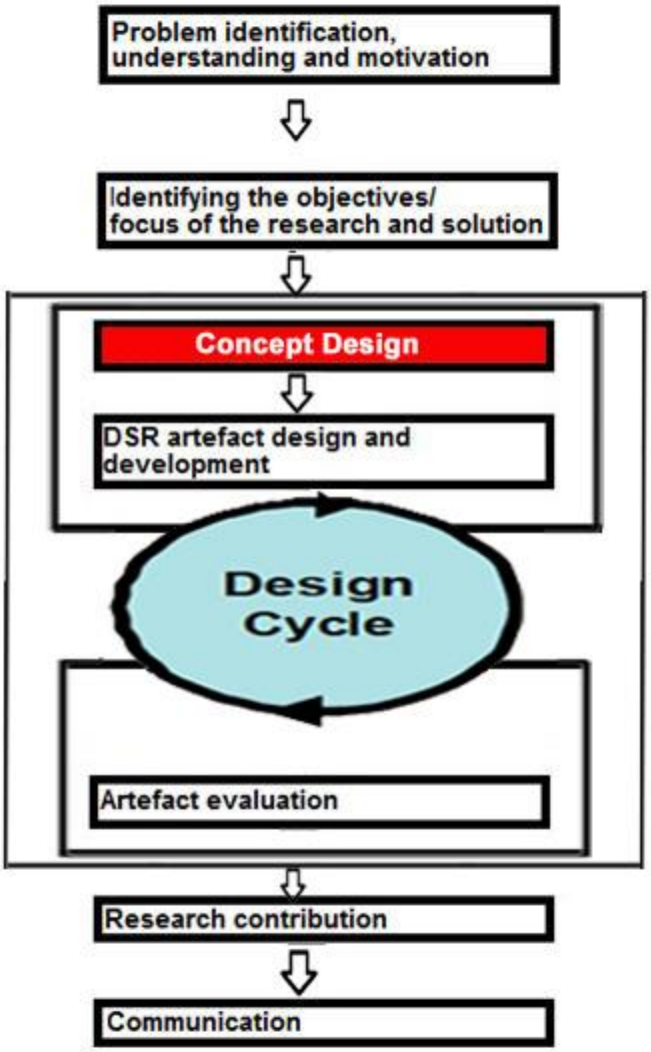


Figure 6.1: *Focus of Chapter 6 in relation to the methodology*

6.2 Concept Design

The first subsection considers the creation of the overall solution concept and details the process undertaken to decide on using a hands-free, wireless voice driven application to attempt to solve the identified problem. The notion of driving the capturing process by the use of a foot driven mechanism was thought of. However, the practicality of it proved too cumbersome to implement and use and was thus dropped entirely. The second subsection continues and considers the internal workings of the intended solution.

6.2.1 General Solution Concept

In Chapter 4, the problem area was analysed and the solution and research problem were identified. The identified solution problem was based on literature review, contextual interviews with experienced birth attendants as well as on observation of student nurses simulating the intrapartum activities. As already demonstrated in the previous chapters, the scarcity of resources, often forced these birth attendants within the level one MOU to multi task which often resulted in untoward results.

Initially the research looked at the current data capturing modus operandi within the level one MOU and its impact on the quality of care but mostly at the possibility of capturing intrapartum data in a manner that does not involve the use of the birth attendant's hands and eyes. This approach at capturing intrapartum data will possibly allow the birth attendant more control over the immediate environment and hopefully translate into improved quality of care.

Most of the assumptions gathered from literature reviews were completely shattered during the course of the research and visits to facilities. It became apparent that the problem with the domain was not a mere case of capturing data. The problem was also that of transferring information from one MOU to another in cases of referrals. Emergency referrals posed the greatest challenge to data capturing and dissemination to a referred MOU (always higher level MOU's) because in critical situations, the capturing of necessary information becomes secondary. For example, when the birth attendant is struggling to stabilize an expectant mother, there is no time to capture information about the interaction and when the ambulance arrives, the mother is rushed off to the referred MOU with the partogram as is (in its current state).

Because of the above realisations the solution concept took on an added dimension from the creation of a tool to enable hands-free and voice driven data capturing to that of also possibly allowing for the sharing of this information with participating higher level MOU's if the need arose. The hope was that any proposed solution would be of high relevance to the problem domain.

It was conceived that an IT-based system could be created which would replace the current paper-based systems and would thus, if scoped, designed and developed correctly, would allow for hands-free and voice driven data capturing of intrapartum data. The partogram will be converted into an 'ePartogram' by digitizing the paper forms, literally copying the structure and field of the paper forms and putting them into a software system. The ePartogram will allow the possibility of linking up the lower MOU's with a higher level MOU and thus will ameliorate the referral process and data sharing between the participating and relevant MOU's. The ePartogram will also act as a monitoring tool or an early warning system by alerting birth attendants and participating higher level MOU's of any deviation from the normal. Within the level one MOU, the ePartogram will seat on a voice engine (Windows speech engine) that will allow speech recognition.

Although the movement of data and especial health information over the network poses a risk, steps such the use of usernames, MD5 hashed passwords, penetration prevention, etc. were taken to mitigate such encumbrances. If the tool was used successfully it would be an effective starting point for not only getting a ground level understanding of the situation within the level one MOU environment, but also a good starting point for future attempts to fix these issues which surround data capturing and sharing with the participating MOU's.

The following section considers the internal solution concepts.

6.2.2 Solution Internal Concepts

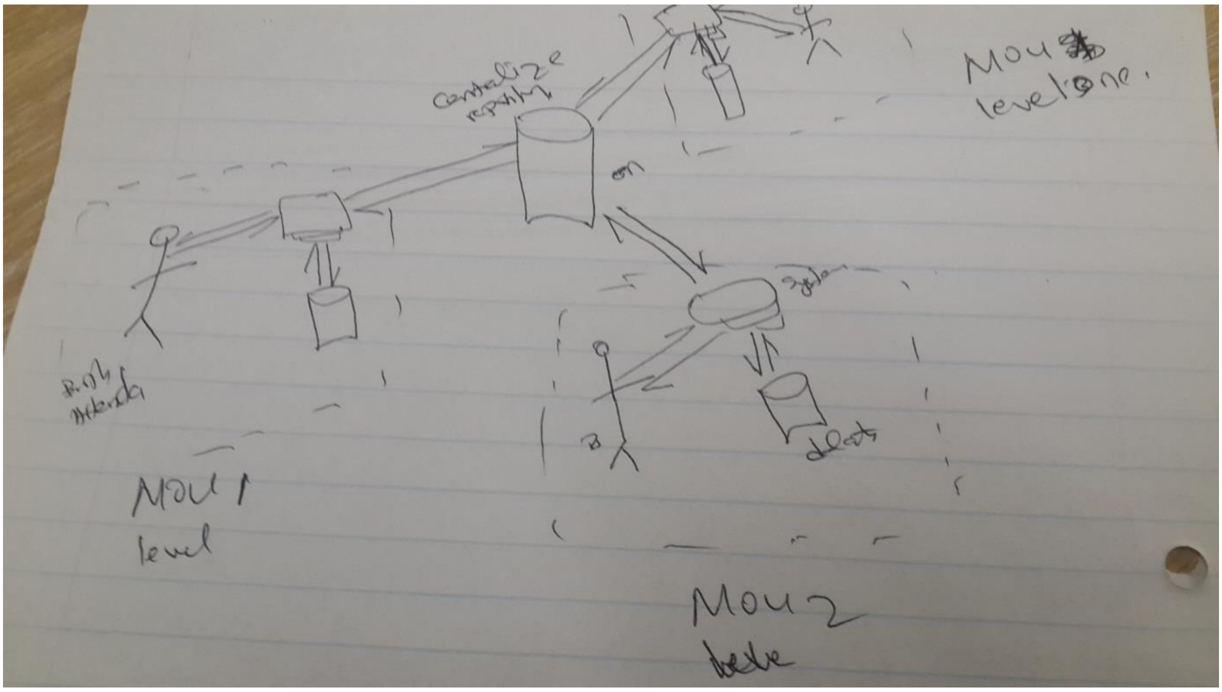


Figure 6.2: *Initial conceptualization of a system that allows data sharing between MOU's*

Figure 6.2, above shows the possible interconnected nature of the various levels of MOU around the Cape Metro.

6.3 Architecture construction, solution design and development

This section considers the actualisation of the above identified solution conceptualisations. This section discusses the technical components of the design and development process undertaken as part of the research.

The voice driven data capturing system was intended to be developed as part of an evolutionary prototype, where the prototype is refined as part of each iteration of the development process, where eventually, the continually refined prototype becomes the finished product. Following an evolutionary prototype development process was ideal because there was no large upfront design involved in the development process. The literature review coupled with contextual interviews conducted on site provided a deeper insight into the solution problem area, the context of use and offered numerous design ideas .Some design and development questions became known during the development process.

This is where DSR becomes useful as a tool for exploring some aspect of the problem area. The design and development of the artefacts take known facts about the problem domain and attempt to develop a number of artefacts. During the development process the researcher/developer needs to make a number of design and development choices based on what he knows and might possibly need to re-examine either the context of use or the literature in order to address any problems that arise. As discussed in Chapter 3 the design and development components of DSR are thus creative knowledge generating processes.

The initial prototype on which the research is based was developed in order to serve as a proof of concept, to demonstrate that the assumption made during the design process was in fact correct. The design and development of the initial prototype also created a number of DSR artefacts that were further of use during the research.

Because of a number of reasons such as the need for the artefact to be networked to allow communication between the participating MOU's, availability of free and open source tools, and the personal skills and preferences of the researcher, it was decided that the initial prototype was to be developed using the PHP/MYSQL scripting language and database respectively. As well, the Windows 7 Speech engine (chosen due to its relative ease of use and the fact that it is bundled onto windows 7 by default at no extra cost) and Firefox web browser were used as the voice driver and web user interface.

Initially CakePhp was used as a framework to develop the artefact. However, due to the researcher's limited familiarity with the framework and lack of enough time, the framework was ditched in favour of pure PHP. It is important to note, that the fundamentals of modern PHP framework which is MVC design pattern (Model, View, Controller) was used as a basis of developing the artefact. MVC approach separates data and logic from the view or user interface and improves maintainability of source code as demonstrated in figure 6.3. Net Beans, a multi-language Integrated Development Environment (IDE) and Dreamweaver IDE were used for developing the prototype and creating of the Webform /CSS respectively.

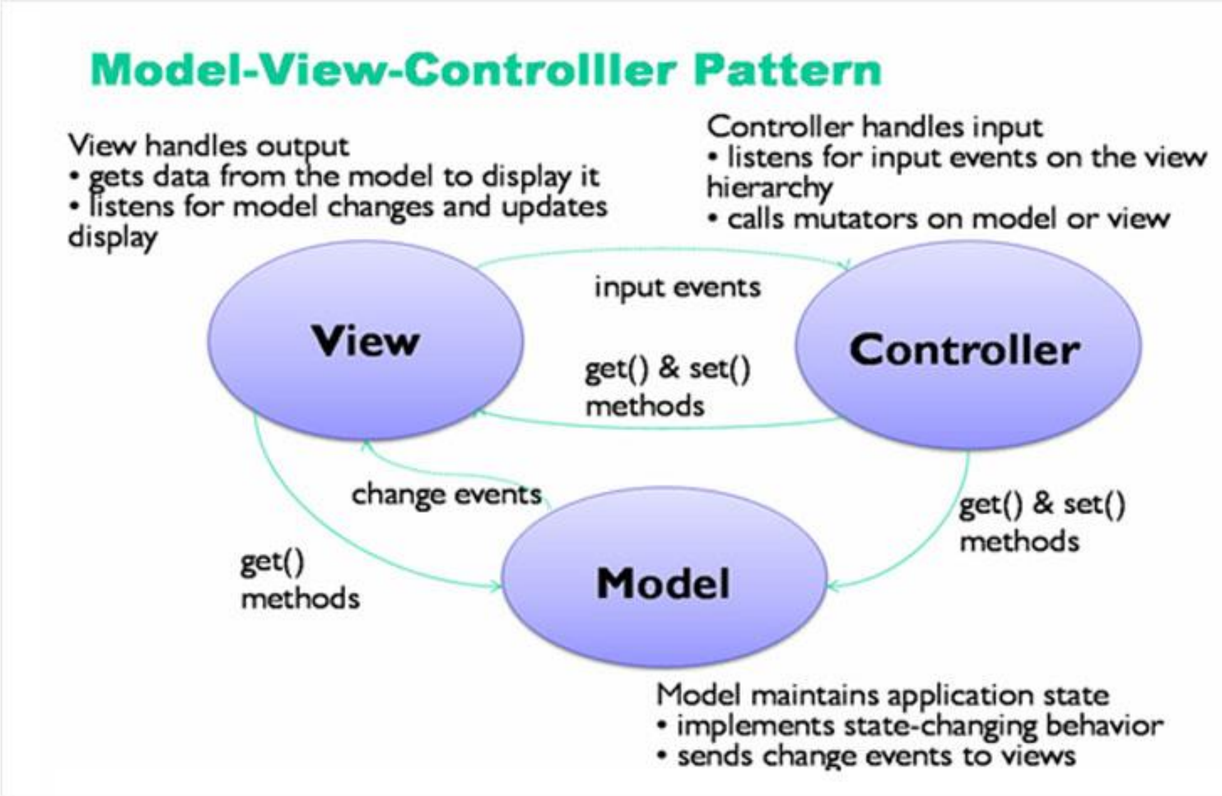


Figure 6.3: *Simplistic representation of MVC*

The model layer is at times considered the central component and consists of application data. A view can be any output representation of information, such as an html page, PDF document etc. The third part, the controller, accepts input and converts it to commands for the model or view and handles the business rules, logic and functions. Figure 6.4 below depicts and adds more description of the MVC design pattern used for the development of the artefact. This approach allowed for changes to be made to the database structure quickly and effectively.

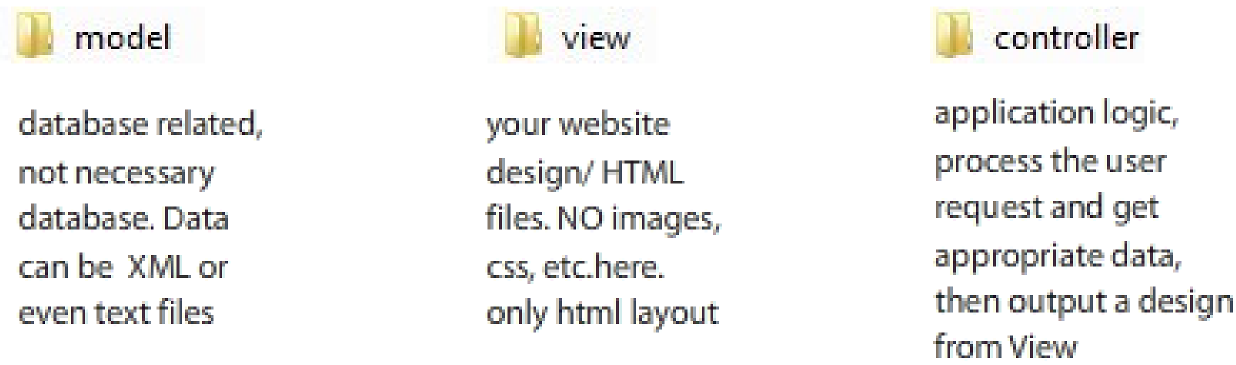


Figure 6.4: *Description of MVC*

The identification of the design considerations and prototyping the solution was an evolutionary process due to increasing understanding and as such, there was not an upfront design to work from. The reason for no large upfront design was because there was little design information available to go on - in fact identifying these design considerations is the primary goal of the research. The MVC design pattern came in handy as specific parts of the solution could be updated without affecting the other.

Because of the evolutionary nature of the design considerations and the need to do prototyping, the test driven development (TDD) approach was used as depicted in figure 6.15 below.

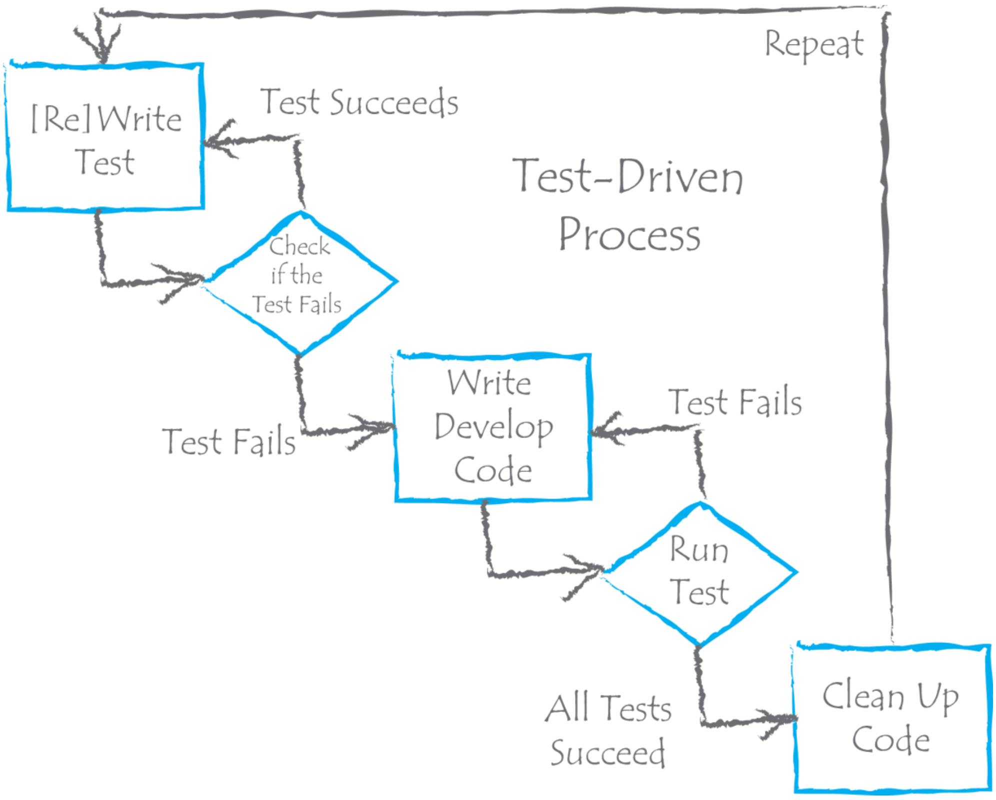


Figure 6.5: *Simplistic description of TD*

This development approach works well for the purpose of this research and allows for a short development cycle. It insures that each unit is tested and each time there is an addition or an update of the code, the entire code base is refactored thus ensuring that the code base is always up to standard and devoid of errors.

As already surmised above, the basic components of the solution are made up of the User interface, Logic/Functionality, Data and finally the Environment. The Environment is the most intricate and difficult to manage as it is outside the domain of the researcher. This involves access to electricity, connectivity to the internet in cases where the solution will be used for referral purposes, users of the system and their various accent, pronunciation styles, capturing devices such as headphone types and their various strengths and weaknesses. The environment plays an important role in defining how, where, when and by whom the system will be used.

The solution could be a standalone system saving all captured data to the local database within each MOU or it could be a situation where the local database synchronizes periodically with a central repository. Synchronization will need access to the internet. An ideal situation is one whereby the solution has access to the internet and saves data captured both locally and centrally. Such a situation will allow monitoring of patient vital data remotely.

To this end the discussion of the architecture of the solution will touch on these topics, specifically the functionality and the data layer. The environment of the solution is discussed as part of the interviews, visits and literature review mentioned in Chapter 4 and the user interface is discussed in the following chapter as part of the solution instantiation.

The next section will look at the functionality of the intended data capturing application.

6.4 Functionality

This section considers the functional component of the designed and developed architecture.

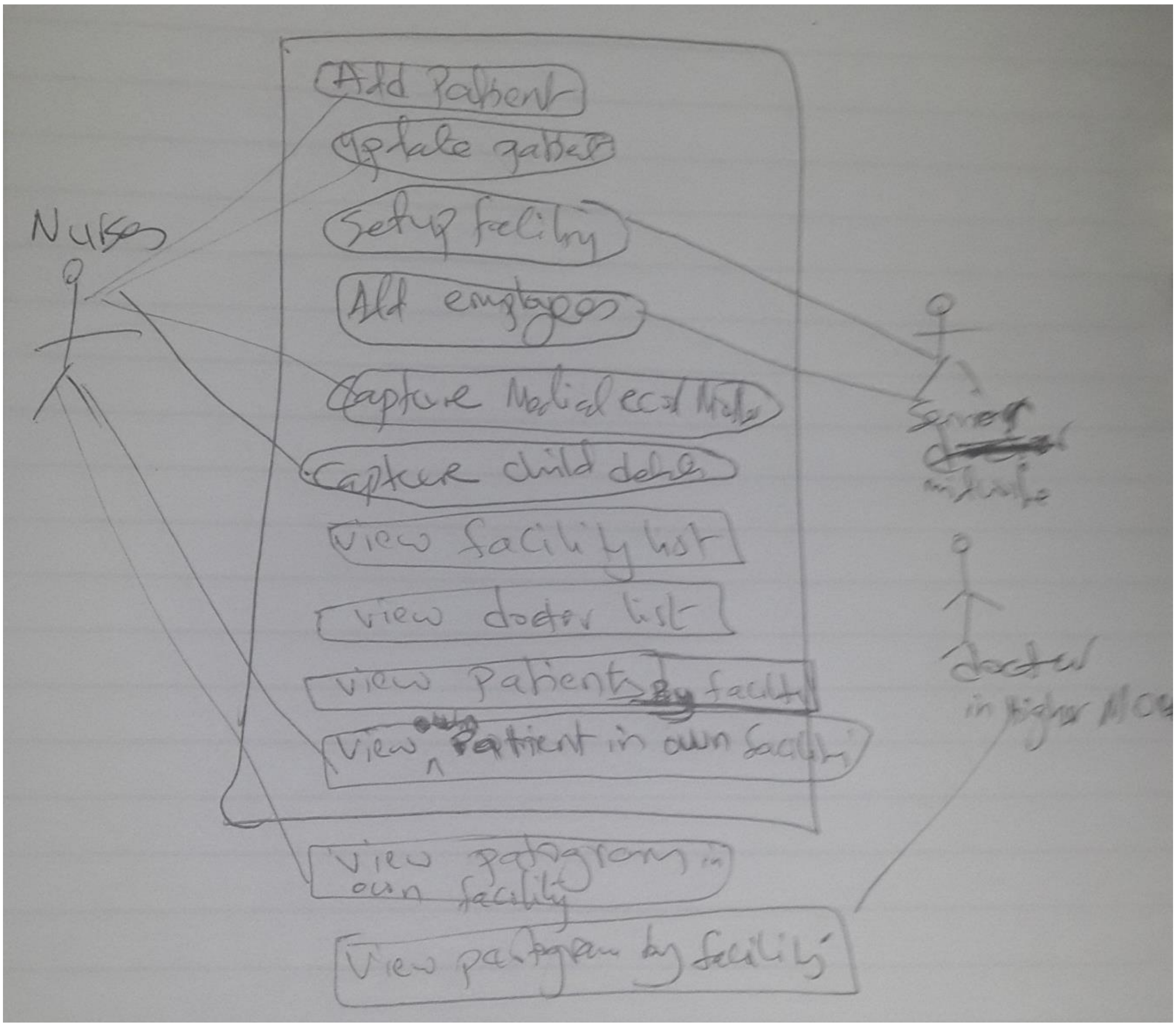


Figure 6.6: *Use-Case Diagram, defining system functionality as captured during interview*

The proposed prototyped solution is to be used as a tool for hands-free capturing of intrapartum data with speech. As depicted in figure 6.6 above and further refined in figure 6.7 below, it provides for CRUD (create, read, update, delete)/management functionality for the different data components, allowing a user to create and manage the data. In order to effectively allow for the management of the data-elements, a voice and visual interface which can transmit/visualise the data and allow for interactivity is required.

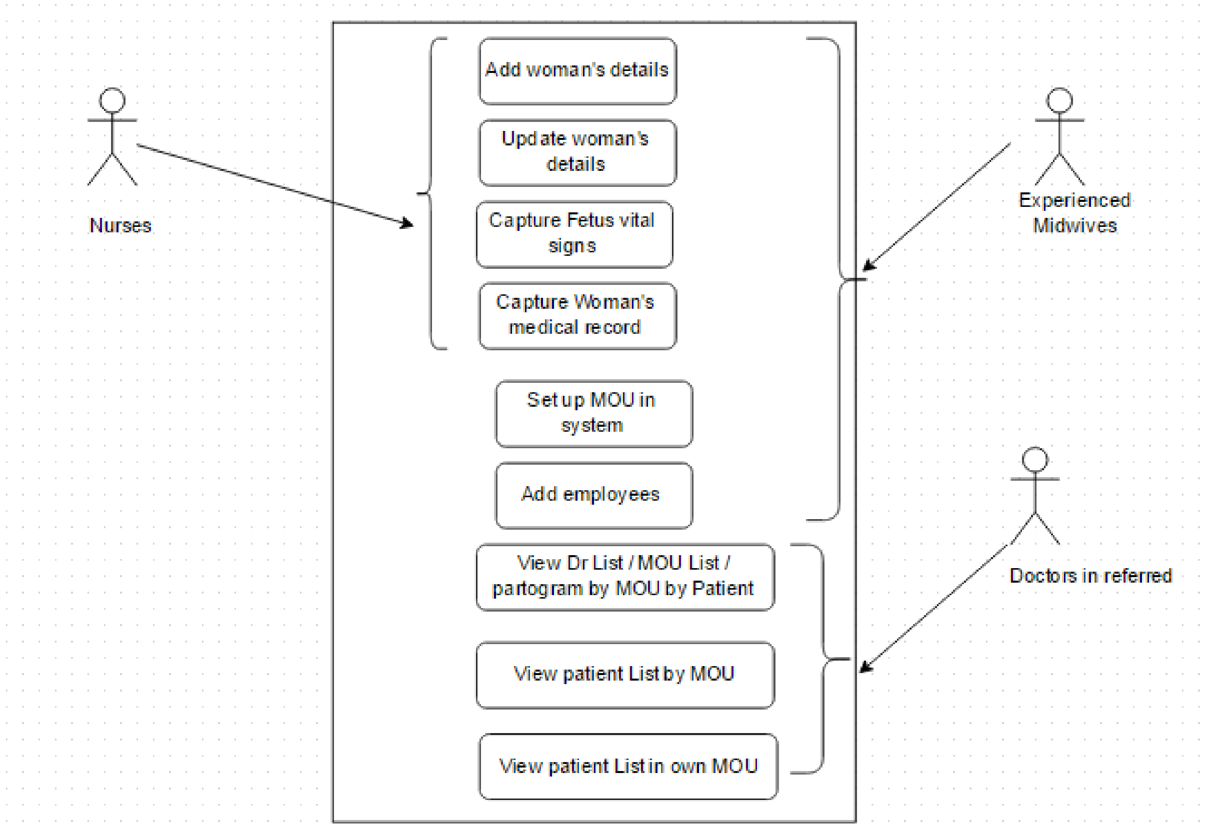


Figure 6.7: *Slightly refined Use-Case Diagram*

The following section considers the data layer of the application, specifically focussing on the database-table structures.

6.5 Database: Entity Relational Diagrams

This section focuses on the database structure created in order to support the hands-free data capturing of intrapartum data.

The ERD was developed based-on the conceptualisations listed in the first section (Section 6.1) of this chapter.

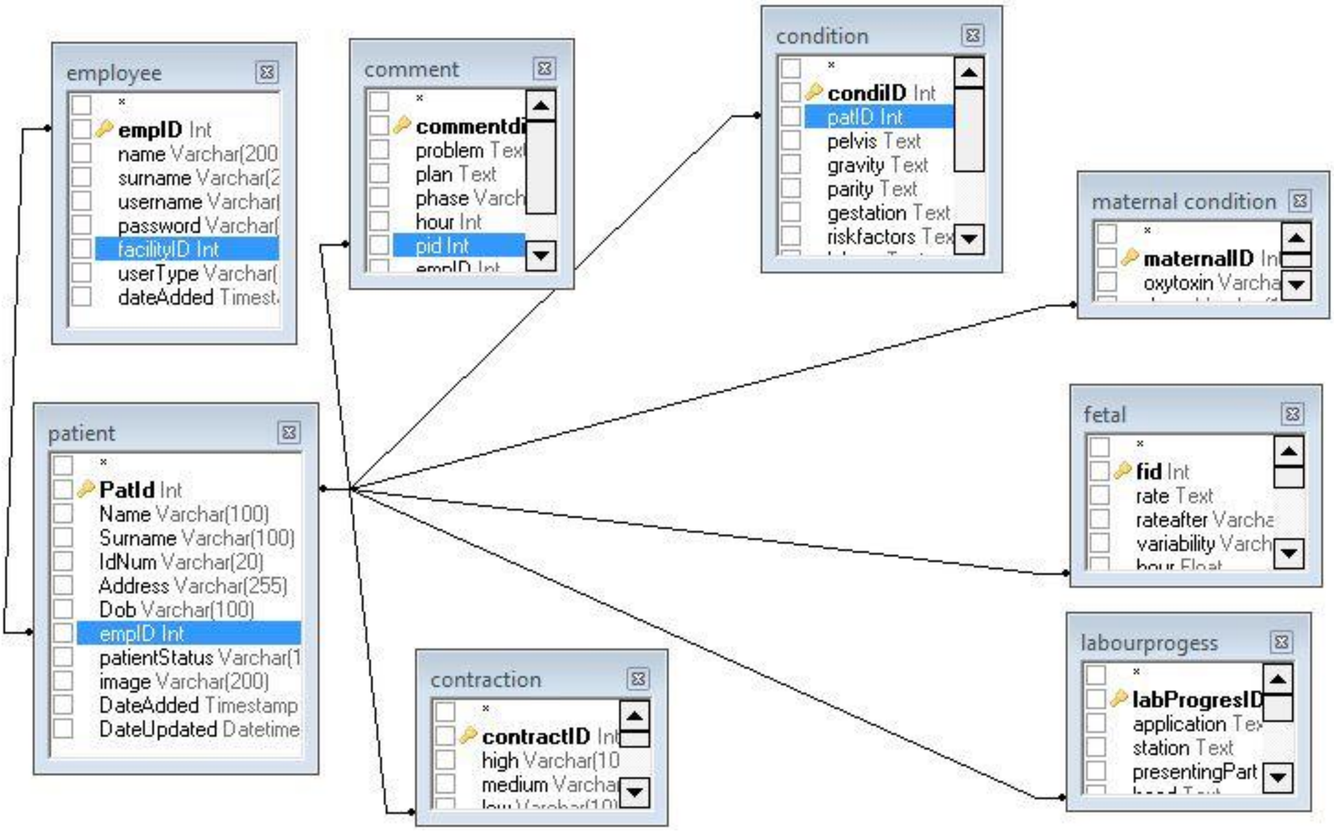


Figure 6.8: *Initial ERD*

The initial requirement was to allow the birth attendants within a specific MOU to be able to capture the various intrapartum data within the specific MOU. As shown in figure 6.8, the various intrapartum data are captured for a specific mother. As well, a birth attendant may be responsible for more than one expectant mother. However, an expectant mother can only be cared for by one birth attendant. It is important to note that there are exceptions to this rule although not often. Because of the referential integrity implemented in the design, an exception can only occur by way of another birth attendant temporarily/absolutely taking control of the management of an expectant mother. This is to ensure that each action taken can be traced by timestamp, user ID etc.

Because the intent of the proposed solution is to allow the exchange of data from a lower level MOU to a higher one, the participating MOU’s could be linked up together via the internet. This will allow data about an expectant mother to be accessed at a higher level MOU in case of referrals. To this end, the ERD was further refined to cater for the possibility of multiple facility interaction and exchange of data. All expectant mothers are cared for by a specific birth attendant and these birth attendants must belong to a specific MOU. The addition of the facility table extends the relationship between expectant mother, birth attendants and facility.

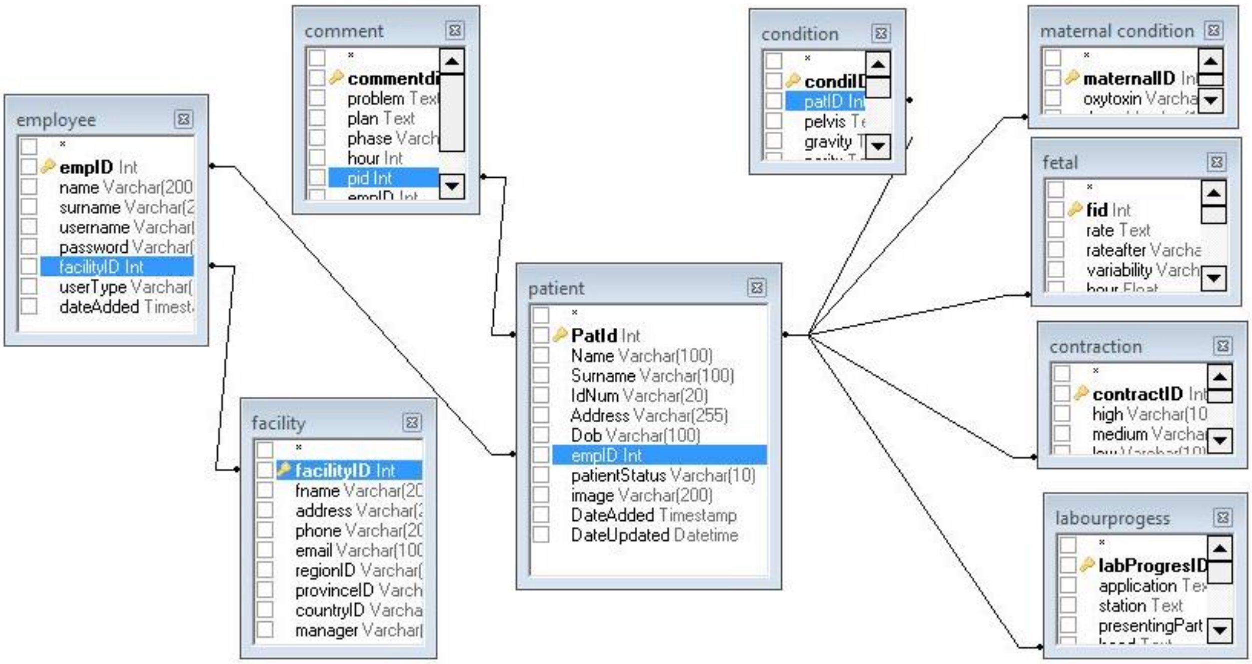


Figure 6.9: *Refined ERD*

The above section discussed the database structure used. The following section briefly considers the environment of the solution artefact.

6.6 Environment

This section very briefly touches on the environment of the data capturing solution. Most of the data capturing environment was discussed in Chapter 4, so within this chapter only the most relevant environment characteristics are discussed.

The initial prototype application was developed for a standard Windows based desktop PC (personal computer) with a sound card and a USB port but with no need for an NIC for internet access or networking capabilities. However, it eventually evolved into a scenario where data could be shared across participating MOU's. This eventuality necessitated that a network card/DSL line or a 3G dongle be used. The usage of these connectivity devices introduces a cost and affordability dimension which is beyond the scope of this research project.

This system will principally be used by the birth attendants within the MOU for data capturing purposes and at a higher MOU level for looking up of the partogram of a referred mother. The most noticeable issue to grapple with is that of the voice recognition. I noticed that training of the voice recognition engine was a bit laborious and the users of the system will have to invest some time to orientate themselves with how it works to achieve a better result.

6.7 Conclusion

This chapter considered the concept design, solution design and development phases of the prototype. Emphasis is on the third and fourth step in the chosen research methodology as defined in Chapter 3. An overview of the design and development phases was provided as well as several of the design diagrams. Some effort was also made to detail some of the design and development choices as well as the factors that gave rise to these choices and the underlying logic behind the given chosen choices. The design and development process produced the various research artefacts, thus this chapter simply considered the creation process and created artefacts.

CHAPTER SEVEN

DEMONSTRATION AND EVALUATION (SIMULATION)

This chapter considers the actualisation and instantiation of the DSR solution using the concepts and designs discussed throughout the previous chapters.

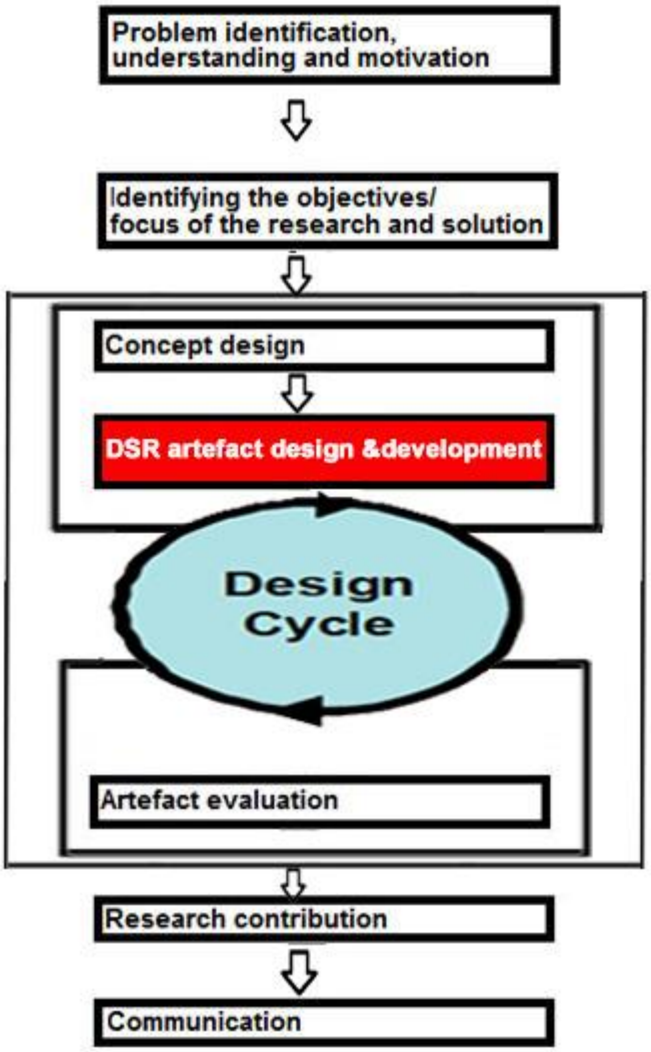


Figure 7.1: *Focus of Chapter 7 in relation to the methodology*

7.1 Introduction

Pries-Heje et al. (2012) concurs with Klecun and Cornford (2005)'s assertion that IS evaluation is generally regarded from one of two perspectives namely: ex ante and ex post. In the ex ante perspective, candidate systems or technologies are evaluated before they are chosen and

acquired or implemented. In the ex post perspective, a chosen system or technology is evaluated after it has been acquired or implemented. This study is only concerned with ext ante evaluation as ex post evaluation is out of the scope of this research study.
In its simplest form within design research, ex ante evaluation provides models for theoretically evaluating a design without actually implementing the material system or technology. This therefore means that the artefact could be evaluated on the basis of its design specifications alone.

Purao and Storey (2008) seem to suggest that the Technology Acceptance Model (Davis, 1989) could be used as a predictive theory (Gregor, 2006) with the objective of evaluating whether a DSR artefact is likely to be accepted in a production environment. Although this non-empirical, artificial evaluation approach focuses on the potential efficacy of the IT artefact, it also presupposes that the artefact must be adopted in order for there to be an efficacious outcome of IS DSR. This study does not take that presupposition into account and thus uses simulation as a valid shard stick to measure efficacy and utility.

Following a DSR-based methodology the underlying development processes formed an important part of the research namely: the analysis and requirements/objective gathering processes form an important part in initial data gathering, while the design and development contributed in data gathering and creation as well as providing proof of concept.

Because the primary focus is usually placed on the analysis, design, development and evaluation, it is thus conceivable that in some cases the presentation of the solution instantiations might not be included in the research or that it would most likely not be thoroughly covered. This research however deemed it important to present the instantiation with the hope that it could contributes in clarifying the research and the research findings. Eekels & Roozenburg (1991) suggest that simulations can be an appropriate demonstration tool. Demonstration refers to the use of the artefact to solve one or more instances of the problem. To this end, the demonstration will be in the form of a simulation.

The following section considers the user interface of the initial-prototype solution created as part of the research.

7.2 User Interface

The UI is the most visible portion of any IS system. The users usually do not know nor need to know about the internal and inner architecture of the system and most often the UI is the means by which the user interacts and gets feedback from the system. However, the UI and the functionality of the system are fundamentally two different but related concepts. It is understandable when users think that the UI is the system. A good system is one that has all the required functionality and provides an appealing and easy to use interface. The degree to which these two concepts are balanced depends on the environment and the overall objective of the system.

The research conducted was focused for the most part on the technical aspects of the design involved in creating the solution artefact. The research does acknowledge the importance of the user's ability to interact with the system, and lightly touches upon it, but the core focus has been on the technical design and development of the intended solution artefact.

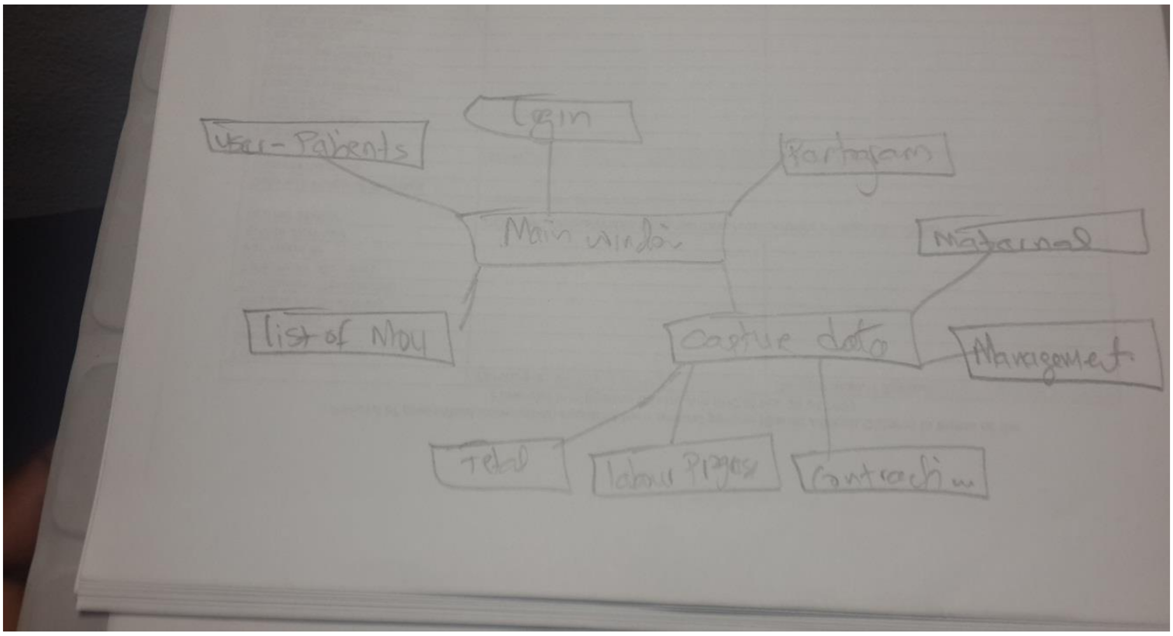


Figure 7.2: *Basic UI navigation as captured during contextual interviews*

Figure 7.2 above and figure 7.3 below shows the navigation of the initial prototype application. It is developed further in the remaining sub section of figure 7.3 below. The main menu acts as the landing page from where the user can navigate accordingly. From the main menu, the user can login and depending on his/her access right will be presented with a navigation link befitting his/her access rights. There are basically three levels of access namely: data capture access level, MOU management access and finally a higher level MOU access level. A higher level MOU can only have access to a specific level one MOU. The access of intrapartum data within the level one MOU by a higher level MOU can only be initiated by the specific level one MOU and to a specific participating higher MOU during the referral process.

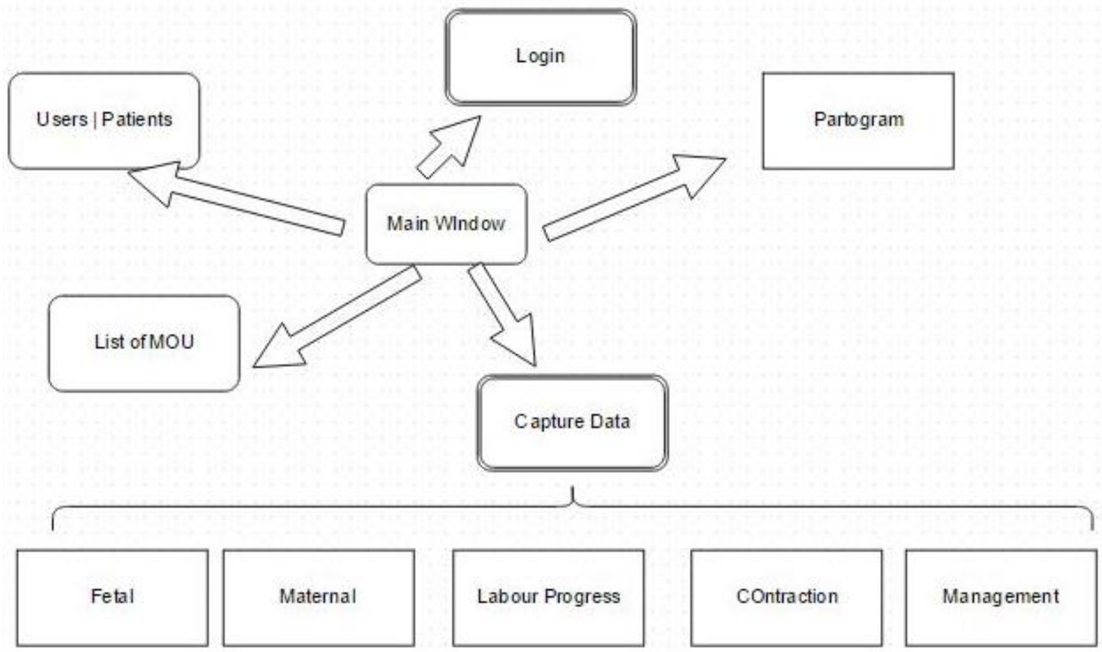


Figure 7.3: *Refined basic UI navigation as captured during contextual interviews*

There is a general navigation link at the top of the form that can easily be accessed from anywhere within the application. This navigation link allows the user to easily jump from part of the system to another. However, certain aspects of the system act as a transaction in the sense that a series of actions need to be taken to complete one operation. The process of capturing the foetal condition requires that a number of data sets (e.g. heart rate before, heart rate after, variability etc.) be entered before submitting. Failing to enter all the data sets required will break the 'transaction' and displays an error message which can picked up by the speech recognition engine relayed to speakers or head phones.

In the following sections the various parts that make up the prototype interface are briefly shown and discussed.

7.3 Main Menu Form

This section considers the UI of the main menu, the initial starting page for the application used to access the various other sub-forms. The main form is the default starting form for the application. It has little functionality other than providing a means for the user to access the other forms and their corresponding functionality.

The figure below presents a screenshot taken of the Main Form of the prototype applications.

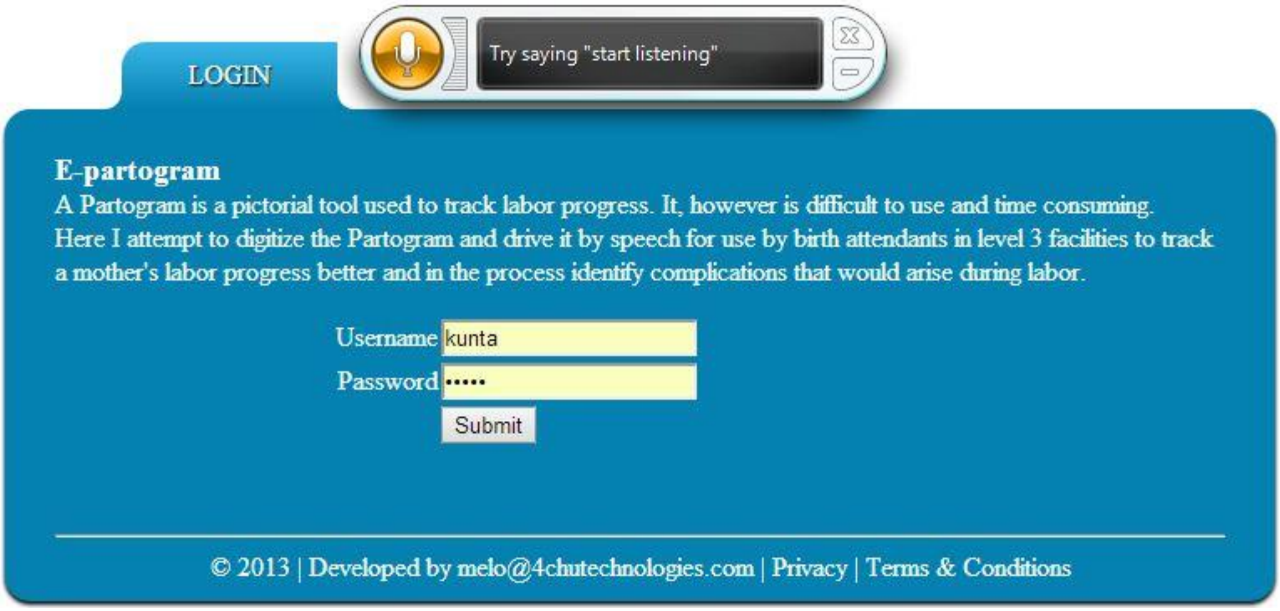


Figure 7.4: System login form

The login form above (figure 7.4) presents the user with a form to collect authentication details. There are many ways of authenticating a user. This research project found using what-you-know approach by means of a unique username and a secret password feasible but of course it could be taken many steps further. The microphone sign is the windows speech recognition engine in action used to drive actions performed on the system. This engine has to be trained with the user's accent, diction, pronunciation etc. for it to be effective.

Figure 7.5: *Simple UI, Menu*

All users of the system must belong to an MOU and on login if the user has expectant mothers assigned to him/her then the patients are listed in alphabetic order at the top with pictures of patients depicted against their names. Details and intrapartum data about each expectant mother are displayed on click. However, because of the alphabetic sort order deployed, a default mother's details are displayed. Thus Abongile's details for argument`s sake are displayed by default and Thabisile's only on click. If the user has an admin access role as shown in figure 7.5 then an added link is displayed. This link will allow the admin to select a specific MOU and view the partogram of a specific expectant mother. However, it is important to note that this only happens when this is a referral from a lower MOU to a higher one.

Figure 7.6: *Simple UI & Menu*

Figure 7.6 depicts a user with no admin access role. This view is the standard view for data capturing. Landing here the birth attendant decides on viewing the high level summary, viewing the partogram or capturing data. Viewing of the partogram will necessitate that the birth attendant be in front of the screen while the capturing of data can be done from a distance, out of sight and hands-freely.

7.4 Partogram

The partogram as depicted in figure 7.7 below shows the various data elements for which intrapartum data is captured. Dilatation and descent of labour progress recording in both the latent and active phases are also shown. An initial pre-captured maternal condition is displayed at the top right corner of the partogram.

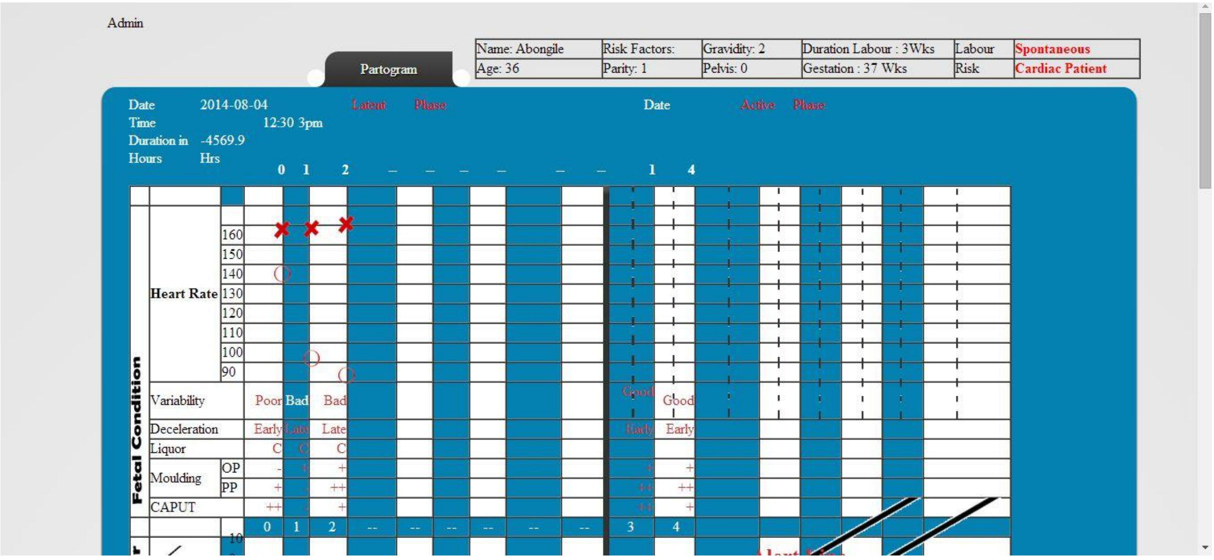


Figure 7.7: A part view of the system partogram

The partogram has been replicated as close as possible as the paper partogram. Because of a lot of information cramped onto one form, not all information can be viewed at once. The user therefore has to scroll up and down to have access to the entire partogram. However, the application can be bootstrapped in the future to allow a responsive and auto resizing web page with no need to scroll.

7.5 Data capturing

Data capturing is at the core of this research project and the following section will demonstrate pictorially the various forms that could be used to capture data. The various types of intrapartum data that require capturing are briefly depicted below.

7.5.1 Foetal Condition

To make it easier for the speech recognition engine to pick up certain words, some of the words were initialized. Words such as deceleration and liquor have been shortened into De and LQ as shown in Figure 7.8.

Figure 7.8: *A view of fetal condition form*

7.5 .2 Progress of Labour

As depicted in Figure 7.9, certain aspects of the form for capturing the progress of labour have been abbreviated. Data items such as head above pelvis amongst others have been abbreviated to HAB. There are error checks in all the form elements to make sure that data inputs are correct before submission. However, in this case, the comments textbox is optional as the birth attendants might not have any comments to enter. This is also true for all the other forms.

Figure 7.9: *A view for progress of labour*

Figure 7.10: *Contraction form*

7.5.3 Contraction

The contraction form handles the strength and duration of contraction. For easy management all the forms have hours and phase data elements ensuring each user activity is logged for the appropriate hour and phase. As demonstrated in figure 7.10, the data element for drugs or intravenous fluids (optional) is not checked against empty values for they can be left empty deliberately by the birth attendant.

7.5.4 Maternal Condition

The form used to capture the maternal condition by the birth attendant is the densest one. It has about twelve form elements. The blood pressure has also been abbreviated. An abbreviation seems to make it less complex and easier to pronounce and thus ensures that the speech recognition engine can also pick it up easily. As shown in figure 7.11, the facility details as well as the birth attendant's details are constantly displayed to the left of the screen

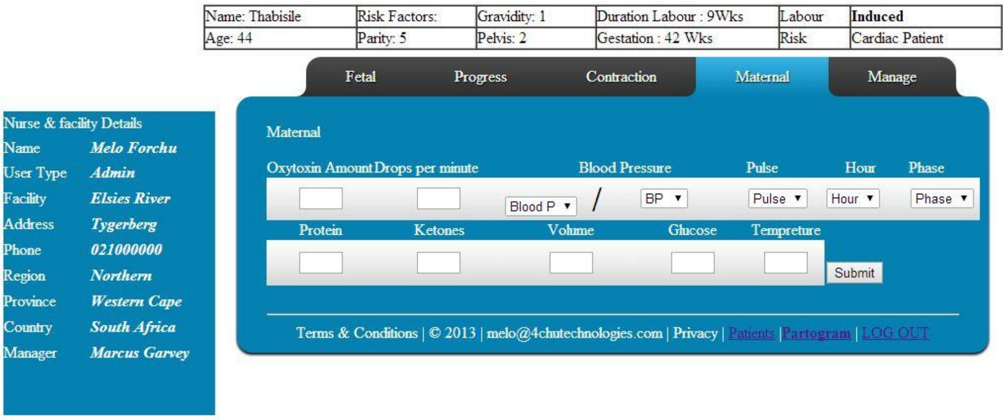


Figure 7.11: *A view for maternal condition*

7.5.5 Management

The last intrapartum data element captured during this capturing process is the management notes. This seems to be one of the most important data elements as this is where the birth attendant can freely enter her notes. As shown in figure 7.12, these notes are critical as they explain any intricacies or complications observed and are excellent handover reference material.

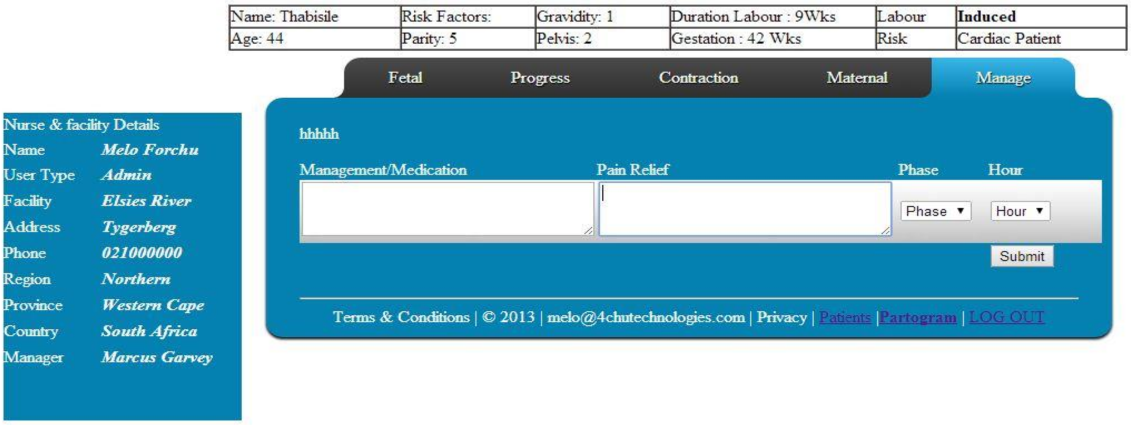


Figure 7.12: *A view for progress of labour*

7.6 SUMMARY

For the sake of clarity, the following section will attempt to summarise to a certain degree the purpose and understanding of a prototype as used in this research. The prototype seeks to understand and provide a data capturing mechanism that could be used within the resource scarce MOU. The idea is to provide birth attendants with a tool with which they can use to support themselves to increase the level of care by not wasting too many resources, knowhow and energy on data capturing. To evaluate and refine the theoretical development of the prototype, simulations are used to investigate the feasibility and viability of speech driven data capturing mechanism in this context.

Due to the nascent nature of voice recognition and its limitation in as much as background noise is concerned, mostly abbreviated words were used. Usage of abbreviated keywords such HR, BP instead of Heart rate and blood pressure respectively increased accuracy.

The investigational design involves generating situations that will trigger (as well as impede) the mechanisms within the confines of the study, just as would happen in practice. To realize this and guarantee external validity for the proof-of-concept, real-world intrapartum datasets are obtained and birth attendants capture this data onto the partogram using a pen while assessing a volunteer student nurse just as they would an expectant mother.

This project employed a series of simulations using the speech driven application to test the capturing of intrapartum data as well as the impacts of background noise on performance. These results are used to validate the metrics developed in the prototype that helps birth attendants capture intrapartum data via speech.

The key findings are that:

- background noise impacts highly on the speech driven data capturing
- the training of the speech engine is laborious
- after training, the accuracy rate increases drastically
- the referral process reduces time and effort
- captured data can easily be saved for posterity and easily retrieved

Based on the internal validity; in this case referring to a robust and careful experimental design and execution (Experiment in this case refers to the comparison carried out between capturing data with pen and paper on the partogram and using the prototype to capture data to see which is a more viable option) and external validity (re-creation of ambient conditions), the case for potential generalizability of the experimental results can be considered.

The rest of this summary is structured as follows. Section 7.3 examines the philosophical basis for this empirical work, linking it back to the research design (Design Science) and research philosophy (Pragmatic). Sections 7.4 introduce the scenarios under examination (including the datasets and "noise" processes) as well as explaining the practicalities and technical details of how the simulations were undertaken. Section 7.5 uses results from the simulations to argue that the prototype developed can be operationalised and used in practical situations.

7.7 Philosophical Basis

This section relates to how concepts from Chapter 3 (Research Method and Design) apply to the design and development of the solution to the question at hand: a speech driven data capturing tool.

The interpretation is based on the attributes of intrapartum data, which may have their roots in the natural world and are defined through social mechanisms such as the law. For example, gender is a complex genetic, biological and social phenomenon. In the setting of intrapartum data and environment, the role of chromosomes is irrelevant; what matters is the social construction, whether that is by legal definition (e.g. birth certificate) or self-definition (e.g. asking the patient). Similar remarks could be made for date of birth and marital status.

It is not the goal of this research to explain why data about the expectant mother and child is captured during the intrapartum stage as it is out of scope. The domain of *the real* refers to the natural world and its laws. The domain of *the actual* is the focus, where we find events. These events include capturing fetal condition, dilatation, descent etc. We donot have access to these events (we cannot perceive them directly) but instead our knowledge of them comes to us through our sense-perceptions of the "traces" they leave in *the empirical*: coloured images flashed on a computer screen, or thermometer reader, heart rate machine, oscilloscope, audio reproductions of human speech from a speaker, text printed on a report etc.

The application/ artefacts developed and deployed in the data capturing processes are themselves transitive objects embedded in the practical situation of the intrapartum environment. The domains of *real* are the underlying laws of nature that govern the operation of electrical and mechanical machinery. The event in the realm of the actual invokes or evokes changes in system state and operation. We access the occurrence of these events through *the empirical*: perceptions of the graphics, texts and sounds (on screen or on paper) through which the state variables are revealed to us. These system events (from *the actual* domain) are designed to reflect, or correspond to, the "real-world" intrapartum events (also from *the actual* domain). Empirically, they may be entirely distinct.

If the underlying data capturing processes, using the speech driven system are deterministic, then any changes in observed events are attributed to changes in the quality of the system alone and we can attempt to establish causality. The internal validity of the experiments is determined by whether the system's "generative mechanisms" (that is, the operation of electro-mechanical machines constrained by software that implements the speech driven data capturing processes) give rise to an improved data capturing experience. More simply, the internal validity depends on how well the study can exclude other potential explanations for the quality in the intrapartum data capturing process. Although the practices of the midwives are predetermined by set processes their use of the partogram remains socially constructed. Generalizability can only be possible if the electronic partogram system is sufficiently tested in different contexts and the midwives adopt this system as part of their practices during the intrapartum stage. Design science research proposes different evaluations to establish the suitability of the new design, in this case the electronic partogram application, firstly a proof-of-concept which is the focus of this study before a proper post ante evaluation that involves all the considerations for implementation and adoption of the proposed electronic partogram - this falls outside the scope of this study.

The next section explains how the experiments(as already stated, the experiments refer to the comparison between using the various modus operandi to capture intrapartum data) were designed to meet these criteria for internal and external validity.

7.8 Scenarios

In order to ensure the external validity of the experiments as a proof-of-concept, a reconstruction of the ambient environment is necessary. This means using real datasets, real tools and real intrapartum data. Background noise is a major impediment to speech recognition. The intrapartum background noise introduced, however, is synthetic and thus constitutes a simulation. Intrapartum background noise refers to a play of pre-recorded sounds that will normally be heard in such environments. What is important with the noise factor is that the noise process introduces the speech driven data capturing deficiencies in a controlled fashion, allowing deductions to be drawn from the observed effects. In practical terms, a well-defined, replicable noise-adding procedure is required.

7.8.1 Datasets

The datasets are real intrapartum data that has been anonymised to rid of all identifying features. The typical use of these datasets is in the design, development and improvement of data capturing process and related algorithms.

In selecting the datasets that represent the ambient environment, the criteria were:

- The selection should provide a representative class of all the subsets of intrapartum data (such as foetal well-being, progress of labour etc.).
- The attributes of data about the expectant mother should be generic (applicable across domains).
- The size and complexity of the datasets should not present practical or resourcing issues for the experiments.

Based on a review of the available options and these criteria, three datasets were selected for analysis, as described below.

7.8.1.1 Maternal WELL-BEING

This dataset was derived from the maternal well-being of an anonymised data (from a mother). An example is shown in table 7.1 below.

Table 7.1: *Maternal Well-being Dataset*

Attribute	Type	Possible Values
Blood pressure	Numerical	120/80)
Pulse	Nominal	
Temperature	Numerical	30 degrees
Urine	Nominal	Nil or +
Protein	Numerical	0
Ketone	Numerical	0

7.8.2 NOISE PROCESS

Since these experiments are concerned with the *feasibility of using a speech driven data capturing visa vis quality of care to expectant mother* and not the *causes of poor quality of care*, a “noise process” is required that can introduce errors to the datasets in a controlled fashion. That is, the noise process is not only required to reflect the ambient conditions but also one that induces extra noise-events in the domain of *the actual*. These extra noise-events as well as all noise-events if suppressed and speech used successfully to capture data, will demonstrate the utility of the speech aspect of prototype.

In order to allow other researchers to verify these results, the background noise and speech recognition process should be simple, practicable (execution and effort), repeatable and generic (applies to all data types) .Failure to meet any of these criteria would undermine the replicability of the study.

7.9 EXPERIMENTAL PROCESS

This section outlines the sequence of steps undertaken to implement the series of simulatory experiments. The goal is to explain how the internal and external validity of the study was maintained, to place the outcomes into context and allow repetition of the study to verify outcomes.

7.9.1 Technical Environment

The technical environment for the experiments was contrived to reproduce the ambient conditions found in practice. As outlined in Section 3, the scenarios (including the datasets) were selected against criteria (successful capturing) designed to realise this reproduction. The implementation platform for the experiments was constructed in keeping with this goal, and comprised the following technical elements:

- Standard low-end desktop PC (i.e. 2GHz processor, 2G RAM, 120GB HDD, networking and peripherals),Windows 7 SP2 (operating system),
- Windows 7 speech recognition engine,
- SPSS analytical tools,
- Microsoft Excel (data analysis spread sheet),
- Chrome browsers,
- A 3G dongle
- Cellular SIM card
- Bluetooth dongle
- Bluetooth headset

IBM SPSS is a powerful analytical tool and was used to analyse the result of simulation data collected. It is the leading analytical tool in the market and the university obtained academic licenses for their academic programmes. After the simulation, a fifteen (15) SUMI(Software Usability Measurement Inventory) type questionnaire on user experience was collected and SPSS analytical tool used to analyse the responses.

SUMI (The Software Usability Measurement Inventory) is highly recommended by ISO 9241 to any organisation which wishes to measure the perceived quality of use of software, either as a developer, a consumer of software, or as a purchaser/consultant. It is important to note that I printed the hard copies of the SUMI questionnaire from the demo part of the SUMI website as I could afford to purchase the live online version. SUMI is increasingly being used to set quality of use requirements by software procurers. Although SUMI is known to have some weaknesses such as the fact that it mainly focuses on software, addresses mostly classical usability issues, the results not being highly informative for re-designers as surmised by Kirakowski (1994), it ultimately in this case, gives an indication of the state of affair of the prototype being assessed.

Windows speech recognition engine bundled with Windows 7 is quite robust and when trained properly can be very productive with accuracy levels hitting upper 90% at times. Based on the tests that I conducted, the finding is that this application is on par with other speech engines such as dragon naturally speaking. This comparison is based primarily on short words verbage. It only requires the user to spend about three minutes on a walk through and voice training. This training allows the speech engine to understand the nuances, accent and pronunciation style of the user.

7.9.2 Questionnaire

Below (ranging from table 7.2 to table 7.21) is the graphical representation of some of the post simulation questionnaires. There were a total of sixty five (65) questions. The objectives of the questions were to test utility. The birth attendants, after doing a simulation using the artefact, were asked to give feedback based on their experience. A few of the responses are listed below. The responses in general give an indication of the utility of the artefact but most importantly, it expresses the amount of work that still has to be done to produce a more viable and durable capturing system. Table 7.2 below shows that for a total of 15 birth attendants who participated in the simulation exercise, up to 11 actively answered the questionnaire. A low number of 18.2% of the respondents felt that the prototype increased efficiency. The prototype is essentially a web-based speech driven application thus the usage of SUMI is justified as it targets mostly web-based systems.

Table 7.2 *I feel efficient when I'm using this application*

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly Agree	2	13.3	18.2	18.2
	Agree	3	20.0	27.3	45.5
	Neutral	3	20.0	27.3	72.7
	Disagree	2	13.3	18.2	90.9
	Strongly Disagree	1	6.7	9.1	100.0
	Total	11	73.3	100.0	
Missing	System	4	26.7		

Total	15	100.0		

For the eleven respondents who answered this question, a large majority of them had a slightly higher than neutral positive response with five agreeing, three disagreeing and 3 remaining neutral.

Table 7.3: *Using this application for the first time is easy for the first time*

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly Agree	3	20.0	27.3	27.3
	Agree	4	26.7	36.4	63.6
	Neutral	1	6.7	9.1	72.7
	Disagree	1	6.7	9.1	81.8
	Strongly Disagree	2	13.3	18.2	100.0
	Total	11	73.3	100.0	
Missing	System	4	26.7		
Total		15	100.0		

A large majority of the respondents had a positive feedback when using the speech recognition epartogram for the first time with 7 agreeing, 3 disagreeing and 1 remaining neutral.

Table 7.4: *This application occasionally behaves in a way I can't understand*

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly Agree	9	60.0	69.2	69.2
	Neutral	3	20.0	23.1	92.3
	Strongly Disagree	1	6.7	7.7	100.0
	Total	13	86.7	100.0	
Missing	System	2	13.3		
Total		15	100.0		

A large majority of the respondents found it hard controlling the flow of logic, likely due to the speech engine misunderstanding the accents and pronunciation.

As shown above in table 12C, 69.2 % of the respondents had a major erratic problem with prototype. This is due to the speech engine having a hard time understanding the human speech and translating it into a meaningful trigger for the system.

Table 7.5: *There are too many steps required to get something working*

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Agree	3	20.0	27.3	27.3
	Undecided	5	33.3	45.5	72.7
	Disagree	3	20.0	27.3	100.0
	Total	11	73.3	100.0	
Missing	System	4	26.7		
Total		15	100.0		

27% of respondents felt that there were too many steps taken to accomplish a task

Table 7.6: *This application is awkward when I want to do something that is not standard*

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Agree	1	6.7	7.7	7.7
	Undecided	8	53.3	61.5	69.2
	Disagree	4	26.7	30.8	100.0
	Total	13	86.7	100.0	
Missing	System	2	13.3		
Total		15	100.0		

30% of the respondents found the system unable to deviate from its pre-set configuration with a 61% undecided. As a supporting information, an example might be things like only saying the word BP for blood pressure at all times.

Table 7.7: *It is obvious that user needs has fully been taken into consideration*

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Agree	7	46.7	53.8	53.8
	Undecided	5	33.3	38.5	92.3
	Disagree	1	6.7	7.7	100.0
	Total	13	86.7	100.0	
Missing	System	2	13.3		
Total		15	100.0		

The respondents seem happy (53%) that their needs were fully considered. Again as additional information, the epartogram was just a digitization of the paper partogram with speech recognition system integrated.

Table 7.8: *I think this software is inconsistent*

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Agree	4	26.7	30.8	30.8
	Undecided	5	33.3	38.5	69.2
	Disagree	4	26.7	30.8	100.0
	Total	13	86.7	100.0	
Missing	System	2	13.3		
Total		15	100.0		

The fifteen respondents found it unable to clearly indicate if the software was consistent all the time. We had almost a tie here. With four agreeing to its inconsistent nature, four disagreeing and five being undecided.

Table 7.9: *I think this software has made me have a headache on occasion*

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Agree	2	13.3	15.4	15.4
	Undecided	7	46.7	53.8	69.2
	Disagree	4	26.7	30.8	100.0
	Total	13	86.7	100.0	
Missing	System	2	13.3		
Total		15	100.0		

15% of the respondent had a terrible experience with the software while a large majority were neutral with a modest 15% having a positive experience.

Table 7.10: *Error prevention messages are not adequate*

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Agree	3	20.0	23.1	23.1
	Undecided	8	53.3	61.5	84.6
	Disagree	2	13.3	15.4	100.0
	Total	13	86.7	100.0	
Missing	System	2	13.3		

Total		15	100.0		

15% of the respondents seem to think that there were enough error prevention measures and messages available with only 23% disagreeing and huge chunk of undecided respondents.

Table 7.11: *It is easy to make the software do exactly what you want*

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Agree	4	26.7	40.0	40.0
	Undecided	5	33.3	50.0	90.0
	Disagree	1	6.7	10.0	100.0
	Total	10	66.7	100.0	
Missing	System	5	33.3		
Total		15	100.0		

Overall, 40% of the respondents concede that the software can follow instructions with 50% staying neutral while 10% disagrees.

Table 7.12: *The software has a very attractive presentation*

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Agree	4	26.7	30.8	30.8
	Undecided	5	33.3	38.5	69.2
	Disagree	4	26.7	30.8	100.0
	Total	13	86.7	100.0	
Missing	System	2	13.3		
Total		15	100.0		

30% of the respondents were happy with the look and feel of the user interface while 38% disagrees. But 38% stayed neutral with regards the user interface

Table 7.13: *Either the amount or quality of the help information varies across the system*

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Agree	5	33.3	38.5	38.5
	Undecided	2	13.3	15.4	53.8
	Disagree	6	40.0	46.2	100.0

	Total	13	86.7	100.0	
Missing	System	2	13.3		
Total		15	100.0		

38% agrees while 16% disagrees with 15% staying undecided

Table 7.14: *It is easy to forget how to do things with this software*

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Agree	6	40.0	46.2	46.2
	Undecided	3	20.0	23.1	69.2
	Disagree	4	26.7	30.8	100.0
	Total	13	86.7	100.0	
Missing	System	2	13.3		
Total		15	100.0		

46% of the respondents who answered agrees that it is slightly confusing enough to make the user forget how to do things while 30% disagrees.

Table 7.15: *It is easy to see at a glance what the options are at each stage*

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly Agree	10	66.7	71.4	71.4
	Agree	2	13.3	14.3	85.7
	Neutral	1	6.7	7.1	92.9
	Strongly Disagree	1	6.7	7.1	100.0
	Total	14	93.3	100.0	
Missing	System	1	6.7		
Total		15	100.0		

The software makes it easier to see at a glance the various options available. This is due to the presence of the always present navigational bar. These responds slightly negate the previous response because the navigation bar would have reduced some of the difficulties.

Table 7.16: *Getting data files in and out of the system is not easy*

		Frequency	Percent	Valid Percent	Cumulative Percent

Valid	Strongly Agree	4	26.7	30.8	30.8
	Agree	4	26.7	30.8	61.5
	Neutral	4	26.7	30.8	92.3
	Disagree	1	6.7	7.7	100.0
	Total	13	86.7	100.0	
Missing	System	2	13.3		
Total		15	100.0		

Averagely, the respondents agree that it is slightly easier to perform file input/output operations.

Table 7.17: *I have to look for assistance most times when I use this software*

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly Agree	4	26.7	33.3	33.3
	Agree	3	20.0	25.0	58.3
	Neutral	3	20.0	25.0	83.3
	Disagree	2	13.3	16.7	100.0
	Total	12	80.0	100.0	
Missing	System	3	20.0		
Total		15	100.0		

A slight majority seem to need assistance each time they use the software. This is probably because each respondent only had one trial run before taking the questionnaire.

Table 7.18: *This website has much that is of interest to me*

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly Agree	4	26.7	33.3	33.3
	Agree	3	20.0	25.0	58.3
	Neutral	5	33.3	41.7	100.0
	Total	12	80.0	100.0	
Missing	System	3	20.0		
Total		15	100.0		

Although a large majority stayed neutral, 33% of the respondents agreed that the software has something of value to them.

Table 7.19: *It is difficult to move around this website*

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly Agree	3	20.0	25.0	25.0
	Agree	1	6.7	8.3	33.3
	Neutral	4	26.7	33.3	66.7
	Disagree	3	20.0	25.0	91.7
	Strongly Disagree	1	6.7	8.3	100.0
	Total	12	80.0	100.0	
Missing	System	3	20.0		
Total		15	100.0		

Briefly, the question of ease of use is neutral as there is a tie between those who agree and disagree. 26% stayed neutral.

Table 7.20: *I can quickly find what I want on this website*

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly Agree	1	6.7	8.3	8.3
	Agree	1	6.7	8.3	16.7
	Neutral	4	26.7	33.3	50.0
	Disagree	4	26.7	33.3	83.3
	Strongly Disagree	2	13.3	16.7	100.0
	Total	12	80.0	100.0	
Missing	System	3	20.0		
Total		15	100.0		

On this question, the respondents agreed strongly that they found it difficult to find what they were looking for. This SUMI question does not relate to this software as it is not a general use application with multiple search items. On the question of navigation above the respondents agreed that it is easy to navigate.

Table 7.21: *This website seems logical to me*

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly Agree	4	26.7	33.3	33.3
	Agree	1	6.7	8.3	41.7
	Neutral	2	13.3	16.7	58.3
	Disagree	3	20.0	25.0	83.3
	Strongly Disagree	2	13.3	16.7	100.0
	Total	12	80.0	100.0	
Missing	System	3	20.0		
Total		15	100.0		

The majority of the users agree or strongly agree to the logical nature of the system.

Although the respondents only had a few minutes training and walk through of the voice driven epartogram system, their responses matter a lot and raised issues that I am fairly confident that if addressed correctly could potentially add value to the voice driven epartogram.
Overall, the respondents conceded that the voice driven epartogram could be of value to them if the following issues amongst others are resolved namely; improving the navigation (table 7.19), issues of efficiency (table 7.19), making the application easier to use most of the times, reducing the number of steps it takes to perform an operation (table7.5), allowing the user more option as opposed to short abbreviated words etc.

The entire list of the questionnaires and their respective feedback are listed in the appendix section in a bar chart format for further perusal.

A simple web based application was developed to act as the front end for the data capturing process. The data sets for these simulations were chosen to be from the maternal well-being. Some form of background noise was also introduced while the simulation was going on. Finally, volunteered birth attendants provided user experience feedback after taking part in the simulation.

7.10 Conclusion

We looked at the demonstration and evaluation of the voice driven epartogram as the proposed artefact by way of simulation. The look and feel of the artefact was presented indicating the various components of the fundamental data capturing tool (partogram) and how it has been digitised. All along, the limitation of the speech recognition engine and the background noise interference was raised.

To ensure the validity of the study, the summary section reiterated the simulation process audits supporting pre-conditional steps. A brief look at the philosophical basis for simulation was touched on.

As a final parting shot, the results of the questionnaire left this researcher humbled but at the same time with a feeling of renewed optimism. From observation and more so by the results of the questionnaire, less than 20% of the respondents found the prototype not able to perform optimally in as much as driving the capturing process by voice is concerned. However, this number is slightly higher for those who have spent more time with the system. I am left then with no other choice but to conclude that the fundamental utility of the artefact could not be achieved due to already mentioned reasons.

CHAPTER EIGHT
EVALUATION

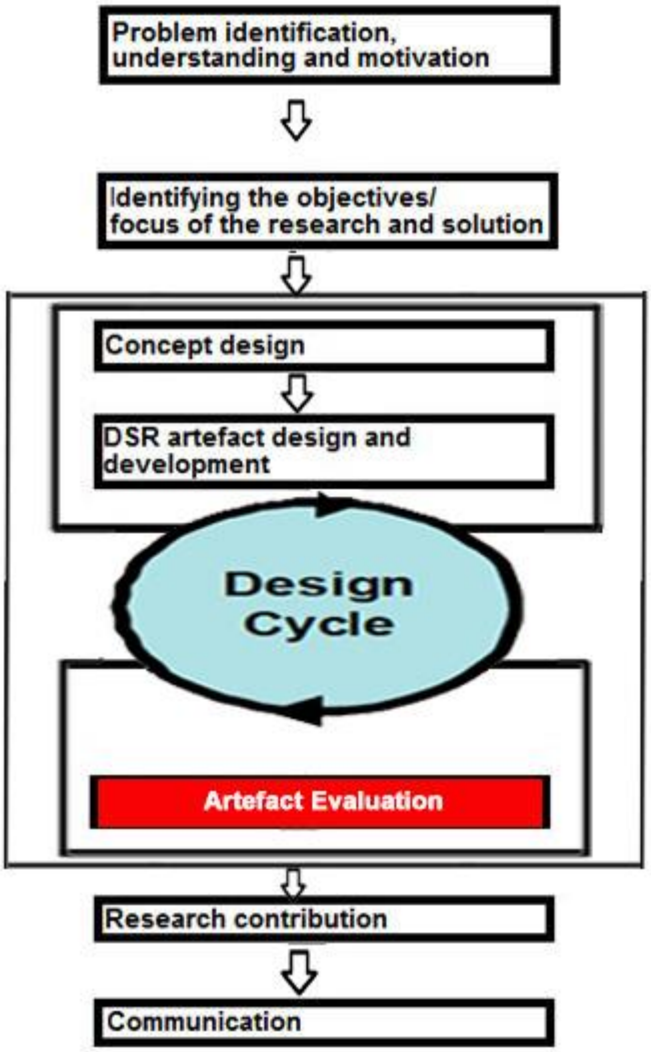


Figure 8: *Evaluation within Design Science*

8.1 Introduction

Within design-based research the DSR artefacts are developed as research tools and the evaluation stage of these DSR artefacts in design-based research is equivalent to the data analysis stage in other forms of research, because these DSR artefacts are viewed as being knowledge containing. DSR artefacts are seen as knowledge containing because: they are constructed with a specific goal in mind; they contain knowledge and insights of the designers and creators as well as a number of assumptions spanning a variety of aspects such as the intended usage, context of use and process of construction. The evaluation aids in assessing if the knowledge was relevant and correctly applied and if the assumptions were correct or not.

This chapter covers the evaluation stage of the research. The evaluation will specifically focus on: the overall solution artefact and will touch on several of the sub-components. In order to manage the bias involved in the evaluation process, where possible both the positive and negative components of any specific evaluation criteria are presented and discussed.
The following section will focus primarily on the evaluation of the overall solution artefact.

8.2 Summary Of Findings

Design Science (or Design Research) has long been an important paradigm within Information Systems research. Its principal difference from other methodologies to research on the ground is the quest of the goal of utility, as opposed to truth (Simon 1996). As outlined in Chapter 2, the design and use of a speech driven data capturing system within the intrapartum environment falls within the domain of Design Science. This chapter explains how both the research process (activities) and artefact (output) constitute part of Design Science and draws upon published guidelines to evaluate the research.

Precisely, following best practice guidelines for research (Hevner et al. 2004), the prototype is presented as an artefact and is assessed against the seven guidelines laid out in their MISQ paper. The case is made that the prototype satisfies the criteria and is both rigorous and relevant, with significance for practitioners and researchers.

8.3 Evaluation In Design Science

When evaluating Design Science research, it is necessary to establish an appropriate set of definitions, guidelines or assessment criteria. Firstly, this is used to ensure that Design Science is the appropriate way to conceive of and evaluate the research effort. Secondly, this set forms the basis of the evaluation proper.

It is important at this juncture to note the distinction between evaluation of the Design Science research (the subject of this discussion) and the evaluation of the artefact itself.
The guidelines chosen for this evaluation are those recommended by Hevner et al. (2004). They offer clear guidelines for understanding, executing, and evaluating the research. It was selected for the following reasons:

- The guidelines specifically address Design Science in an Information Systems research context
- Hevner et al. (2004)'s article was published in MISQ. This journal is one of the leading journal in Information Systems and this paper is widely read and cited,
- The authors have experience in conducting DS research projects and prior publications on the topic,
- The paper is contemporary and reflects current thinking,

- The guidelines provide seven clear dimensions for evaluation, with a number of examples.

Although Hevner et al. (2004) and Hevner (2007) do not represent an absolute consensus within the IS academic community about evaluation of artefact within the IS domain, it is a credible, familiar and useful basis for discussion.

The artefact was developed in Chapter 6 (with a conceptual study) and tested and refined in Chapter 7 (with simulations) with the expressed intention of solving an organisational problem. Specifically, that problem is: “How can a voice driven data capturing system be designed and used within the intrapartum environment?” This problem statement arose from a qualitative analysis of literature review; contextual interviews with student birth attendants; experienced birth attendants and senior midwives, who indicated the existence of a dilemma with the capturing of intrapartum data as well as the fact that it is an *important* and *persistent* problem that requires investigation. As well, it is important to note it is a problem that falls within the domain of IS because it directly involves the planning and use of IS within organisations.

According to Hevner et al. (2004:77), DS deals with the creation and evaluation of IT artefacts intended to solve identified organizational problems. Such artefacts are in a nature that may vary from software, formal logic, and rigorous mathematics to informal natural language descriptions.

The approach to solving the problem consisted of asking prospective users within the intrapartum environment such as student midwives, birth attendants and senior midwives about the form a solution to such a problem would take; investigating a wide range of “kernel theories” (or reference theories) and applying skill, knowledge and judgement in selecting and combining them; and undertaking a rigorous testing/refining process of the initial conceptualisation.

To reiterate, one of the goal of this research project is to demonstrate utility. In this context, that means the artefact is likely be valuable for organisations because it allows for a hands free voice driven data capturing of data within the intrapartum environment. A solution that requires infeasible pre-conditions in the problem domain (in terms of time, prerequisite technology, human resources or other resources) will not have this utility.

This project is research, as opposed to a design project, because the principles of the resulting artefact contribute towards the knowledge of a novel design that is useful to midwives in a real-life situation; insights in their practices when recording data on a partogram; insights in the possibility of releasing their hands and eyes from physical data recording; as well as knowledge about how to involve users in the design process in a highly sensitive and complex work environment. These insights can contribute towards generic principles for similar designs so that it can be applied to a wide range of hospital settings and situations. It also has a degree of evaluative rigour and reflection that exceeds what is required for a one-off design effort.

The artefact is an instantiation of a design in a practical setting but also comprising of a prototype framed in theory.

> *"IT artefacts are broadly defined as constructs (vocabulary and symbols), models (abstractions and representations), methods(algorithms and practices), and instantiations (implemented and prototype systems)"*(Hevner et al. 2004:336).

It is worth noting that other authors, such as Walls et al. (1992) and Gregor and Jones (2007), regard the abstract artefacts (constructs, models and methods) as a special kind of artefact, dubbed as an Information System Design Theory (ISDT):

Authors such as Gregor and Jones (2007:322) suggest that artefacts could be products (e.g, a database) or methods (e.g. a prototyping methodology) because the word "design" is both a noun and a verb. A theory therefore could be about both the principles underlying the form of the design and also about the act of implementing the design in the real world (an intervention).However, the broader sense of artefact, which encompasses "IS design theory", will be used here as recommended by Hevner et al.(2004).

As stated above, the artefact is an Instantiation .Instantiations show that constructs, models, or methods can be implemented in a working system. They demonstrate feasibility, enabling concrete assessment of an artefact's suitability to its intended purpose. They also enable researchers to learn about the real world, how the artefact affects it, and how users appropriate it. (Hevner et al. 2004:341).

According to Hevner et al. (2004:349), artefacts constructed in design science research are not meant to be full-size information systems that are used in practice. Instead, they are innovations that define the ideas, practices, technical capabilities, and products through which the analysis, design, implementation, and use of information systems can be effectively and efficiently accomplished. This is the case in this study where the electronic partogram is a novel solution for a problem experienced in the intrapartum environment when midwives capture data on a partogram.

The primary purpose of a proof of concept or artefact instantiation is to demonstrate the feasibility of the research process and the product (prototype). In this case, the feasibility of the research process is argued for by the existence of the prototype itself (i.e. the process did produce a product). Further, feasibility of the prototype is demonstrated by noting that the input measurements are either common organisational parameters (e.g. maternal condition) or have been derived from the real datasets sourced for the simulations (e.g. temperature). Whether these are likely to be useful or not is discussed in Section 8.4.

This research project has all the elements required to constitute Design Science research: It identifies an existing, important, persistent, unsolved Information Systems problem. The proposed solution is a novel artefact informed by reference theories, intended to be used by practitioners in solving their data capturing problems. The steps of requirements-gathering, solution design and testing/refinement constitute the construction and evaluation phases identified in DS research. It is of sufficient abstraction and rigour that its product (the prototype) can be applied to a wide range of organisational settings and situations.

8.4 Presentation Of Prototype As An Artefact

The prototype is conceptualised in Chapter 5, which involves elucidating and applying the relevant "kernel theories" to the broad organisational situation mapped out during the context interviews (Chapter 4). This results in the broad constructs, candidate measures and boundaries for the prototype. In Chapter 7 (Simulations), the speech recognition aspects are "fleshed out", new measures are derived, tested and refined, the sequence of steps clearly articulated and a simple "tool" (system) is provided for birth attendants to use. The resulting prototype is articulated below.

The prototype takes an organisational-wide view of data capturing with the following actors in mind namely: mother/foetus, birth attendants, their managers/senior midwives and referral processes.

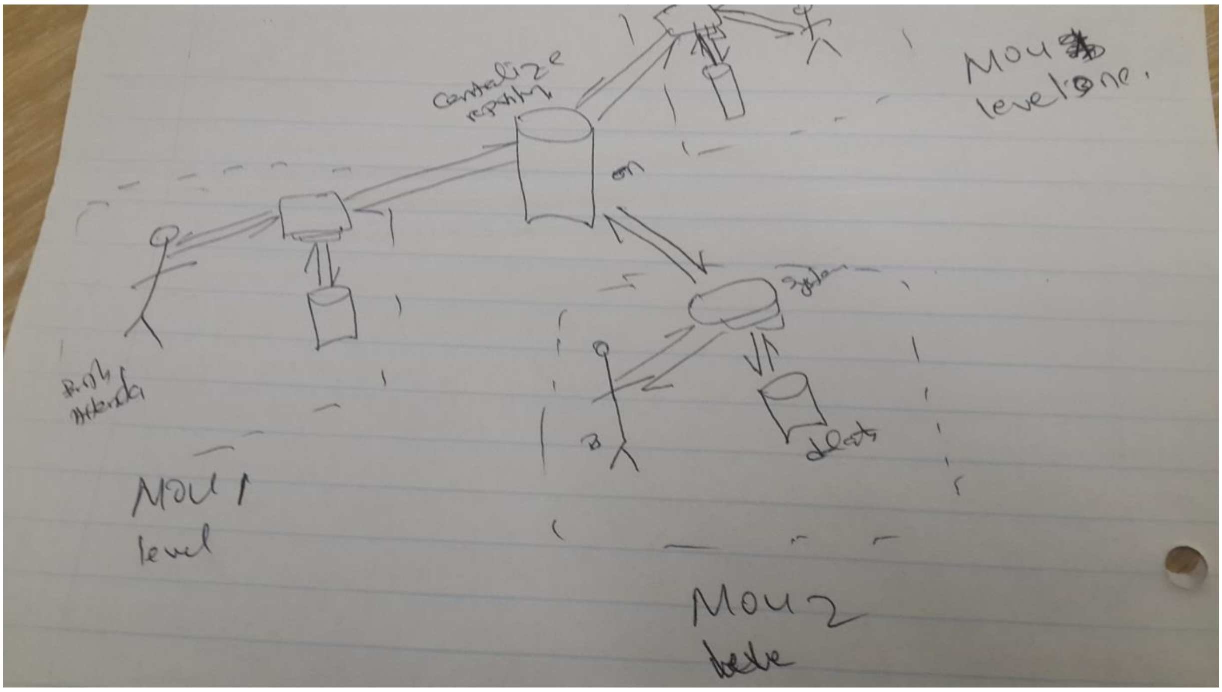


Figure 8.1: *An initial design of a High-level communications between MOU's*

As shown in figure 8.1a, the prototype depicts that there is one system within each level one MOU. Users within each MOU capture data using the speech recognition engine embedded in Windows 7 onto their respective in house database. It is this captured data that is reflected on the partogram. On referrals, the patient's data gets copied securely onto the central repository on the clouds which then becomes accessible to the referred higher level MOU.

Figure 8.1b below further describes the communications between MOU's. It also depicts the current state in data capturing as well the various desired states. As a matter of fact, it is an extension of the theoretical model with intra MOU communication indicated

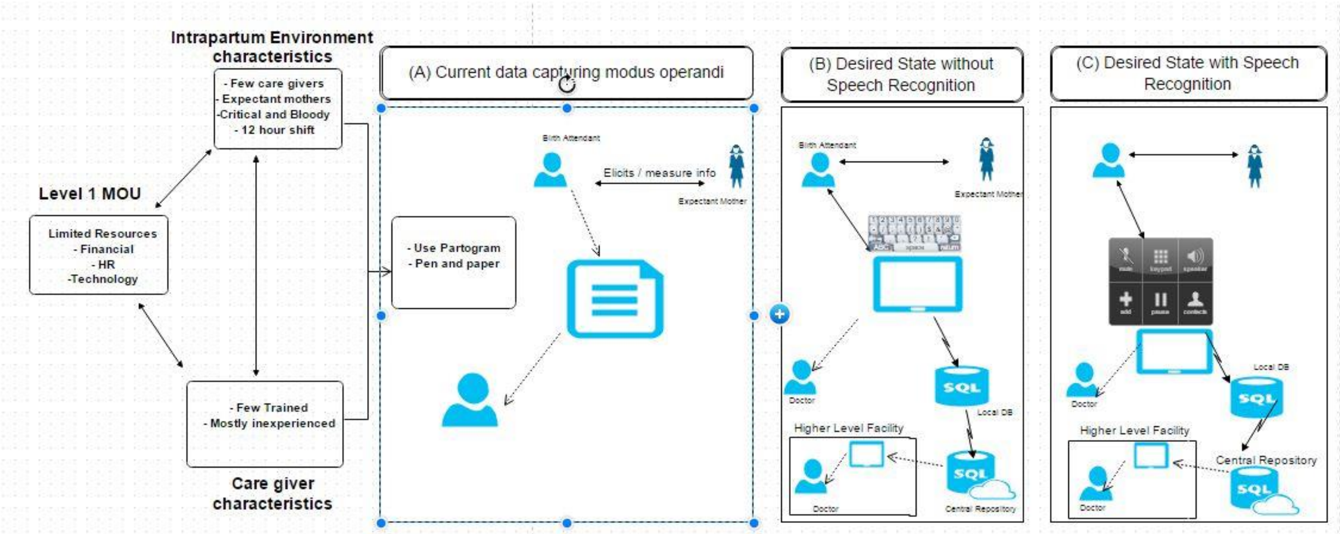


Figure 8.2: *Intra-MOU communication*

Avison and Fitzgerald (2002)'s Framework for Comparing Methodologies (slightly modified) is used as an outline to summarise this prototype

8.4.1 Philosophy

a. Paradigm

The underpinning philosophy in this research is pragmatic research. The purpose of building and evaluating this prototype is based on end-user birth attendants' perceptions of its utility in practice.

b. Objectives

The prototype is focused on developing a hands-free data capturing system and to a certain degree the sharing of the captured data with a participating third party.

c. Domain

Here, the domain addressed by the prototype is at the level of organisational capturing of intrapartum data.

d. Target

The kinds of organisations targeted are level one MOU where there is a limitation on the number of resources but more specifically those situated within the Cape Metropole.

8.4.2 Model

Figure 8and 9 above expresses the model of the prototype. It is made up of a high-level view of the intra-MOU processes.

8.4.3 Techniques and Tools

The principle technique expressed here is the measurement of the performance of the system in capturing intrapartum data.

8.4.4 Scope

The prototype's method begins with a review of the organisation's set of data element that needs capturing and looks at how it is normally captured. It ends with a hands-free system that could add value to the capturing process.

This system could be used to capture intrapartum data hands-freely without the uses of hands and paper.

8.4.5 Outputs

The key outputs of the prototype are 1) a hands-free approach at capturing data; and 2) a generic system that allows data capturing and to a certain degree, the sharing of captured data with participating higher level MOU in cases of referral.

This section has outlined the conceptual *constructs* and sequence of *method* steps for the prototype. The next section applies the chosen guidelines for evaluating the research.

8.5 Assessment Guidelines

This section applies the Design Science evaluation guidelines from Hevner et al. (2004) to the research project. The goal is to show how the research (including the process and the product) satisfies each of the criteria.

8.5.1 Design As An Artefact

"Design-science research must produce a viable artefact in the form of a construct, a model, a method, or an instantiation" (Hevner et al. 2004:347).

As outlined in Section 3 above, the artefact is a *prototype*. The viability of the artefact is claimed in the fact that it can be instantiated and used in a problem domain. Further, its feasibility is argued from the point of view that real intrapartum data sets could be captured using the prototype.

8.5.2 Problem Relevance

The objective of design-science research is to develop technology-based solutions to important and relevant business problems (Hevner et al. 2004:347). This question of problem relevance is discussed in chapter 2. The literature review, interviews with midwives, birth attendants and student nurses identified the data capturing dilemma within the level MOU within the Cape metro. Within the above unit of analysis, there arises a notion that the problem is persistent, widespread – and largely unsolved.

8.5.3 Design Evaluation

The utility, quality, and efficacy of a design artefact must be rigorously demonstrated via well-executed evaluation methods (Hevner et al. 2004:347). The specific evaluation of the key elements of the prototype is the simulation study (Chapter 6). According to Hevner et al. (2004) there are many types of experiments and simulation is a typical example. With simulations, the researcher executes the artefact with "artificial data". Here, the artefact is executed with "synthetic data": real data with "artificial noise" added to it. Hill (2010) concurs that in this way, the behaviour of the model (relationship between different parameters and measures) can be explored.

Chapter 3 (Research Design) explains how this is the most suitable method for evaluating the artefact since access to a live intrapartum environment is neither feasible nor practicable due to the private and sensitive nature of the environment. This constraint eliminates case and field studies and is thus not the objective of this research project to establish such. However, the goal of rigour (especially internal validity) requires that the underpinning voice driven, electronic capturing and hands-free assumptions be tested. Purely descriptive approaches would not test these: the prototype must ultimately be given a chance to fail. Reproducing “in the lab” the conditions found in the external-world is the best way to do this, providing sufficient care is taken to ensure that the conditions are sufficiently similar to invoke the intended generative mechanisms.

As is the norm with Design Science research, the evaluation and development cycles are carried on concurrently. Hevner et al. (2004) note that *“[a] design artefact is complete and effective when it satisfies the requirements and constraints of the problem it was meant to solve*” (Hevner et al. 2004:352). In this context this means that a suitably-trained birth attendant can use the prototype in a problem environment and efficiently capture intrapartum data without the usual encumbrances.

8.6 Research Rigour

Design-science research relies upon the application of rigorous methods in both the construction and evaluation of the design artefact (Hevner et al. 2004:347). The rigour of this research project relates to the processes involved in carrying it out and how the processes impact upon the subsequent claims to knowledge. In Chapter 2 (literature review), the research project determined the nature of the problem, requirements and constraints for any proposed solution. This research follows prescribed qualitative sampling, data capture and analysis methods. Chapter 6 (Simulations) engaged cautious investigational measures to diminish the likelihood of unplanned mechanisms meddling with the entity under study. In both cases, adequate detail is provided to allow subsequent researchers to recreate (and so verify through replication) the outcomes, or to make a valuation as to their scope, applicability or validity.

In the conceptual work, rigour is applied in the design of the overall study in the selection of pragmatic research as a unifying philosophical position and the adoption of Design Science to describe and evaluate the study. The literature review (Chapter 2) draws upon prevailing knowledge bases and create a prototype from them. This chapter (Evaluation) involves pondering on the research as a whole, how its fundamental parts fit together and how it fits within a broader knowledge base.

During the research project, the expressed ethical values were upheld, adding to the rigour of the process. These values include, for example, fair and honest dealings with research participants and stakeholders and academic integrity in acknowledging other people’s contributions and reporting adverse findings.

8.7 Design As A Search Process

> *"The search for an effective artefact requires utilizing available means to reach desired ends while satisfying laws in the problem environment" (Hevner et al. 2004:347).*

The prototype can be thought of as the outcome of a broad exploration process. The conceptual study (Chapter 5) analyses a varied array of contending ideas from engineering, economics and philosophy (introduced in the Literature Review, Chapter 3) and creates an appropriate sub-set of them into an expansive draft, the conceptual prototype. This is additionally polished over and over by means of Simulations (Chapter 6) to yield the constructs, models and method that encompasses the prototype. Doing so requires the judicious selection of test intrapartum data to be captured by speech. Throughout, the constraints of the problem domain (intrapartum environment within an MOU) are kept in mind.

Understood in this regard, the prototype is a "satisficing" solution (Simon 1996) to the problem of capturing of intrapartum data by speech and hands-freely. In particular, the use of windows speech recognition engine which is robust, cheaper and readily available on Windows computers constitutes a pragmatic approach to the problem.

8.8 Conclusion

This chapter considered the design science research approach and motivated it as an appropriate research methodology to be used for this study. Its various sub components such, evaluation of artefact, and presentation of a prototype as an artefact were demonstrated. Importantly, the guidelines for carrying out design science research were delineated. Furthermore, design as a search process is portrayed.

CHAPTER NINE

RESEARCH CONTRIBUTION AND COMMUNICATION

9.1 Introduction

This chapter does not simply present the research findings and contributions, but further attempts to provide reflection and insight in regard to a number of areas touched by the research, specifically in terms of the literature, the research process and methodology and the research findings.

Some of the research findings were produced by the initial literature review conducted as part of the research process and research area contextualisation, the development of the research and finally the design and development process itself produced a fair number of findings in regard to the problem and solution domain.

9.2 Research Contribution

> *Effective design-science research must provide clear and verifiable contributions in the areas of the design artefact, design foundations, and/or design methodologies. (Hevner et al. 2004:347)*

The principal research contribution is the prototype, encompassing the constructs, models and method. Hevner et al. (2004) specify that “the artefact must enable the solution of heretofore unsolved problems. It may extend the knowledge base … or apply existing knowledge in new and innovative ways”. They suggest looking for novelty, generality and significance across the artefact itself (research product), “foundations” (theory) and methodology (research process).

Firstly, this prototype enables the capturing of intrapartum hands-free and wirelessly and allows the capturing to be done with voice. This problem is important, widespread, persistent and an unsolved problem within the intrapartum environment within the level one MOU. While this may have direct applicability within my specific unit of analysis, it may also prove useful to research, in that it provides a generic, theoretically-sound basis for understanding and to a certain degree measuring the complexity involved in automating intrapartum data capturing and driving it by speech. The utility or lack thereof of the artefact as elicited from the birth attendants through the evaluation process has been demonstrated in the concluding section of chapter 7.

The literature provided numerous frameworks and guidelines for conducting design science research. Quite a large number of these frameworks and guidelines appeared to be similar to

what we know as conventional software development life cycles (SDLC). However, the authors of these frameworks rarely mention these commonalities nor refer to any particular software development methodology while discussing their particular framework or guideline for conducting DSR.
This lack of reference to the SDLC or any particular software development methodology seemed fairly odd, since DSR in most cases involves both the design and development of components / artefact and the various available software development methodologies influence the design and development process differently. The development phase of this research was conducted using the agile software development approach. An agile approach was preferred by the researcher and further deemed to be relevant to the research being conducted. The relevance of an agile approach is because it assumes that all requirements cannot be known upfront and that as the development process continues, new insights will be gained and the design and requirements will most likely have to change in order to meet these requirements. This was important because of the nature of the design-based research being conducted. DSR sees the process of design and development as a knowledge generation process whereas a development approach such as the waterfall model assumes that all requirements can be elicited upfront and that the problem being addressed can be fully explored and understood before design and development.

Finally, the creative development and use of evaluation methods (e.g. experimental, analytical, observational, testing, and descriptive) and new evaluation metrics provide design-science research contributions. As suggested by Hevner et al. (2004), measures and evaluation metrics in particular are crucial components of design-science research.

Lastly, from a methodological perspective, the use of pragmatic as a philosophy to underpin hybrid (qualitative and quantitative) research focused on designing a prototype is a contribution to the academic knowledge base. Using pragmatic concepts like "generative mechanisms" to articulate and explain both the simulations and contextual interviews meant that a unified approach could be taken to analysing quantitative and qualitative data.

Figure 28 below demonstrates the contributions of the literature review and the ethnographic study (contextual interview and observation). The figure shows how the literature review and ethnographic study contributed to the various phases in the DSR methodology and attempts to show the importance of understanding the research problem, research context and the research area (the ethnographic data) and the value of conducting DSR on a strong foundation of academic literature / knowledge.

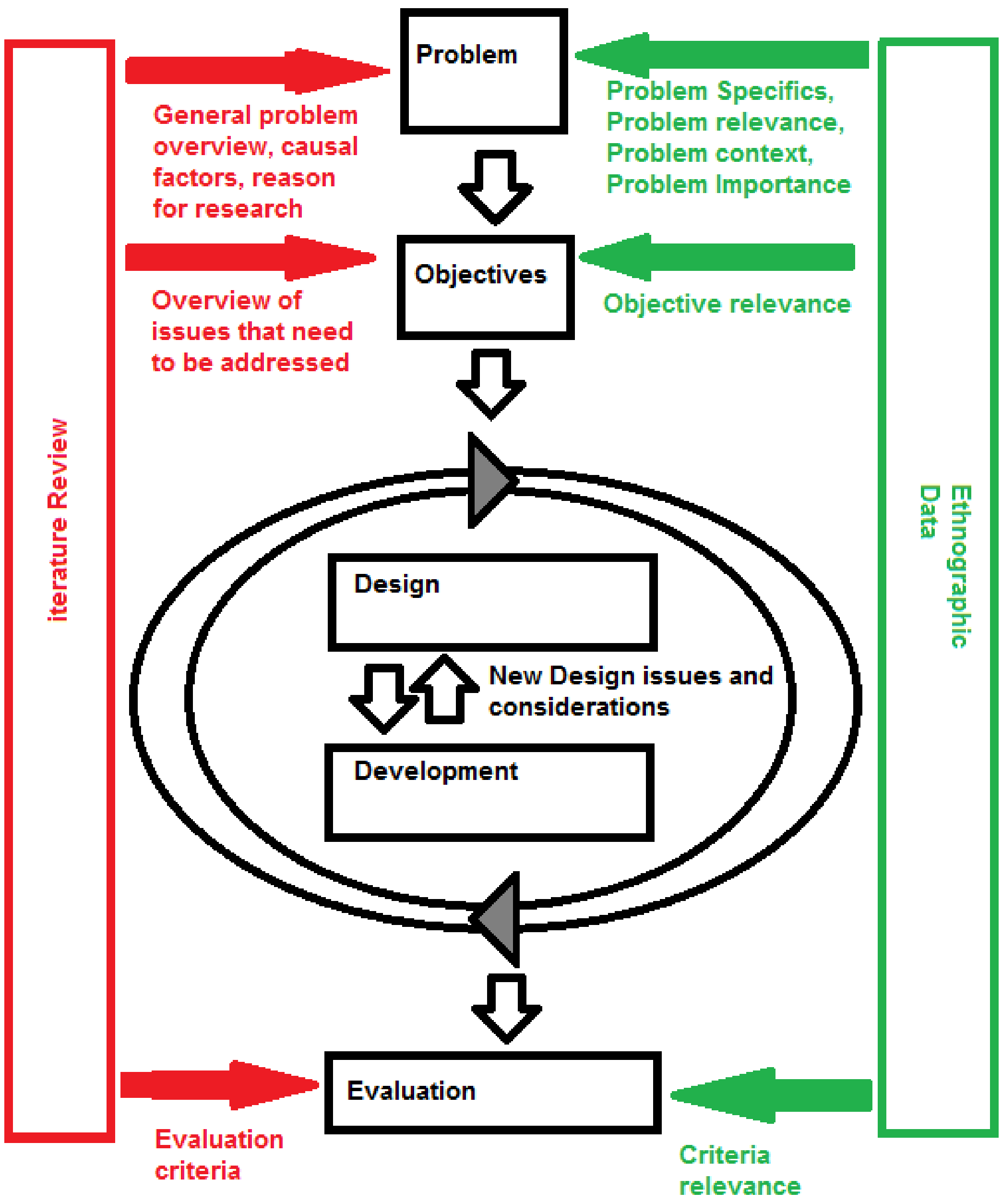


Figure 9.1: *Contributions of the literature and ethnographic (contextual interview) data to the design and development. Adapted from Van der Watt (2011)*

9.3 Research Communication

> *"Design-science research must be presented effectively both to technology-oriented as well as management-oriented audiences"* (Hevner et al. 2004:347).

Chapter 2 (Research Design) elucidates why, at this juncture of the research, it is not practicable to present the prototype to practitioners within the intrapartum environment to evaluate its effectiveness or how readily it could be applied.

So, as a piece of academic study, the prototype is presented to an academic audience for the purpose of adding to the knowledge base. (See "Research Contributions" above.) There is sufficient detail in the presentation of the constructs, models and method to allow researchers to test the capturing of intrapartum data by means of speech in order to verify the reported results and extend or further refine the artefact. The prototype offered above could be assessed with the option of deploying it within a specific level one MOU, providing the birth attendants an improved data capturing mechanism.

Birth attendants are the intended beneficiaries of this prototype. For them, the prototype can be treated as a “black box”, whereby intrapartum data is communicated and the data gets captured into the database and displayed on the partogram. As well, the prototype also acts as a referral mechanism. These goals emerged during the contextual interviews (Chapter 4) with birth attendants and student nurses, as well as, they participated with guiding requirement elicitation for the development and modification of the prototype.

This segment has considered the research process and product against the seven DS guidelines advanced by Hevner et al. (2004). The research is found to meet the criteria for DS as it has the requisite features or elements:

- created an artefact (the prototype with its constructs, models and method);
- that tackles an important, widespread and persistent problem (speech driven intrapartum data capturing);
- through a development cycle (conceptual study and simulations);
- with a rigorous evaluation of the artefact (simulations);
- which draws upon and adds to the knowledge base (Information Theory); and
- resulting in a purposeful, innovative and generic solution to the problem at hand.

9.4 Conclusion

Chapter nine considered the research contribution and research communication. In a nutshell, it does not simply only present the research findings and contributions but further attempts to provide reflection and insight in regard to a number of areas touched by the research, specifically in terms of the literature, the research process and methodology and the research findings.

It furthermore attempts to do two things recommended by Hevner et al. (2004) namely: that effective design-science research must provide clear and verifiable contributions in the areas of the design artefact, design foundations, and/or design methodologies as well as that design-science research must be presented effectively both to technology-oriented as well as management-oriented audiences.

Finally, the challenges involved in developing a natural speech driven system and the impact of such challenges in the outcome was appreciated as demonstrated in the preceding chapters especially chapter 7. Thus, the utility of the speech driven epartogram was greatly restricted.

CHAPTER TEN

CONCLUSIONS

10.1 Overview of Chapters

This research project consists of 10 chapters. The first and introductory chapters detail the research problem, motivation and research question. This introduction is later expounded and refined much later in chapter 3.

The literature review forms the second chapter and this is in accordance with the generic thesis structure. The literature review presents and discusses the academic literature which was deemed relevant to the research. The literature review looks at literature on intrapartum environment, data capturing, the use of partogram, IT infrastructure, health informatics etc. The justification and motivation for the research within the academic literature is also depicted. Further the literature review provides a source for the technological due-diligence providing a solution to design and development issues and questioned. Finally the literature also provided details and information for the research.

Chapter number three delineates the research design and details of the research process and surrounding topics. This chapter describes the research problem, the research question and objectives, the research methodology, ethical concerns of the research, research rigour, the scope of the research and how research data will be gathered and evaluated.

True to the DSR methodology, chapter four corresponded to the Problem Identification, Understanding and Motivation also known as the first phase. In order to achieve to identify, understand and motivate, contextual interviews were carried out at the target facilities.

The fifth chapter corresponded to the second phase of the DSR methodology, the identification of the Research Focus and Objectives. This chapter makes use of the findings from the literature review and the contextual interviews to provide general objectives for both the research and the DSR artefacts that were developed as part of the research.

Chapter 6 encompasses 2 related phases of the DSR methodologies, specifically the conceptual design phase and the design and development phase. Chapter 6 details the process of creating initial solution concepts, creating more concrete designs and the process of instantiating the designs.

Chapter 7 demonstrates the instantiation and simulation of the design created and detailed in Chapter 6. Primarily the demonstration of the instantiation involved detailing and showing the UI components of the solution, going through the various UI and discussing the purpose of a particular interface. To provide a detailed demonstration of the instantiation and simulation the chapter also covers some of the more technical design aspects.

Chapter 8 corresponds to the fifth phase in the DSR methodology, the evaluation. The evaluation involves evaluating the artefacts created during the research process using criteria originating in the academic literature, but supported by the ethnographic findings emanating from contextual interviews and observation. The evaluation only encompassed a handful of artefacts including: the overall solution artefact, the epartogram structural model and the usage and product of using the solution artefact.

Within Chapter 9 the overall research is reflected on and the primary research contributions are identified. Chapter 9 deals with the research contribution and research communications.

10.2 Summary

There exists a scarcity of resources within the level one MOU within the Cape Metropole. These resources might include but are not limited to human resources, financial resources, technological resources etc. The capturing of intrapartum data and provision of care to both expectant mother and foetus poses a dilemma as the birth attendant's attention is split between capturing of much needed intrapartum data and the provision of care (primary responsibility of the birth attendant). The limited availability of resources for this tandem activity engenders an overall low quality output for both of the activities.

The artefact (prototype) developed and evaluated in the preceding chapters offers the birth attendant and respective partners within the level one MOU, as well as a participating (for referral) higher level MOU, a tool with which to capture data by speech and to a certain extend exclude the use of hands and paper and thus possibly increases quality of care and intrapartum data captured. Further, this prototype allows the easy referral of patients from one MOU to another thus ensuring that less time is spent on data capturing and referral. This is quite critical as the referral process normally involves a good amount of time over the telephone to get the ambulance to fetch the patient to a participating higher level MOU. The artefact also acts as an early warning system, providing the possibility of qualified caregivers at a higher level MOU to get advanced warning and view the expectant mothers partogram remotely.

The research process followed a Design Science approach, underpinned by a Critical Realist philosophy. Here, the prototype was cast as an artefact with utility as the goal. Motivated by a series of practitioner interviews, this artefact was developed through a theoretical study. This was followed by a quantitative investigation using simulations which provided further detail and empirical support. Finally, the prototype was successfully evaluated against a leading set of guidelines from the field of Design Science.

10.3 Research Findings

According to the United Nations, the maternal mortality ratio in developing regions is still 14 times higher than in the developed regions and to mitigate this disparity, much effort has been put into the safety and well-being of mother and child as espoused by the MDG (millennium development goal) number 5. The objective of MDG number 5 had been to reduce by three quarters, between 1990 and 2015, the maternal mortality ratio. To this end, the maternal mortality ratio dropped by 45 per cent between 1990 and 2013, from 380 to 210 deaths per 100,000 live births. There has been some improvement but accelerated interventions are required in order to meet the target.

While there is a significant decrease in overall maternal mortality, it does mask widely differing rates of improvement in different regions and countries. Between 1990 and 2010 maternal mortality fell by 66% in Northern Africa but only by 41% in sub Saharan Africa. The need for better access and improved maternal health services is particularly great in rural areas of sub Saharan Africa. These rural areas are characterized by a scarcity of resources inter alia technological, human resource, financially. Maternal mortality represents the single greatest health disparity between high and low income countries / regions / health facilities Gans-Lartey et al. (2013). This inequity is especially felt again in low income countries and regions in sub Saharan Africa and Southeast Asia where 99% of the global burden of maternal death is borne. A critical skill is ongoing intrapartum monitoring of labour progress and maternal / fetal well-being. The WHO (World Health Organization)'s partogram was designed to assess these parameters. A partogram is a data capturing tool used to improve monitoring of labour progress, maternal and foetal well-being. This partogram enables birth attendants to plot examination findings from their assessments of the expectant mother and foetus onto it.

The partogram provides birth attendants and other intrapartum care professionals with a pictorial overview of labour progress, maternal and foetal condition. This pictorial view allows early identification and diagnosis of pathological labour. Its use is critical in preventing maternal and perinatal morbidity and mortality. The use of these partograms by birth attendants ultimately reduce the cumulative quality of care provided and data captured as a result of duelling on both of the activities concurrently.

A series of semi-structured interviews with practitioners was required to assess the current state of data capturing within the level one MOU and to capture the intended requirements of the prototype. This involved interviewing intrapartum healthcare professionals (Senior midwife, midwives and student nurses) with varying ranges of backgrounds and experiences, for 30 minutes to 45 minutes (over a period of six months) about their experiences with intrapartum data capturing.

10.4 Research Questions answered

This Section revisits the research questions and attempts to provide a deeper understanding of how these questions were addressed in the research and why.

What are the contextual implications for designing a hands free data capturing system for the intrapartum environment?

To better understand the contextual implication which influenced the design and development, the literature provided a good starting point but was not satisfactorily exhaustive and appropriate enough and thus an ethnographic study (contextual interviews and observation of simulations) was conducted to add an impetus to the findings of the literature review.

The ethnographic study provided not only the context for the design process but also provided a deeper understanding of the intrapartum environment, intrapartum data and capturing methodology, information which in turn heavily aided in focusing and guiding the design process.

From this it is concluded that the contextualisation and using an ethnographic study were the most effective means of addressing this question.

What unique design issues are necessary to consider for this specific problem?

During the course of this research project, a number of issues that directly impact the design consideration were identified. Due to the low cost nature of the target environment, hardware might be difficult to acquire. Thus, only minimal and low cost apparatus can be considered during the design phase of the study. This prototype might need to be accessed on mobile, desktop and tablet devices thus necessitating an agnostic approach to make it device and platform independent. Lastly, the end user proficiency is an added design consideration to factor. A complex and bulky artefact might be cumbersome and time consuming to learn and navigate, thus such considerations are major factors.

How can the appropriate design considerations for a hands free data capturing tool be identified within a research process?

In order to understand the design considerations of a hands-free data capturing tool, it was deemed that the most appropriate means was to actually design such a system. But clearly differences exist between the research process and design and development process.

The literature offers a means of bridging the gap between research and design / development, specifically DSR which is detailed in Chapter 3, Section 3.5. However, the literature presented numerous different DSR-based methodologies, but none met the requirements exactly.

From the above, the research concluded that the best means of discovering the appropriate design considerations was to use a DSR based methodology which was an amalgamation of the existing methodologies, taking from these methodologies the most relevant and meaningful phases, as detailed in Chapter 3 Section 3.7.

What are the characteristics of hands-free speech driven partogram used by birth attendants within the intrapartum environment?

To better understand and quantify the utility of the artefact, it was deemed necessary that the characteristic of the speech driven system should at least be delineated. Ultimately the following characteristics were imbued namely: the modus operandi of manual capturing of intrapartum data by birth attendants, issues regarding the capturing of intrapartum data electronically, wirelessly, hands-freely. The possible use of the prototype (voice driven epartogram) as a referral tool for participating MOU's.

10.5 Future research

By defining and limiting the overall scope and focus of the research, it ensures that the research does not grow too large and beyond the control of the researcher Van der Walt (2012). In such a situation where the scope is too broad there is the possibility that too many questions might arise and too many variables might need to be taken into account. A limited scope provided necessary focus for the research and ensured that key priorities could be achieved.

The scope of the research was specifically focused toward understanding what was required to design an adequate hands-free intrapartum data capturing application. The research specifically focused on the technical components. It was decided to focus only on the technical components of the research because the human components such as the user interface or the user's interaction with the system would have made the scope too wide to manage easily, because these aspects could easily constitute their own research undertaking.

For that reason, possible future research could look into the design of the user interface and user interaction. Ideally this potential path of research could draw on the current research allowing it to focus primarily on the design aspects of the user interface or user interaction components.

More future research is also needed in as much as speech recognition is concerned. Background interference seems to be a major limiting factor to speech recognition. Further research into this area is thus necessary to see if there are newer and better speech engines that could minimize or eliminate the background noise.

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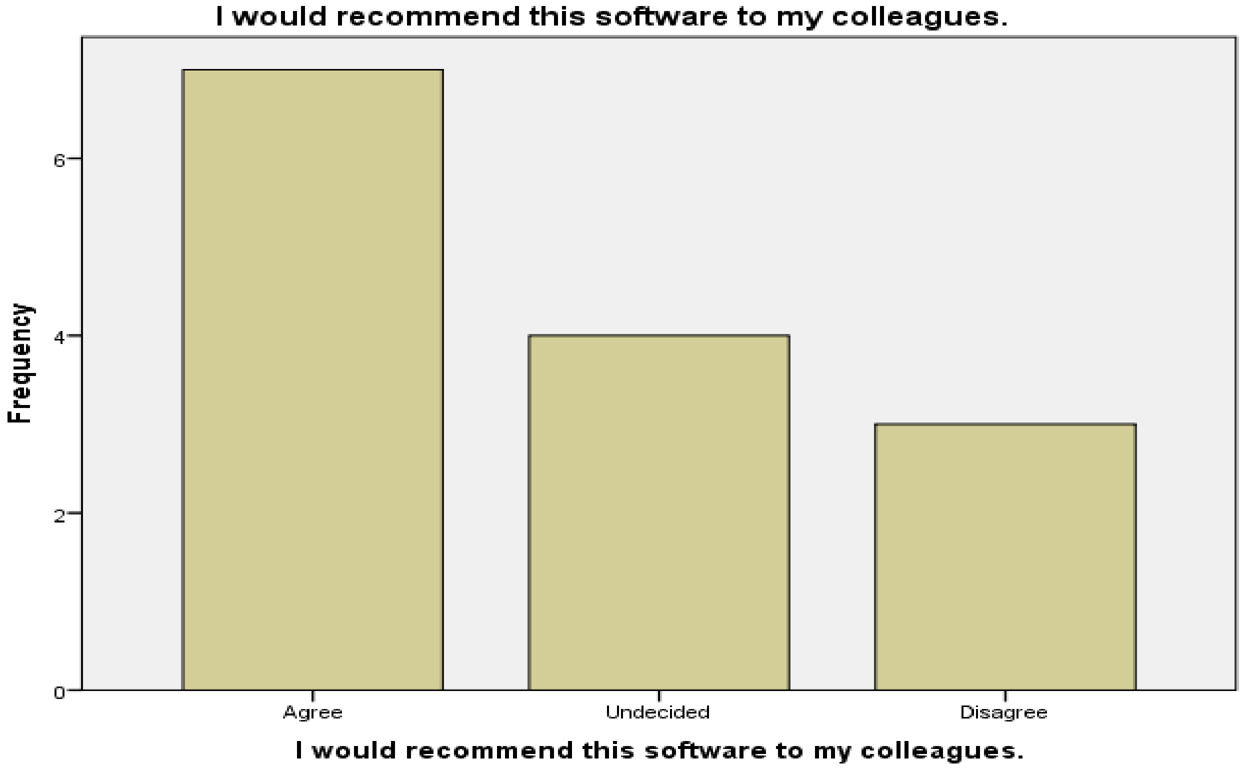
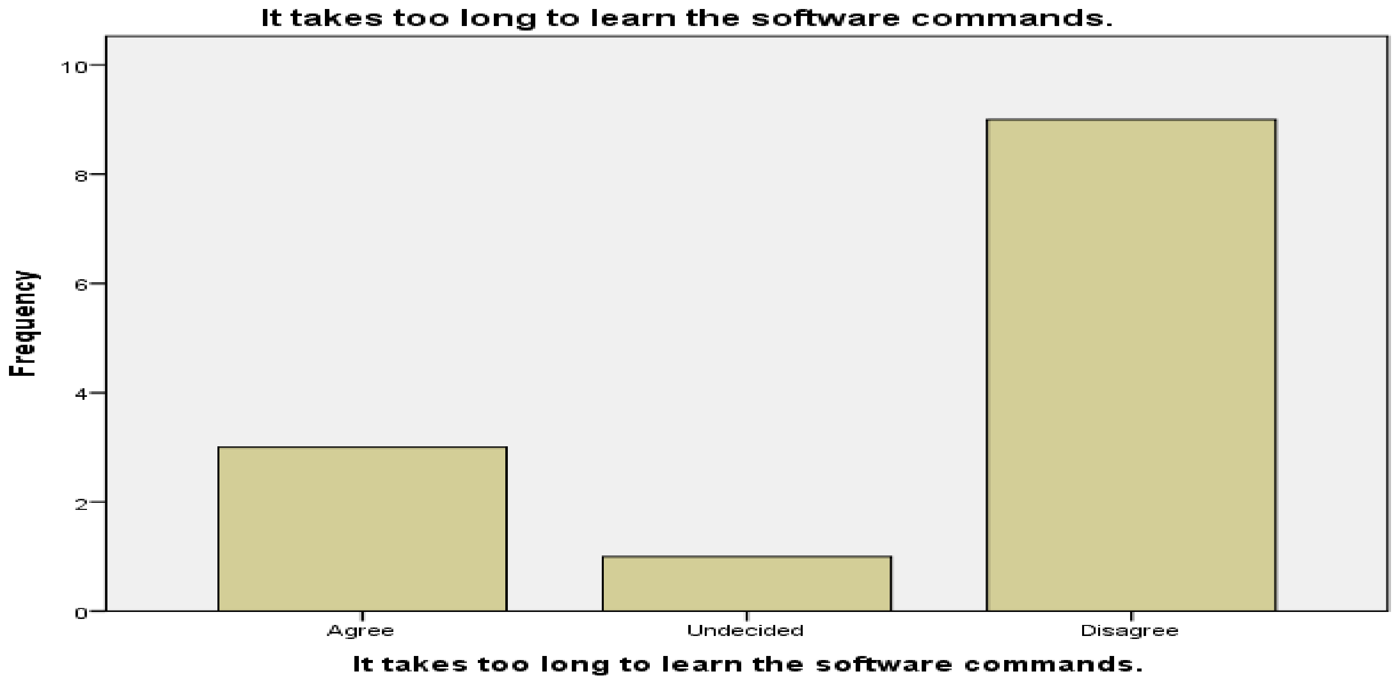
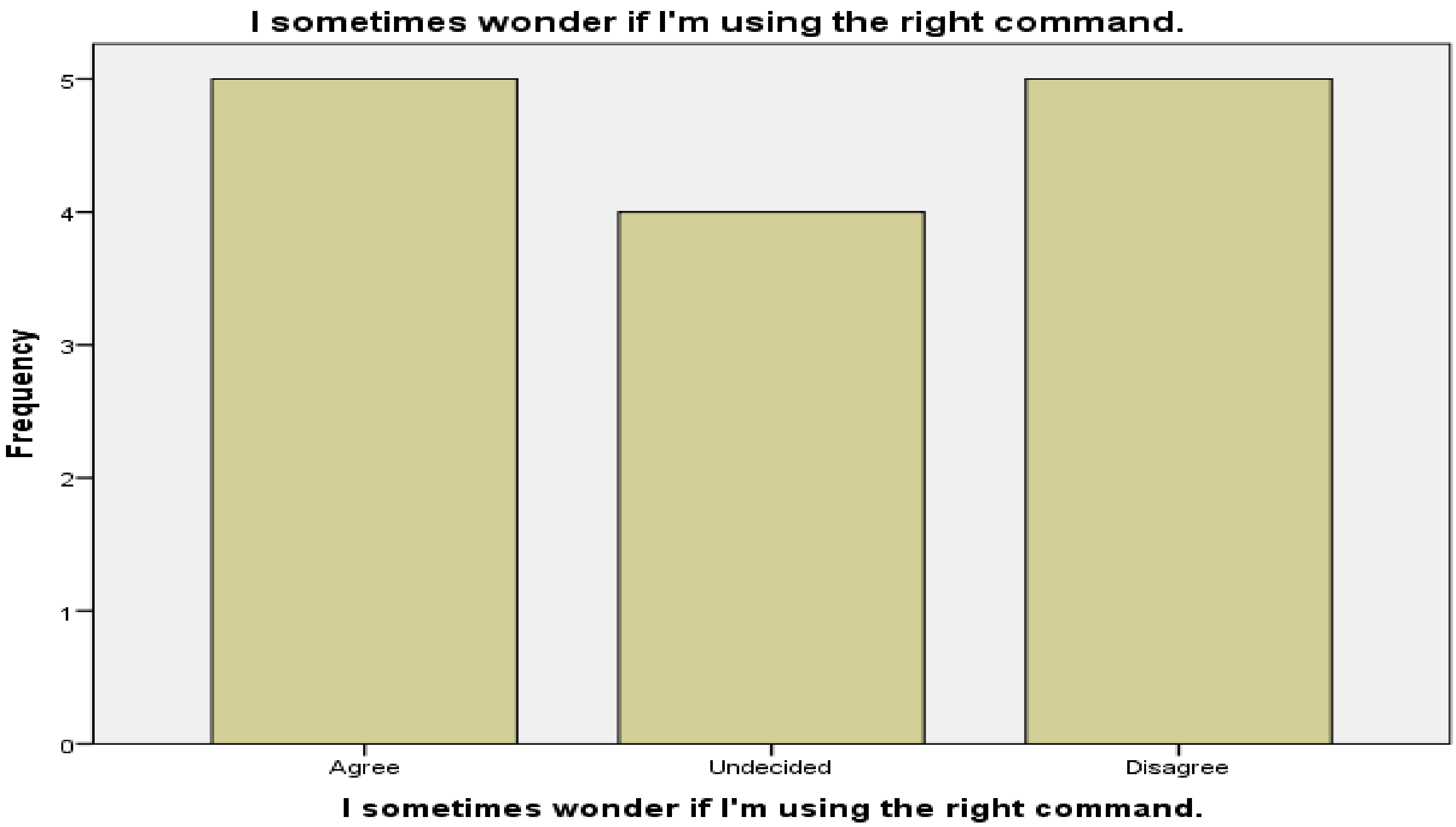
APPENDICES

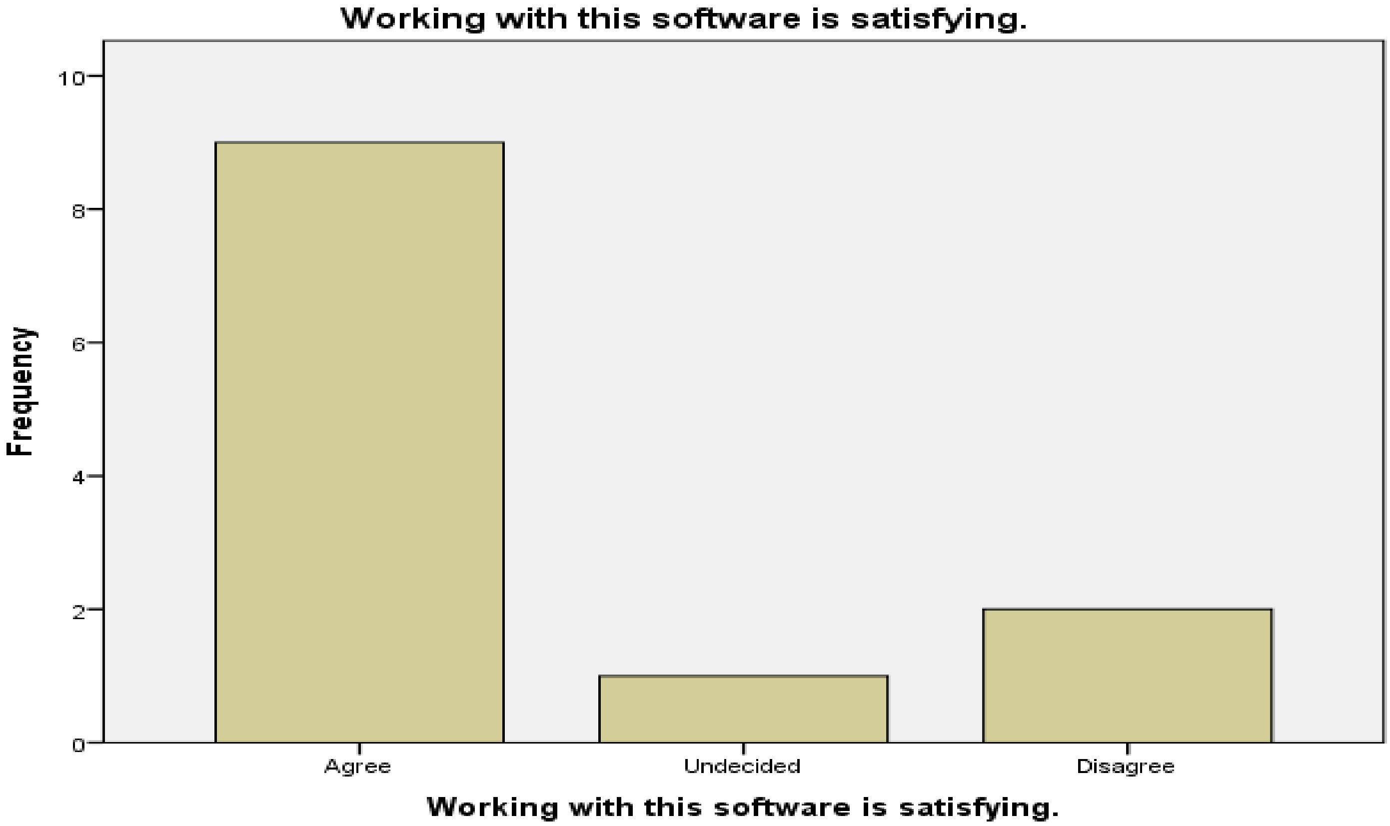
Questionnaires and responses

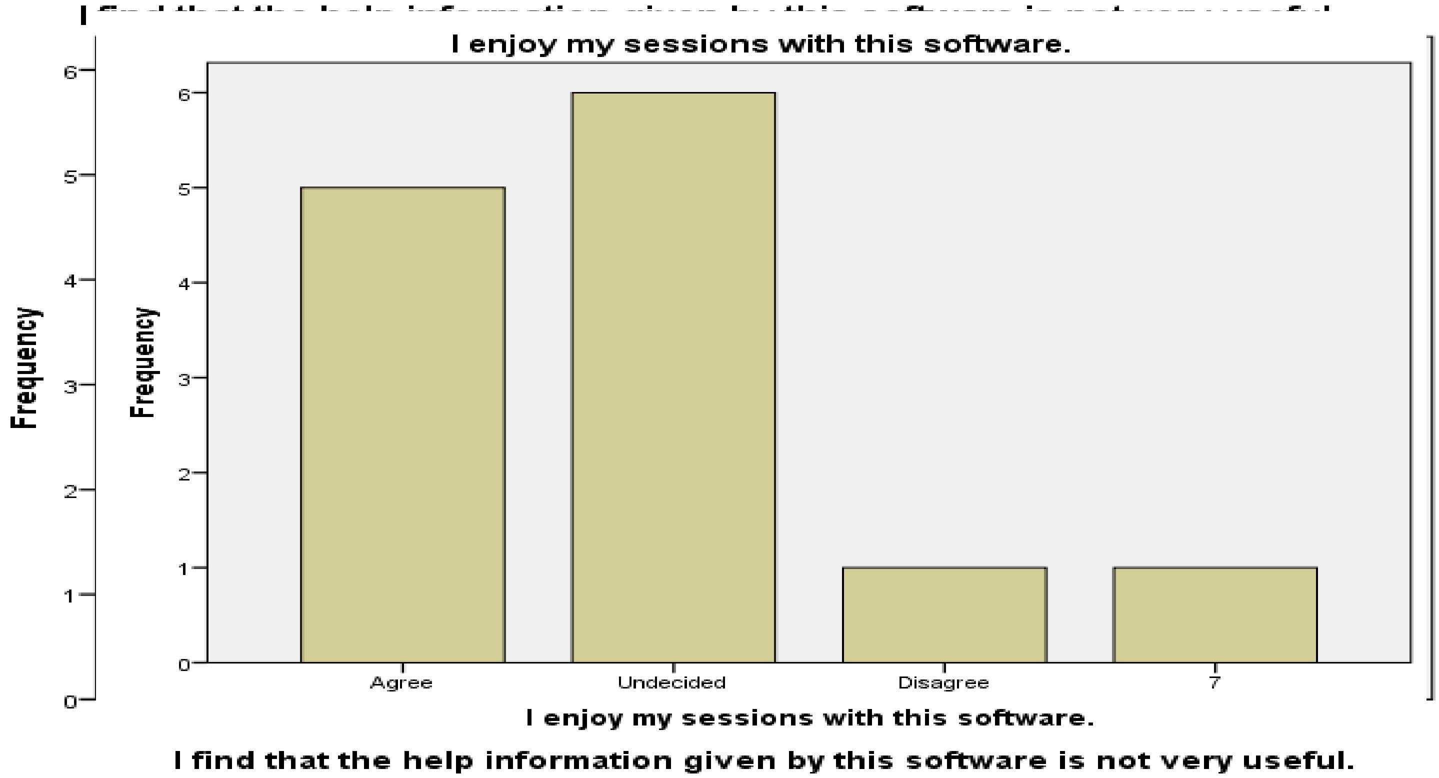
This software responds too slowly to inputs

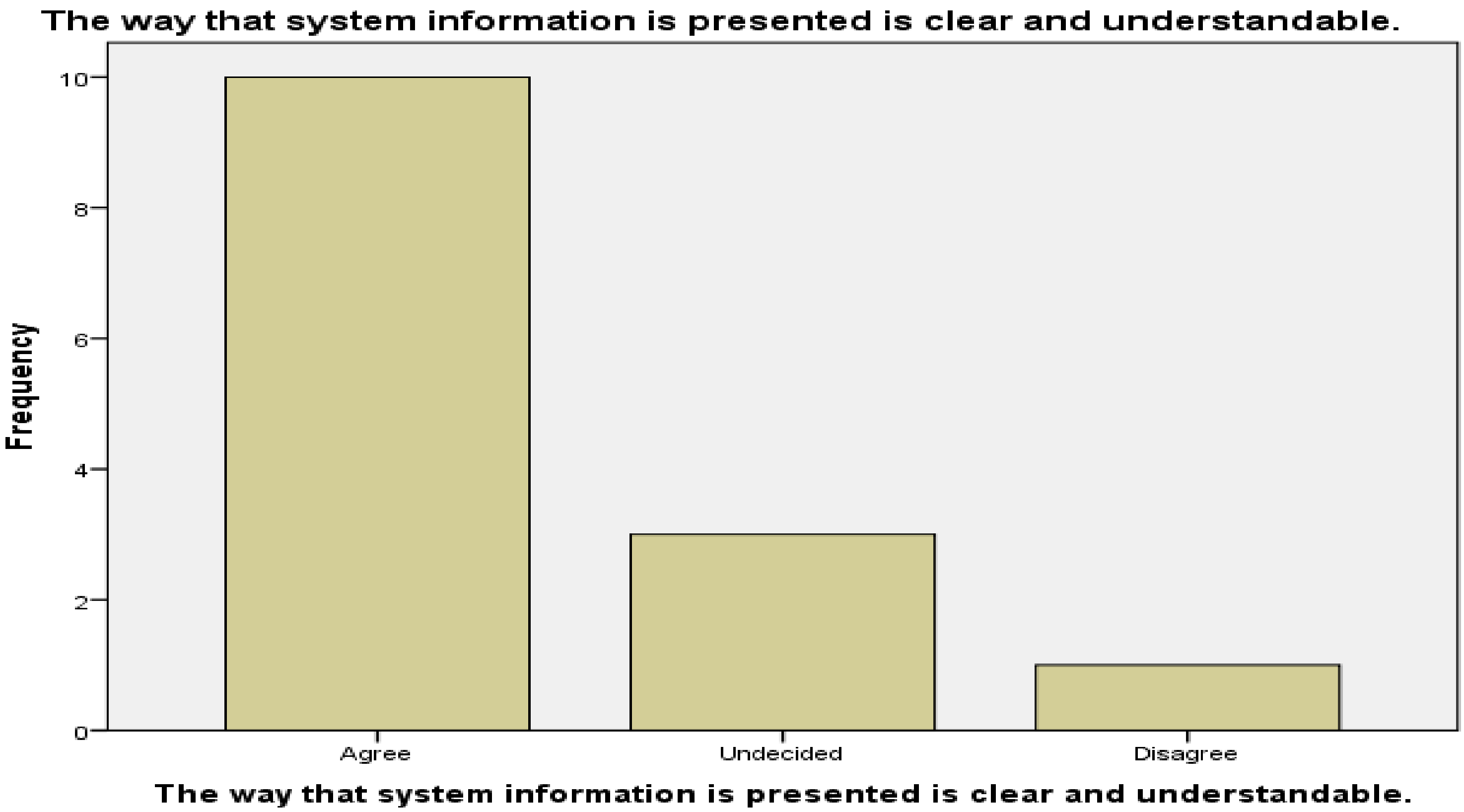



It takes too long to learn the software commands.
Frequency
0
2
4
6
8
10
Agree
Undecided
Disagree
It takes too long to learn the software commands.

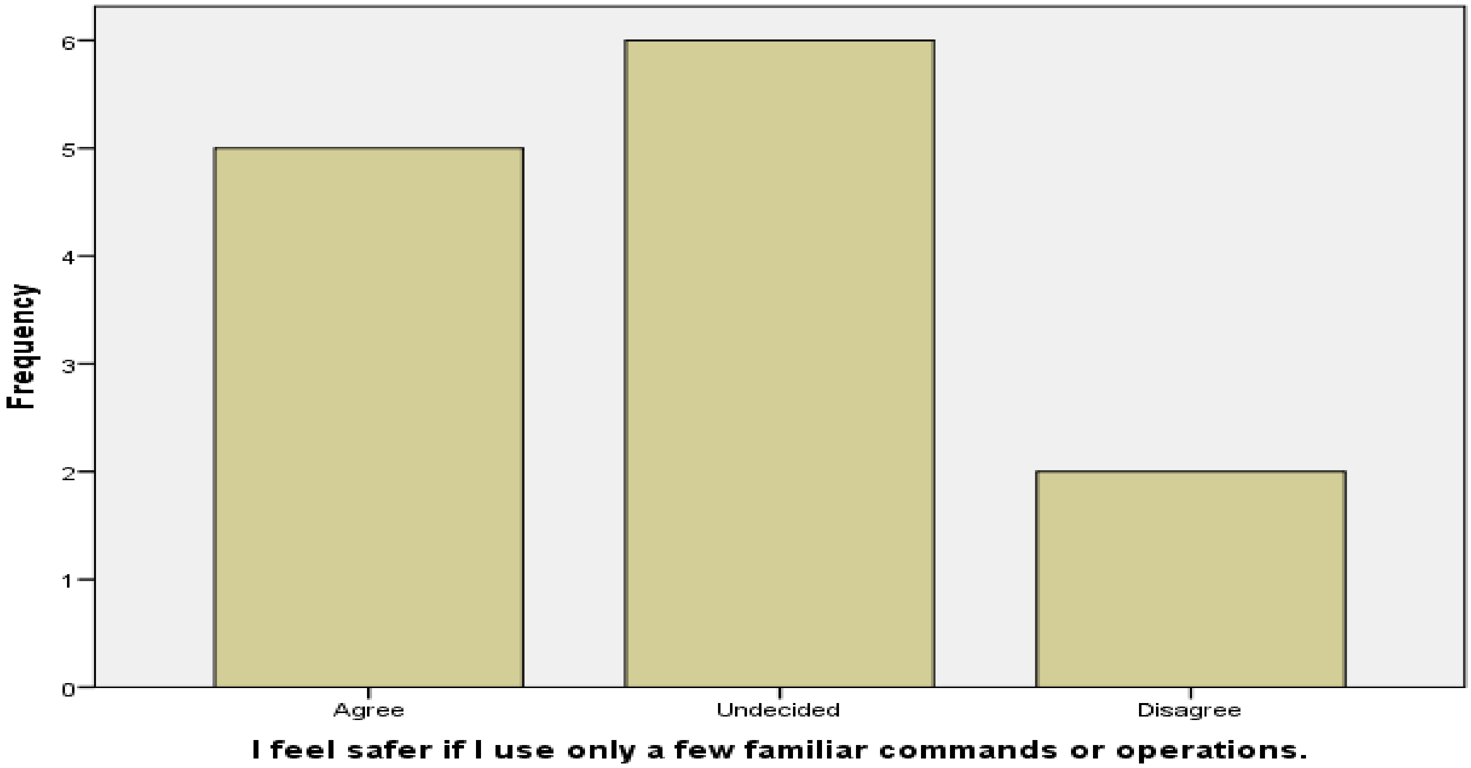

I sometimes wonder if I'm using the right command.
Frequency
0
1
2
3
4
5
Agree
Undecided
Disagree
I sometimes wonder if I'm using the right command.

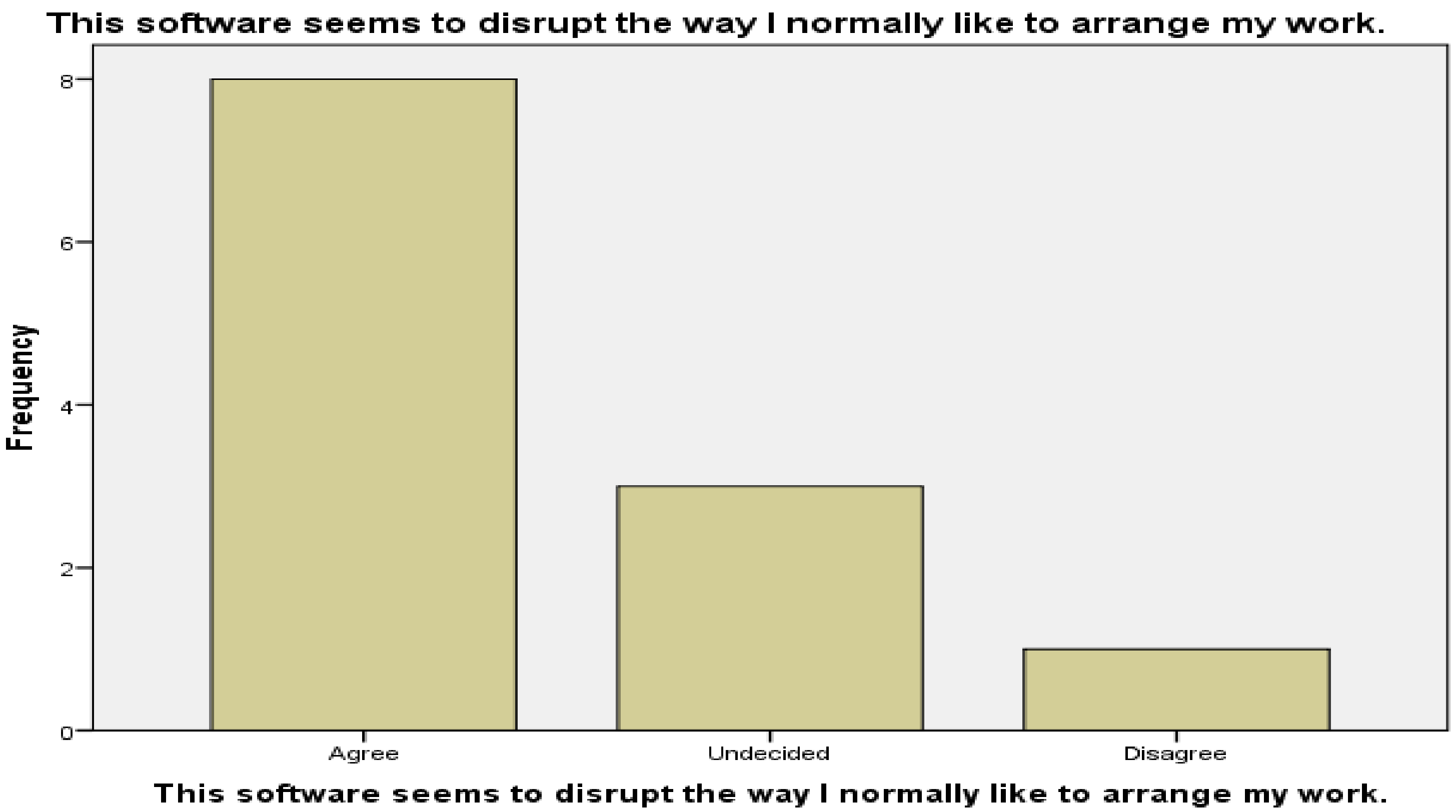

Working with this software is satisfying.
Frequency
10
8
6
4
2
0
Agree
Undecided
Disagree
Working with this software is satisfying.

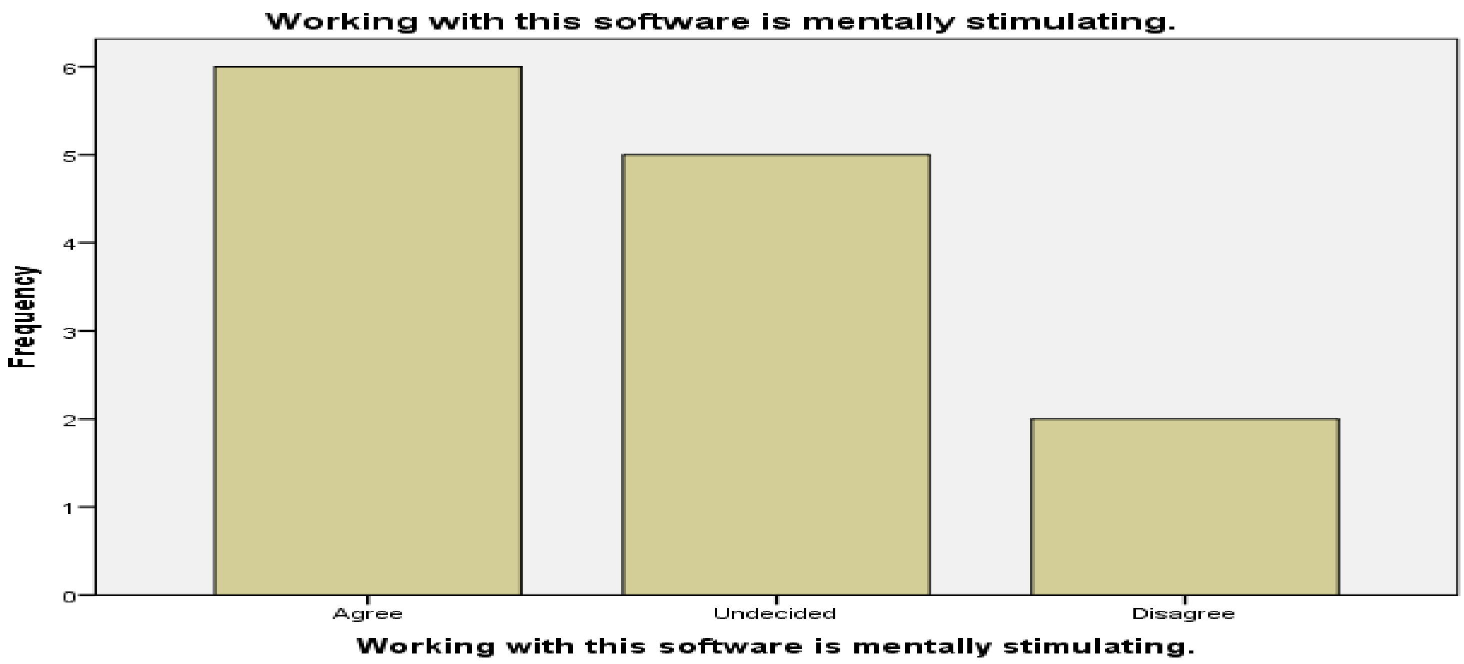

I enjoy my sessions with this software.
Frequency
Frequency
Agree
Undecided
Disagree
7
I enjoy my sessions with this software.
I find that the help information given by this software is not very useful.

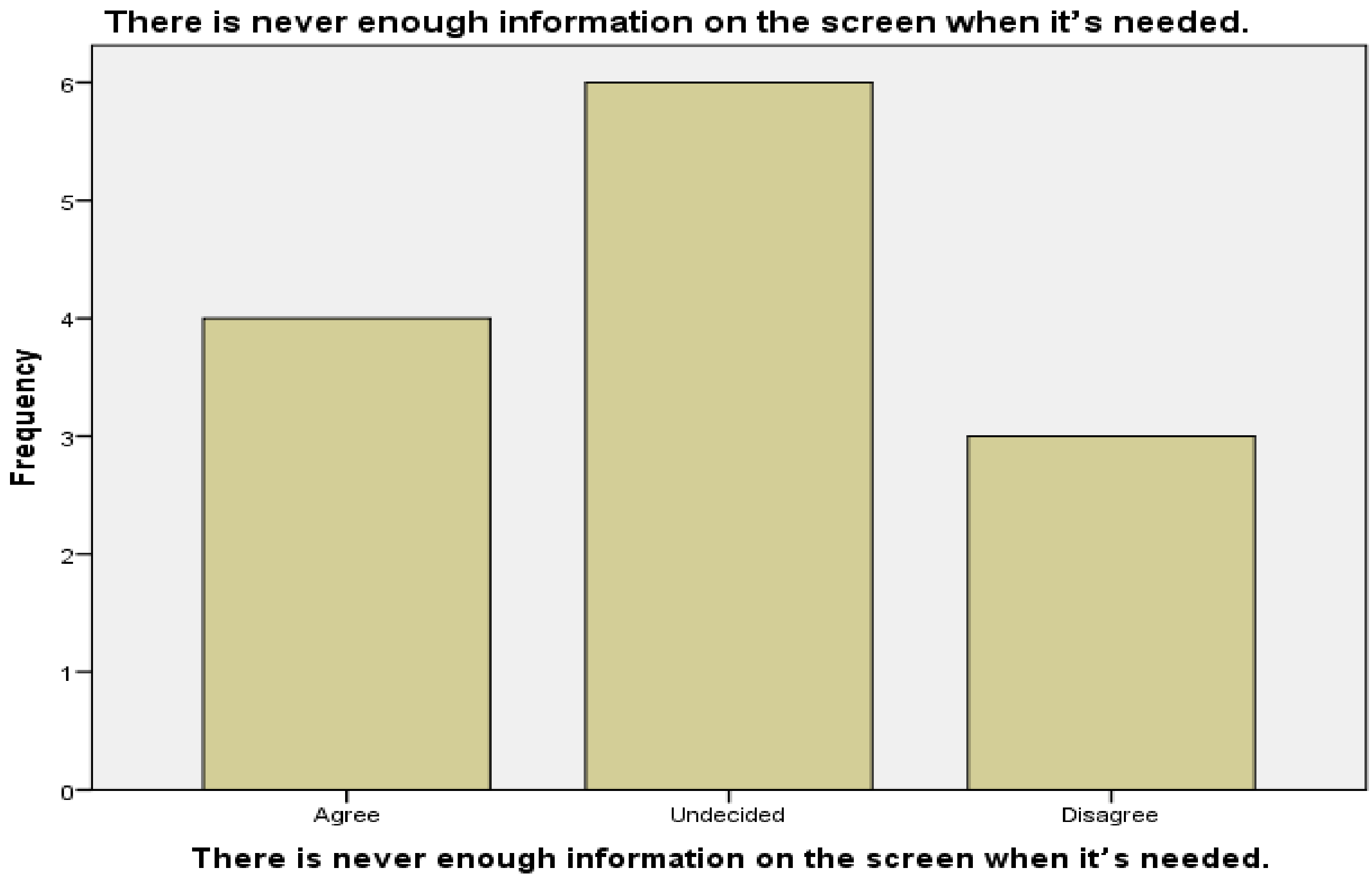

The way that system information is presented is clear and understandable.
Frequency
Agree
Undecided
Disagree
The way that system information is presented is clear and understandable.

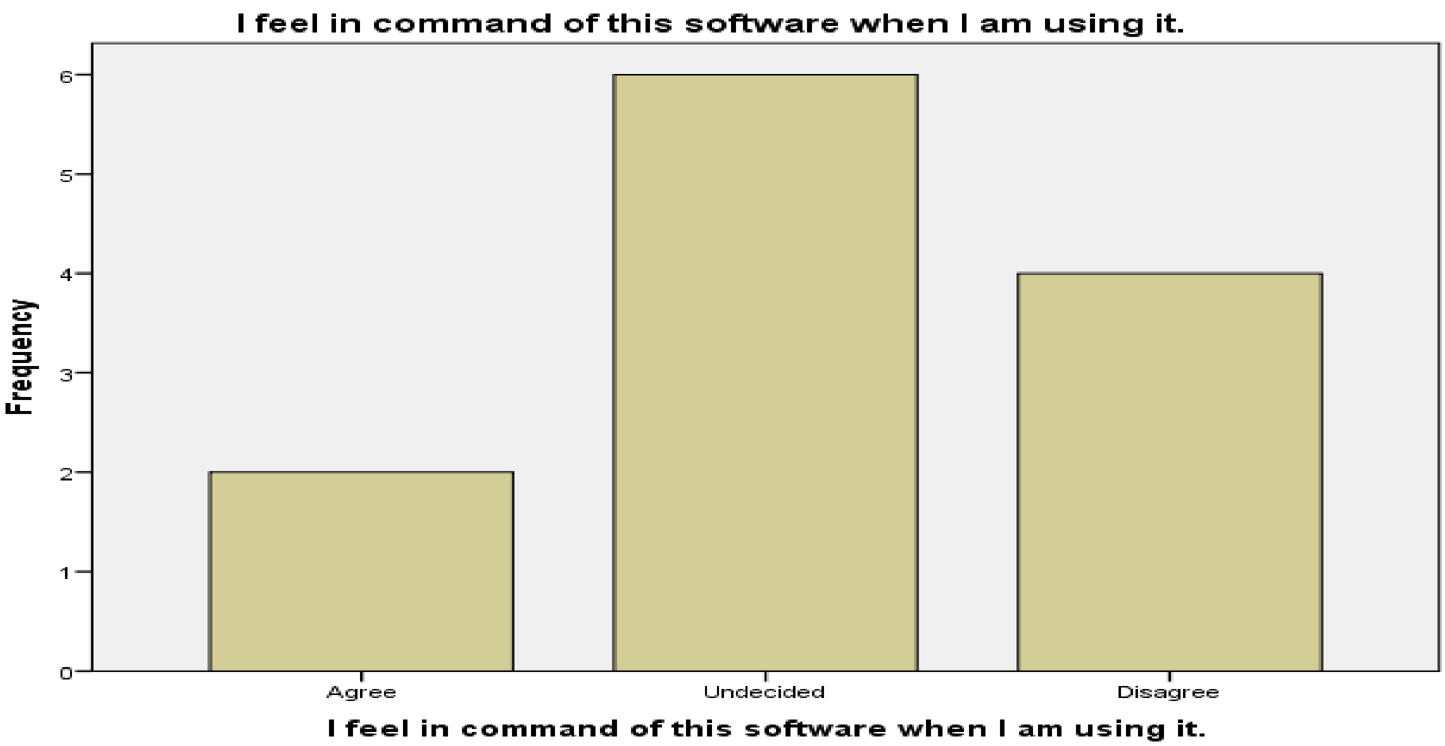
I feel safer if I use only a few familiar commands or operations.

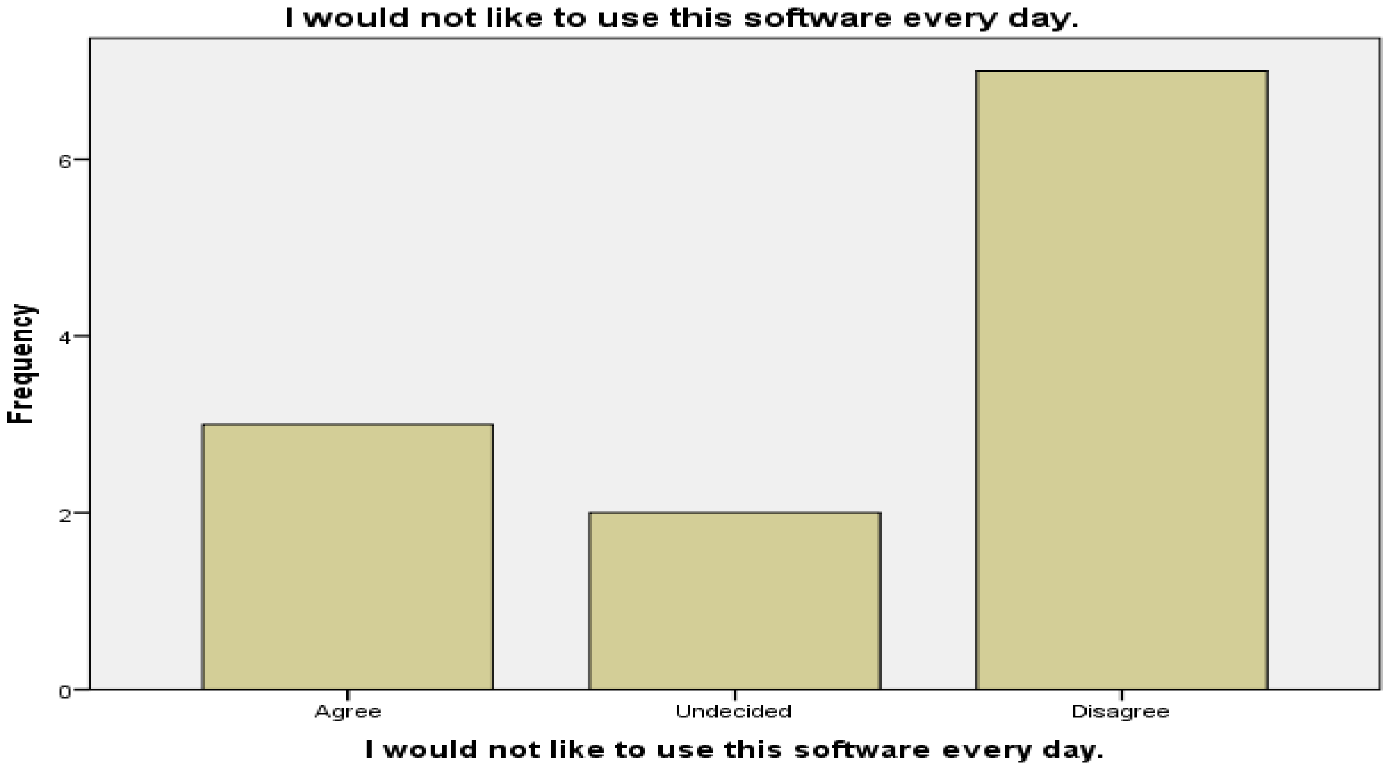


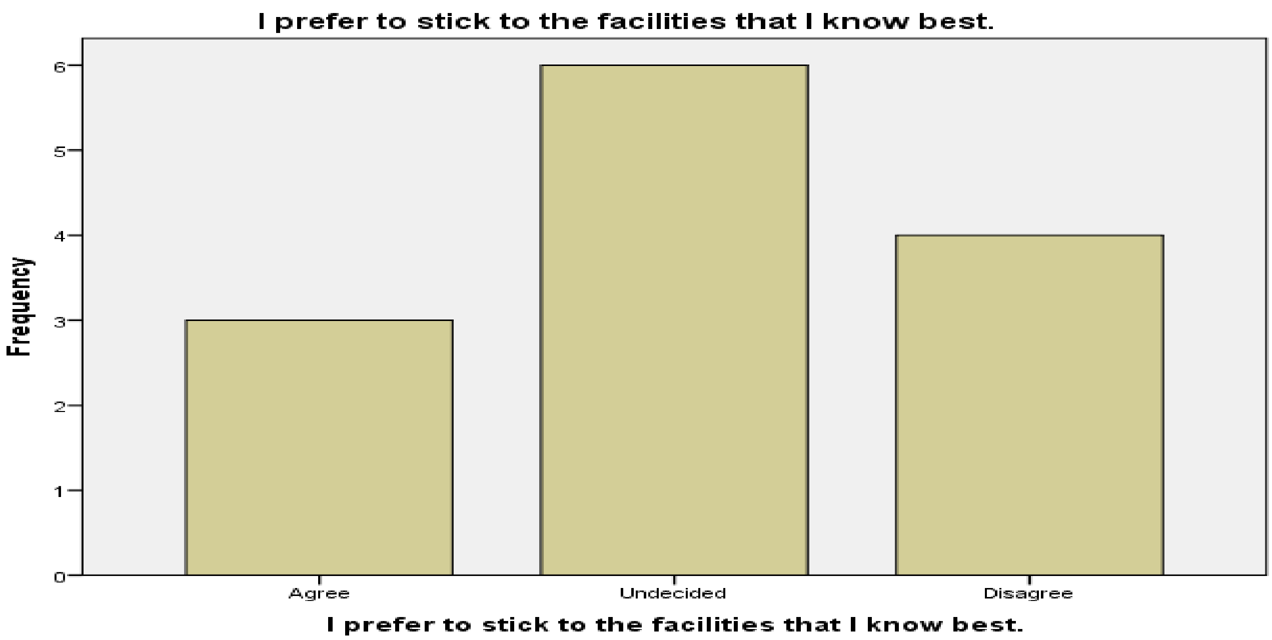

This software seems to disrupt the way I normally like to arrange my work.
Frequency
8
6
4
2
0
Agree
Undecided
Disagree
This software seems to disrupt the way I normally like to arrange my work.

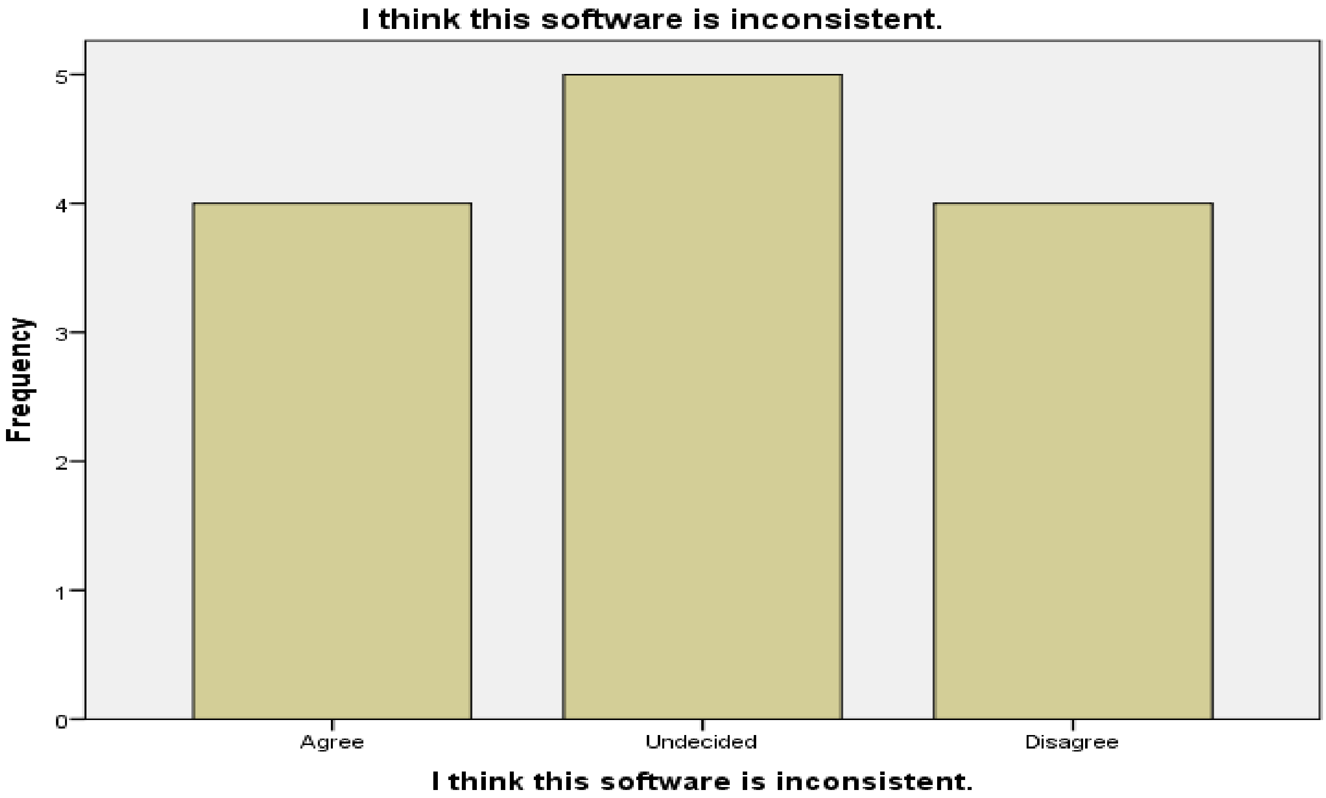

Working with this software is mentally stimulating.
Frequency
6
5
4
3
2
1
0
Agree
Undecided
Disagree
Working with this software is mentally stimulating.

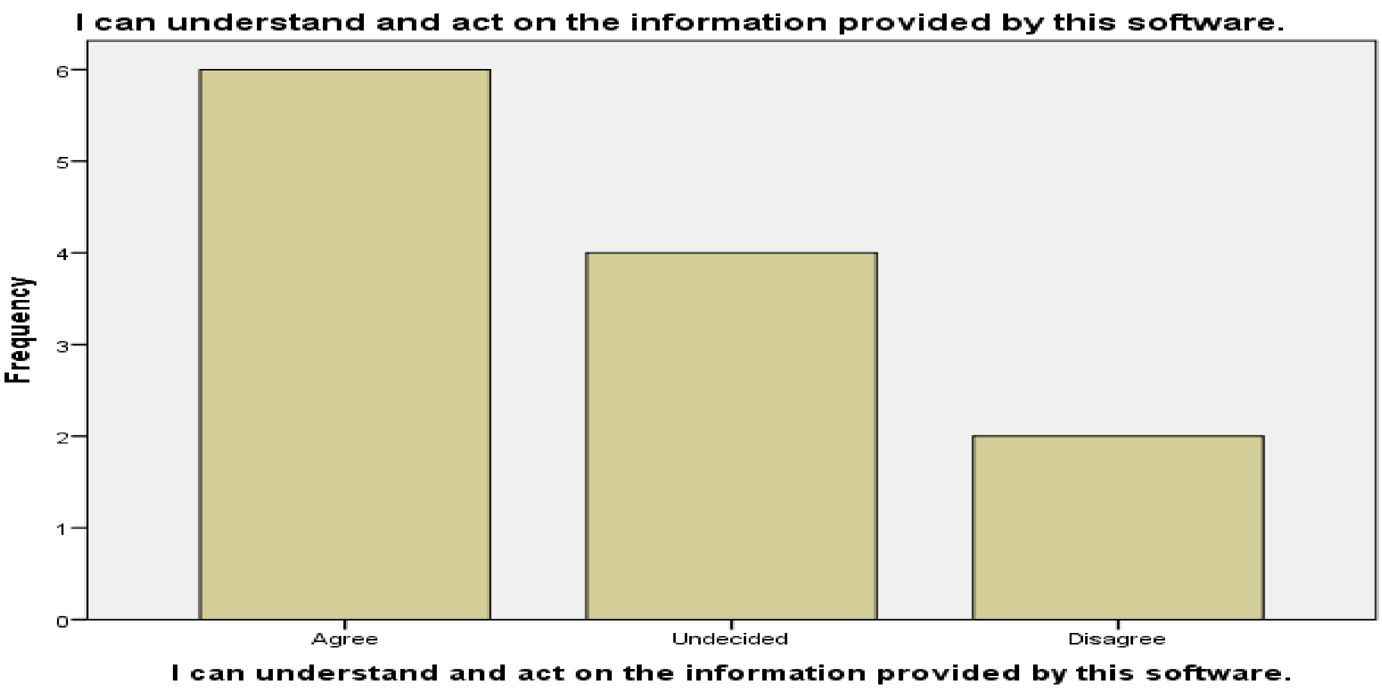

There is never enough information on the screen when it's needed.
Frequency
0
1
2
3
4
5
6
Agree
Undecided
Disagree
There is never enough information on the screen when it's needed.


I feel in command of this software when I am using it.
Frequency
0
1
2
3
4
5
6
Agree
Undecided
Disagree
I feel in command of this software when I am using it.

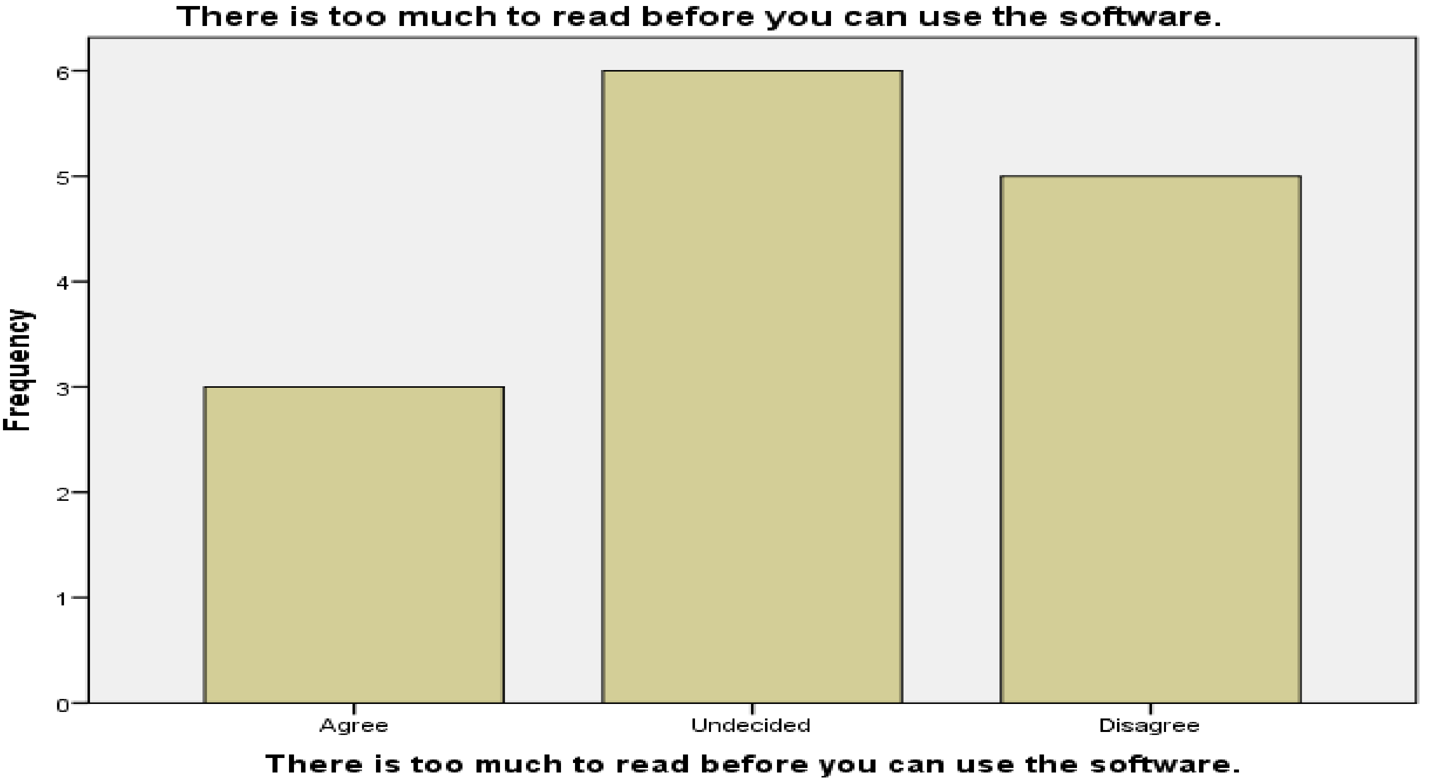

I would not like to use this software every day.
Frequency
0
2
4
6
Agree
Undecided
Disagree
I would not like to use this software every day.

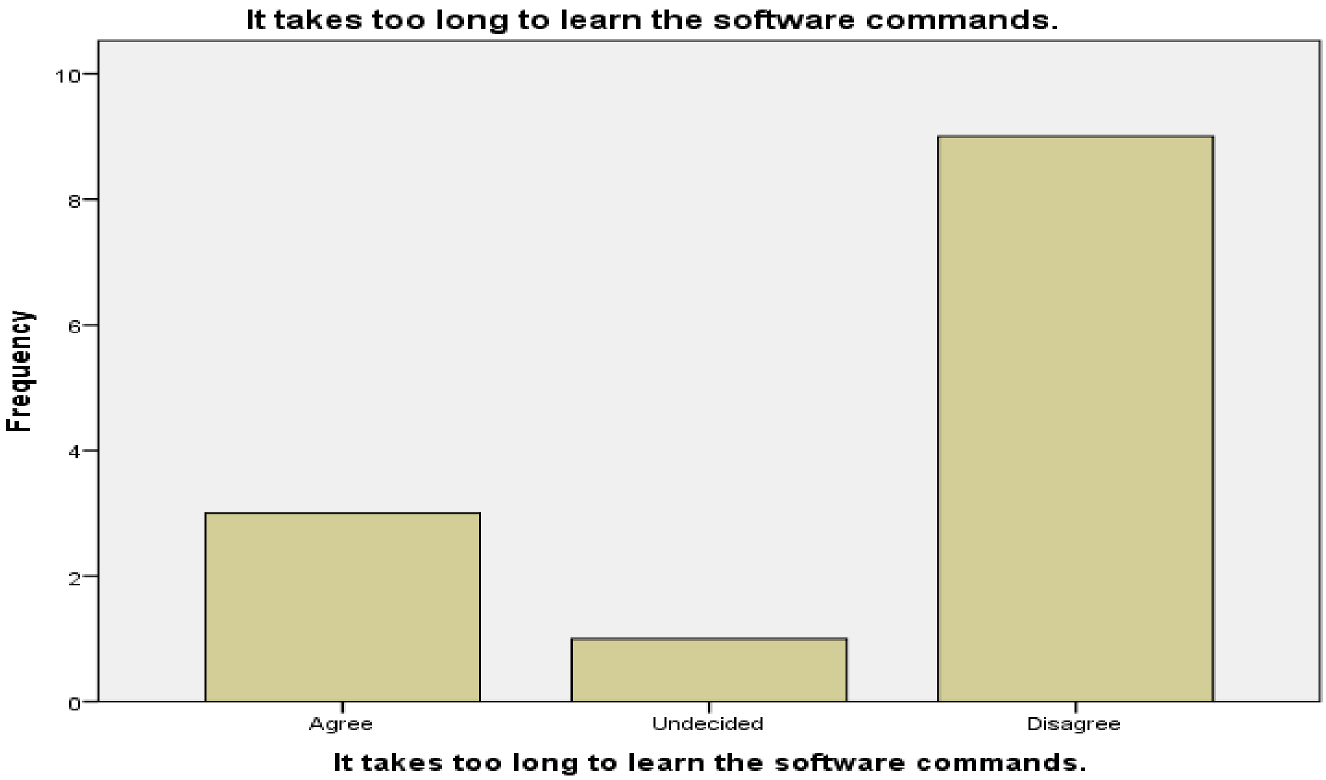

I prefer to stick to the facilities that I know best.
Frequency
0
1
2
3
4
5
6
Agree
Undecided
Disagree
I prefer to stick to the facilities that I know best.

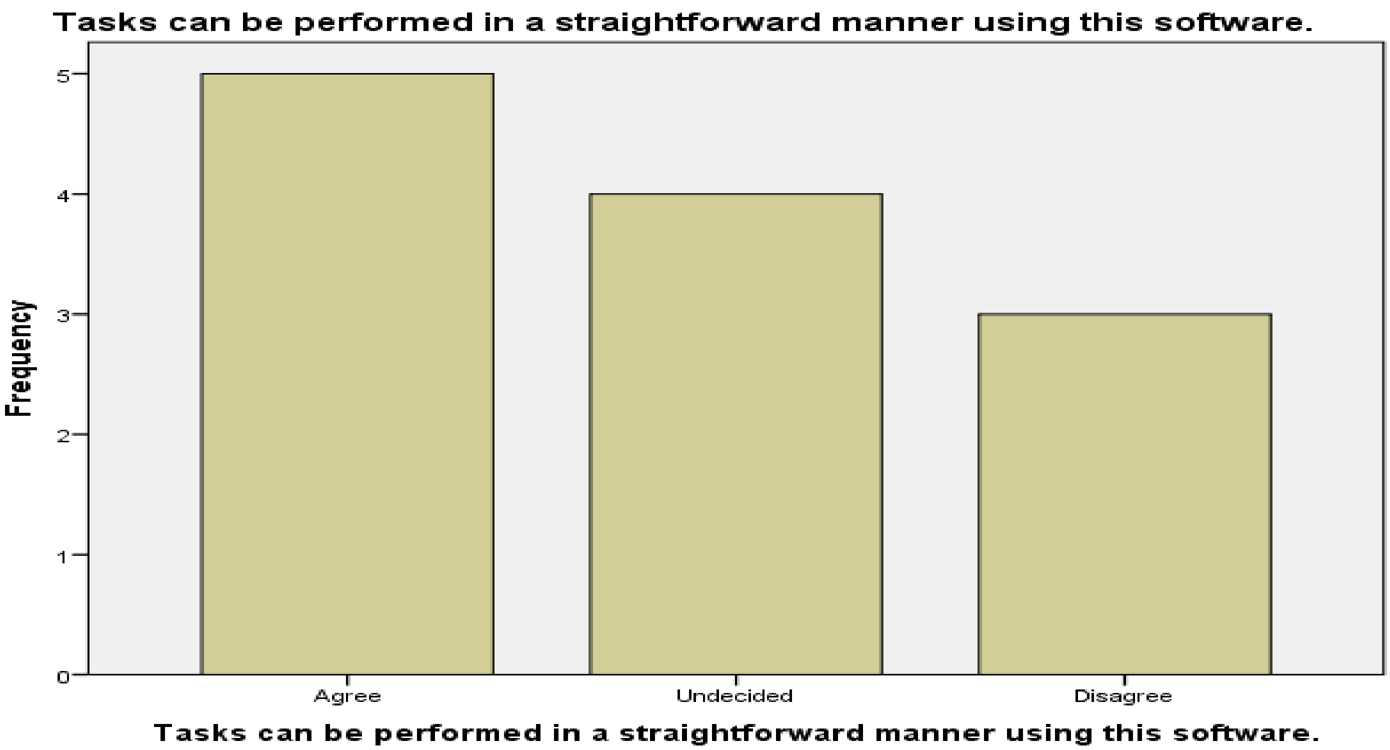

I think this software is inconsistent.
Frequency
0
1
2
3
4
5
Agree
Undecided
Disagree
I think this software is inconsistent.

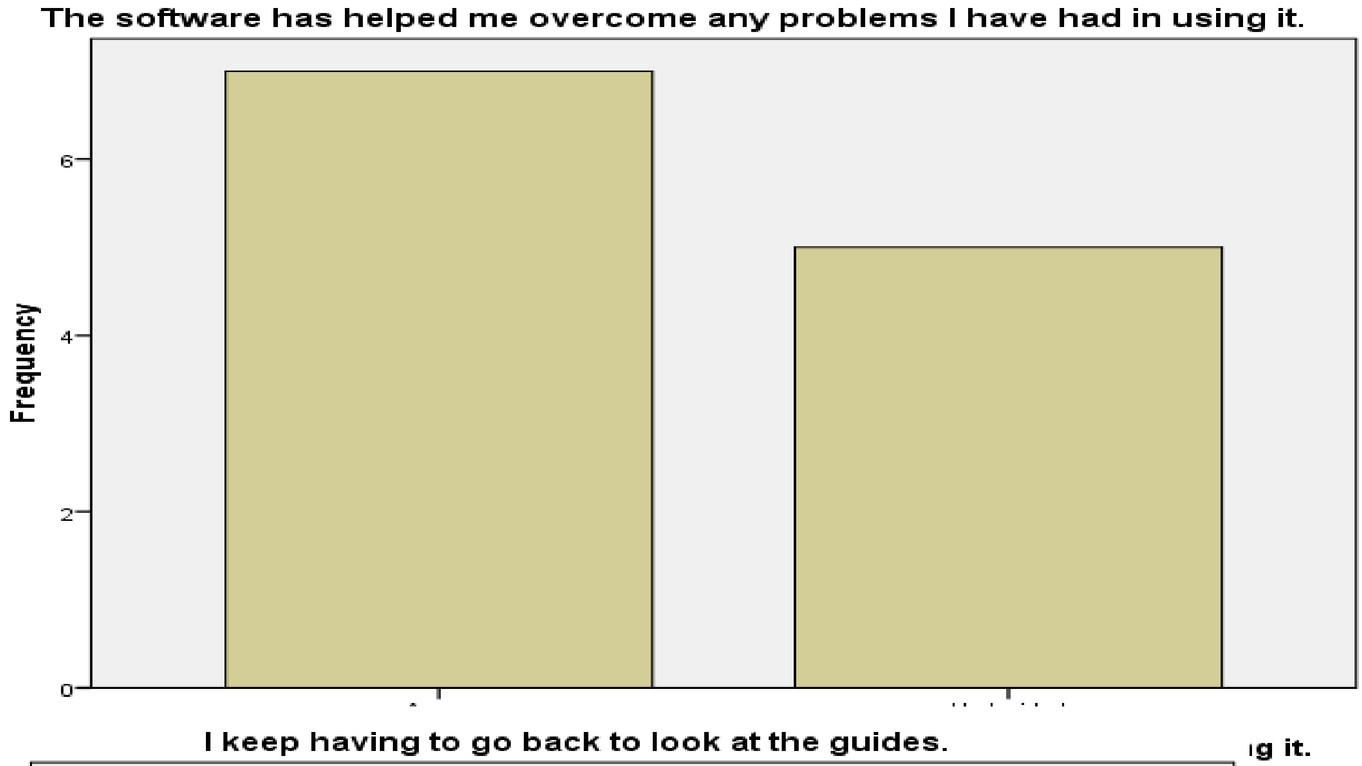

I can understand and act on the information provided by this software.
Frequency
0
1
2
3
4
5
6
Agree
Undecided
Disagree
I can understand and act on the information provided by this software.

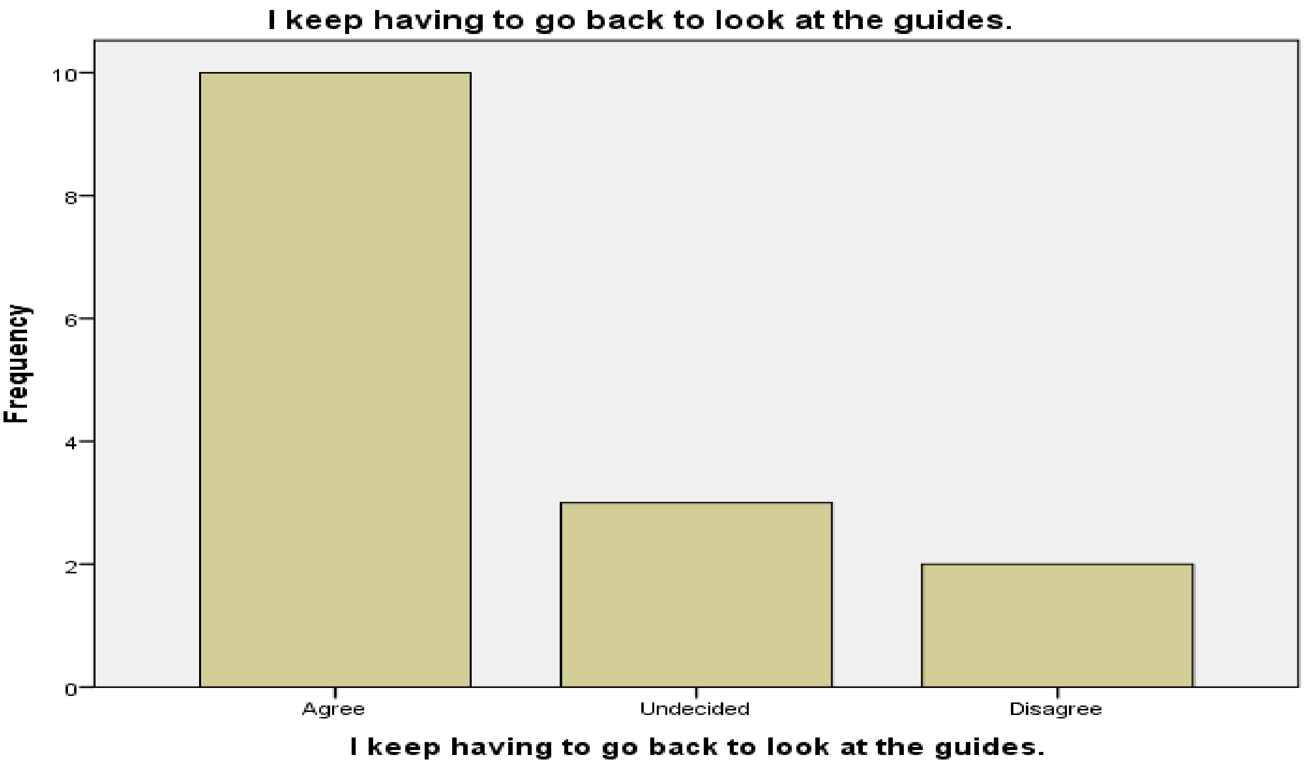
This application behaves awkward when I want to do something which is not

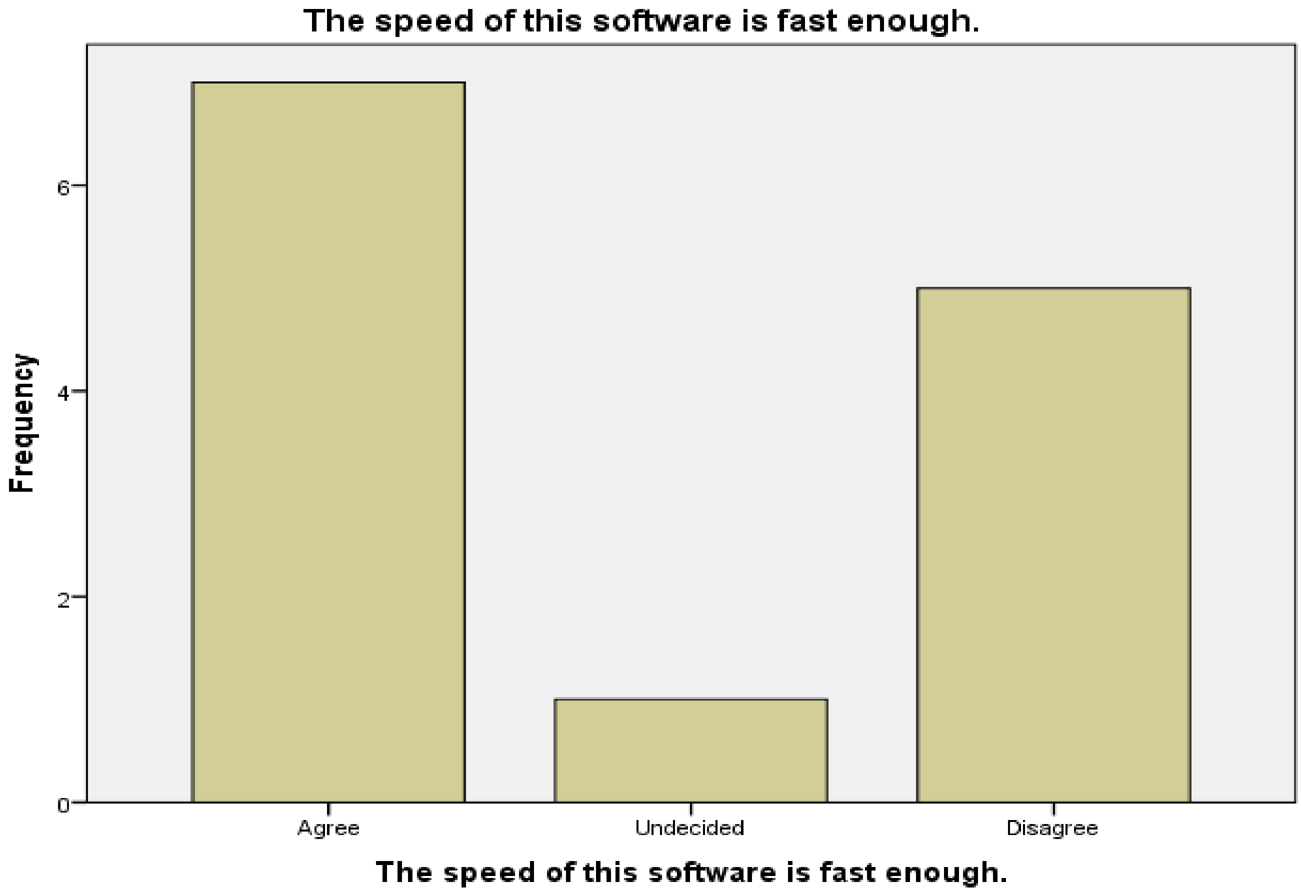


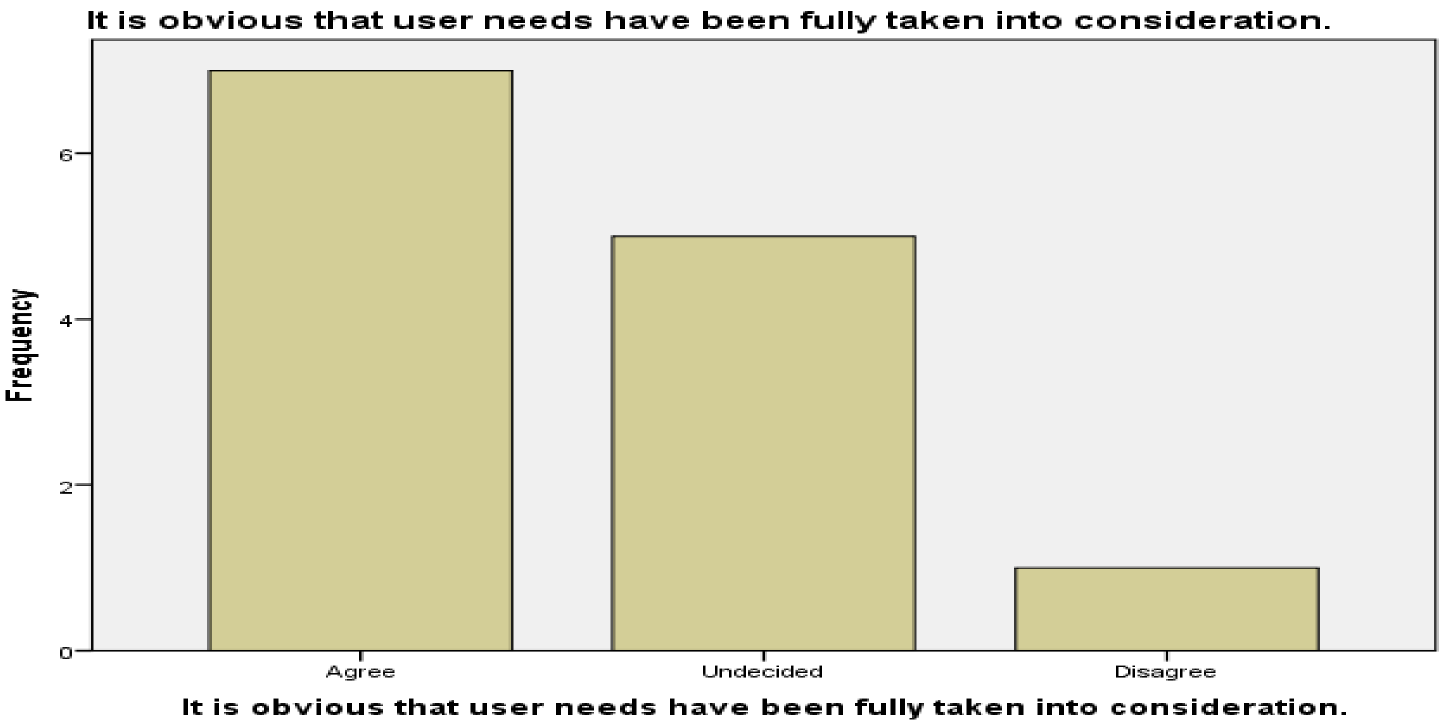

It takes too long to learn the software commands.
Frequency
10
8
6
4
2
0
Agree
Undecided
Disagree
It takes too long to learn the software commands.

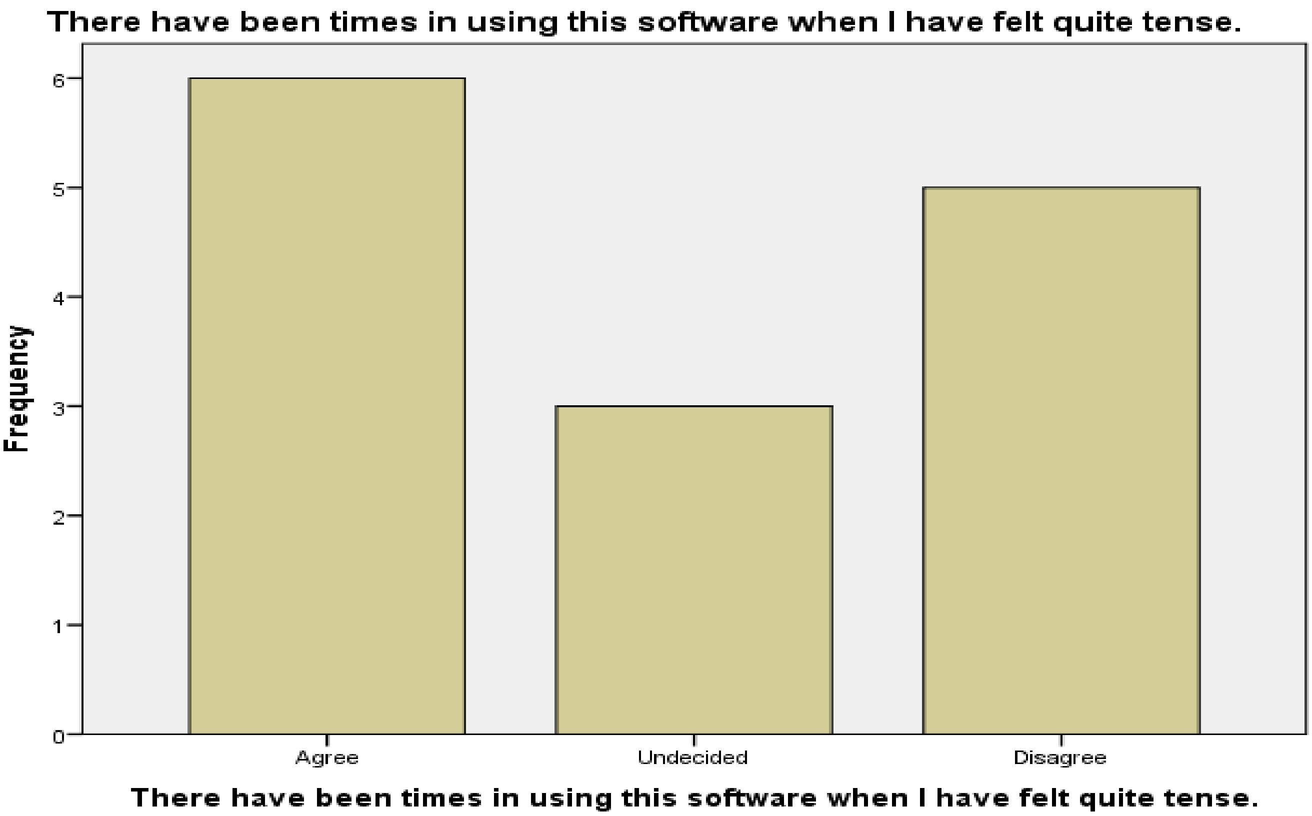

Tasks can be performed in a straightforward manner using this software.
Frequency
5
4
3
2
1
0
Agree
Undecided
Disagree
Tasks can be performed in a straightforward manner using this software.

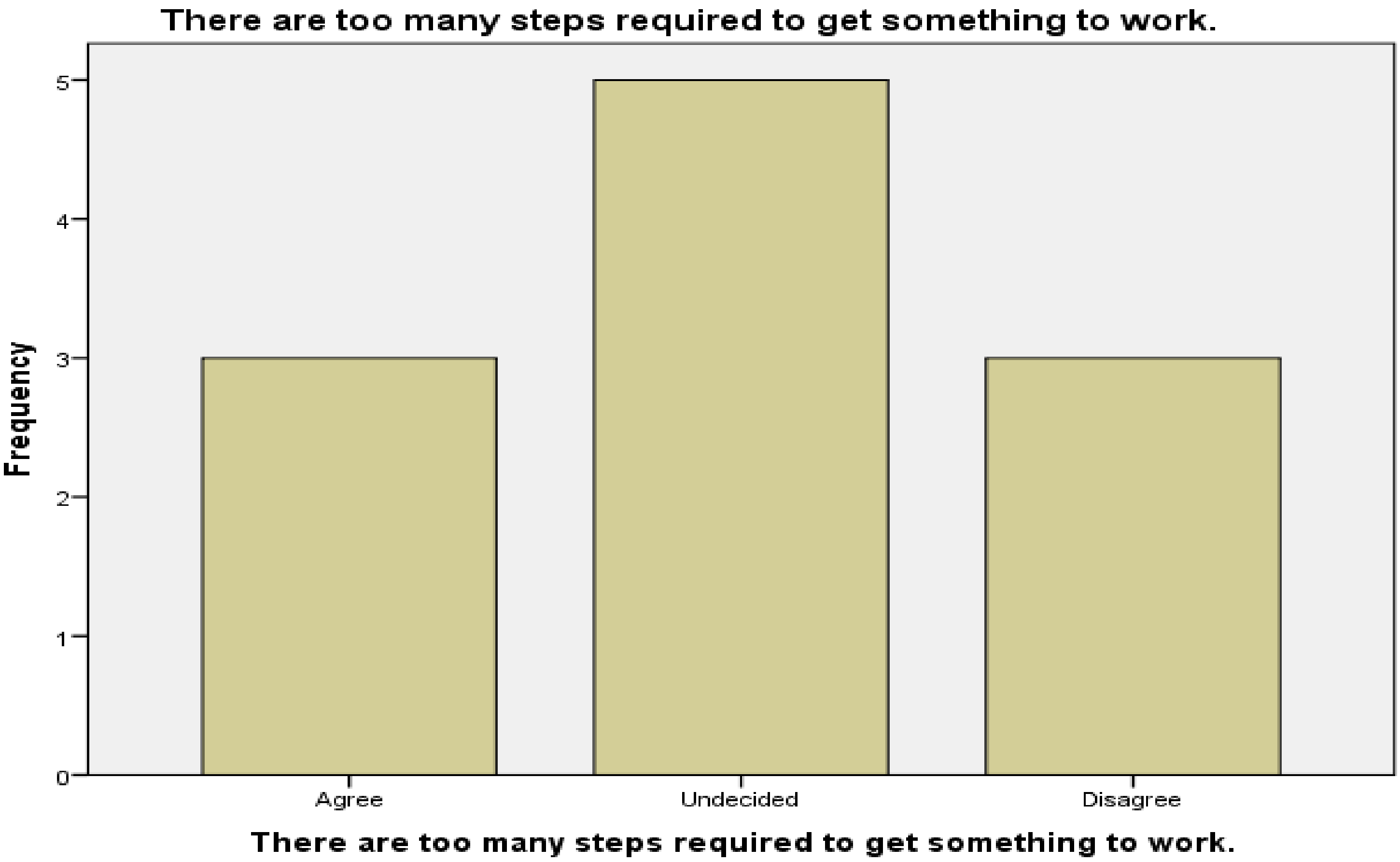

The software has helped me overcome any problems I have had in using it.
Frequency
6
4
2
0

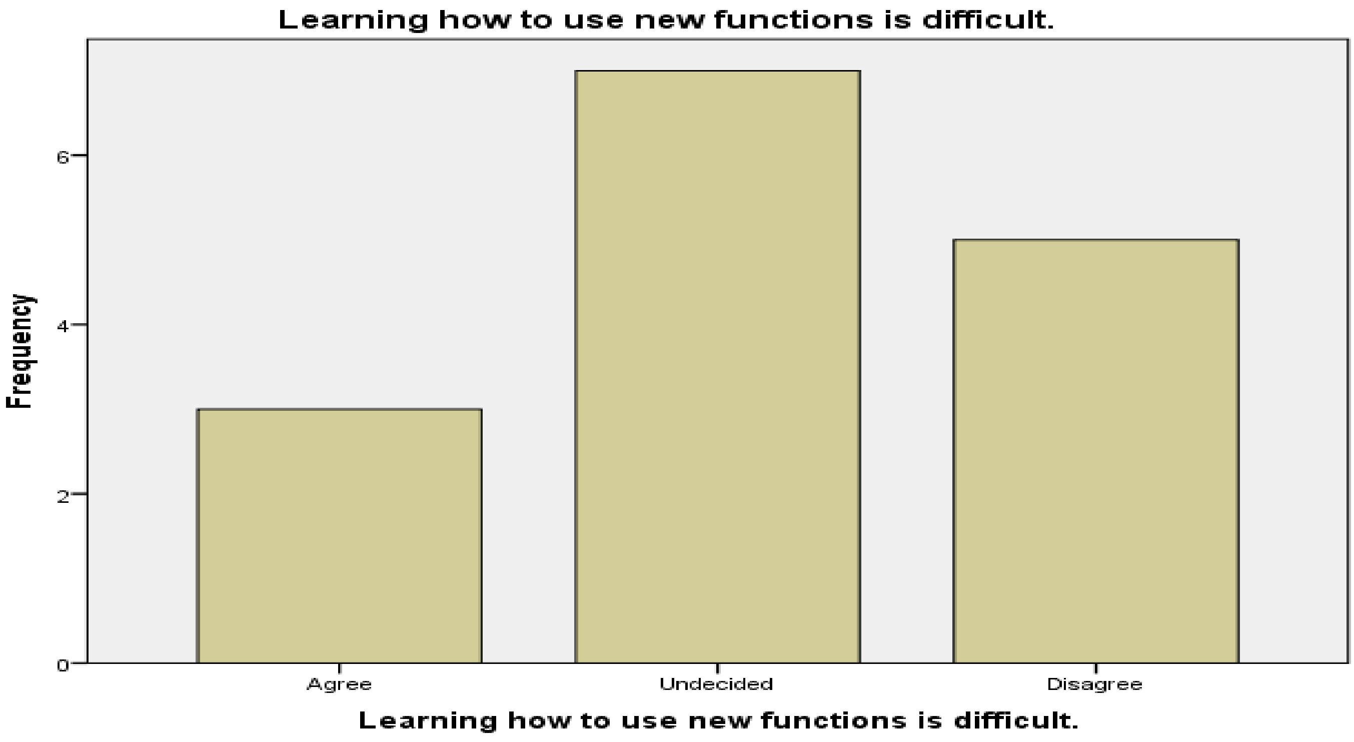

I keep having to go back to look at the guides.
Frequency
10
8
6
4
2
0
Agree
Undecided
Disagree
I keep having to go back to look at the guides.

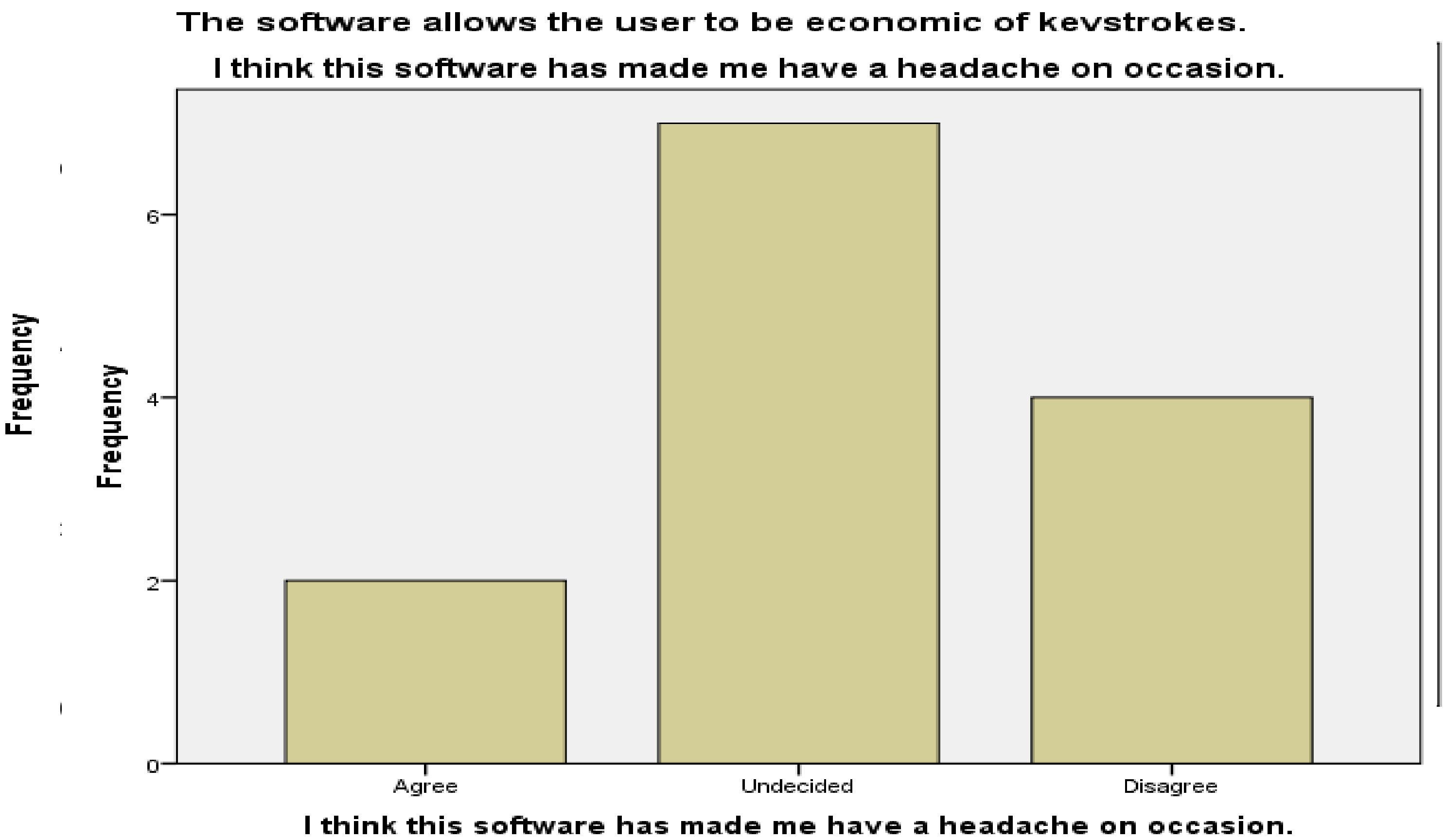

The speed of this software is fast enough.
Frequency
0
2
4
6
Agree
Undecided
Disagree
The speed of this software is fast enough.

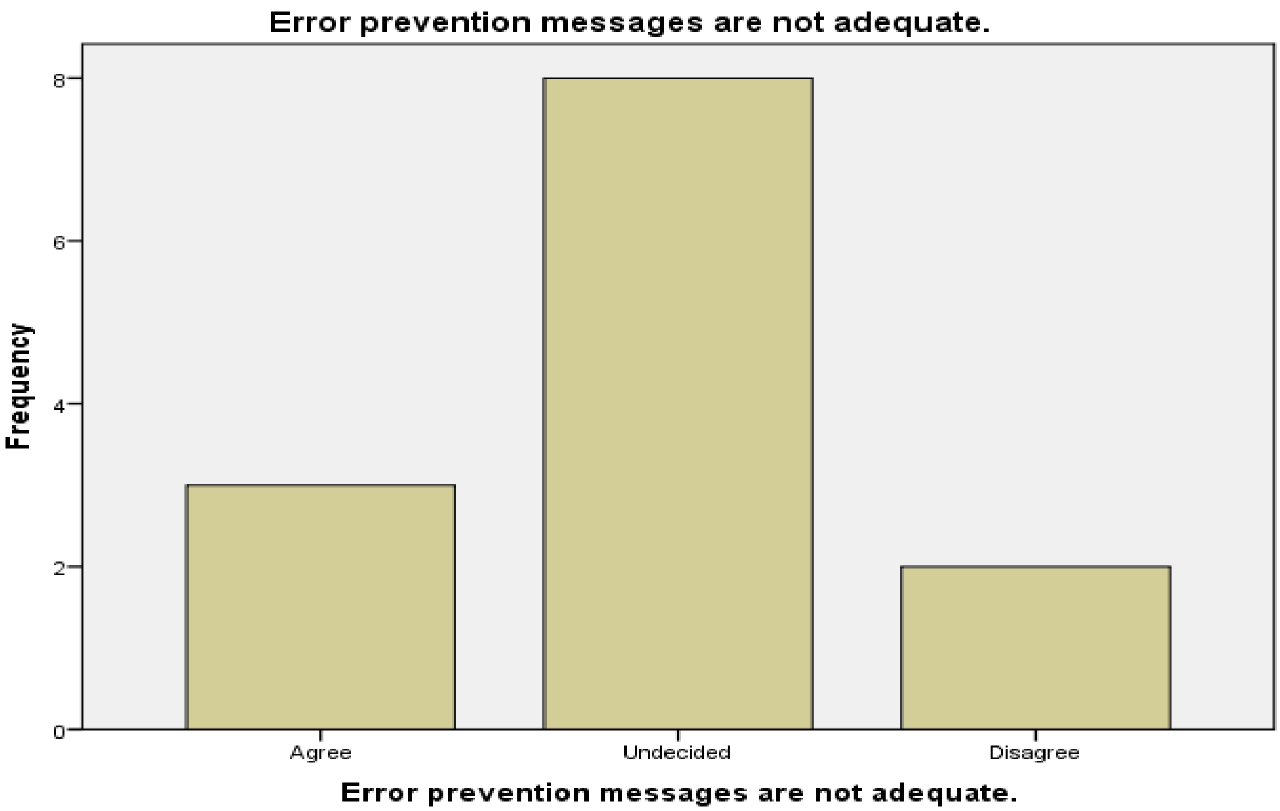

It is obvious that user needs have been fully taken into consideration.
Frequency
0
2
4
6
Agree
Undecided
Disagree
It is obvious that user needs have been fully taken into consideration.

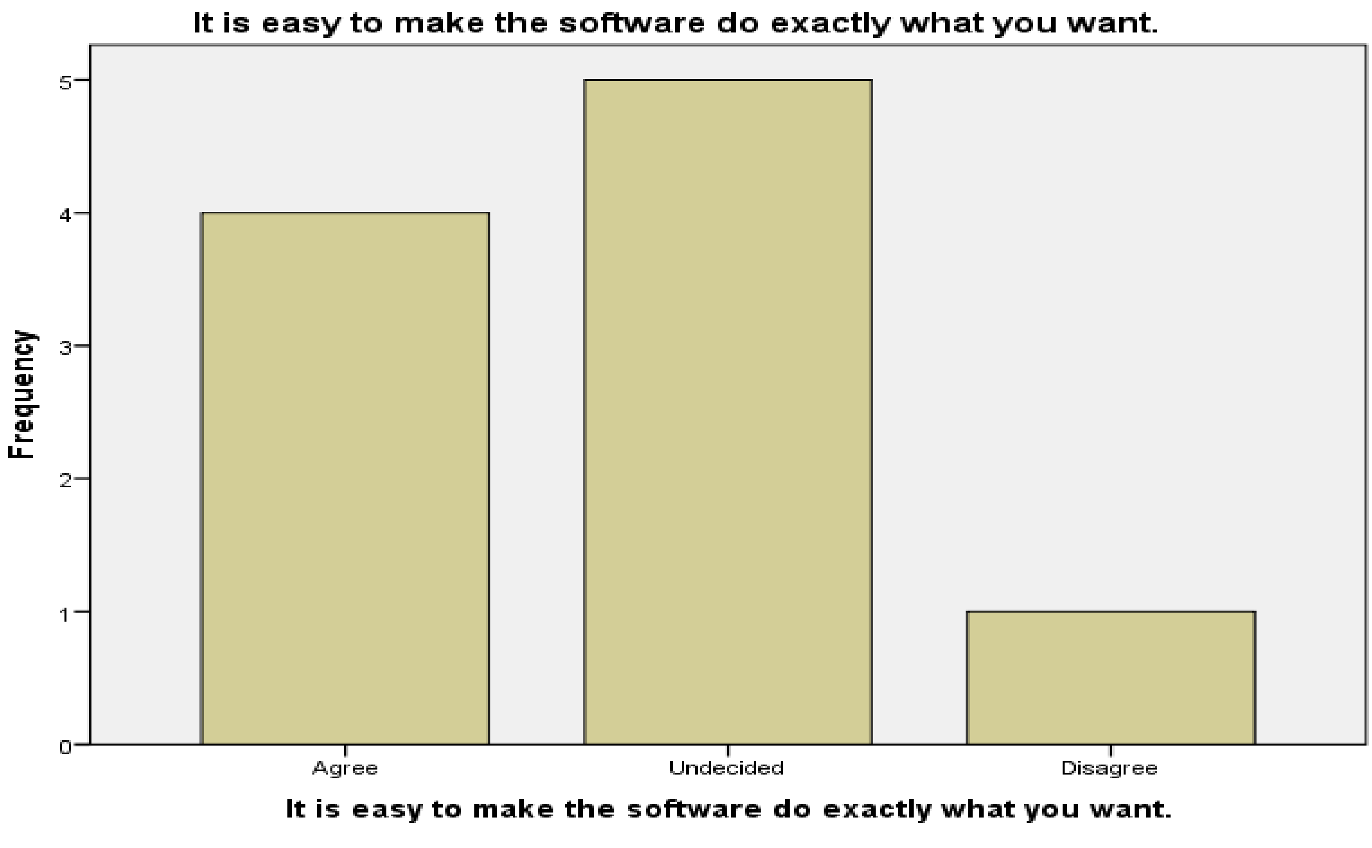

There have been times in using this software when I have felt quite tense.
Frequency
0
1
2
3
4
5
6
Agree
Undecided
Disagree
There have been times in using this software when I have felt quite tense.

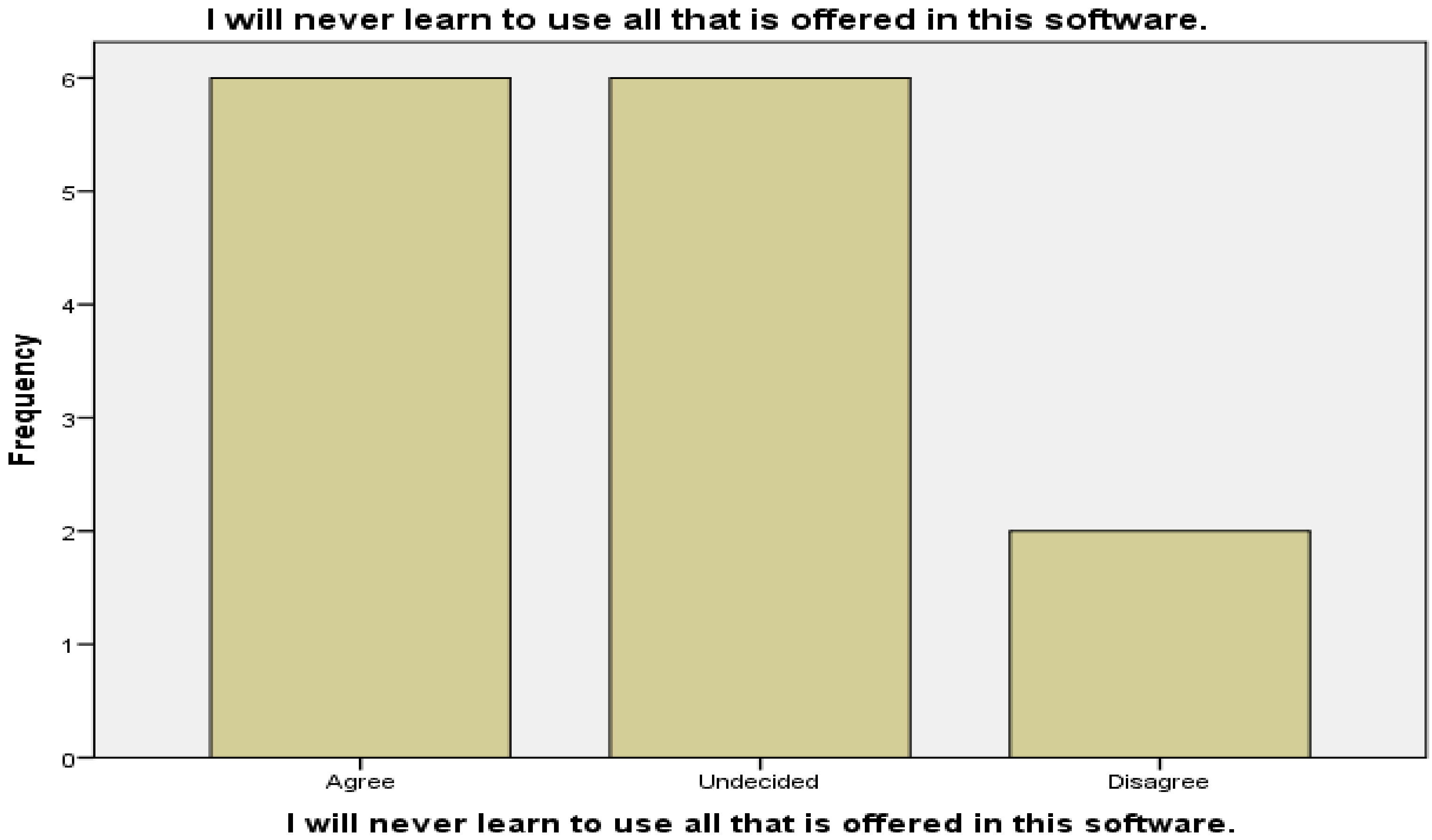

There are too many steps required to get something to work.
Frequency
0
1
2
3
4
5
Agree
Undecided
Disagree
There are too many steps required to get something to work.

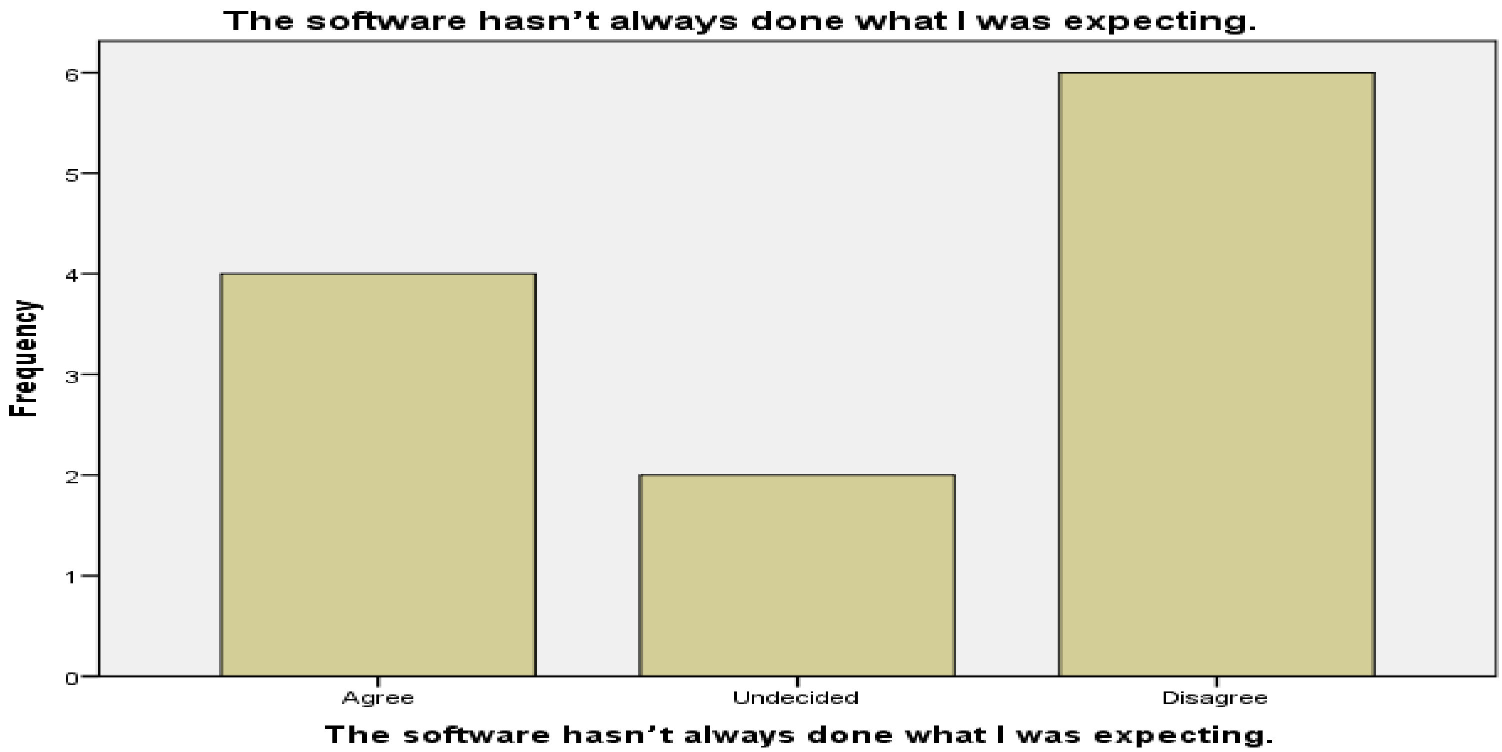

Learning how to use new functions is difficult.
Frequency
0
2
4
6
Agree
Undecided
Disagree
Learning how to use new functions is difficult.

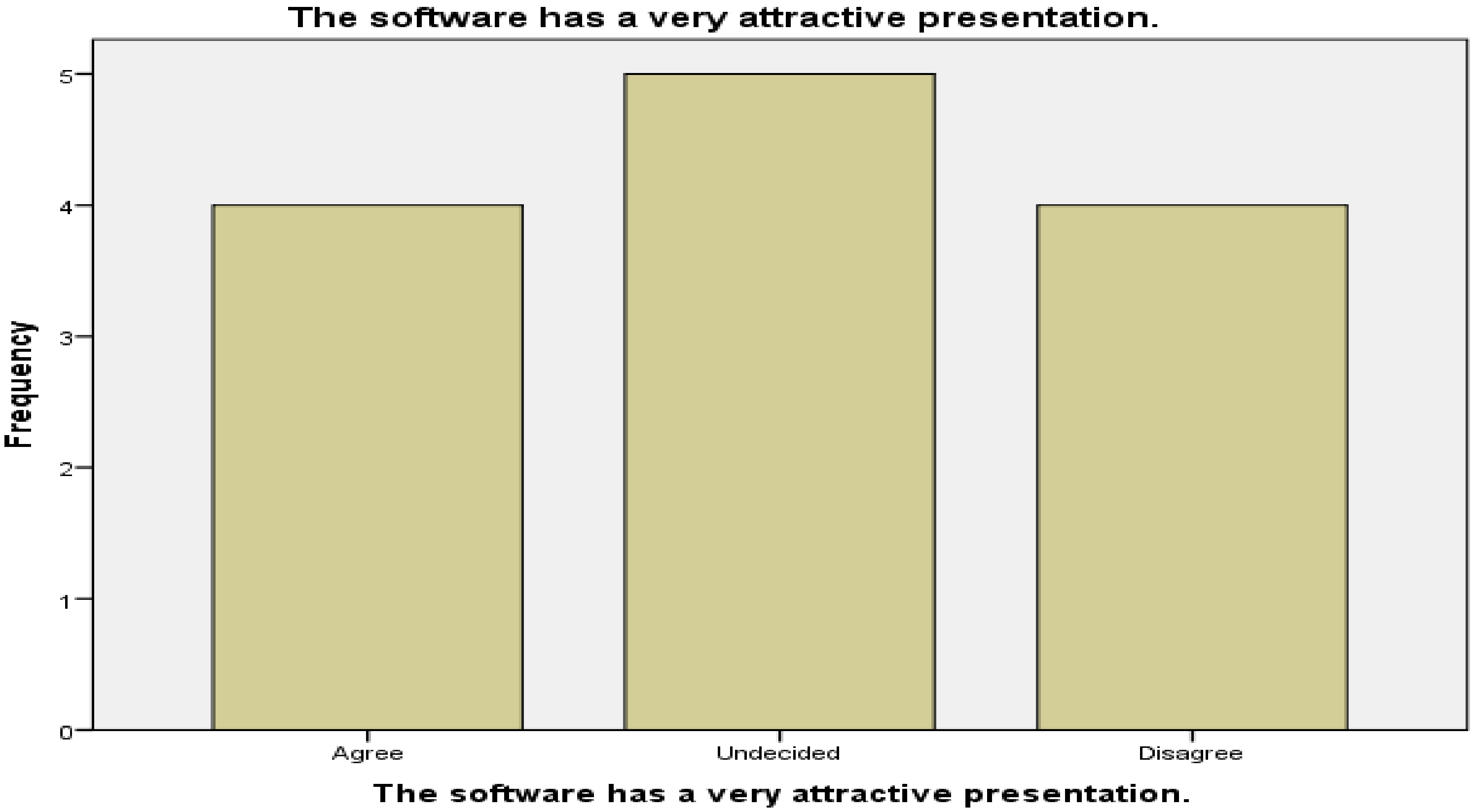

The software allows the user to be economic of kevstrokes.
I think this software has made me have a headache on occasion.
Frequency
Frequency
0
2
4
6
Agree
Undecided
Disagree
I think this software has made me have a headache on occasion.


Error prevention messages are not adequate.
Frequency
0
2
4
6
8
Agree
Undecided
Disagree
Error prevention messages are not adequate.

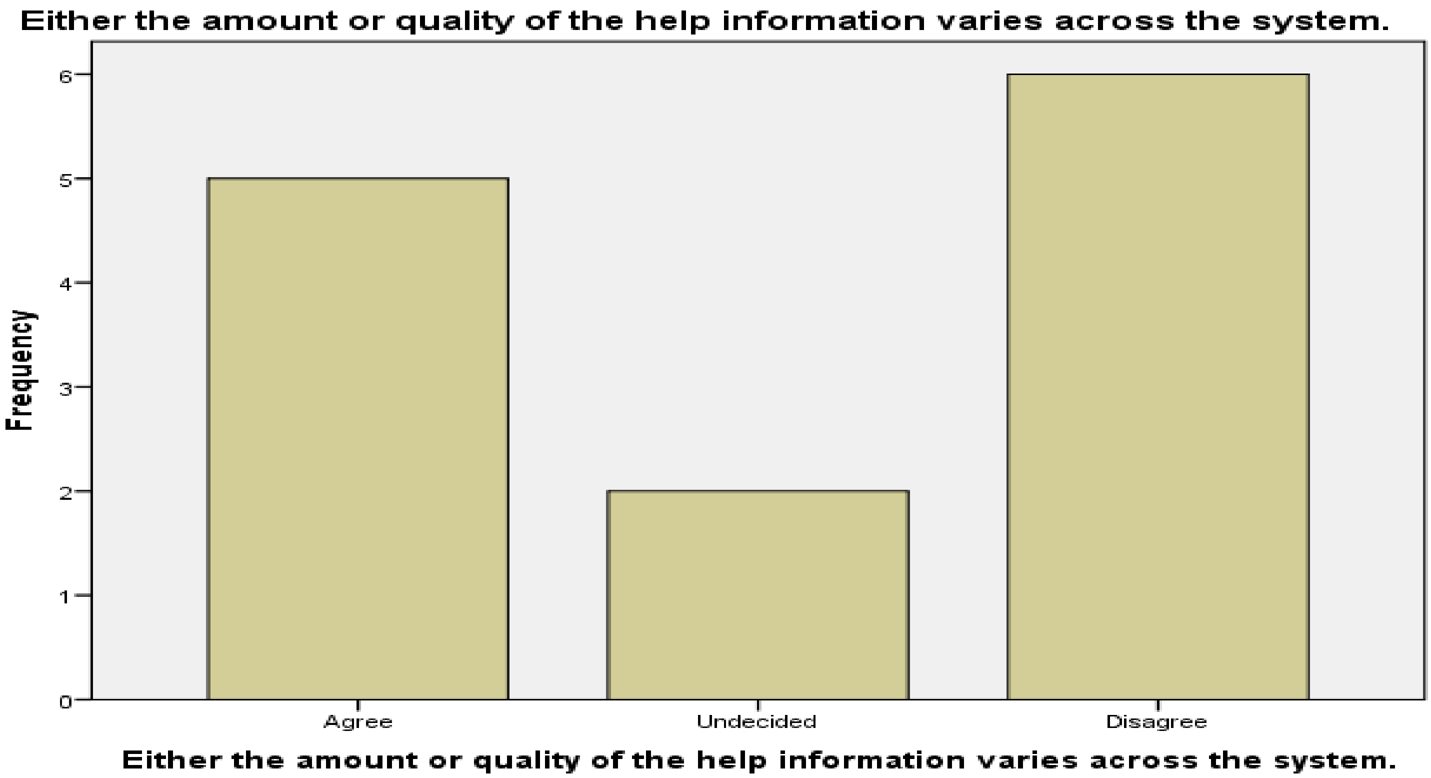

It is easy to make the software do exactly what you want.
Frequency
0
1
2
3
4
5
Agree
Undecided
Disagree
It is easy to make the software do exactly what you want.


I will never learn to use all that is offered in this software.
Frequency
0
1
2
3
4
5
6
Agree
Undecided
Disagree
I will never learn to use all that is offered in this software.

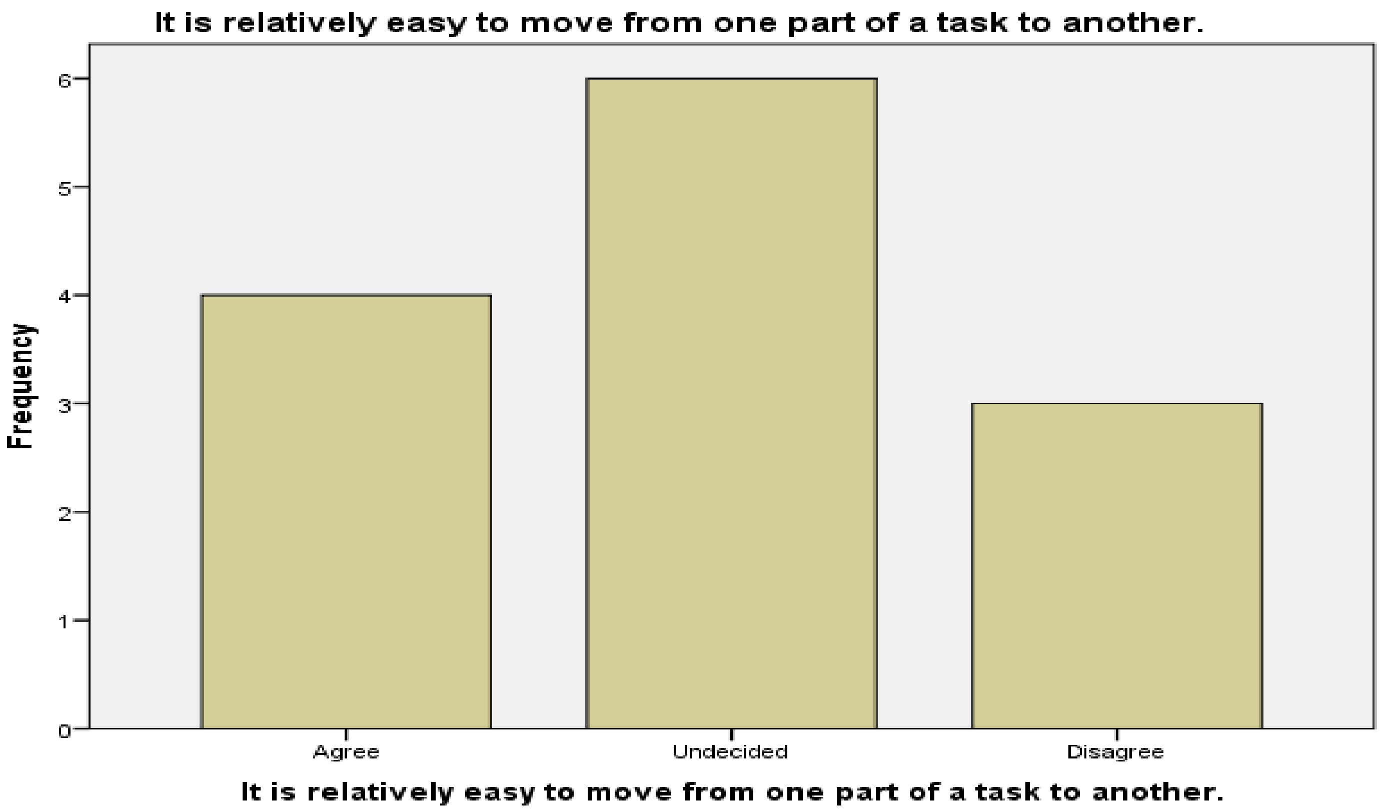

The software hasn't always done what I was expecting.
Frequency
0
1
2
3
4
5
6
Agree
Undecided
Disagree
The software hasn't always done what I was expecting.

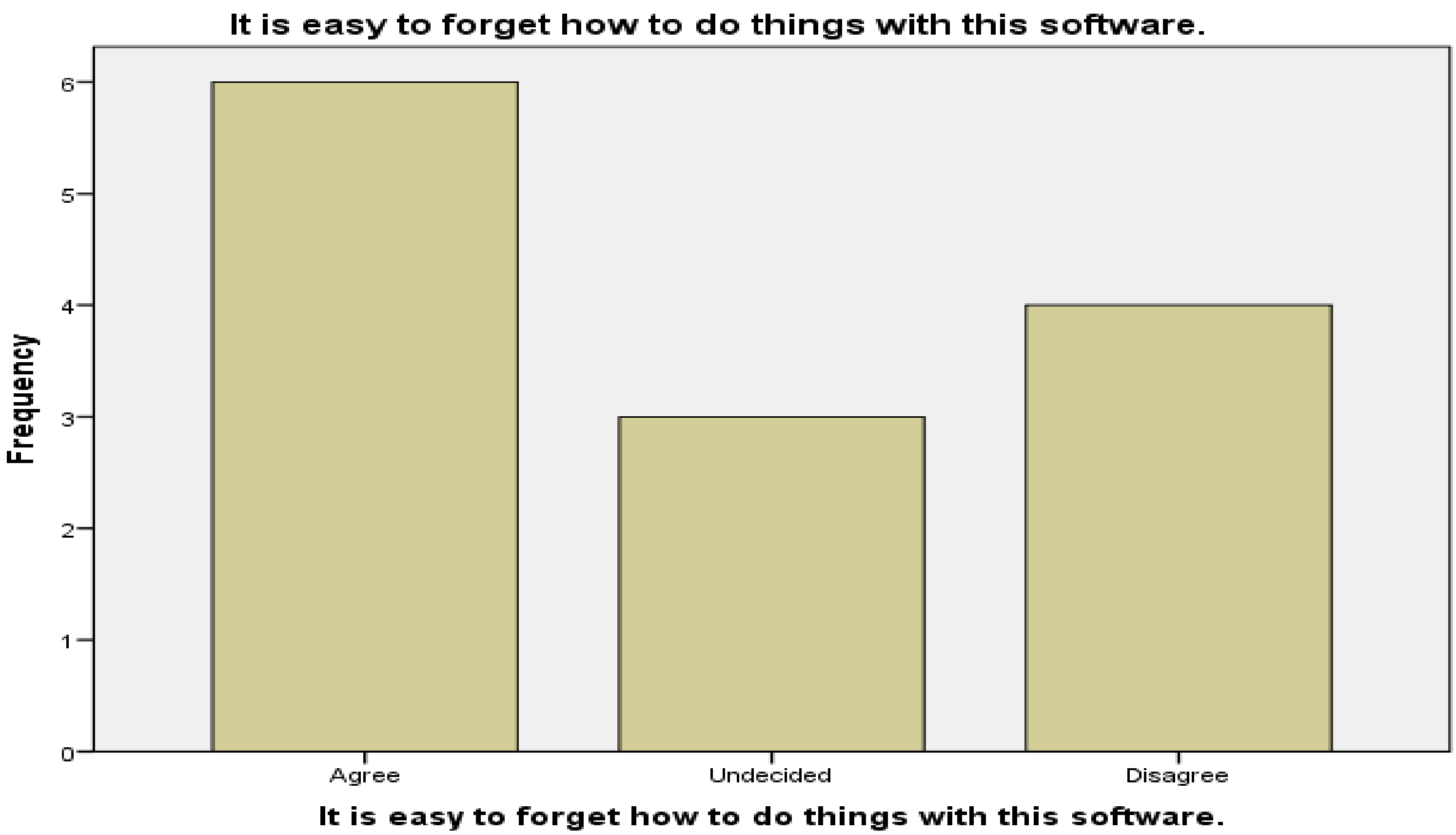


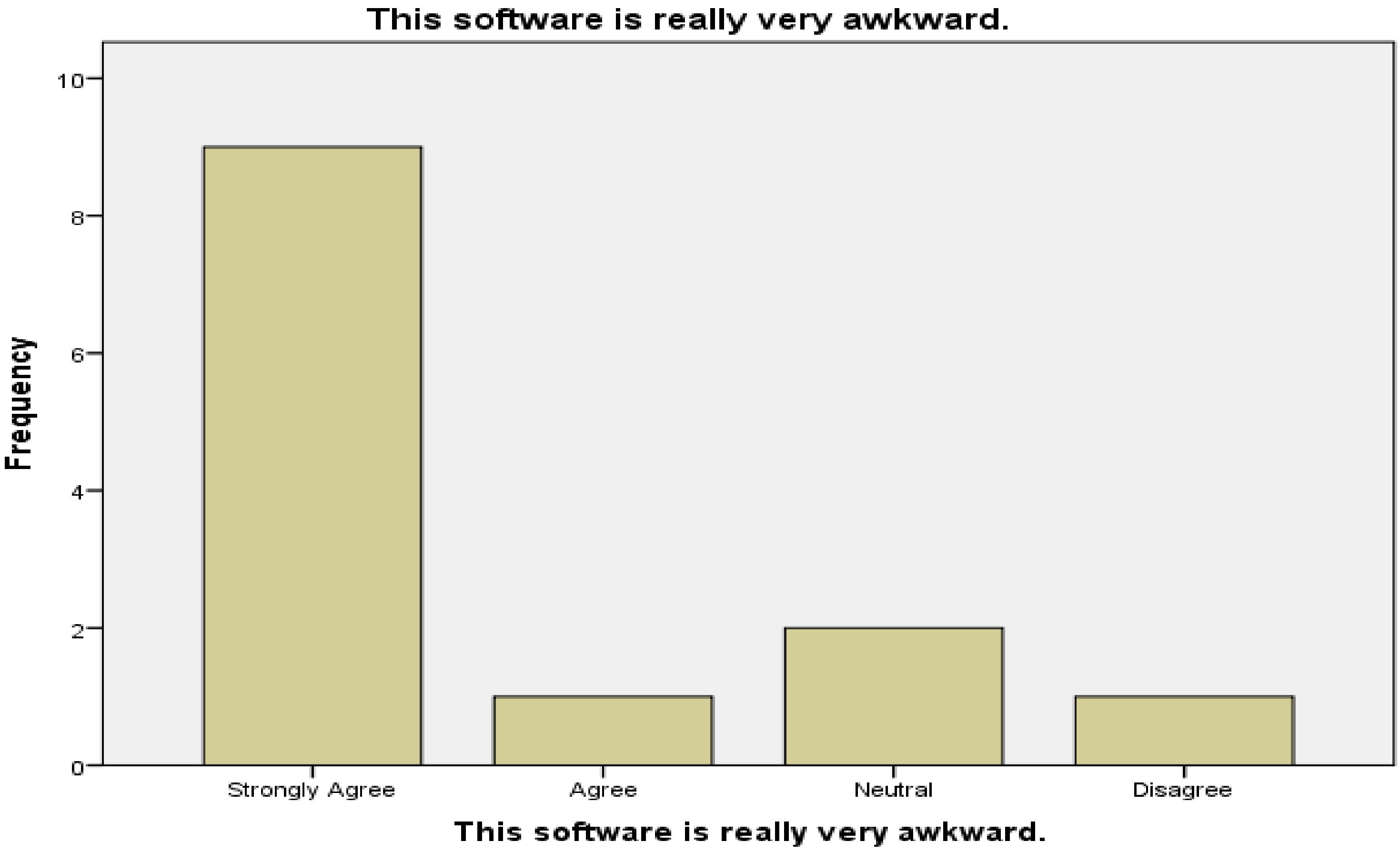
The software has a very attractive presentation.
Frequency
0
1
2
3
4
5
Agree
Undecided
Disagree
The software has a very attractive presentation.

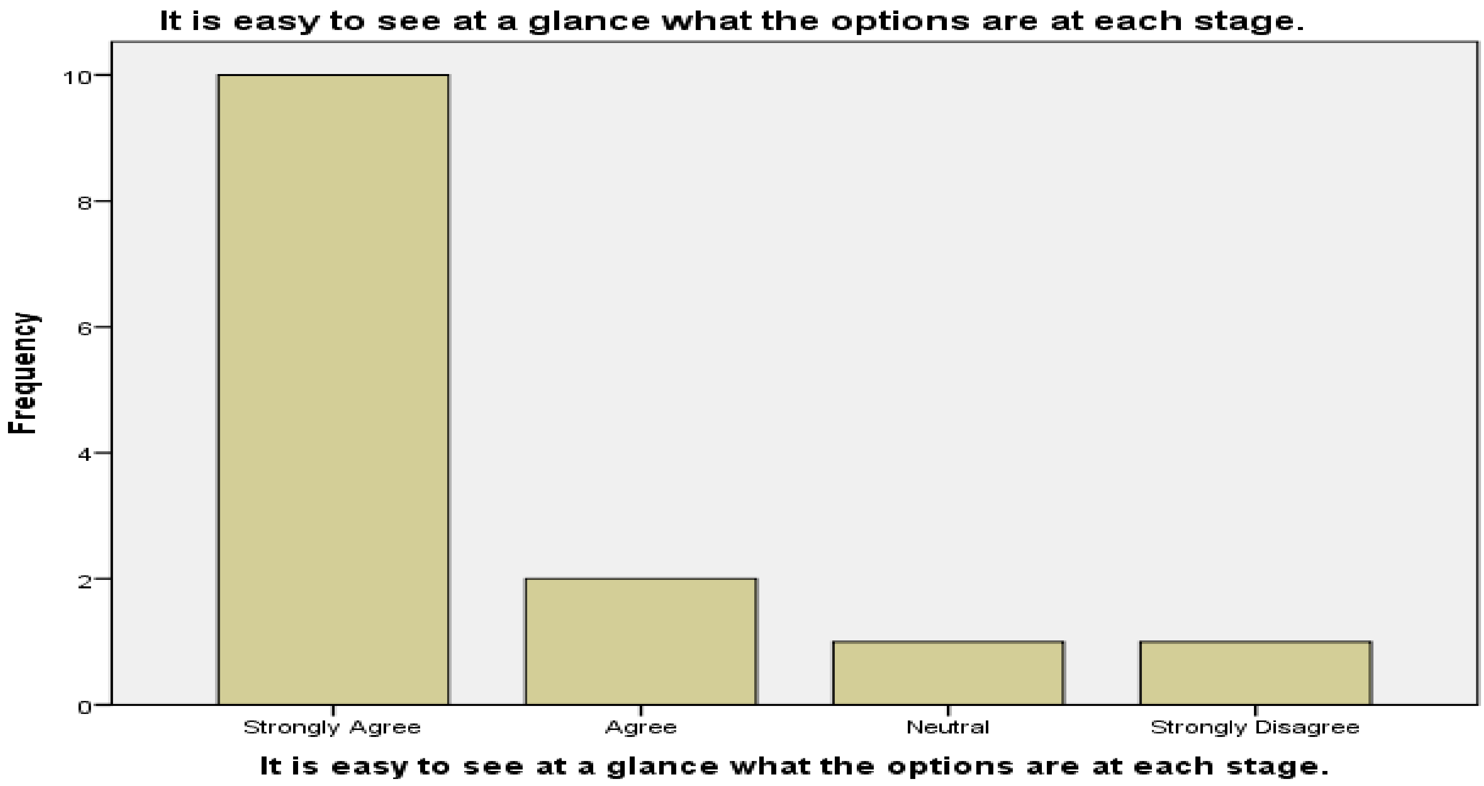


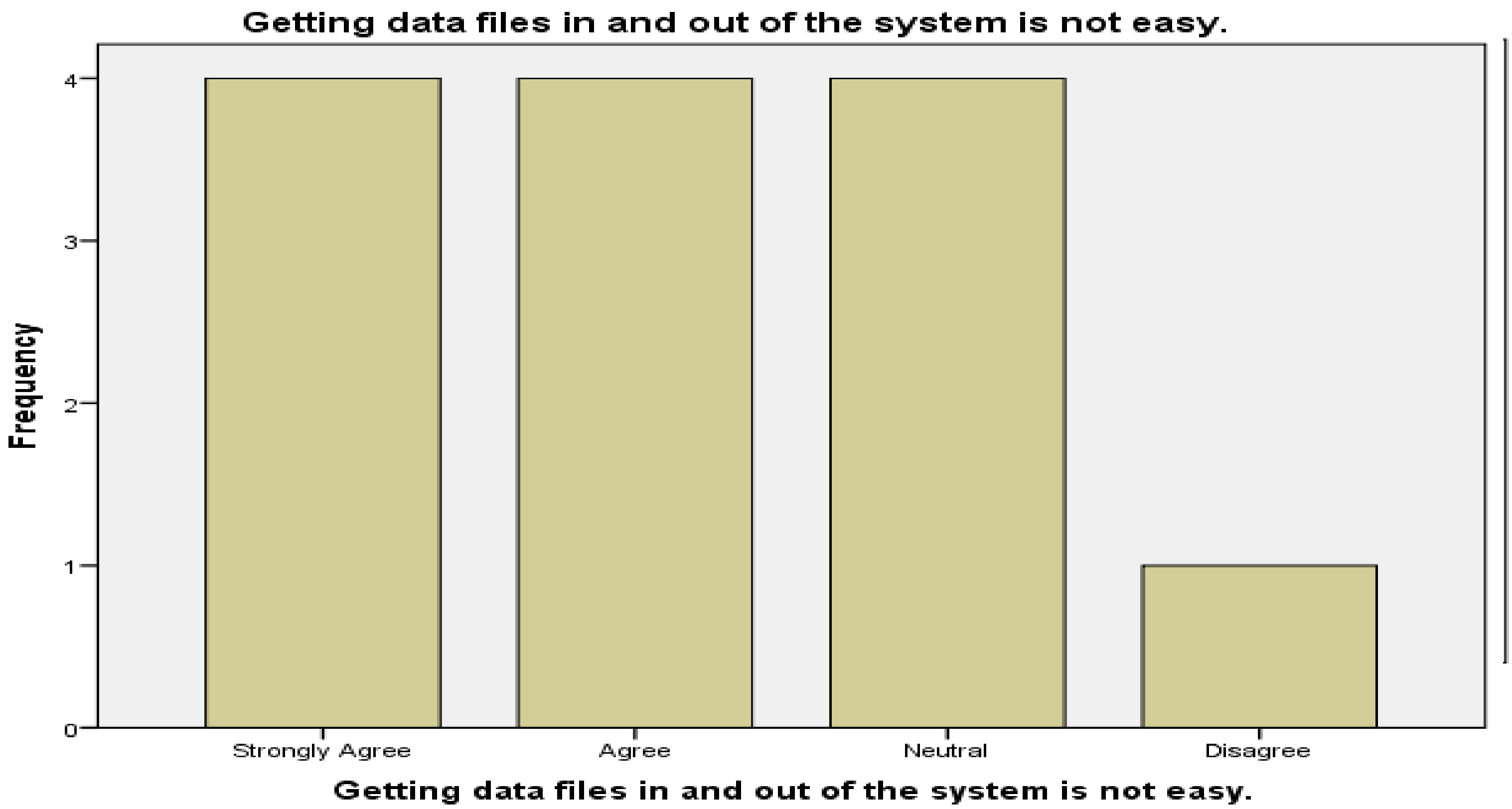
Either the amount or quality of the help information varies across the system.
Frequency
0
1
2
3
4
5
6
Agree
Undecided
Disagree
Either the amount or quality of the help information varies across the system.

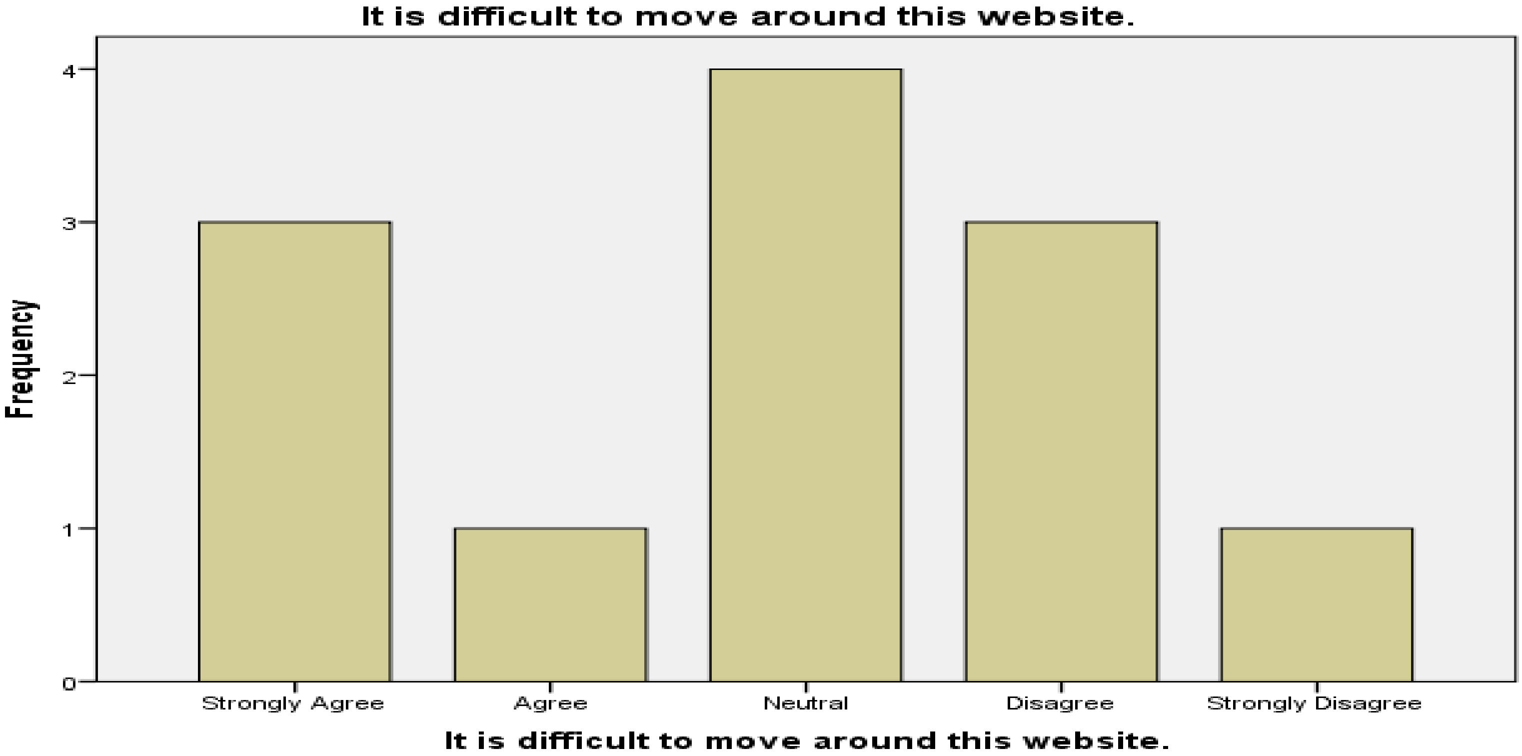

It is relatively easy to move from one part of a task to another.
Frequency
0
1
2
3
4
5
6
Agree
Undecided
Disagree
It is relatively easy to move from one part of a task to another.

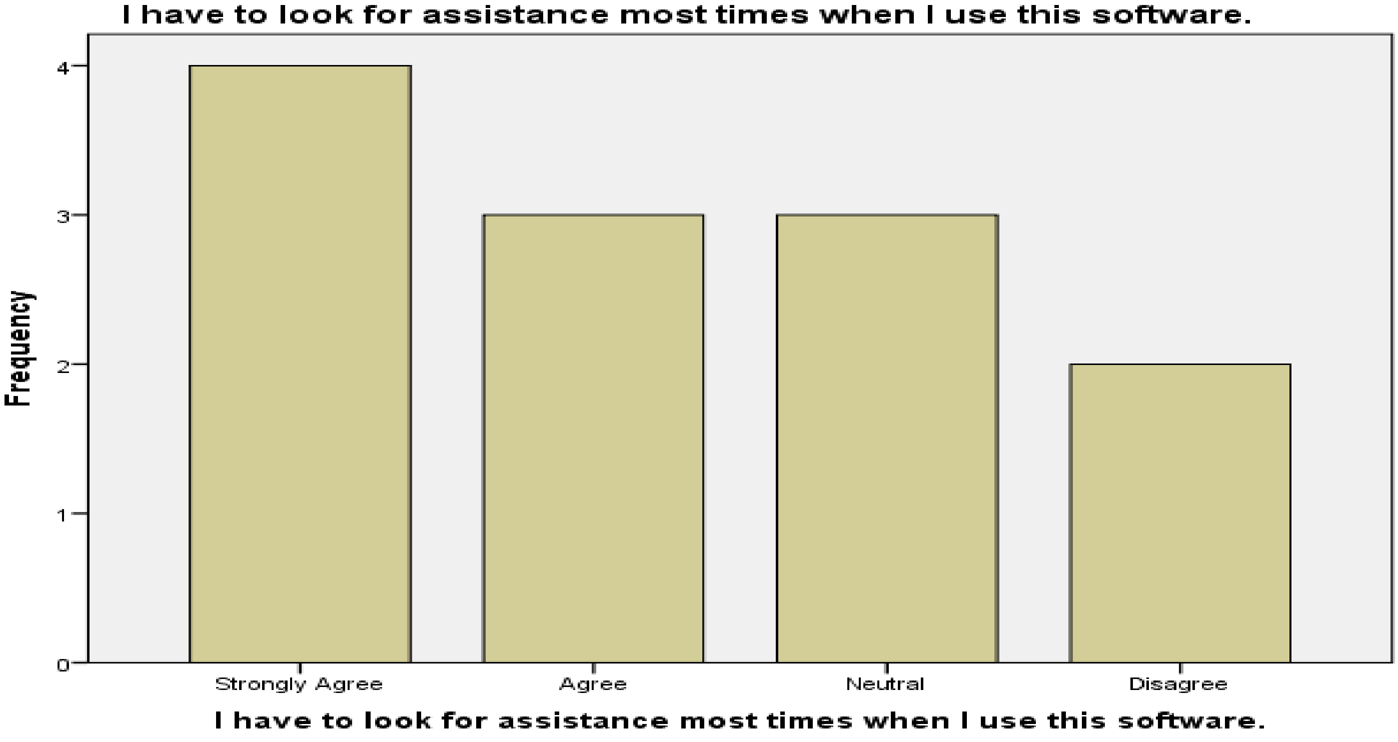

It is easy to forget how to do things with this software.
Frequency
0
1
2
3
4
5
6
Agree
Undecided
Disagree
It is easy to forget how to do things with this software.

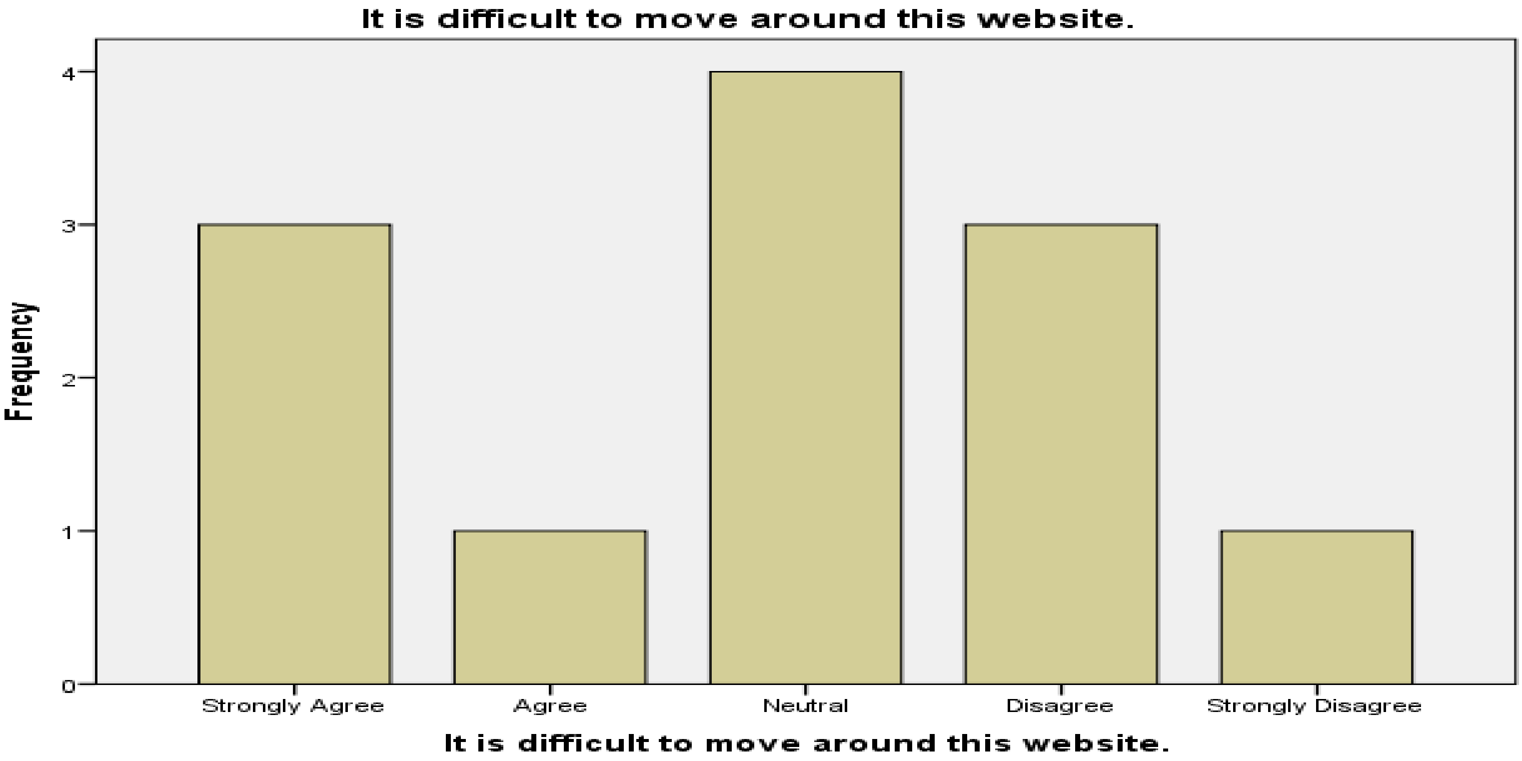

This software is really very awkward.
Frequency
10
8
6
4
2
0
Strongly Agree
Agree
Neutral
Disagree
This software is really very awkward.

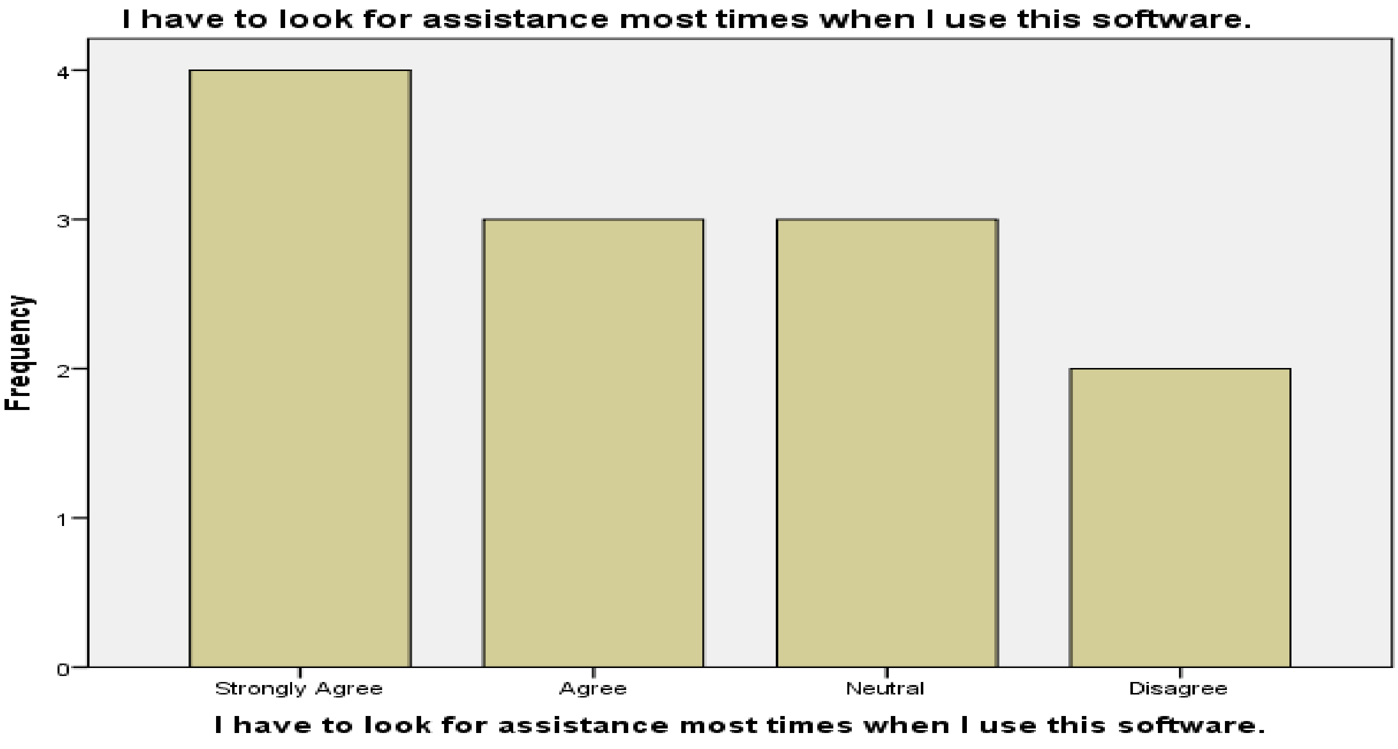

It is easy to see at a glance what the options are at each stage.
Frequency
0
2
4
6
8
10
Strongly Agree
Agree
Neutral
Strongly Disagree
It is easy to see at a glance what the options are at each stage.

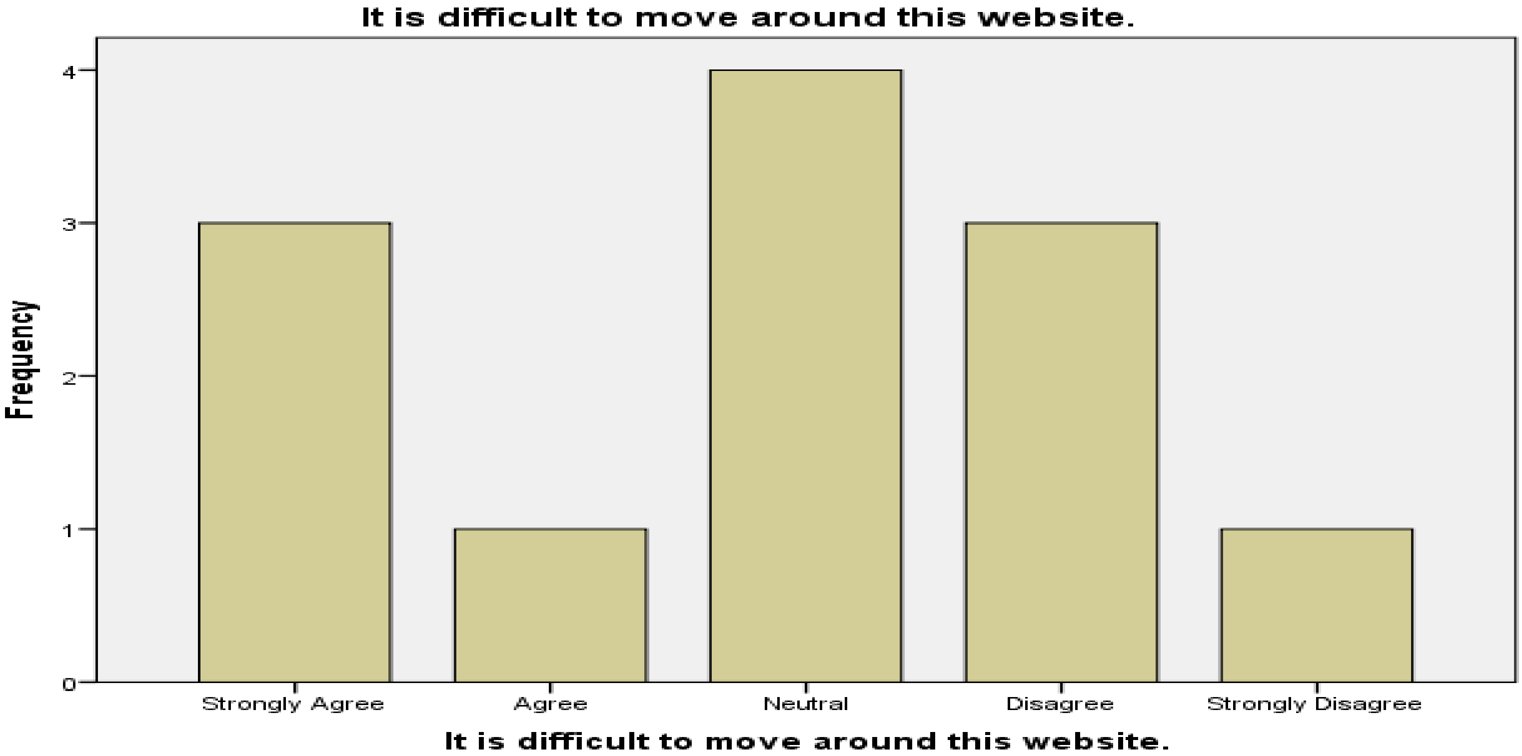

Getting data files in and out of the system is not easy.
Frequency
0
1
2
3
4
Strongly Agree
Agree
Neutral
Disagree
Getting data files in and out of the system is not easy.

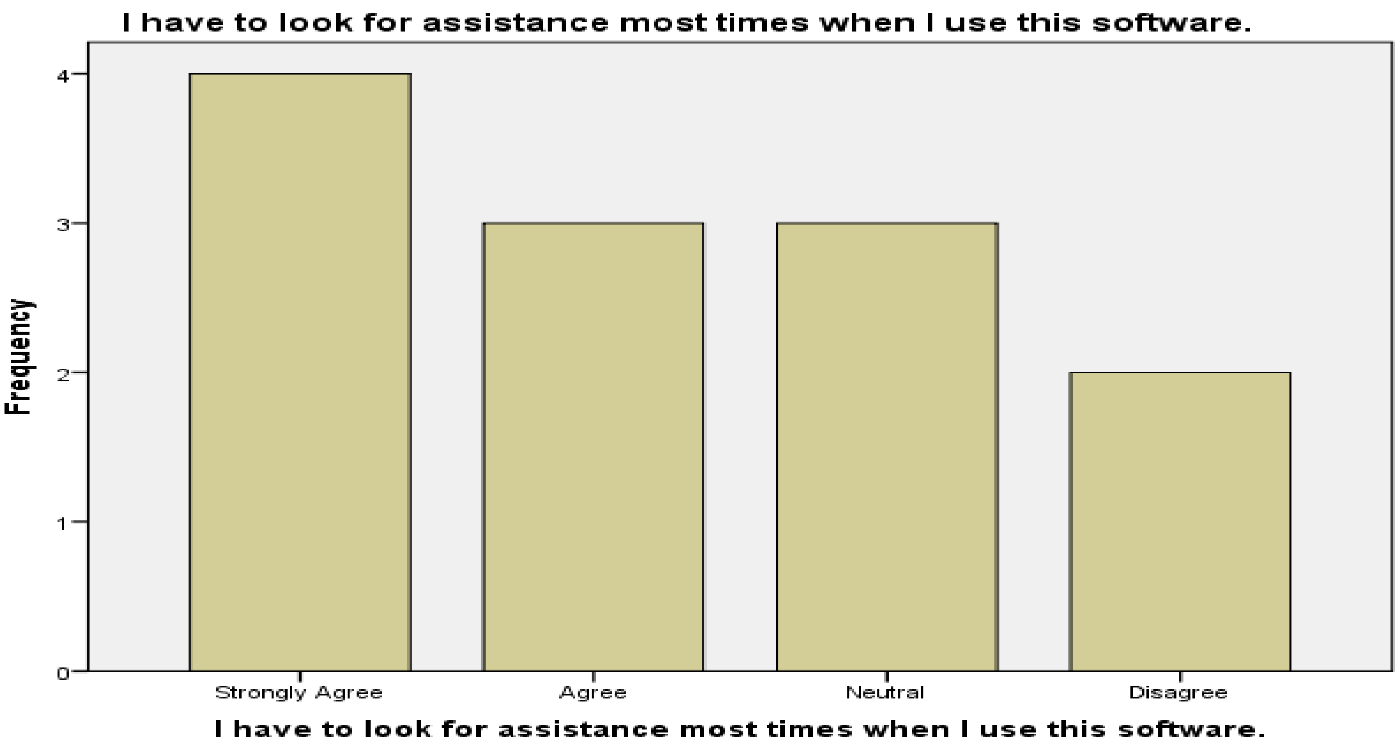

It is difficult to move around this website.
Frequency
4
3
2
1
0
Strongly Agree
Agree
Neutral
Disagree
Strongly Disagree
It is difficult to move around this website.

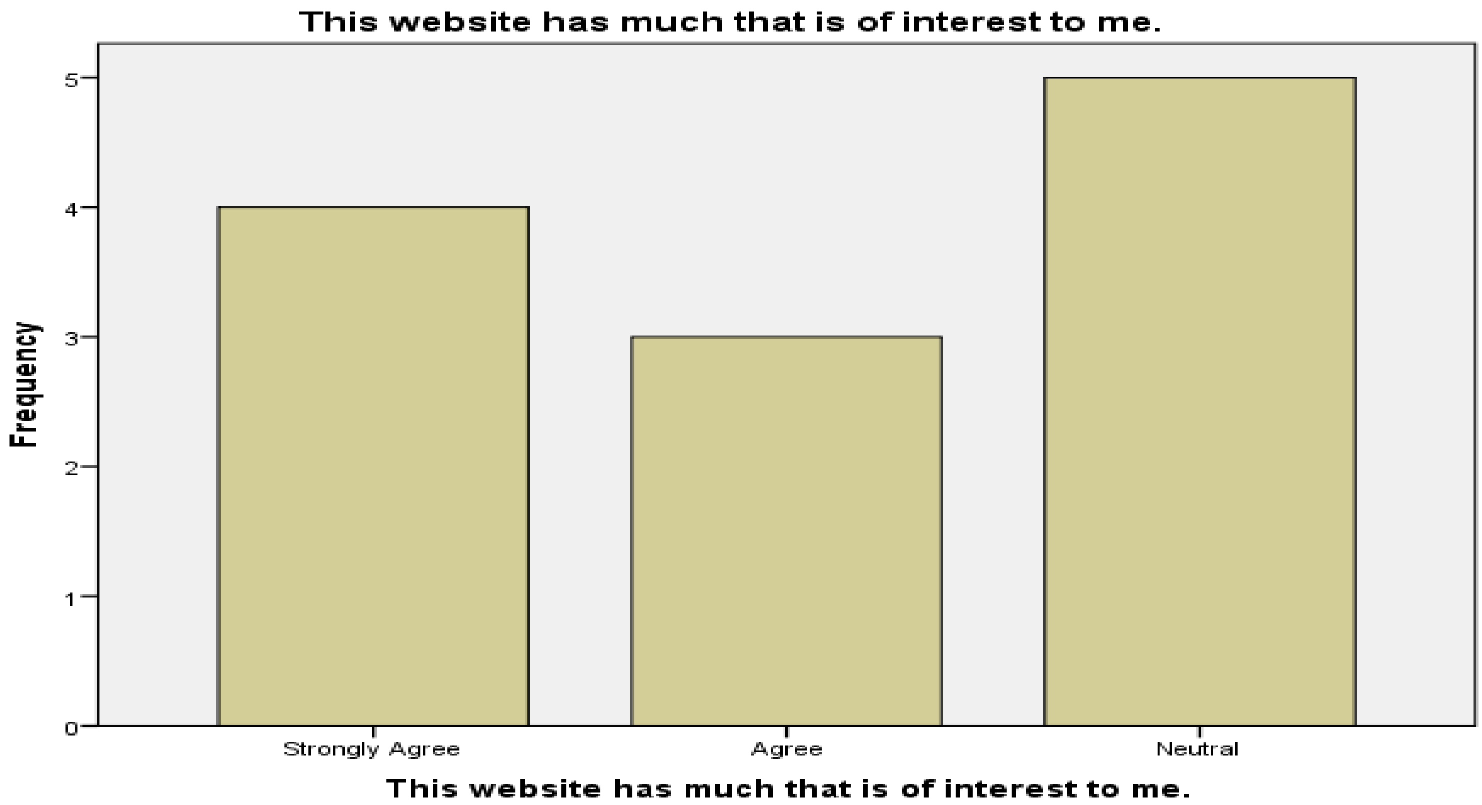

I have to look for assistance most times when I use this software.
Frequency
4
3
2
1
0
Strongly Agree
Agree
Neutral
Disagree
I have to look for assistance most times when I use this software.

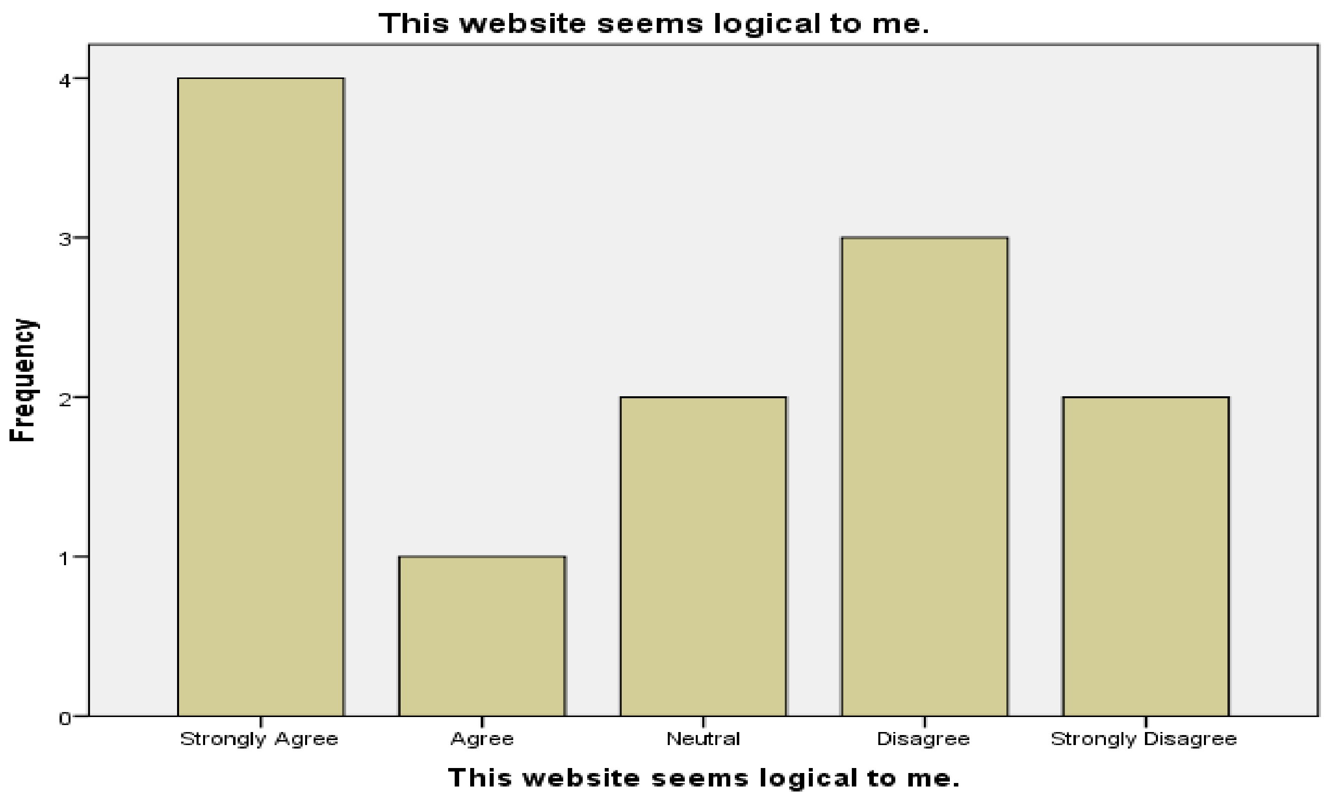

It is difficult to move around this website.
Frequency
0
1
2
3
4
Strongly Agree
Agree
Neutral
Disagree
Strongly Disagree
It is difficult to move around this website.

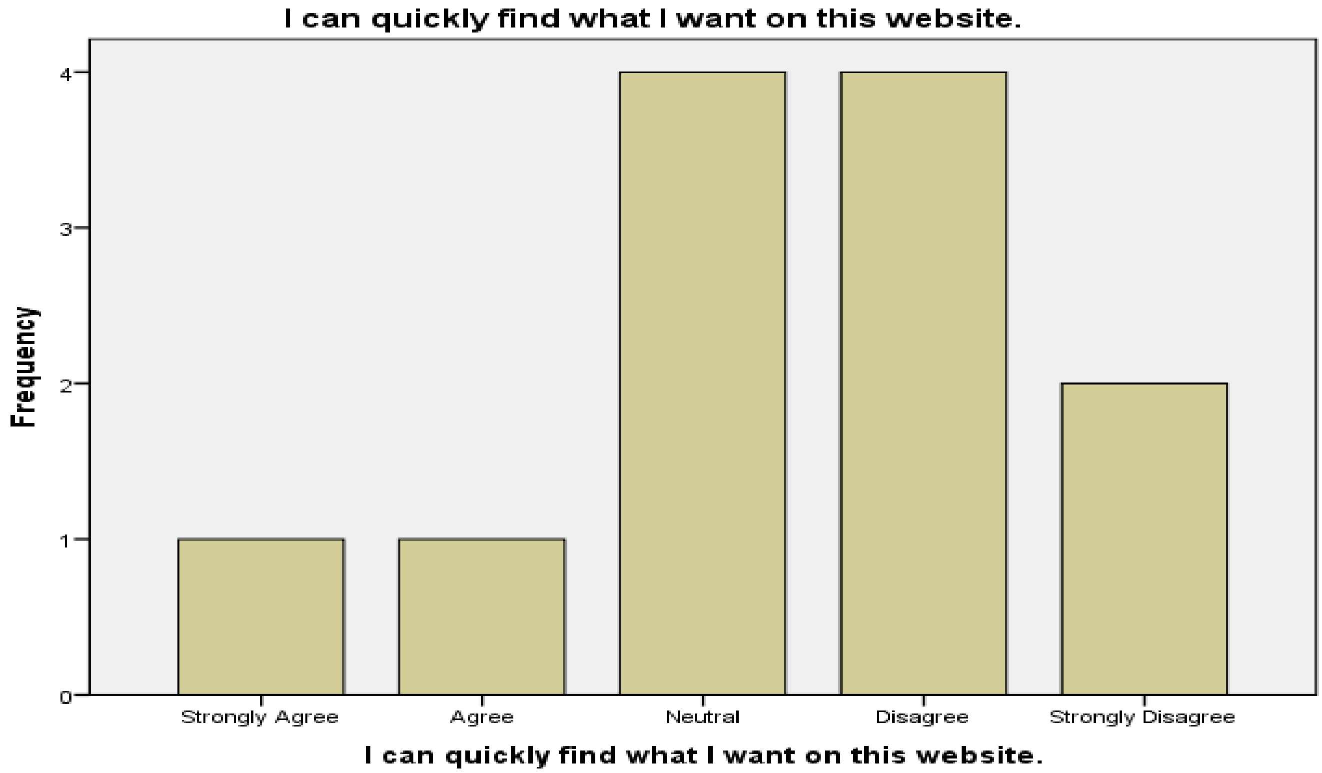

I have to look for assistance most times when I use this software.
Frequency
0
1
2
3
4
Strongly Agree
Agree
Neutral
Disagree
I have to look for assistance most times when I use this software.

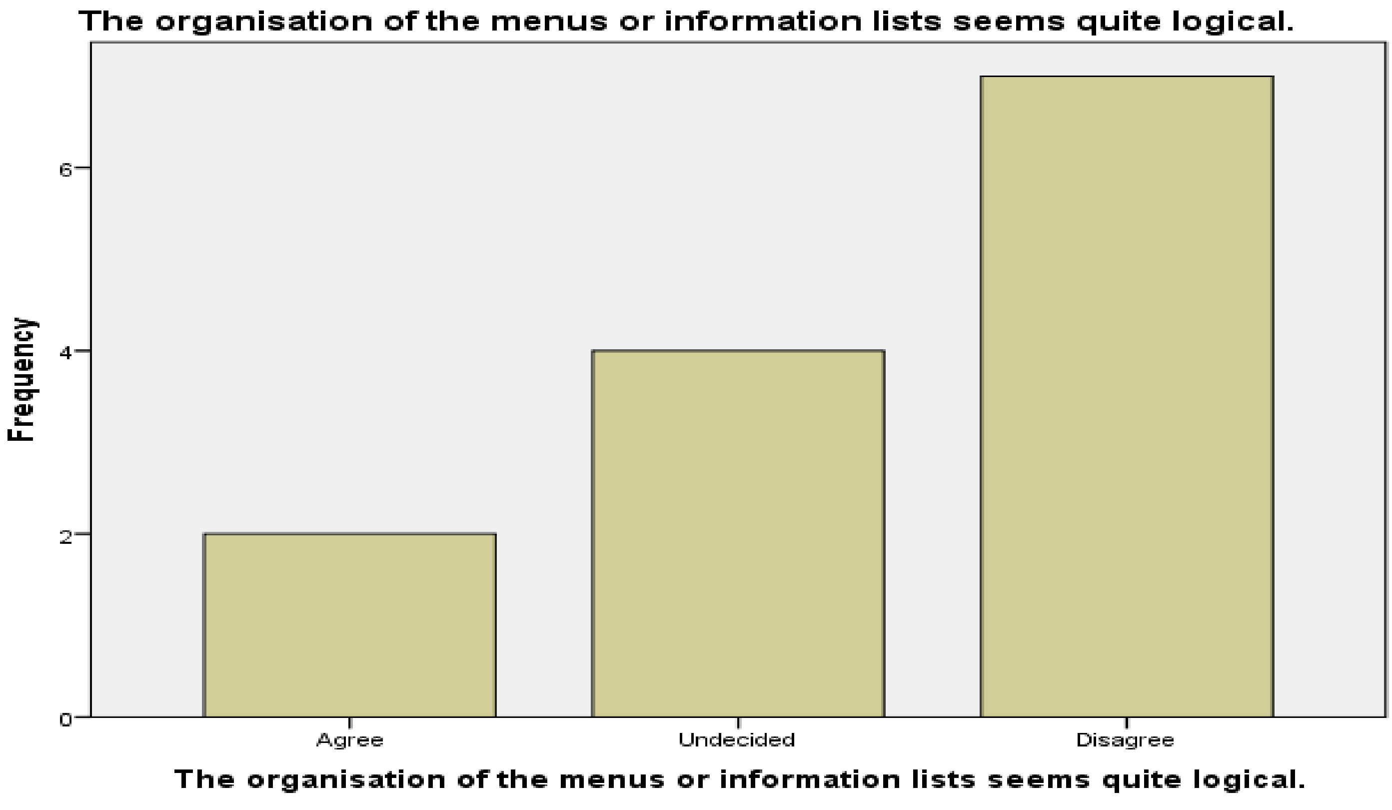

It is difficult to move around this website.
Frequency
0
1
2
3
4
Strongly Agree
Agree
Neutral
Disagree
Strongly Disagree
It is difficult to move around this website.

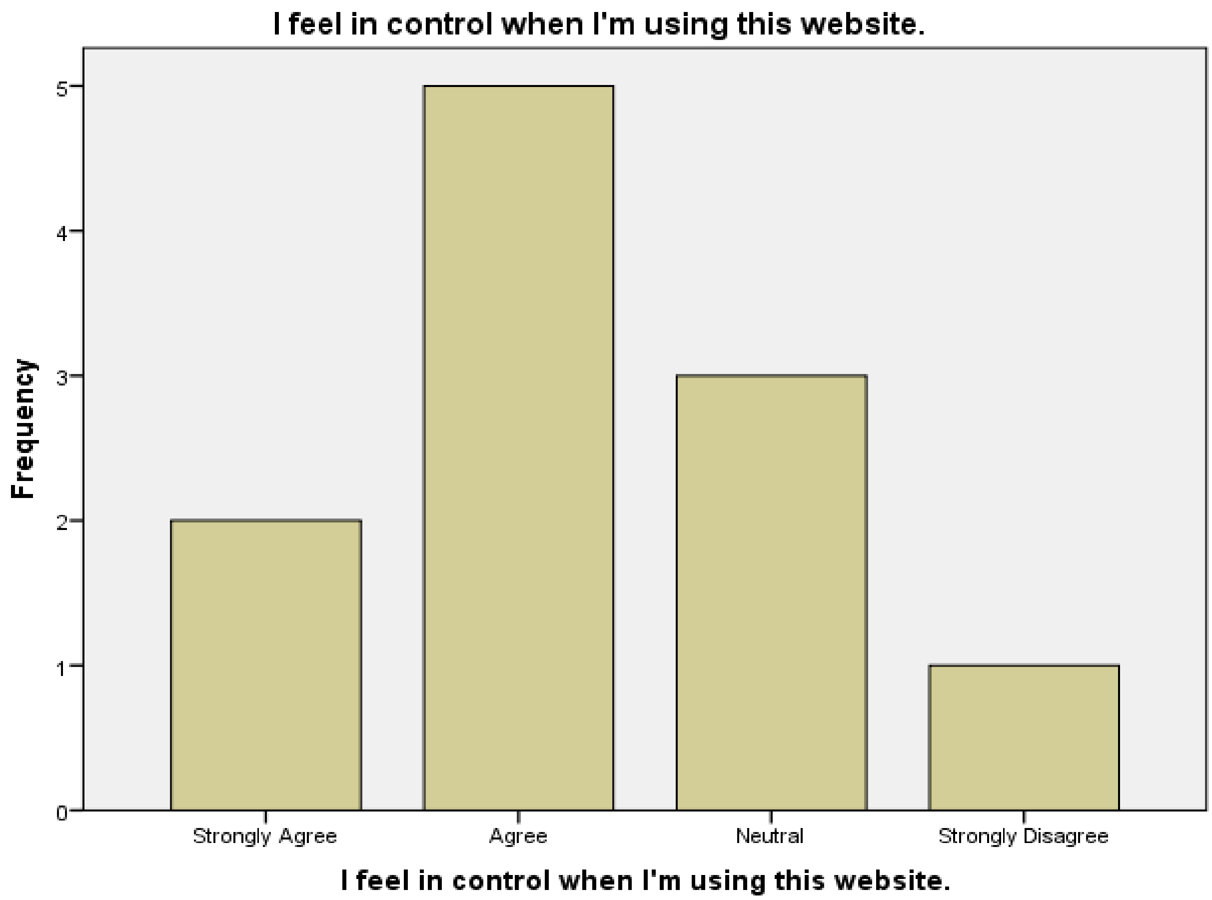

I have to look for assistance most times when I use this software.
Frequency
0
1
2
3
4
Strongly Agree
Agree
Neutral
Disagree
I have to look for assistance most times when I use this software.

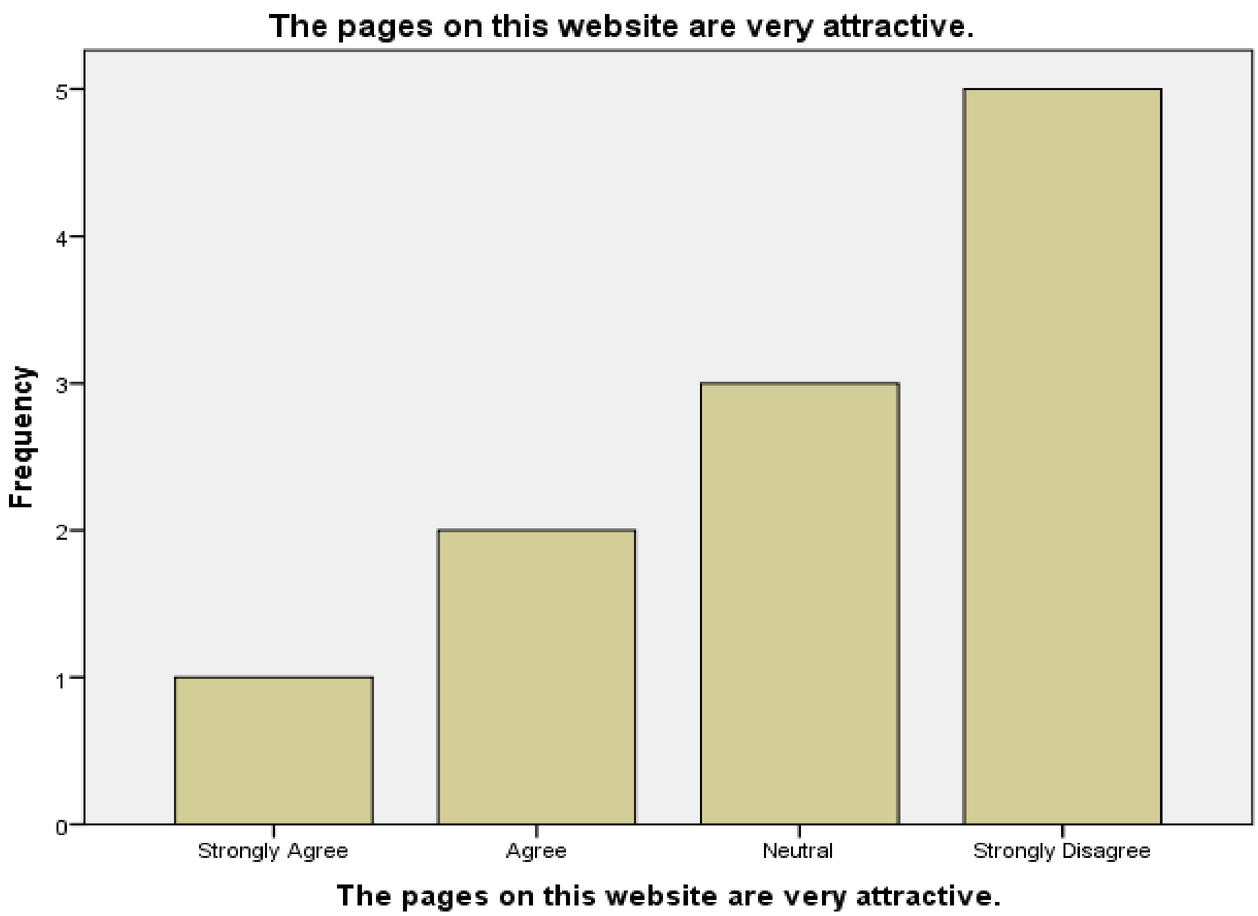

This website has much that is of interest to me.
Frequency
5
4
3
2
1
0
Strongly Agree
Agree
Neutral
This website has much that is of interest to me.

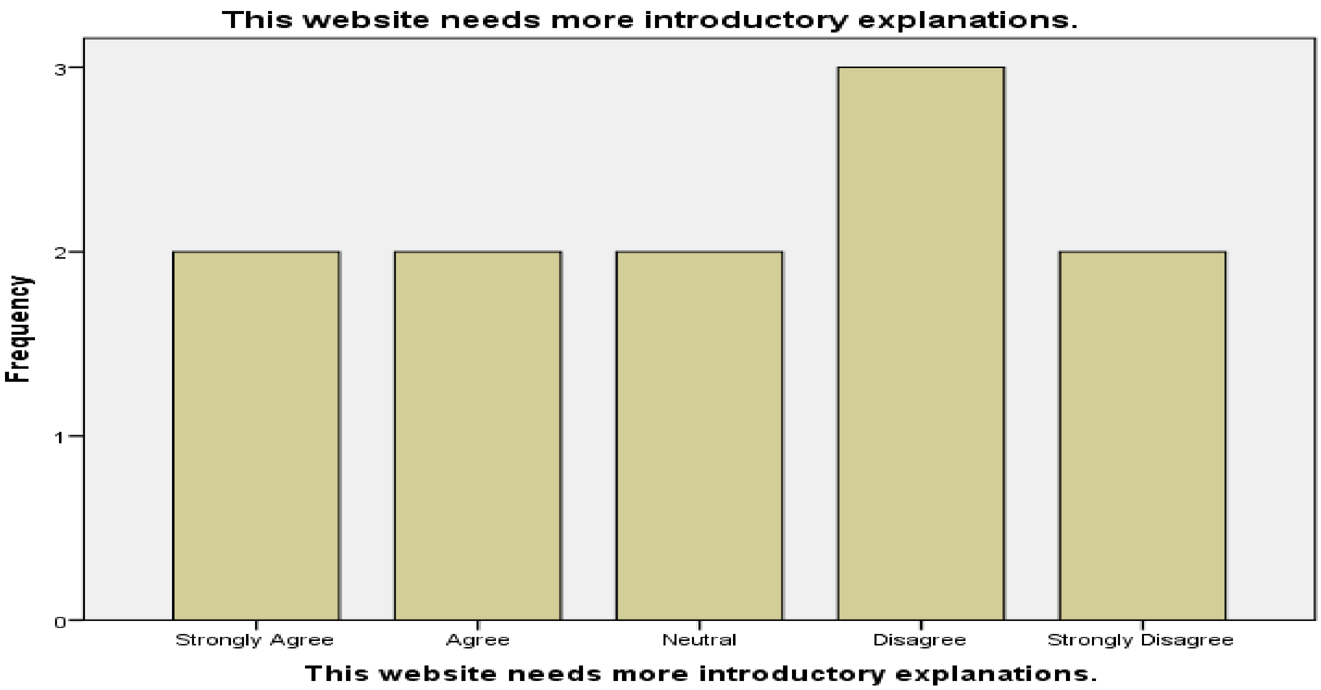

This website seems logical to me.
Frequency
4
3
2
1
0
Strongly Agree
Agree
Neutral
Disagree
Strongly Disagree
This website seems logical to me.

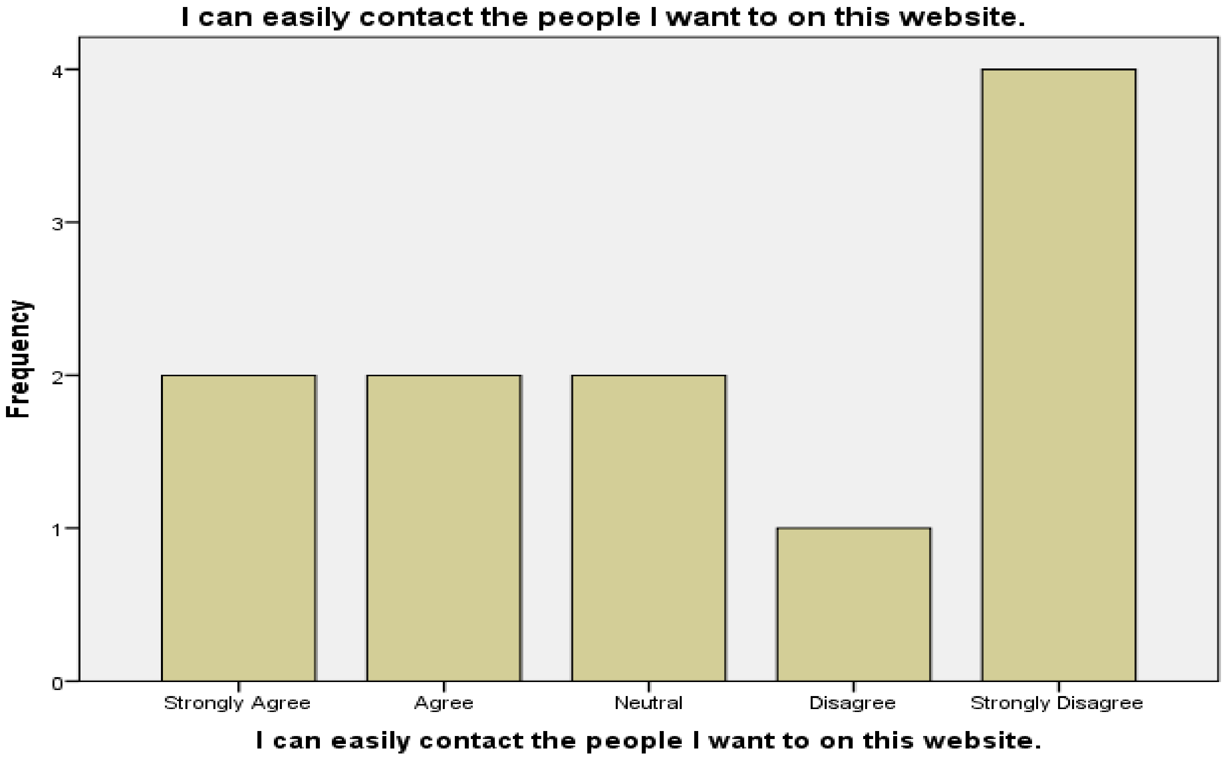

I can quickly find what I want on this website.
Frequency
0
1
2
3
4
Strongly Agree
Agree
Neutral
Disagree
Strongly Disagree
I can quickly find what I want on this website.

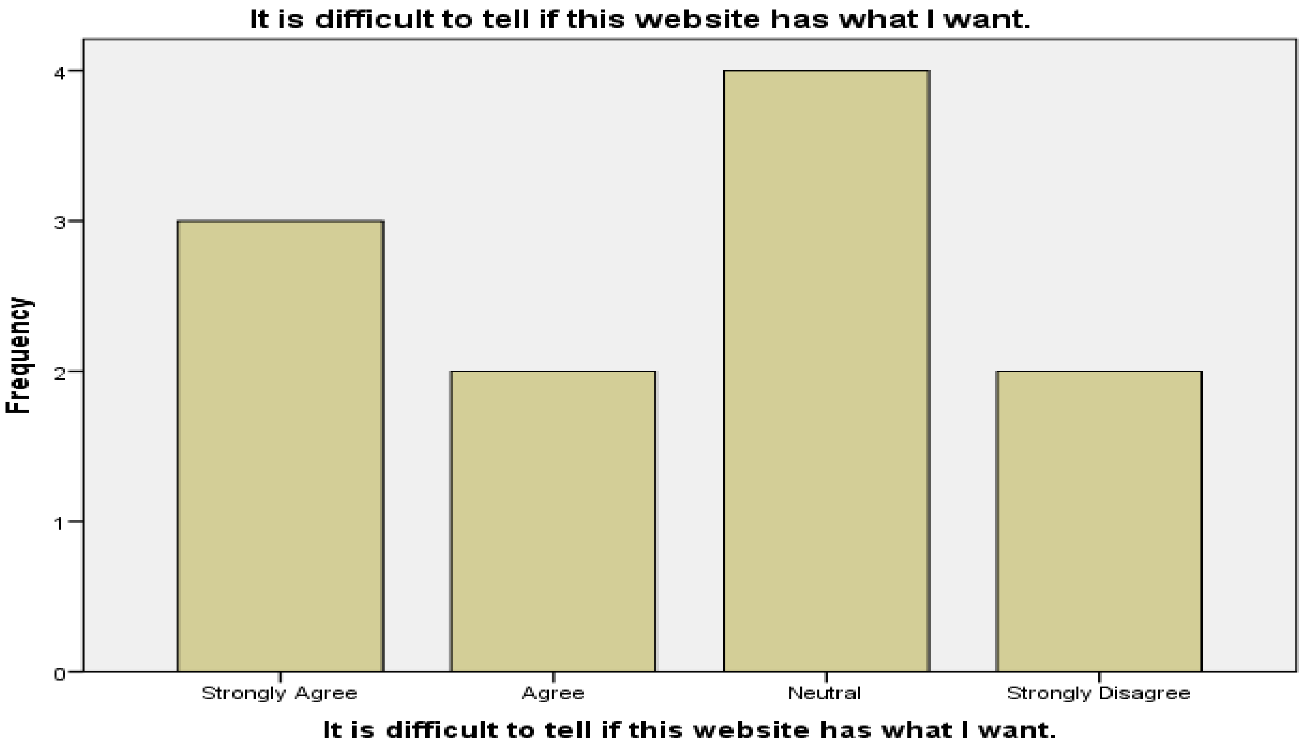

The organisation of the menus or information lists seems quite logical.
Frequency
0
2
4
6
Agree
Undecided
Disagree
The organisation of the menus or information lists seems quite logical.

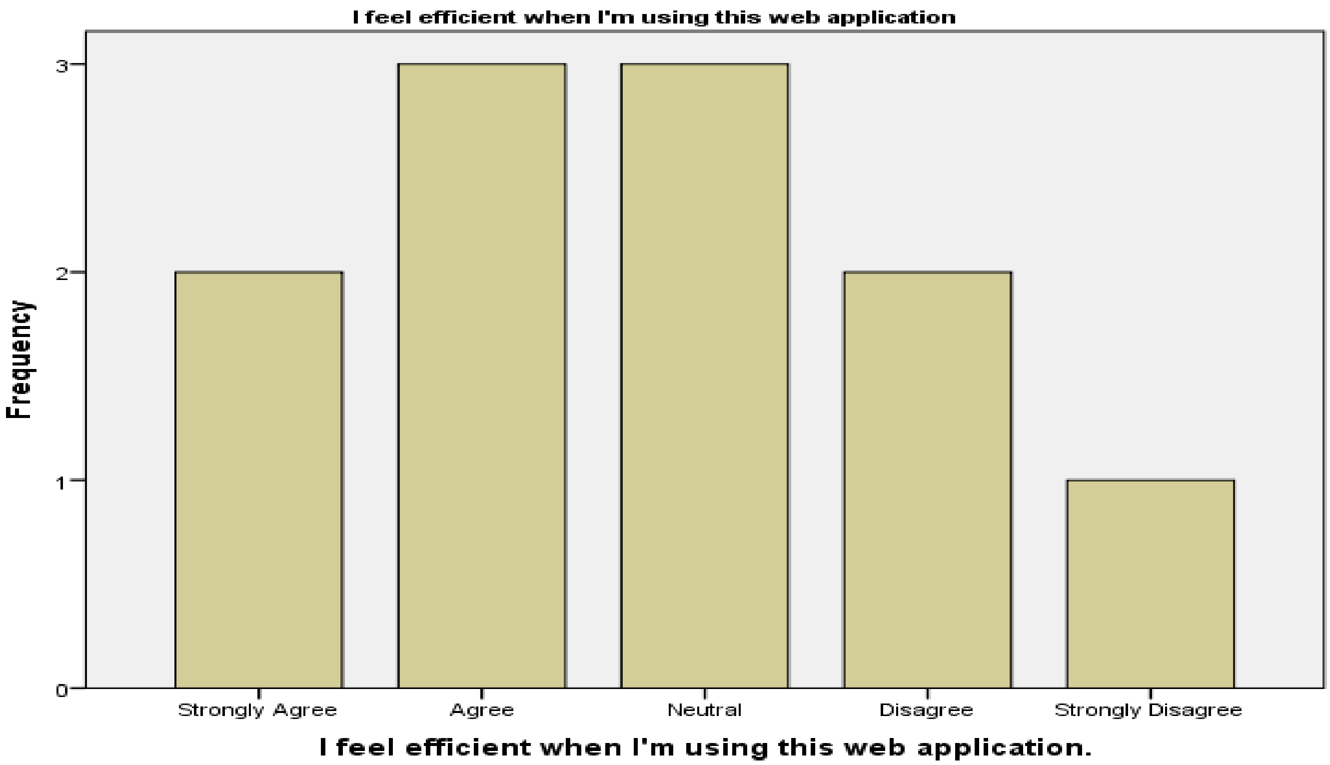

I feel in control when I'm using this website.
Frequency
0
1
2
3
4
5
Strongly Agree
Agree
Neutral
Strongly Disagree
I feel in control when I'm using this website.

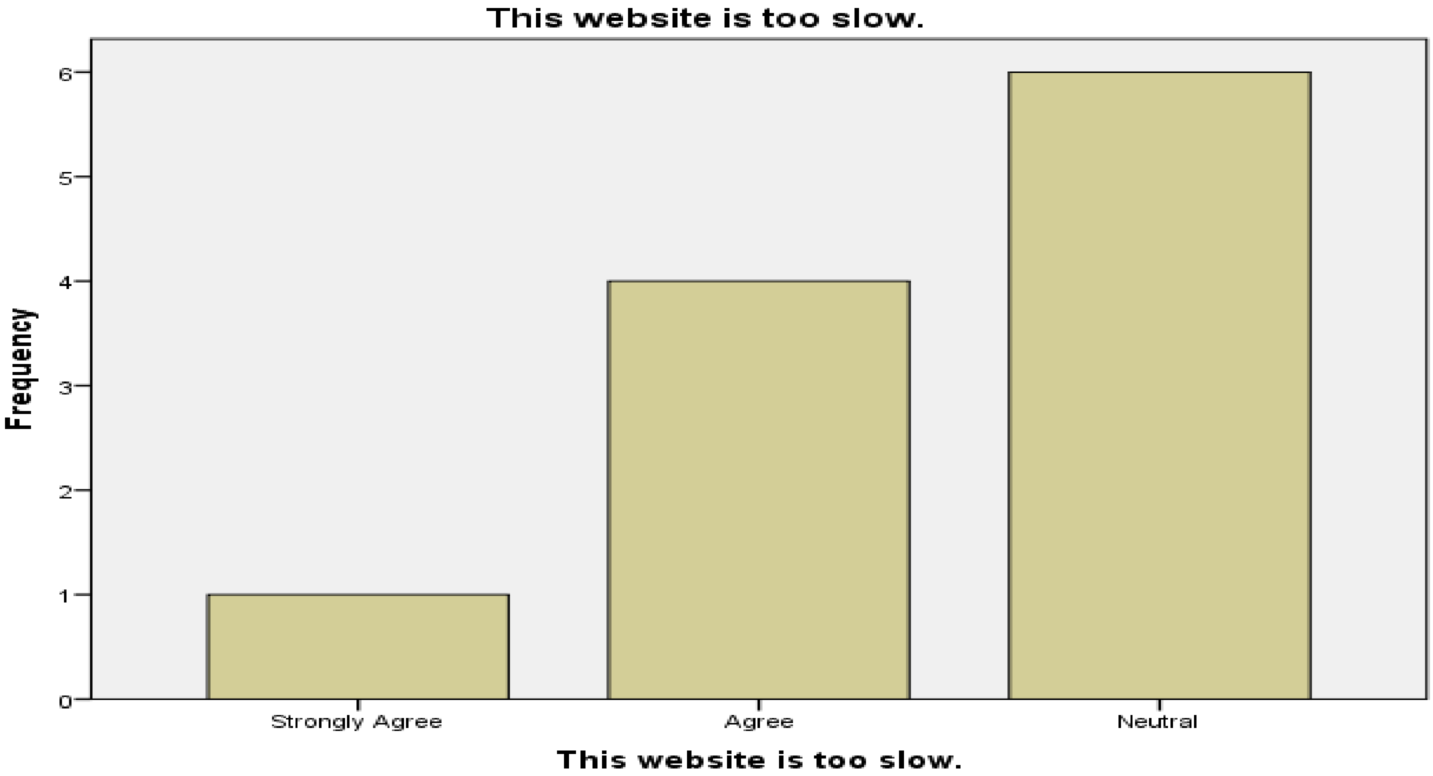

The pages on this website are very attractive.
Frequency
0
1
2
3
4
5
Strongly Agree
Agree
Neutral
Strongly Disagree
The pages on this website are very attractive.

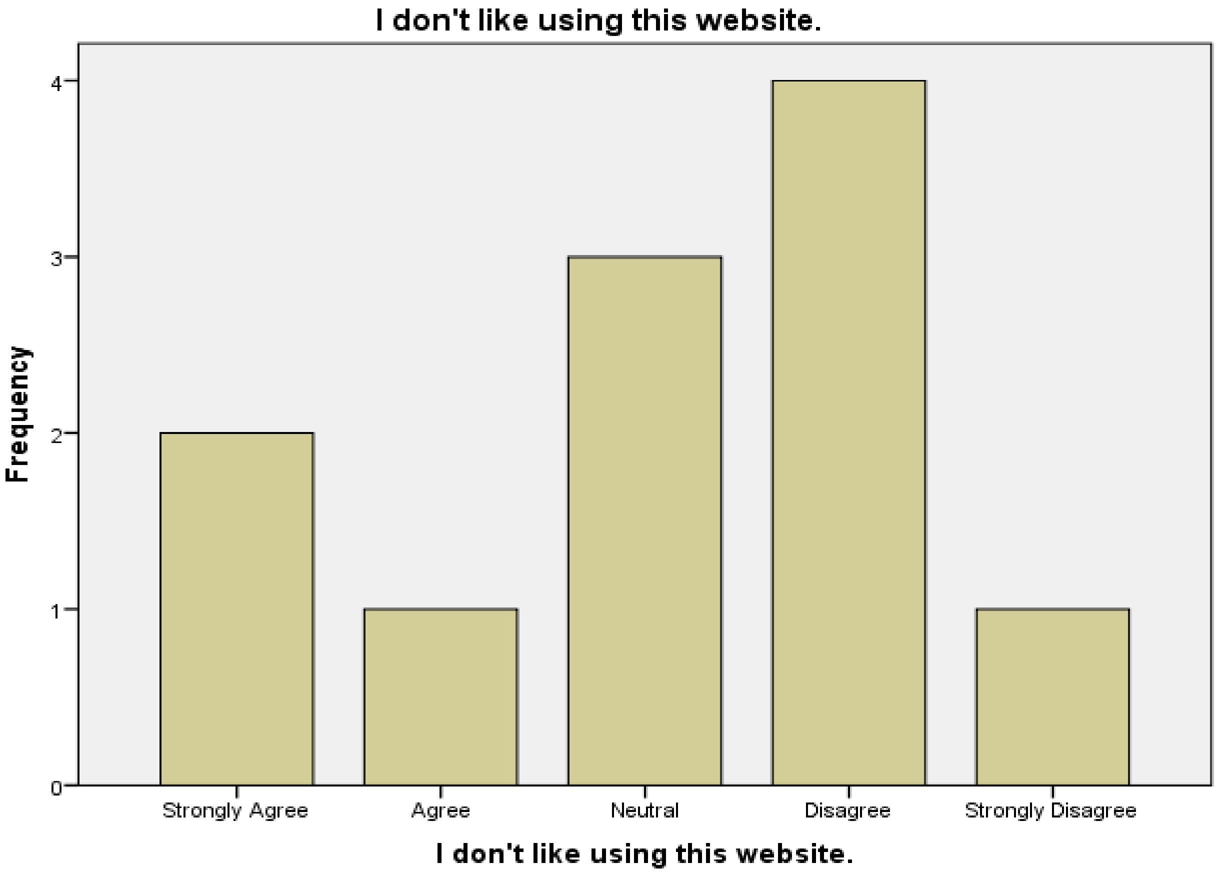

This website needs more introductory explanations.
Frequency
0
1
2
3
Strongly Agree
Agree
Neutral
Disagree
Strongly Disagree
This website needs more introductory explanations.


I can easily contact the people I want to on this website.
Frequency
0
1
2
3
4
Strongly Agree
Agree
Neutral
Disagree
Strongly Disagree
I can easily contact the people I want to on this website.


It is difficult to tell if this website has what I want.
Frequency
0
1
2
3
4
Strongly Agree
Agree
Neutral
Strongly Disagree
It is difficult to tell if this website has what I want.


I feel efficient when I'm using this web application
Frequency
0
1
2
3
Strongly Agree
Agree
Neutral
Disagree
Strongly Disagree
I feel efficient when I'm using this web application.


This website is too slow.
Frequency
0
1
2
3
4
5
6
Strongly Agree
Agree
Neutral
This website is too slow.


I don't like using this website.
Frequency
0
1
2
3
4
Strongly Agree
Agree
Neutral
Disagree
Strongly Disagree
I don't like using this website.

Database Extract

```
-- phpMyAdmin SQL Dump
-- version 3.5.2
-- http://www.phpmyadmin.net
--
-- Host: localhost
-- Generation Time: Dec 02, 2014 at 10:53 AM
-- Server version: 5.5.25a
-- PHP Version: 5.4.4

SET SQL_MODE="NO_AUTO_VALUE_ON_ZERO";
SET time_zone = "+00:00";
-- Database: `masters3`
-- Table structure for table `comment`
--

CREATE TABLE IF NOT EXISTS `comment` (
  `commentdid` int(11) NOT NULL AUTO_INCREMENT,
  `problem` text NOT NULL,
  `plan` text NOT NULL,
  `phase` varchar(100) NOT NULL,
  `hour` int(11) NOT NULL,
  `pid` int(11) NOT NULL,
  `empID` int(11) NOT NULL,
  `datecaptured` timestamp NOT NULL DEFAULT CURRENT_TIMESTAMP ON UPDATE CURRENT_TIMESTAMP,
  PRIMARY KEY (`commentdid`)
) ENGINE=InnoDB  DEFAULT CHARSET=latin1 AUTO_INCREMENT=14 ;

--
```

```
-- Dumping data for table `comment`

--

INSERT INTO `comment` (`commentdid`, `problem`, `plan`, `phase`, `hour`, `pid`, `empID`, `datecaptured`) VALUES

(10, '5% dextose 100mls IV', 'N/A', 'Latent', 0, 7, 2, '2013-11-03 17:42:02'),

(11, 'pethidine', 'medication as boarded', 'Active', 2, 7, 2, '2014-01-26 07:52:32'),

(12, 'patient is stable', 'none', 'Latent', 1, 5, 2, '2014-01-26 08:15:58'),

(13, 'patient is okay.sodium chloride administer.', 'none', 'Active', 8, 3, 2, '2014-01-26 08:34:45');

--

-- Table structure for table `condition`

--

CREATE TABLE IF NOT EXISTS `condition` (

  `condiID` int(11) NOT NULL AUTO_INCREMENT,

  `patID` int(11) NOT NULL,

  `pelvis` text NOT NULL,

  `gravity` text NOT NULL,

  `parity` text NOT NULL,

  `gestation` text NOT NULL,

  `riskfactors` text NOT NULL,

  `labour` text NOT NULL,

  `durationofRom` text NOT NULL,

  `durationoflabour` text NOT NULL,

  `highRisk` varchar(10) NOT NULL,

  `datecaptured` timestamp NOT NULL DEFAULT CURRENT_TIMESTAMP ON UPDATE CURRENT_TIMESTAMP,

  PRIMARY KEY (`condiID`)

) ENGINE=InnoDB  DEFAULT CHARSET=latin1 AUTO_INCREMENT=10 ;

--
```

```
-- Dumping data for table `condition`

--


INSERT INTO `condition` (`condiID`, `patID`, `pelvis`, `gravity`, `parity`, `gestation`, `riskfactors`, `labour`, `durationofRom`, `durationoflabour`, `highRisk`, `datecaptured`) VALUES

(2, 7, '0', '2', '1', '37', 'Cardiac Patient', 'Spontaneous', '5', '3', 'high', '2013-10-27 07:01:27'),

(7, 4, '2', '1', '5', '42', 'Cardiac Patient', 'Induced', '1', '9', 'low', '2013-10-27 07:01:35'),

(8, 3, '34', '34', '3', '12', 'Lupus', 'Induced', '21', '12', 'high', '2013-10-27 07:01:38'),

(9, 5, '23', '21', '4', '23', 'None', 'Spontaneous', '23', '4', 'low', '2013-10-27 07:01:45');


-- Table structure for table `contraction`

--


CREATE TABLE IF NOT EXISTS `contraction` (

  `contractID` int(11) NOT NULL AUTO_INCREMENT,

  `high` varchar(10) NOT NULL,

  `medium` varchar(10) NOT NULL,

  `low` varchar(10) NOT NULL,

  `hour` float NOT NULL,

  `phase` varchar(20) NOT NULL,

  `drugsnintravenous` text NOT NULL,

  `empId` int(11) NOT NULL,

  `pid` int(11) NOT NULL,

  `DateCaptured` timestamp NOT NULL DEFAULT CURRENT_TIMESTAMP ON UPDATE CURRENT_TIMESTAMP,

  PRIMARY KEY (`contractID`)

) ENGINE=InnoDB  DEFAULT CHARSET=latin1 AUTO_INCREMENT=52 ;


--

-- Dumping data for table `contraction`

--
```

```
INSERT INTO `contraction` (`contractID`, `high`, `medium`, `low`, `hour`, `phase`, `drugsnintravenous`, `empId`, `pid`, `DateCaptured`) VALUES

(46, '1', '2', '0', 0, 'Latent', 'peni', 2, 7, '2013-11-03 15:36:05'),

(47, '2', '0', '1', 1, 'Latent', 'none', 2, 7, '2013-11-03 17:36:46'),

(48, '4', '5', '0', 2, 'Latent', 'Your key instead is it of a insect OK ', 2, 7, '2013-11-22 05:13:03'),

(49, '3', '0', '0', 4, 'Active', 'pethidine', 2, 7, '2014-01-26 07:48:24'),

(50, '1', '1', '1', 1, 'Latent', 'nothing', 2, 5, '2014-01-26 08:11:45'),

(51, '1', '0', '0', 8, 'Active', 'sodium chloride', 2, 3, '2014-01-26 08:30:42');


-- Table structure for table `employee`

--


CREATE TABLE IF NOT EXISTS `employee` (

  `empID` int(11) NOT NULL AUTO_INCREMENT,

  `name` varchar(200) NOT NULL,

  `surname` varchar(200) NOT NULL,

  `username` varchar(100) NOT NULL,

  `password` varchar(100) NOT NULL,

  `facilityID` int(11) NOT NULL,

  `userType` varchar(50) NOT NULL,

  `dateAdded` timestamp NOT NULL DEFAULT CURRENT_TIMESTAMP ON UPDATE CURRENT_TIMESTAMP,

  PRIMARY KEY (`empID`)

) ENGINE=InnoDB  DEFAULT CHARSET=latin1 AUTO_INCREMENT=3 ;


--

-- Dumping data for table `employee`

--


INSERT INTO `employee` (`empID`, `name`, `surname`, `username`, `password`, `facilityID`, `userType`, `dateAdded`) VALUES

(1, 'Melo', 'Forchu', 'kunta', 'kinte', 1, 'admin', '2013-07-19 17:40:59'),

(2, 'Mansa', 'Munsa', 'mansa', 'munsa', 1, 'Nurse', '2013-07-14 05:44:07');
```

```
-- Table structure for table `facility`

--


CREATE TABLE IF NOT EXISTS `facility` (

  `facilityID` int(11) NOT NULL AUTO_INCREMENT,

  `fname` varchar(200) NOT NULL,

  `address` varchar(200) NOT NULL,

  `phone` varchar(20) NOT NULL,

  `email` varchar(100) NOT NULL,

  `regionID` varchar(255) NOT NULL,

  `provinceID` varchar(255) NOT NULL,

  `countryID` varchar(255) NOT NULL,

  `manager` varchar(200) NOT NULL,

  PRIMARY KEY (`facilityID`)

) ENGINE=InnoDB  DEFAULT CHARSET=latin1 AUTO_INCREMENT=4 ;


--

-- Dumping data for table `facility`

--


INSERT INTO `facility` (`facilityID`, `fname`, `address`, `phone`, `email`, `regionID`, `provinceID`, `countryID`, `manager`) VALUES

(1, 'Elsies River', 'Tygerberg', '021000000', 'elsies@capetown.gov.za', 'Northern', 'Western Cape', 'South Africa', 'Marcus Garvey'),

(2, 'Mowbray', 'Durban Rd', '021432000', 'mowbray@capetown.gov.za', 'Southern', 'Western Cape', 'South Africa', 'Spike Lee'),

(3, 'Gugulethu', 'Gugs', '0216790003', 'gugs@capetown.gov.za', 'Southern', 'Western Cape', 'South Africa', 'Samora Machel');


-- --------------------------------------------------------


--
```

```
-- Table structure for table `fetal`
--

CREATE TABLE IF NOT EXISTS `fetal` (
  `fid` int(11) NOT NULL AUTO_INCREMENT,
  `rate` text NOT NULL,
  `rateafter` varchar(100) NOT NULL,
  `variability` varchar(10) NOT NULL,
  `hour` float(11,0) NOT NULL,
  `phase` text NOT NULL,
  `deceleration` text NOT NULL,
  `liquor` text NOT NULL,
  `op` varchar(100) NOT NULL,
  `p` varchar(100) NOT NULL,
  `caput` varchar(100) NOT NULL,
  `comment` text NOT NULL,
  `empID` int(11) NOT NULL,
  `pid` int(11) NOT NULL,
  `datecaptured` timestamp NOT NULL DEFAULT CURRENT_TIMESTAMP ON UPDATE CURRENT_TIMESTAMP,
  PRIMARY KEY (`fid`)
) ENGINE=InnoDB  DEFAULT CHARSET=latin1 AUTO_INCREMENT=70 ;

--
-- Dumping data for table `fetal`
--

INSERT INTO `fetal` (`fid`, `rate`, `rateafter`, `variability`, `hour`, `phase`, `deceleration`, `liquor`, `op`, `p`, `caput`, `comment`, `empID`, `pid`, `datecaptured`) VALUES
(60, '140', '160', 'Poor', 0, 'Latent', 'Early', 'C', '-', '+', '++', '', 2, 7, '2013-11-03 15:20:14'),
(61, '100', '160', 'Bad', 1, 'Latent', 'Late', 'C', '+', '-', '-', '', 2, 7, '2013-11-03 19:10:37'),
(62, '90', '160', 'Bad', 2, 'Latent', 'Late', 'C', '+', '++', '+', '', 2, 7, '2013-11-20 19:24:30'),
(63, '100', '120', 'Bad', 1, 'Latent', 'Late', 'C', '-', '-', '-', '', 1, 4, '2013-11-18 21:10:30'),
```

```
(64, '', '', 'Good', 1, 'Latent', 'Late', '', '-', '-', '-', '', 2, 7, '2013-11-21 08:17:53'),
(65, '', '', 'Good', 2, 'Latent', 'Early', '', '-', '-', '-', '', 2, 7, '2013-11-21 08:22:29'),
(66, '', '', 'Good', 4, 'Active', 'Early', '', '+', '++', '+', '', 2, 7, '2014-01-26 07:25:46'),
(67, '', '', 'Good', 1, 'Active', 'Early', '', '+', '++', '++', '', 2, 7, '2014-01-26 07:45:32'),
(68, '', '', 'Good', 1, 'Latent', 'Early', '', '-', '-', '-', '', 2, 5, '2014-01-26 08:08:14'),
(69, '', '', 'Good', 8, 'Active', 'Early', '', '+', '+', '++', '', 2, 3, '2014-01-26 08:25:18');

-- --------------------------------------------------------

--
-- Table structure for table `labourprogess`
--

CREATE TABLE IF NOT EXISTS `labourprogess` (
  `labProgresID` int(11) NOT NULL AUTO_INCREMENT,
  `application` text NOT NULL,
  `station` text NOT NULL,
  `presentingPart` text NOT NULL,
  `head` text NOT NULL,
  `hour` int(11) NOT NULL,
  `phase` varchar(20) NOT NULL,
  `comment` text NOT NULL,
  `empID` int(11) NOT NULL,
  `pid` int(11) NOT NULL,
  `dateCaptured` timestamp NOT NULL DEFAULT CURRENT_TIMESTAMP ON UPDATE CURRENT_TIMESTAMP,
  PRIMARY KEY (`labProgresID`)
) ENGINE=InnoDB  DEFAULT CHARSET=latin1 AUTO_INCREMENT=53 ;

--
-- Dumping data for table `labourprogess`
--
```

```
INSERT INTO `labourprogess` (`labProgresID`, `application`, `station`, `presentingPart`, `head`, `hour`, `phase`, `comment`, `empID`, `pid`, `dateCaptured`) VALUES

(31, '0', '120', 'Good', '0', 0, 'Latent', 'n', 2, 7, '2013-11-03 19:02:12'),

(32, '1', '120', 'Bad', '1', 1, 'Latent', 'n', 2, 7, '2013-11-03 19:02:15'),

(33, '2', '120', 'Bad', '2', 2, 'Latent', 'a', 2, 7, '2013-11-03 19:21:25'),

(34, '2', '120', 'Poor', '3', 3, 'Latent', 'a', 2, 7, '2013-11-03 19:22:37'),

(48, '1', '120', 'Good', '4', 4, 'Active', 'a', 2, 7, '2013-11-03 21:27:44'),

(49, '1', '120', 'Good', '4', 4, 'Latent', 'a', 2, 7, '2013-11-03 21:27:44'),

(50, '', '110', '', '', 3, 'Active', 'adxwqd', 2, 7, '2014-01-26 07:46:42'),

(51, '', '100', '', '', 1, 'Latent', 'none', 2, 5, '2014-01-26 08:10:24'),

(52, '', '100', '', '', 8, 'Active', 'patient is doing well', 2, 3, '2014-01-26 08:26:52');


-- --------------------------------------------------------


--

-- Table structure for table `maternal condition`

--


CREATE TABLE IF NOT EXISTS `maternal condition` (

  `maternalID` int(11) NOT NULL AUTO_INCREMENT,

  `oxytoxin` varchar(100) NOT NULL,

  `drops` varchar(100) NOT NULL,

  `bp` varchar(100) NOT NULL,

  `bpl` varchar(100) NOT NULL,

  `pulse` varchar(100) NOT NULL,

  `hour` int(11) NOT NULL,

  `phase` varchar(100) NOT NULL,

  `protein` varchar(100) NOT NULL,

  `ketones` text NOT NULL,

  `volume` varchar(100) NOT NULL,

  `glucose` text NOT NULL,
```

```
  `temp` text NOT NULL,
  `comment` text NOT NULL,
  `empID` int(11) NOT NULL,
  `pid` int(11) NOT NULL,
  `dateAdded` timestamp NOT NULL DEFAULT CURRENT_TIMESTAMP ON UPDATE CURRENT_TIMESTAMP,
  PRIMARY KEY (`maternalID`)
) ENGINE=InnoDB  DEFAULT CHARSET=latin1 AUTO_INCREMENT=66 ;

--
-- Dumping data for table `maternal condition`
--

INSERT INTO `maternal condition` (`maternalID`, `oxytoxin`, `drops`, `bp`, `bpl`, `pulse`, `hour`, `phase`, `protein`, `ketones`, `volume`, `glucose`, `temp`, `comment`, `empID`, `pid`, `dateAdded`) VALUES
(61, '3', '3', '130', '170', '150', 0, 'Latent', '3', '10', '4', '12', '32', '', 2, 7, '2013-11-03 15:28:15'),
(62, '2', '3', '160', '110', '120', 1, 'Latent', '3', '10', '4', '12', '30', '', 2, 7, '2013-11-03 17:37:33'),
(63, '0', '0', '120', '80', '100', 2, 'Active', '0', '3+', '20', '5', '38.5', '', 2, 7, '2014-01-26 07:51:20'),
(64, 'none', 'none', '110', '80', '100', 1, 'Latent', 'negative', 'negative', '200', '4', '36', '', 2, 5, '2014-01-26 08:13:54'),
(65, '10 ', '1', '140', '80', '100', 8, 'Active', 'none', 'none', '0', 'neg', '37', '', 2, 3, '2014-01-26 08:32:48');

-- --------------------------------------------------------

--
-- Table structure for table `patient`
--

CREATE TABLE IF NOT EXISTS `patient` (
  `PatId` int(11) NOT NULL AUTO_INCREMENT,
  `Name` varchar(100) NOT NULL,
  `Surname` varchar(100) NOT NULL,
```

```
  `IdNum` varchar(20) NOT NULL,
  `Address` varchar(255) NOT NULL,
  `Dob` varchar(100) NOT NULL,
  `empID` int(11) NOT NULL,
  `patientStatus` varchar(10) NOT NULL,
  `image` varchar(200) NOT NULL,
  `DateAdded` timestamp NOT NULL DEFAULT CURRENT_TIMESTAMP ON UPDATE CURRENT_TIMESTAMP,
  `DateUpdated` datetime NOT NULL,
  PRIMARY KEY (`PatId`)
) ENGINE=InnoDB  DEFAULT CHARSET=latin1 AUTO_INCREMENT=8 ;

--
-- Dumping data for table `patient`
--

INSERT INTO `patient` (`PatId`, `Name`, `Surname`, `IdNum`, `Address`, `Dob`, `empID`, `patientStatus`, `image`, `DateAdded`, `DateUpdated`) VALUES
(1, 'Salamatu', 'Mbunga', '89uu7', '78 Wuka Ave', '1960-10-19', 2, 'active', 'sala.jpg', '2013-10-20 15:44:36', '0000-00-00 00:00:00'),
(3, 'Elizabeth', 'Mbobo', '88787621', '124 long st', '1978-09-09', 2, 'active', 'elize.jpg', '2013-10-27 06:31:39', '0000-00-00 00:00:00'),
(4, 'Thabisile', 'Thobile', '3256543245', '12th Avenue ', '1970-09-10', 1, 'active', 'thabi.jpg', '2013-10-27 06:31:51', '0000-00-00 00:00:00'),
(5, 'Debra', 'patra', '6765444', '8 kloof ', '1967-08-08', 2, 'active', 'asa.jpeg', '2013-10-27 06:32:03', '0000-00-00 00:00:00'),
(7, 'Abongile', 'Ndebelo', '88787665555', '124 D 6', '1978-04-18', 1, 'active', 'abo.jpeg', '2014-05-24 18:52:10', '0000-00-00 00:00:00');

/*!40101 SET CHARACTER_SET_CLIENT=@OLD_CHARACTER_SET_CLIENT */;
/*!40101 SET CHARACTER_SET_RESULTS=@OLD_CHARACTER_SET_RESULTS */;
/*!40101 SET COLLATION_CONNECTION=@OLD_COLLATION_CONNECTION */;
```