2015

Factors affecting nursing staff use of nursing information systems in residential aged care homes

Malatsi Galani
University of Wollongong

UNIVERSITY OF WOLLONGONG

Faculty of Engineering & Information Sciences

School of Information Systems & Technology

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Malatsi Galani

B.Ed. (Sc.) [University of Botswana], MICT Adv. [University of Wollongong]

This thesis is presented as part of the requirements for the award of the Degree of Doctor of Philosophy of the University of Wollongong

March 2015

DEDICATION

This thesis is dedicated to *Lepani Hazel Galani*,

Thatayotlhe Galani

My parents *Justice Khaladi Galani* (late) and *Oakantse Motsumi*

and

My late great grandmother *Lipani Galani*

CERTIFICATION

I, Malatsi Galani, declare that this thesis, submitted in fulfilment of the requirements for the award of Doctor of Philosophy, in the Faculty of Engineering and Information Sciences, University of Wollongong, is entirely my work unless otherwise referenced or acknowledged. This document has not been submitted for qualifications at any other academic institution.

Malatsi Galani

March 2015

ABSTRACT

The use of nursing information systems (NIS) has the potential to improve the delivery of nursing care. In particular, these systems facilitate accurate, efficient and high quality documentation.

Further, the other benefits of using NIS are to reduce staff time on documentation, facilitate organisational management and improve communication. Although NIS have been introduced throughout the healthcare sector in recent years, the use of these systems is still limited in residential aged care homes (RACHs). To date, there is limited or no research in Australia that has examined the factors that can facilitate or hinder exploitation of the potential of NIS by RACHs.

The main purpose of this study is to identify the technology-related, organisational, and individual factors that may influence the use of NIS among nursing staff in RACHs.

The study consisted of two phases using a combination of qualitative and quantitative methods. In the first phase of the investigation, a qualitative content analysis technique was used to examine factors influencing the use of NIS from interview data collected pre-implementation, six months post-implementation, and two years post-implementation in two RACHs from 30 nursing staff members.

The second phase was carried out between 2012 and 2013 using questionnaire surveys, and video-based observation to collect nursing staff characteristics and human-computer-interaction data. Data from video recording software and self-report ratings were used to gain insight into the performance and cognitive differences of nursing staff in terms of expertise with NIS (inexperienced vs. experienced) and task complexity (simple vs. complex). Each group had 12 staff members consisting of managers, registered nurses, enrolled nurses and personal care workers from two RACHs.

This study identified three technology-related factors that influenced NIS use by nursing staff in RACHs: ease of use, usefulness of the NIS and design and technical constraints. Four organisational factors were identified: training, work-related time constraints and staffing levels, access to computers, and peer and information technology (IT) support. Demographics

of nursing staff, attitudes toward NIS and cognitive load (cognitive factor) were identified as individual factors.

The top five frequently mentioned factors that emerged from the interview data were positive attitudes, usefulness of the NIS, training, negative attitudes, design, and technical constraints. The other factors identified from the questionnaire survey and human-computer interaction study were expertise, task complexity, and cognitive load, and were analysed to determine how they affect nursing staff computer interaction.

In conclusion, this study provided insight into technology-related, organisational, and individual factors, which may facilitate or hinder the use of NIS in RACHs. Firstly, the results indicated that perceived ease of use, usefulness of the system, adequate training, sufficient access to computers and readily available support (including peer and IT support) might facilitate nursing staff use of the system.

Secondly, the results indicated that interface design, lack of key functions, technical or network problems, insufficient staffing levels, and inadequate numbers of computers may hinder the use of the NIS in RACHs. Thirdly, results indicated that the lack of a systematic approach to training may affect the amount of time it will take staff members to fully use and adopt NIS. Five years post-implementation of the NIS, nursing staff were still struggling to use the system. The level of expertise significantly affected the cognitive load experienced in interaction with the system. The performance measures indicated that expertise played a significant role in the effective and efficient use of the system. The results suggest that it is important to design an effective training program to facilitate effective use of NIS by nursing staff. Therefore, to optimise the benefits of NIS, organisations introducing these systems should invest in strategies to support staff members and overcome the challenges of unproductive use of such technology in the work place.

ACKNOWLEDGEMENTS

I would like to express my deepest appreciation for their efforts and guidance to my supervisors Professor Paul Chandler and Professor Fred Paas who provided me with immeasurable support, advice, and constructive criticism throughout my study. I would not be where I am today without your support and I am extremely grateful for that. Thank you to my other supervisors, Associate Professor Ping Yu and Dr William Tibben who provided their support in the conduct of the research and preparation of this thesis.

I would also like to thank my wife, Thatayotlhe, for always being there for me, providing me unwavering love, encouragement, and support through my seemingly unending daunting education process. For that, I am eternally grateful.

I am indebted to the nursing staff and management of the participating residential aged care homes and their efforts as participants in this study. I acknowledge that without their support and commitment, it would have been impossible for me complete this study.

I would also like to acknowledge Dr Madeleine Cincotta for her generous support in editing published papers and the support you provided to my family. You were more than "my mother away from home." Thank you Mado, you and your generosity have a special place in my heart!

My heartfelt thanks go to Tanya Nikolic who provided a listening ear, advice, encouragement and patiently helped solved more issues than I probably thought. Thank you.

I also thank my PhD colleagues, Siyu Qian, Xiaojun Zhang and Tao Jiang for their companionship. Thank you for the friendship, words of encouragement and time we spent critiquing each other's work.

To my brother, Thebe Makhwa special thanks for your support throughout the entire education journey. I could not have done it without your encouragement.

LIST OF ABBREVIATIONS

ACFI	Aged Care Funding Instrument
CAQDAS	Computer-Assisted Qualitative Analysis Software
CNCP	Computerised Nursing Care Planning
EHR	Electronic Health Record
HIS	Hospital Information Systems
HTML	HyperText Markup Language
ICT	Information and Communications Technology
ICUs/CCUs	Intensive Care Units / Critical Care Units
IT	Information Technology
LANs	Local Area Networks
NATC	Nurses' Attitudes Towards Computers
NIS	Nursing Information Systems
NPSS	Nursing Process Support System
PDA	Personal Digital Assistants
RACHs	Residential Aged Care Homes
RSM	Residential Service Manager
SNCEQ	Staggers Nursing Computer Experience Questionnaire
TIGER	Technology Informatics Guiding Education Reform
VOIP	Voice Over Internet Protocol
WANs	Wide Area Networks

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Chapter 1 Introduction

It is now well known to both federal and state governments in Australia that a number of challenges face the aged care sector. One of them is population ageing with unprecedented numbers and proportions of older people, often with an increased prevalence of multiple chronic conditions. Because these people need intensive and complex support, there will be an increasing burden on the aged care system to take the pressure off expensive hospital beds (Australian Government Productivity Commission, 2011). A result of this is that long-term care will need more skilled and dedicated nursing staff to provide its residents with the best care possible to make their life peaceful and enjoyable. However, there is a persistent shortage of nursing staff in the sector and the recruitment and retention of nursing staff in RACHs is a major problem (Department of Health and Ageing, 2013). The increasingly complex nature of care required by residents in aged care facilities is labour intensive, but the wages, terms and conditions are generally not as good as in the public healthcare sector (Department of Health and Ageing, 2013). Further, in contrast to hospitals and other healthcare settings, there is still a significant shortage of registered nurses in RACHs (Department of Health and Ageing, 2013).

In addition to these factors, one of the key issues in the recruitment and retention of nursing staff is the onerous task of documenting all aspects of resident care in order to meet accreditation or funding requirements (Department of Health and Ageing, 2002). Even though documentation of care is widely accepted as crucial, aged care nursing staff has reported frustration about being required to justify, substantiate, and validate their care, often spending more time on paper work at the cost of time available for hands-on resident care (Department of Health and Ageing, 2002). Moreover, staff members are dissatisfied with nursing record management (Daskein, Moyle, & Creedy, 2009), because it is often characterised by inefficiency of paper-based records such as poor quality of the records that are either inaccurate or illegible, out-dated, difficult to access and frequently lead to duplication of effort (Cheevakasemsook, Chapman, Francis, & Davies, 2006; Munyisia, Yu, & Hailey, 2011b).

In recent years in Australia, aged care organisations have introduced NIS into nursing homes in an effort to enable effective delivery of quality aged care by providing resident-centred

information for carers (Dorda, Duftschmid, Gerhold, Gall, & Gambal, 2005), relieving the pressures of documentation and care record management for the nursing staff (Boroughs, 1999; Munyisia, Yu, & Hailey, 2012), and allowing them to spend more time in direct care for residents. Furthermore, these systems are anticipated to enhance the quality of nursing records, access to residents' data, and data accuracy, as well as to minimise redundancies, reduce paper work and save staff time (Cheng, 2003; Cherry, Carter, Owen, & Lockhart, 2008; Fossum, Ehnfors, Fruhling, & Ehrenberg, 2011).

Despite the investment and the existence of acceptance of the notion that NIS will address some of the aged care challenges, there is a paucity of evidence that the anticipated benefits of NIS in RACHs are achieved. In Australia, the use of computers in RACHs to support the management of residents' records and delivery of care are not yet widespread and paper records still prevail (Yu, Li, & Gagnon, 2009). Perhaps this is because the overall aged care sector has seen little evidence to be convinced of the benefits of IT, and there is uncertainty about how this technology will influence the work of nursing staff including documentation. Other reasons for reluctance or the slow pace of introduction of NIS include cultural issues (Alexander, Rantz, Flesner, Diekemper, & Siem, 2007), cost barriers (Cherry et al., 2008), and the risks of unintended adverse consequences such as increased complexity of information management and increased documentation. (Burns, Perkins, & Larsen, 2007; Yu, Zhang, Gong, & Zhang, 2013).

Further, lack of understanding of the impacts of NIS has led decision makers in the aged care sector to abandon the technology or lose confidence in the NIS once they encountered difficulties during implementation (Menachemi & Brooks, 2006) and reverted to concurrent use of both paper and the system (Munyisia et al., 2012). To date, there is a lack of evidence about what technology-related, organisational, and individual factors influence nursing staff use of NIS.

Understanding factors that influence nursing staff use of NIS in RACHs may help health care providers, policy makers, aged care organisations, end users, and system developers to choose appropriate NIS, establish systematic implementation and maintenance strategies for the system, better assess its impact on documentation and ascertain how to enhance certain system functionalities and user interfaces. Filling this essential knowledge gap is crucial to aged care providers and other stakeholders. It can provide evidence to encourage investment

in innovative NIS to optimise the nursing care services, promote acceptance and help with the full adoption of the system by nursing staff in RACHs. The work presented in this thesis is intended to provide this information.

1.1 Aim of the study

The aim of the study was to identify technology-related, organisational, and individual factors that influence nursing staff use of NIS in RACHs, cognitive load nurses experiences in learning to use NIS and how to optimise those factors that facilitate nursing staff use of such systems.

To achieve the research aim, the specific research question to be answered is: What factors influence nursing staff use of NIS in RACHs?

To provide a comprehensive and holistic answer to the main research question, the following sub-questions are identified to cover the different factors that influence the use of NIS.

1. What technology-related factors influence nursing staff use of NIS in RACHs?
2. What organisational factors influence nursing staff use of NIS in RACHs?
3. What individual factors influence nursing staff use of NIS in RACHs?
4. What cognitive factors influence nursing staff use of NIS in RACHs?

All four questions are equally significant in the examining the underlying factors that are influential in the use of NIS. To explore whether cognitive factors, and in particular cognitive load, task complexity and expertise of nursing staff can be used to predict their productive use of NIS Question 4 was sub-divided further. The sub-questions from Question 4 were used to generate hypotheses to be tested. These sub-questions were useful in identifying the potential differences in cognitive load between lower expertise and higher expertise nursing staff in their interaction with NIS. Expert nursing staff refers to staff members with more experience in the nursing domain, with a higher level of experience with general computers and the NIS being evaluated than novices. Therefore, they will most likely experience less cognitive load in interaction with the NIS. Understanding the cognitive differences between these two groups of users should give us useful insight into designing the appropriate training strategies to support nursing staff to learn to use NIS effectively.

4.1 Are there differences in perceived cognitive load between lower expertise and higher expertise nursing staff?

4.2 Are there differences in task completion efficiency between lower expertise and higher expertise nursing staff?

4.3 Are there differences in task performance in completing simple and complex tasks between higher and lower expertise nursing staff?

4.4 What is the relationship between cognitive load, as measured by subjective task ratings (e.g., self-reported cognitive load measures), and cognitive load identified by human-computer interaction study (e.g., errors made, number of mouse clicks and keystrokes, and sub-tasks completely solved)?

Questions 4.1 to 4.4 can be phrased positively as hypotheses to facilitate the design of scientific experiments to answer them.

4.1 Are there differences in perceived cognitive load between lower expertise and higher expertise nursing staff?

a. H1: Experienced users will experience lower cognitive load (i.e. invest less effort) than inexperienced users as they are more efficient when interacting with the computer system.

4.2 Are there differences in task completion efficiency between lower expertise and higher expertise nursing staff?

a. H2: Experienced users will demonstrate more relevant keystrokes or presses (mouse clicks) and engage more frequently in activities that are efficient to complete a given task than inexperienced users.

4.3 Are there differences in task performance in completing simple and complex tasks between higher and lower expertise nursing staff?

a. H3: Experienced users will achieve higher performance than inexperienced users on both simple and complex tasks when performing these tasks on the computer system. This difference will be more pronounced for complex tasks than for simple tasks.

4.4 What is the relationship between cognitive load, as measured by subjective task ratings (e.g., self-reported cognitive load measures), and cognitive load identified by human-computer interaction study (e.g., errors made, number of mouse clicks and keystrokes, and sub-tasks completely solved)?

- H4. Self-reported cognitive load rating scores will be positively correlated to the number of errors made during task performance.

- H5. Self-reported cognitive load rating scores will be positively correlated to the number of mouse clicks made during task performance.

- H6. Self-reported cognitive load rating scores will be negatively correlated to the number of keystrokes made during task performance.

- H7. Self-reported cognitive load rating scores will be negatively correlated to the number of sub-tasks completely solved.

1.2 Research approach and its justification for this study

The study comprises of several research approaches. The first research approach is a comprehensive literature review aimed at discovering the major findings of other studies and providing background for the research. Secondly, the study adopts an interpretative approach (Klein & Myers, 1999). Due to the limited knowledge about the factors that influence nursing staff use of NIS in residential aged care, a qualitative approach with interpretative approach was considered suitable (Walter, 2013). The literature survey findings were used to guide the interviews and the subsequent content analysis. Content analysis was performed to analyse the interview data and allowed the researchers to immerse themselves in the data to gain insights directly from the text data without preconceived theoretical perspective or categories imposed (Elo & Kyngäs, 2008; Hsieh & Shannon, 2005). The analysis was conducted to develop categories of factors that hinder or facilitate the use of NIS by nursing staff.

Two RACHs, comprising 30 staff belonging to one organisation participated in the study through formal research collaboration with the University. Web-based commercial aged care NIS (system X) from one company was used by the two RACHs.

The content analysis was carried out using Microsoft Word and Excel software. The semi-automated content analysis methods of highlighting cells, data sorting, filtering, automated counting of contents in cells and the PivotChart functions of Excel were used to develop a classification system of content themes.

The third research approach was designed to validate the findings from the in-depth case study. In this phase of the research, 12 experienced and 12 inexperienced nursing staff, from the same RACH, of all the types of nursing positions was observed and video recorded while they carried out nursing documentation tasks in a NIS. To understand how efficient and effective staff members used the system a combination of structured interview survey and cognitive load self-reported rating scale was used. Cognitive load self-report offered insight into mental effort exerted during the interaction.

1.3 Organisation of the thesis

This thesis is organised into seven chapters. Following this Introduction chapter is an extensive literature review of the studies on the topics relevant to this study. This is presented in two chapters: Chapter 2 focuses on the introduction of the study context and factors affecting the use of NIS in nursing; and Chapter 3 centres on cognitive load theory literature. Chapters 2 and 3 lead to the identification of the knowledge gap in the field, which provides the rationale for this research. Chapter 4 discusses the methodological approach to address the research questions. Chapter 5 and 6 present the results of the content analysis and human-computer interaction study. Chapter 7 compares in detail the findings from this study with the previous studies. The contributions and limitations of this research are also in Chapter 7 and recommendations for further studies are provided.

Chapter 2 Literature review on nursing and NIS

2.1 Introduction

To better understand issues surrounding the present study, a search of the literature was undertaken. The literature review relates this study to the larger, ongoing dialogue about the adoption and use of information systems in nursing. Further, it facilitates the identification of some gaps in the previous literature that drive this study to explore the role of these technology-related, organisational and individual factors influencing the use of NIS by nursing staff, especially in Australian RACHs.

In order to access the broadest range of literature available, the literature search included scientific scholarly reports and journal publications, government reports, web pages, industry reports and books (Creswell, 2014).

This chapter is divided into six sections. Section 2.2 provides a brief discussion of trends in the Australian ageing population and the healthcare challenges associated with this ageing population. Section 2.3 provides a description of nursing documentation, its importance to care provision (aged care), and challenges to documenting nursing care in Australian aged care.

Section 2.4 provides a brief overview of NIS in nursing and the benefits of using NIS in aged care nursing. Section 2.5 presents the characterisation of "aged care" and how it is distinctly different from other fields of nursing/hospital settings. Section 2.6 is the literature review of factors that influence nursing staff to use of NIS. This section elaborates on the three categories of factors that influence the use of NIS and their variables. Each factor is defined and relevant studies are discussed. Finally, this chapter concludes in Section 2.7 and 2.8 with summary observations that identify the rationale and literature gaps this study attempts to address.

2.2 Australia's ageing population and aged care

In the developed world, the population is ageing rapidly. The proportion of the Australian population aged 65 years and over increased from 11.8% to 14.7% between 1994 and 2014 (Australian Bureau of Statistics, 2014). This demographic growth trend is expected to continue into the next few decades. An ageing population presents several challenges,

including increased demand on healthcare services and the use of care services such as home cleaning help, assistance with meals preparation or delivery of meals and personal care because ageing leads to increases in the prevalence of chronic conditions (Australian Government Productivity Commission, 2014; Harrison, Miller, & Henderson, 2013).

In 2011-2012, 67% of Australians aged 70 and over used aged care services (Australian Bureau of Statistics, 2012; Australian Institute of Health and Welfare, 2013). Aged care refers to residential, community or flexible care services, or a combination of either one or more of these services, available to an individual of a mature age who, because of the effects of ageing, illness or other ageing-related disabilities is unable to live independently without assistance (Aged Care Act 1997 (Cth)). Residential care is targeted at the frail or disabled who can no longer live independently in their own homes without support (Australian Government Productivity Commission, 2011). This type of aged care is the focus of this study.

2.2.1 Impact of the ageing population on residential aged care services

The increasing number of older and frail people will impose heavy demands on residential care services. Nursing staff in RACHs are increasingly going to be caring for older people with far greater care needs than before. For instance, the Australian Institute of Health and Welfare (2013) estimated over 50% of people living in RACHs have dementia. Safe, effective healthcare for people with aged-related conditions, such as dementia, depends upon attraction and retention of qualified nursing staff. Australian estimates of skilled staff (particularly qualified nurses) required to provide care for this projected older and frail population vary by state and territory, but are around 40,000, lower than the projected demand (Australian Institute of Health and Welfare, 2009). Further, since 2007 the number of registered nurses in RACHs has fallen from 17% to 15% (King et al., 2014).

In general, direct aged care services for people with dementia and chronic health conditions are labour intensive, however the employment terms and conditions of nursing staff in RACHs are generally less favourable than for public healthcare staff (Australian Government Productivity Commission, 2011). This has resulted in a skill shortage among nursing staff as well as low ratio of registered nurses as a proportion of the direct care workforce (King et al., 2014).

With the declining number of registered nurses within the aged care workforce, the greater part of direct dementia care is provided by personal care workers (i.e., an estimated 68%) (King et al., 2014) whose education and training in dementia and other aged-related chronic conditions are often inadequate to prepare them to provide the desired type and standard of care services required in Australia (Fleming & FitzGerald, 2009; Keenan & Kennedy, 2003).

To sum up, the above characterisation makes the aged care setting distinct from hospitals and general practice setting in a number of ways. Firstly, people cared for in RACHs have long-term complex chronic conditions; dementia is common among this demographic. Therefore, an increasing number of elderly people need personal assistance for the activities of daily living and amplify the burden on the Australian aged care system. Secondly, the complex care conditions of the demographic means more responsibility is taken by declining numbers of registered nurses working in RACHs. Thirdly, high turnover and failure to retain qualified staff means staff members with inadequate education and training will provide care. Lastly, there is limited after-hour access to and some communication problems with general practitioners (Chaudhry et al., 2006). For these reasons, there is an urgent call for innovative, cost-effective, and efficient ways to provide and document care in RACHs.

2.3 Nursing documentation

Documentation of nursing care provided in residential aged care is crucial in understanding in what ways an innovation technology solution might address some of the challenges to meeting the residents' needs and maintaining high quality care. For the purposes of this thesis, "resident" refers to males and females who are 65 years of age or older residing in a RACH.

Firstly, the concept of nursing is reviewed. Thereafter, a discussion of what the role of nursing documentation including its inherent challenges is presented and finally, a discussion of nursing documentation in Australia's RACHs is presented.

2.3.1 The concept of nursing documentation

Although, there is no universal definition of the concept of nursing documentation, Tapp (1990) describes nursing documentation as written evidence of nursing practice: it is a communication tool about the patient or resident status, and the record of patient responses to intervention.

Dehghan et al. (2013) define it "as the record of nursing care that is planned and given to individual patients and clients by qualified nurses or other caregivers under the control of a qualified nurse". A nursing record system definition by Urquhart et al. (2009) is similar to this nursing documentation description. Urquhart et al. (2009) describe a nursing record as "the record of care that is planned or given to individual patients and clients by a qualified nurse". These definitions are often used interchangeably, and are so used in this study. This is because it can be seen that they describe reasonably similar objectives.

2.3.2 The role of nursing documentation

Documentation of nursing care is a fundamental and crucial skill utilised by nursing staff to communicate the health status of the patient's personal needs and reactions to care (Björvell, Wredling, & Thorell-Ekstrand, 2003). Therefore, it is recognised that quality information provided by documentation is necessary for effective nursing practice and is useful in decision-making for continuity of care (Pelletier, Duffield, Gietzelt, Larkin, & Franks, 2002).

Documentation of care is the principal way that nursing staff communicate their contribution, not only to other professionals but also to funding and accrediting bodies (Martin, Hinds, & Felix, 1999). For instance, in Australia in order to verify RACHs claims for funding, Outcome Standards Monitoring Teams visit RACH to review documentation kept by the facilities in assessing, planning, and recording residents' care (Courtney, Minichiello, & Waite, 1997). These teams use the Aged Care Funding Instrument (ACFI) to determine the level of care payment for residents in RACHs (Department of Health, 2010). The instrument relies heavily on legible and accurate nursing documentation for appropriate reimbursements.

Clearly, as shown above, nursing documentation offers rich records of the interaction between health professionals and the residents. However, achieving and enhancing the quality of nursing records of care remain a challenge for nursing staff in RACHs.

2.3.3 Challenges in nursing documentation

There is a variety of challenges facing attempts to improve or maintain a high standard in nursing documentation. These are incomplete records (legibility problems), lack of time for documentation, and inaccessibility of information.

Incomplete or illegible nursing records are an ongoing problem within nursing practice (Cheevakasemsook et al., 2006; Voutilainen, Isola, & Muurinen, 2004; Webb & Pontin, 1997; Yu, Hailey, & Li, 2008; Zegers et al., 2011). For instance, an action research study conducted to evaluate the use of a care plan introduced into nursing practice found that each nurse produced his or her own version of the core care plan (Webb & Pontin, 1997). There was great variation in the completion of the documents and inconsistencies in the documentation. Another study evaluating the quality of nursing care in four nursing homes in Finland found that only 73% of the nursing home residents had an up-to-date care plan, the rest either did not have one at all or had a plan that was out of date (Voutilainen et al., 2004). These deficiencies in recording nursing care present an obvious risk to patient safety and negatively affect the continuity of care. Further, inaccurate, and incomplete records provide less information on which to base clinical judgements.

Nursing care provided is often not documented or the content of the documentation is poor due to a lack of time and this is a common obstacle in nursing practice (Kim & Park, 2005). Despite recognising the importance of maintaining accurate nursing documentation (Cheevakasemsook et al., 2006), during work shifts staff find it difficult to find sufficient time to document everything necessary. This is because of a heavy-patient/resident load, understaffing and cumbersome charting formats, all of which lead to situations where there is a lack of time to adequately document care (Brooks, 1998; Kim & Park, 2005; Rosenbloom et al., 2011).

Other difficulties encountered in maintaining an adequate nursing record system include inaccessibility, which causes time to be lost in searching for various information relevant to continuity of care (Voutilainen et al., 2004). Kihlgren et al.'s (2003) study on referrals from home care to emergency hospital care reported that nurses had a problem with inaccessible records, because they were kept in different offices or at a distance from patients, which also led to communication difficulties with the physician on duty. These issues all led to wasted time, high costs, and incomplete charting.

Nursing documentation is fraught with the problems and challenges discussed above. The same is true for Australian RACHs as documentation is the compulsory component of nursing practice and reflects the accountability of nursing staff to residents. Given these problems, information systems are believed to hold the key to addressing these challenges

(Shortliffe & Cimino, 2006). The use of such technology in aged care provides an opportunity not only to address these problems but also to provide better care outcomes (Mekhjian et al., 2002). Hopes for such positive outcomes have motivated the development and introduction of NIS into healthcare settings and the age care setting (Lee, Mills, Bausell, & Lu, 2008; Moody, Slocumb, Berg, & Jackson, 2004). The following section presents the background to information systems in nursing and aged care settings.

2.4 Background to information systems in nursing and aged care settings

Saba and McCormick (2006) suggest the incorporation of computers and related information systems into nursing started in the 1950s in response to changing and developing technologies in nursing practice. During this period, nursing was undergoing major transformation: nursing practices and services were expanding in scope and complexity, and the number of nurses was rising (Saba & McCormick, 2006). These changes provided the momentum to adopt these technologies.

By the early 1990s to post-2000, computers and information systems became an integral part of nursing practice and the nursing profession (Saba & McCormick, 2006; Shortliffe & Cimino, 2006). In these two decades, there was continued rapid change in computer technology, such as the use of faster laptops/notebooks that are accessible at the bedside and all point-of-care settings. Workstations, local area networks (LANs), wide area networks (WANs), the internet, various network standards and technologies were developed for linking hospital nursing units, linking care across healthcare facilities and integrating other information systems into bedside systems (Saba & McCormick, 2006). This growth resulted in developments such as wireless point-of-care, open source solutions, relational databases, integrated distributed networking, integrated information systems solutions, wireless tablets, personal digital assistants (PDA), cellular telephones and voice over internet protocol (VOIP) targeted to all healthcare environments.

As we moved further into the 21st century, various design specific software applications were implemented in different nursing care settings such as in maternity wards, emergency units, intensive care units/critical care units (ICUs/CCUs), inpatients departments, outpatients departments, paediatric units, RACHs/long-term care facilities and palliative care settings.

The introduction of NIS is considered to offer numerous benefits that can help to achieve a high quality of life for residents (Cherry, Ford, & Peterson, 2011; Pelletier et al., 2002). Those benefits include the following:

- **Improved efficiency:** by saving nursing time in a number of ways such as reducing redundant tasks (Chen, Brennan, & Magrabi, 2010), and facilitating faster and efficient data entry, storage and retrieval (Zhang, Yu, & Shen, 2012).
- **Patient safety and satisfaction:** by increasing sense of security by averting infection when the system was used to detect it (Parente & McCullough, 2009), reducing medical errors (O'Brien, 2006), and patient satisfaction with the overall service if NIS is used (Al-Azmi, Mohammed, & Hanafi, 2006).
- **Reduction in the burden of work and improvement in the quality of care:** printing charts obtained from the electronic system resulted in quicker, more efficient medication rounds and the clarity of electronic medication charts has improved (Burns et al., 2007; Fossum et al., 2011).

However, findings of various studies that examined these benefits are mixed. For example, Munyisia, Yu and Hailey (2011a) found that NIS did not reduce time nursing staff spent on documentation, while other studies found that documentation time increased following NIS introduction (Ammenwerth et al., 2001; Hakes & Whittington, 2008). Another study reported that underestimation of completion of quality-of-care process when using NIS (Kerr et al., 2002), and workload had not decreased after the introduction of an information system (Moody et al., 2004).

The mixed results can be due to a number of factors that hinder and facilitate the use of the NIS. For this reason, it is important to determine these factors and is the aim of the current research. The next section discusses some of the factors identified by the previous studies.

2.5 The difference between nursing in an RACH and hospital or primary care

Firstly, people cared for in RACHs have long-term complex chronic conditions; dementia is common amongst this demographic (i.e., estimated over 50%) (Australian Institute of Health and Welfare, 2013). Safe, effective healthcare for people with aged-related conditions, such as dementia, depends upon recruitment and retention of qualified nursing staff.

Secondly, one of the obvious challenges involves the shortage of skilled workforce in RACHs. Not only are work-age adults in decline but also nurses are in short supply (i.e., since 2007 registered nurses numbers have fallen from 17% to 15% in 2012) (Australian Institute of Health and Welfare, 2013). There are an increasing numbers of elderly people needing personal assistance for the activities of daily living thus amplifying the burden on the Australian aged care system. The complex care conditions of the ageing population means more responsibility is taken by declining numbers of registered nurses working in RACHs.

Thirdly, high turnover and failure to retain qualified staff means staff members with inadequate education and training will provide care. With the declining number of registered nurses within the aged care workforce, the greater part of direct dementia care is provided by personal care workers (an estimated 68%) (King et al., 2014) whose education and training in dementia and other aged-related chronic conditions are often inadequate to prepare them to provide the desired type and standard of care services required in Australia (Fleming & FitzGerald, 2009; Keenan & Kennedy, 2003).

Lastly, there is limited after-hour access to and some communication problems with general practitioners (Chaudhry et al., 2006). It is for this reason that hospital setting findings may not be relevant to the nursing staff use of NIS in RACHs and the provision of care of older people in a nursing home.

2.6 Factors influencing nursing staff use of NIS

Nursing staff in both aged care and non-aged care settings (hospitals and general practices) are noted to resist NIS acceptance and use due to a number of factors (Gagnon et al., 2012; Yu & Comensoli, 2004). These factors are broadly categorised as technology-related, organisational, and individual factors.

2.6.1 Technology-related factors

According to Brender et al. (2006) the use of information systems is not a simple process of installing and using a new technology (Brender et al., 2006). Rather, it is a complex process, which includes technology-related factors. These factors are perceived usefulness and ease of use, design, and technical constraints. The next sections, therefore, provide definitions of technology characteristics and review various studies that have examined these technology-related factors.

Perceived usefulness (or relative advantage)

Perceived usefulness is defined as the degree to which a person believes that using a particular system would enhance his or her job performance (Davis, 1989). The original context of Davis's seminal study was to define, develop and validate new measurement scales for two specific variables, perceived usefulness and perceived ease of use, that are hypothesised to be fundamental determinants of user acceptance of information systems.

For this study, perceived usefulness represents subjective beliefs of nursing staff about using NIS to achieve job goals within an aged care setting. Nursing staff perceived usefulness is partly based on a cognitive comparison of what the target system is capable of doing with what they need to be done in their job. For example, an ethnographic, participant observation study by Hibbert et al. (2004) was conducted to document the responses of specialist nurses about the use of a home tele-health technology system for patients with chronic obstructive pulmonary diseases. Results indicated that nurses focussed more on whether the technological tool supported their daily nursing activities and they had reservations about the tool's usefulness for nurses and patients. The "virtual" consultation only offered limited access to the relevant aspect of patient care, and did not meet the needs of nursing that are required when visiting patients in their home setting (Hibbert et al., 2004). Overall, the technology was seen to be less useful.

The majority of studies investigating the perceived usefulness of information systems in health have focused on causalities of this variable on behavioural intention to use. For example the Hsiao, Chang and Chen (2011) study conducted in a Taiwanese hospital found that top management support, compatibility, and information quality significantly impact nurses' perceived usefulness of a hospital information systems (HIS). Nurses' perceptions of HIS usefulness had a significant influence on the system's acceptance and use, thereby explaining 45.1% of the total variance. Other studies also found that perceived usefulness significantly affected hospital personnel's behavioural intention to use the system (Aggelidis & Chatzoglou, 2009; Hikmet, Banerjee, & Burns, 2012).

Several interesting studies have been conducted in a similar context. Chow, Chin, Lee, Leung, and Tang, (2012) examined the attitudes of 342 Hong Kong based nurses and their satisfaction level towards an HIS. The study reported a relatively weak positive correlation

between ability to use and perceived usefulness. Specifically, nurses were less convinced that HIS could improve patient care or improve staff efficiency when compared with manual procedures. The results are similar to those of Hasan's (2006) study which reported a weaker contribution of perceived usefulness in explaining behavioural intention to use. In contrast, another study using a questionnaire survey to investigate factors affecting acceptance of NIS by using collected data from 101 nurses at a Hong Kong hospital found that perceived usefulness singificantly affected NIS acceptance (Hsiao, Wu, & Chen, 2013).

The majority of the studies presented above used pre-defined questionnaire surveys to collect data on nursing staff perception of usefulness of NIS (see Hasan, 2006; Hsiao, Chang, & Chen, 2011) and the results are inconclusive although from similar settings, i.e. hospital settings (see Chow et al., 2012; Hsiao et al., 2013). Further, because they were conducted in hospital settings and the majority of participants were nurses, this reduces generalisation of the findings to other settings such as RACHs where less than 20% of the workforce are registered nurses (King et al., 2014).

Ease of use

Perceived ease of use refers to the degree to which users believe that using a particular NIS would be free from effort (Davis, Bagozzi, & Warshaw, 1989; Yarbrough & Smith, 2007). The definition of "ease" is free from difficulty or great effort. Davis (1989) further indicated that perceived ease of use has an important influence on an individual's usage of a system. It is believed that nursing staff will be more likely to adopt and use the NIS if the systems are perceived as both useful and easy to use (Dillon, McDowell, Salimian, & Conklin, 1998).

Rogers and Shoemaker (1971) argued that the concept of perceived ease of use parallels the concept of complexity quite closely. Complexity is defined as the degree to which a system or an innovation is perceived difficult to understand and use. Even if a staff member considers that a given system or software application is useful, they may believe that the system is difficult, or cumbersome to use. Hence, they may conclude that the performance benefits are out-weighed by the amount of effort expended in using the application. For instance, if a computerised medication chart takes more time to complete because of system complexities, nurses may avoid using the system. However, once nursing staff perceive that it is easier to learn how to use a system, they adopt a more positive attitude in accepting using the system (Di Pietro et al., 2008; Dillon et al., 1998). One study (Tung, Chang, & Chou,

2008) examined nurses' acceptance and use of an e-logistic information systems in ten public and private Taiwanese hospitals. The results indicated that perceived ease of use had a positive effect on behavioural intention to use. The authors concluded by stating that improving an individual's perception about ease of use and usefulness of NIS can lead to increased frequency of using the technology. Other studies reported similar results (Chow et al., 2012; Dillon et al., 1998; Hsiao et al., 2013). However, the generalisation of findings is only limited to hospitals settings, as most of the respondents were nurses in private hospitals.

Research has shown that both perceived usefulness and perceived ease of use may possibly have a crucial role in NIS use among nursing staff. However, perceived ease of use has not been found significant for other types of health technologies (Chau & Hu, 2002) or demonstrated a less consistent effect across studies (Chen, Yang, Tang, Huang, & Yu, 2008; Venkatesh & Davis, 2000).

Perceived ease of use, has been shown to be credible and influential in decision-making in reference to intention to use NIS (Chow et al., 2012; Dillon et al., 1998; Hsiao et al., 2013). However, a less consistent effect was demonstrated across studies, although most of the studies reviewed are in a hospital setting. The findings of these studies indicated that perceived ease of use is influenced by many other exogenous factors. In this regard, there is a need for further research in the RACHs setting where few studies have been conducted to explore factors that may influence perceived ease of use and whether it influences nursing staff use of NIS.

Design and technical concerns

Design refers to the visual aspects of the software application such as layout, as perceived by the individual. Research findings highlight the need to find an appropriate balance between technology processes and nursing practice activities. People are not passive recipients of technology, rather, they are often in constant dialogue with system designers (Greenhalgh, Robert, Macfarlane, Bate, & Kyriakidou, 2004). Hence, if the NIS has significant design issues and technical challenges, nursing staff are likely to become frustrated and resist using it unless it fits in with their needs.

To demonstrate challenges in design and technical concerns, a systematic literature review study (Gagnon et al., 2012) examined 106 studies that focused on factors that can facilitate or

limit the use and adoption of ICT by healthcare professionals in clinical settings. Design and technical concerns was found to be one of the most cited barriers to adopting and using IS in healthcare settings in twelve out of twenty-three (52%) studies.

Other investigations into use of NIS continued to reveal the impact of design and technical concerns, specifically how they hinder system use. For instance a study by Wilson and Fulmer (1998) explored nurses' experiences of using wireless, pen-based computing in a home based-care setting and found numerous design and network concerns. Nurses reported that there were problems with network transmission, as they could not transmit data to their offices via wireless connection from the patient's home. As one nurse stated, they needed to move to a window in order to transmit data in certain areas. In addition, they discovered glitches in the small keyboard and pen, which they used to check-off certain menus and drop down lists. Although, this was a pilot study, it highlighted concerns and provided insights into the design and technical issues that were likely to affect the use of this technology.

Another interesting study using a multi-method evaluation combining both quantitative and qualitative approaches evaluated the impact of a NIS on nurses' daily practice (Lee, Mills, & Lu, 2009). Nurses viewed the NIS design as unsatisfactory. One nurse said, "When I chart I wish to link with the lab data/orders without jumping between different windows." Another said, "I prefer that the patient problem classification be based on nursing, not medical diagnoses." This is an indication of the mismatch between the system design and nursing task or nursing workflow. Other frequent complaints brought up in the interviews were recurrent network problems and slow computer response time. Delays are likely to increase the perception that using NIS increases one's workload (Lee et al., 2009). Eventually, fewer nurses may use the system as intended or may use it less frequently.

A quasi-experimental study conducted by Yeh et al. (2009) tried to assess obstacles to use of a nursing process support system in Chinese (NPSSC) at a Taiwanese long-term care facility pre and post implementation. Fifty-five licensed nurses participated in the study. The reported obstacles were nurses' opposition to the changes in documentation required by NPSSC. In addition, nurses found that computerised resident records did not match the size and space of the hand written resident record. They indicated the NPSSC introduced new protocols into the nursing practice and did not support how they normally performed certain functions (Yeh et al., 2009). These design issues hinder the use or lead to suboptimal use of the system. This

study included only registered nurses and did not include nursing assistants or personal care workers who, as stated in Section 2.5., constitute 68% of the nursing staff in Australian RACHs.

Technical concerns such as recurrent network and transmission problems, glitches in the small keyboard and pen, mismatch between system design and nursing task or nursing workflow, highlighted in the above studies, are mostly pragmatic difficulties. These practical matters will differ for each organisation and for each specific system. They are likely to be influenced by the extent of human resources and funds an organisation can invest in NIS implementation and on-going maintenance. Hence, design and technical concerns remains one of the crucial factors and it must be established whether they have any effect on nursing staff.

2.6.2 Organisational factors

Organisational factors were found to have a significant influence on nursing staff use of NIS implemented in the workplace (Brender et al., 2006; Lorenzi, Riley, Blyth, Southon, & Dixon, 1997). These factors include adequacy of training, time constraints and workload issues, accessibility and availability of NIS resources and technical support for the systems. The next section elaborates on these organisational factors, based on the literature review of NIS studies.

Training

In the literature, there is no clear agreement on the definition of training. Different studies defined training and its effectiveness in numerous ways. For example, Sadler-Smith (2006) defines training as a systematic acquisition of skills, rules, concepts, or attitudes that may result in improving performance in another environment. The use of the phrase "in another environment" points out the need to transfer, as it demonstrates the current level of skills might not be adequate to continue being productive in a changing environment. It implies that organisations need to adapt to such change by equipping staff with new knowledge, skills, and attitudes in a timely manner.

Dearden (1984, p59) refers to training as

> "typically involving instruction … aimed at reaching a particular level of competence or operative efficiency. Often, training addresses itself to improving performance in

> direct dealing with things...Other sorts of training are more concerned with dealing with people … Yet other kinds of training are more indirectly concerned with changing or controlling people or things … But in every case what is aimed at is an improved level of performance or operative efficiency brought about by learning."

These training definitions raise the question of whether NIS training has been effective in the past. The impact of NIS training on nursing staff in order to accept and use these systems is crucial. Even though training is widely accepted as necessary, a literature search reveals that training is a complex area. The current problems associated with training include lack of guided practices, providing too much new information at once, and overwhelming training.

For instance, Adaskin et al. (1994) conducted a study in a large Canadian hospital to investigate the impact of an NIS on nursing. Training of nurses was completed one day before the system went live. Then the training module named "Play Hospital" was set up and made available to all units. Contrary to the intention of the project manager, nurses resisted practising using the system because they felt overwhelmed. This was an indication that the basic training was ineffective and lack of guided practice sessions led to nurses resisting using Play Hospital because they lacked the necessary skills to explore the system on their own and needed someone to facilitate their practice.

Whittaker, Aufdenkamp, and Tinley (2009) conducted a qualitative study to evaluate the implementation of an electronic health record (EHR) system in a rural hospital where all nursing staff attended a one day introduction and training session on the entire EHR system before implementation. All nurses reported that too much information was presented during training, stating that by the end of the 4th hour they could not concentrate any longer. They became frustrated and overwhelmed. In the end, both fast and slow learners reported they lacked the basic knowledge to operate the system. Training provided too much information in a single day.

An investigation into nurses' perceptions of adopting an information system in a Taiwanese medical centre reported the feedback of a selected few nurses about the training after going through a train-the-trainer session (Lee, 2006). They reported that training was too short, and that they had to learn by "trial and error." Although such strategies can help nurses to learn to use the new system, continuous attempts to trial different features imposed a high mental load

(van Gog, Paas, & van Merriënboer, 2006) and often resulted in frustration about and resistance to using the system. The nurses in this study (Lee, 2006) suggested that training time was insufficient.

Another qualitative case study by Sidebottom et al. (2012) examined nurse's attitudes and reactions to the use of EHR alerts (i.e., the alerts were divided into two categories: banners which provide information about a patient and notifications of action required) in an inpatient setting as perceived by 50 nurses at three non-profit Allina Health System hospitals in the United States. In a focus group setting, nurses were asked about how alerts could help or hinder their work. Results revealed that nurses were aware of the alerts but tended not to use them as a primary source of information. The reasons provided for not using the alerts were that they had forgotten about it, did not know how to access it, distrusted its data and some topics about alerts had not been covered in their training. The findings demonstrate the need for more appropriate training that considers the learning needs of nurses in order to facilitate an improved use of NIS.

In summary, the findings described above indicate that, firstly, the typical one-day training approach presents a large amount of information in a short period. This makes it challenging for the trainees to process and understand the training information quickly. Secondly, there is not sufficient time set aside for training. Thirdly, because the trainees are unable to acquire prerequisite skills during training, they revert to trial and error strategy, which is not an effective learning strategy for novices. As a result, nurses were frustrated, overwhelmed, and resisted using the system. They may view the system as adding to their workload and time consuming. Lastly, these studies do not consider the effect of cognitive load, particularly when selecting the training strategies to design and deliver training materials. The concept of cognitive load is briefly presented in Section 2.6.3, and an elaborate description of cognitive load and its consequences for learning is discussed in Chapter 3.

Time constraints and workload

In the nursing environment, lack of time is often a result of heavier workload. Nursing workload is defined as "the amount of performance required to carry out nursing activities in a specified time period" (Morris, MacNeela, Scott, Treacy, & Hyde, 2007). Edirippulige (2005), McGinn et al. (2011) and Eley et al. (2009) all identified workload as the principal

barrier to computer use in nursing practice. Several other studies identifies the high rate of staff turnover in nursing homes (Castle & Engberg, 2005; Mukamel et al., 2009).

Many RACHs are understaffed as highlighted in Section 2.2. Nursing staff that remain working in the facilities often have a heavier workload until replacement staff are found. Heavy workload led to staff viewing NIS as creating extra work instead of a way to decrease their workload (Australian Nursing Federation, 2010; Eley, Fallon, et al., 2009). Unfortunately, heavy workload as indicated is an ongoing challenge that continues to plague RACHs in Australia.

Darbyshire (2004) reported that nurses felt the EHRs had not decreased their workload but instead increased it. The reasons stated include having to remember passwords, the insufficient linking of modules and documents resulted in cumbersome navigation as the system lacked both intuitive icons and user-friendly graphic interfaces and was thus time consuming to use. Further, computers were not available at the bedside and nurses would record patient care activities on paper and enter the information into the system later (Darbyshire, 2004). The double data entry increases nurses' workload. This is consistent with the findings in a study conducted by Smith et al (2005). These studies demonstrate that heavy workload combined with NIS may not necessarily help free up nurses but instead increase their work.

The above literature from both aged care and hospital settings suggest the negative impact of these two problems: time constraints and workload. This issue has always been one of the problems within the healthcare setting. Hence, for our study it will be interesting to know whether RACHs investigated have addressed or mitigated these issues.

Access and availability of resources to support NIS

Residential aged care homes or any healthcare organisation must have the infrastructure and hardware to support the technology implemented. These include having a sufficient number of computers, phone lines, internet connections, and appropriate network infrastructure. A number of studies have explored these issues and are presented in the next section.

Fifty six Finnish nurses from psychiatric wards of two hospitals participated in a qualitative study to identify barriers and facilitators that influence the use of an interactive internet-based

application (Koivunen, Hätönen, & Välimäki, 2008). The results indicated barriers to using the application were lack of enough computers and lack of internet access on the wards. Furthermore, nurses also noted that the number of computers was inadequate for their core nursing duties, for this reason they could not use the portal in patient education, which was the goal of the portal. Here, the authors reported that the hospitals did not have the financial means to acquire the necessary hardware and lack of computers significantly contributed to the portal remaining underused.

Fossum et al., (2011) and Whittaker et al., (2009) identified that some organisations lack the "basic" facilities or hardware needed to support NIS implementation and this hinders the frequent use of NIS. Smook (1992) states that not all key factors were examined in the previous studies into the implementation and use of NIS. Other issues previously not identified include understanding the hardware requirements to support the objectives of the software implemented into nursing practice.

Similarly, 12 nurses at a Dutch hospital participated in a mixed-method study exploring a post-implementation audit of an NIS, but mainly focused on the impact of implementation processes and training on the use of the system (Verwey, Claassen, Rutgers, & de Witte, 2008). Nurses reported equipment insufficiency (laptops and connection to the intranet) as one of the factors restricting acceptance and proper use of an NIS.

In another study of Yeh et al. (2009) nurses identified computer access as a major obstacle to the use of the nursing process support system in Chinese (NPSSC) for Taiwanese long-term care facilities. Most of the facilities had only one computer terminal in each site for data entry and nurses did not have immediate access to computers. Thus, they reverted to writing down nursing notes by hand and then typed their notes on the computer when it was convenient to do so. Other computer-related issues in the same study included printing problems and unreliable internet connection.

A nurse in a study by Kossman and Scheidenhelm (2008, p.74) stated, when discussing the operation speed of NIS; "It's very slow, the computer is slow. When there is a glitch or a problem with it, it can really upset your whole day." It is evident that the NIS must have adequate technological support for its proper use; there should be immediate access to computers, and the technological connections should be available. The findings of this study

are similar to the results of others studies in which technology problems and maintenance of computer hardware were found to hamper the use of NIS (Cherry et al., 2011; Lee et al., 2009).

All of the studies above highlight the importance of sufficient numbers of computers and appropriate network infrastructure in determining nursing access and productive use of NIS. Residential aged care homes need an evaluation of their entire computer resources to ascertain that the necessary support is in place. Computers and network congestion requires human resources to maintain and troubleshoot. The next section presents a literature review on technical support provided to support NIS use.

Information systems technical support

A large and growing body of literature has investigated organisational factors. This literature indicates that technical IT support of NIS, especially at the initial stage of use, facilitates end users to adjust and adapt their use of the system (Hsiao et al., 2013; Rigby, 2006; Trivedi et al., 2009), because evidence shows that individual perception of a new system and acceptance may increase over time with sufficient support.

Technical support has been confirmed to have an impact on an individual's ability to utilise NIS. A study in a Taiwanese hospital investigating mobile healthcare system acceptance by various healthcare professionals, including nurses, reported that technical support has a significant, direct impact on nurses' belief in their ability to use mobile healthcare systems in nursing practice (Wu, Wang, & Lin, 2007). This finding indicates that technical support influences an individual's use of mobile healthcare systems. Although this study provides interesting insights, it did not investigate changes in user reactions over time. Thus, little is known about whether this behavioural change will directly result in more frequent use of NIS.

Similarly, in a Taiwanese teaching hospital, 22 nurses took part in a longitudinal qualitative study exploring nurses' experiences in using NIS (Lee, 2007). It was found that most nurses purposely chose the most stable patient for online charting. When probed further on this, one nurse said, "When we encounter problems using the system, we do not know who to ask or how to send the problem to the IS [information system support team] to get answer immediately. So, we just skip it [the problem] or make the charting quick and easy." Nurses

reported that they purposely choose to document only patients who are stable because there is less information to record. This minimised the time they interacted with the system. The lack of IT technical support raised the frustration level of nurses when problems arose and led to their avoiding the use of the NIS.

In a multi-method approach study nurses expressed their dissatisfaction with user IT support, amongst other things, after two years using NIS in four Taiwanese hospitals (Lee et al., 2009). In response to the open-ended questions, most of the comments were negative, particularly about user support. Some nurses needed technical support when faced with difficulties in using the system. Even though the results of this study were limited to a specific setting they provide evidence that IT support is a critical factor that may influence an individual's use of NIS and the frequency of use.

Therefore, when RACHs bring in a new technology, it is incumbent upon them to provide necessary support to lessen the effects brought by the new technology such that nurses are trained to either have the required technical skills or feel confident in discharging their nursing duties. However, it is important to ensure that the technical staff is aware of the characteristics, requirements of the RACHS, the technology and end users.

Most of the reported studies were about the detailed experiences of nurses in hospital settings, which mean that they may not be generalised to aged care.

2.6.3 Individual factors

Studies exploring the relationship between individual factors and information system use have investigated various variables that may play a significant role in influencing the efficient use of NIS among nursing staff. The variables investigated included basic demographics, attitudes, computer competencies, and workload/cognitive load. The following section discusses previous studies in health IT that investigated these variables.

Demographic characteristics

Studies exploring nurses' acceptance and use of NIS have also focused on user demographics. Demographic variables include age, job position/ranking, nursing experience, and education levels.

Age

Use of NIS may vary depending on age. A descriptive study investigating the impact of individual factors on computer use in a Finnish psychiatric hospital found that younger nurses were more likely to use computers (Koivunen, Välimäki, Koskinen, Staggers, & Katajisto, 2009). The results of this study are consistent with other findings from previous studies evaluating NIS in nursing practice that indicated that younger nurses were inclined to use computers regularly and efficiently (Lee, Lee, Lin, & Chang, 2005; Oroviogoicoechea & Watson, 2009). On the other hand, Yu, Li and Gagnon (2009) found no significant effect of nursing staff's age on the intention to use NIS in a residential age care setting. This study finding is not compatible with previous studies suggesting that younger nurses are more inclined to use NIS. One possible reason is the fact that the RACH workforce is generally older than the national Australian workforce and ageing further with the median age for RACH nursing staff 48 years (King et al., 2014). Possibly, for this is the reason that age is not considered an important factor in this research.

Job position/ranking

Studies exploring computer use have also focused on nurses' positions. Job position or simply "position" is defined or specified according to skills, knowledge, and responsibilities an individual has in an organisation. The term job position in the NIS literature is used interchangeably with job ranking or job role. Eley et al. (2009) reported that job role significantly correlated to the computer use in their study, which was conducted to determine factors that hinder the use of NIS by Australian nurses. Participants were 4330 nurses from all Australian states and territories. The findings of Eley et al. (2009) are consistent with those in the published literature (Webster et al., 2003). In Eley et al. (2009) participants were enrolled nurses and registered nurses only and did not include personal care workers. In RACHs, personal care workers comprise 68% of the workforces (King et al., 2014), consequently, the respondents do not sufficiently represent the nursing staff population in RACHs, hence inhibiting generalisation of the findings. The research findings of this thesis attempt to address this gap.

Nursing experience

Nursing experience refers to the number of years working in nursing. Several studies have explored the impact of nursing experience on computer use. For instance, in a phenomenological study, O'Connell, Reid and O'Loughlin, (2007) used a semi-structured in-

depth interview to explore the education and training experiences of ICU nurses in using two clinical IT systems: a clinical information system and a central monitoring system. The researchers interviewed six nurses with different levels of nursing or clinical experience; the least experienced nurses had 12 months experience. Nurses with more years of nursing experience were found to have a higher degree of confidence in using clinical IT systems (O'Connell et al., 2007). Similar results were reported by Weber (2007), Koivunen, et al. (2009), Dowding et al. (2009) and Yu, Li and Gagnon (2009).

Yu et al.'s (2009) study examined factors determining the acceptance of health IT applications in RACHs. This study was conducted before NIS was introduced and nursing staff had very little experience using the system. The other three studies are from a hospital setting with registered nurses as study participants. Therefore, drawing inferences from the results may need to be considered with caution. Even with the limitations in this study, nursing experience is used and may be considered an influential factor for the use of NIS.

Education level

Studies of individual use of technology have explored education level, which refers to the highest level of education completed. Koivunen, et al. (2009), when examining whether individual factors of nursing staff are associated with computer use in psychiatric hospitals, reported that education is a major factor that is correlated with the use of computer applications. The results further showed that younger nurses with higher education levels and nursing managers with higher education levels were more inclined to use computers frequently than others in the workplace. In another study, according to Lee et al. (2005) hospital clinical nurses' education levels were significantly correlated with daily use of the computerised nursing care planning (CNCP) system. Similar findings were also reported by Webster et al. (2003).

The findings of these studies have possible limitations related to how the results can be generalised for two reasons. Firstly, the studies were conducted in hospital settings. Secondly, the respondents were registered nurses (i.e., did not include personal care workers or assistants in nursing). Hence, there is a need to investigate the effect of education level in influencing nursing staff use of NIS in RACHs where 68% of the RACH's workforce is personal care workers with the minimum post-secondary qualification, Certificate IV, in aged care.

In summary, past research has indicated that nurses' demographic characteristics play an important part in influencing NIS acceptance and most likely impact how often it is used. Various settings have investigated these characteristics and there is a strong indication of certain influence by these variables. The review has demonstrated that is a need for further investigation, particularly in RACHs, to understand the influence of these various factors for this setting. The following section discusses various studies examining nursing attitudes.

Nursing staff attitudes toward NIS and computers in general

Attitude is a predisposition to respond in a consistently positive or negative way. It captures what the user knows or believes about the system, how much they like or dislike the idea of using the system, and how they regularly act or behave toward the system (Ajzen & Fishbein, 1980). Attitude is individual mental processes directed towards some object and facilitates how a person reacts to such an object.

Because of the continued development and integration of information technology in RACHs, it becomes important to be aware of the current attitudes of nursing staff towards computerisation (McDonald & Russell, 2012). As the use of computers increases, attitudes towards computer use may also be changing with continued exposure. Awareness of the potential change in attitude of nursing staff is vital in developing strategies to maximise computer system usage or manage resistance to using computers. A review of literature on nursing staff attitudes is one way to understand how they behave, think, and act.

In 1985, Stronge and Brodt developed a questionnaire survey tool to gauge nurses' attitudes towards computers (NATC) and computerisation. Many studies related to nurses' attitude toward computers have used this tool. Brodt and Stronger (1986) used NATC and the results showed that hospital nurses with higher educational qualifications and greater number of years employed in nursing had more favourable attitudes towards computerisation. Age and gender were not significant influences on nurses' attitude. Similar results were reported by other studies using the Stronge and Brodt questionnaire (Scarpa, Smeltzer, & Jasion, 1992; Stricklin, Bierer, & Struk, 2003; Yu et al., 2009).

Simpson and Kenrick (1997) used the Stronge and Brodt questionnaire to determine nurses' attitudes toward computers amongst 208 nurses in a British hospital. The study had a

secondary goal to compare their findings to Brodt and Stronge's (1986) findings. The results showed that there was no significant effect of nurses' age on attitudes toward computers. Despite this, Simpson and Kenrick (1997) found that younger nurses had positive attitudes towards computers which is contradictory to Brodt and Stronge's findings.

McBride and Nagle (1996) used the tool developed by Stronge and Brodt to study factors influencing the attitudes of baccalaureate students' and hospital registered nurses toward computers. Both students and registered nurses were found to have positive attitudes toward computers. No significant differences in nurses' attitudes were found among the demographic variables. McBride and Nagle (1996) raised concerns regarding the construct validity of Brodt and Stronge's instrument, because of the lack of consistency of the emerging factor pattern in their study. The authors argued that because of this construct weakness the effect of various demographic variables on nurses' attitudes toward computers were inconclusive.

Another study (Smith et al., 2005) conducted in an academic hospital in the US was focused on determining the rationale for attitude change pre and post-implementation of NIS using the NATC questionnaire. Results from 46 nurses showed a significant decrease in nurses' positive attitudes toward use of NIS in the post-implementation phase. The study showed the challenges of introducing nurses to a new system and when the system did not support workflow as efficiently as the nursing care process demands nurses would view the system negatively.

Some researchers have proposed that a nurse's intention to adopt and use NIS can be predicted from different perspectives, including different individual factors. For example, Dillon, Blankenship and Crews (2005) used a survey to assess attitudes and image profile towards a new electronic patient record system prior to installation. The image profile is defined as the personal experiences (such as work experience, sex, age, level of education, computer expertise, home computer ownership) combined with information communicated by others which then form the basis for development of images in the mind's eye of the individual. The researchers found somewhat positive overall attitudes. In addition, their findings revealed that age is a significant factor when determining nurses' attitudes toward the new system. The study concludes that nurses are receptive toward a new system and somewhat supportive of the technology in general (Dillon et al., 2005). Similarly, the Eley et al. (2009) study showed a positive attitude towards information technology by Australian

nurses but identified issues that must be addressed to support continued interest such as matching that enthusiasm by providing information about NIS benefits, training and suitability of the technology.

A more recent quasi-experimental study using a modified Stronge and Brodt questionnaire was conducted by Smith, Morris and Janke (2011) into changes in nursing satisfaction and attitudes toward an EMR system between pre-implementation and post-implementation, at a 340-beds tertiary-care medical centre in the US. The study found that nurses reported less favourable attitudes towards computerisation after implementation. Similar to the attitude scores, nurses were less satisfied with EMR after implementation. Despite the facility having implemented a comprehensive program that involved input from nurses, training sessions, and development of a technical support team, there was a significant decline in satisfaction and attitudinal scores between pre and post implementation (Smith et al., 2011).

Laramee et al. (2012) used modified Stronge and Brodt questionnaire at an academic medical centre to compare nurses' attitudes before, and at 6 and 18 months after implementation of an EHR. The study found that, on average, nurses' attitudes towards the EHR became less positive between pre-implementation and 6 months after implementation and pre-implementation and 18 months after implementation. No significant improvement between 6 and 18 months after implementation was noted. Overall nurses were more positive pre-implementation but the attitudes decreased significantly over time.

To summarise, numerous studies have explored the relationship of various individual characteristics to nurses' attitudes toward NIS at both pre and post implementation. Results demonstrated that the various factors do in one way or another affect nursing attitudes toward computerisation. Therefore, studies have shown that there are various reasons why nurses might have more positive or negative attitudes towards NIS. It is not only individual factors, but there may be organisational factors such as workload, technical IT support, lack of proper training, and technology-related factors such as usefulness and ease of use of the system or the system might not support the workflow as efficiently as the nursing care process demands. The majority of studies reviewed above have been confined to hospital and medical centres, as such restricting their generalisation to non-medical institutions (i.e., the RACH setting which is the focus of this study) and may not be relevant to aged care.

Therefore, the research will attempt to investigate some of these factors, in order to provide insight into why nursing staff in an RACH may or may not have positive attitudes toward NIS. Being armed with such new insights might lead to better organisation and development of strategic approaches to implement, and use a system to improve the attitudinal perspective of nursing staff in RACHs. The following discussion will focus on the computer competencies of nursing staff to use NIS.

Computer competencies to use NIS

Computer competency included the ability to understand and/or use computer applications and to learn fundamental operations and concepts of NIS. Although nursing staff do not necessarily require a higher degree of computer competency, their interaction with computers will be much more efficient if they possess acceptable nursing computer literacy skills.

Nursing computer literacy

In general, computer literacy or competence means the ability to use a computer. The Technology Informatics Guiding Education Reform (TIGER) created a nursing informatics competency model with three parts: basic computer competency, information literacy, and information management (TIGER, 2009). With increased use of NIS in healthcare settings, high informatics literacy among nursing staff will assist them to operate computers proficiently, and in turn, quickly access care-related information (Smedley, 2005; TIGER, 2009). Thus, improved informatics literacy will improve competency in NIS use.

During the past two decades, information systems have been rapidly integrated into healthcare. Consequently, nursing graduates need to be educated to be able to deal with advanced technology. Despite this there has been relatively little improvement in terms of nurse graduates as demonstrated by McDowell and Ma's (2007) study which evaluated nursing informatics competence of undergraduate baccalaureate students upon admission and graduation. The study addressed whether level of experience with computer software and hardware by baccalaureate nursing students and graduates increased. In particular, the researchers looked at whether there was a significant difference in their level of experience when they entered and when they graduated from a baccalaureate nursing program during the past 8 years. Students indicated that their computer ownership, e-mail, internet and presentation graphics overall had improved. Bibliographic database searches and statistical program knowledge improved between admission and graduation dates. However,

spreadsheet and database knowledge did not significantly improve. The study argues that nursing informatics competency for graduate nurses must include database, spreadsheet, word processing, presentation graphics, and keyboard skills. The results of this study indicate that nursing education programs currently may not be providing graduate nurses with the necessary skills needed to work effectively and efficiently in IT-enabled nursing care settings (McDowell & Ma, 2007). Hence, nursing graduates do enter the workplace with limited computer competence. This may negatively affect how often they use NIS and there may be some resistance by new staff once in the workplace.

Other studies have correlated educational level to computer competency. For instance, Hsu et al. (2009) investigated computer competencies for Taiwanese and South Korean nurses in two hospitals. Nurses' education was a significant factor influencing computer literacy. In spite of this, nurses reported that computer or informatics training was not provided in a clinical setting and 33% reported they were not given an opportunity to engage in informatics during formal nursing training. These findings do indicate that nurses' competencies as they graduate are not sufficient (Bembridge, Levett-Jones, & Jeong, 2011). For that reason, they are likely to be unable to effectively use a computer or they perceive it as an obstacle to their daily activities (Hsu et al., 2009).

With the continued expansion and integration of NIS within RACH settings, nursing staff must exhibit aptitude and competence in computers (Johnson, 1995). In one study, nurses throughout Australia participated in a mixed-method approach to collect both qualitative and quantitative data to determine their current use of ICT and barriers to using it. Nurses reported a high experience level in the use of ICT ranging from 90% for a common application such as word processing to 64% for references tools. However apart from nurses in management positions, experience and confidence in use of ICT is confined to basic computer and common applications and even in these instances it is lower than desired (Eley, Fallon, et al., 2009).

In our study, two constructs not entirely independent of each other are used - computer knowledge and computer experience – to express the perceived accumulated knowledge and skills from previous computer use as indicators of computer literacy. Computer knowledge is not a simple, one-dimensional concept and there has been ongoing debate about its conceptualization in the literature (see Staggers, 1994). Computer knowledge refers to "self-

perception of the extent of knowledge regarding the use of computers across different application domains" (He & Freeman, 2010). Computer experience is a combination of computer knowledge, past and present computer use, and the frequency of using a particular application (Staggers, 1994).

Insufficient NIS knowledge and skills by nursing staff may lead to only a few being able to understand the aims of the system use and when the computerised tools do not work according to their expectations they may become irritated, stressed, annoyed and lose motivation (André, Ringdal, Loge, Rannestad, & Kaasa, 2008; Lorenzi, Kouroubali, Detmer, & Bloomrosen, 2009).

The literature described above suggests that nurses enter the workplace with insufficient computer competence required for proficient and intended use of the NIS. The findings are pertinent to training, as discussed in Section 2.6.2 specifically related to the need to train nurses in order to attain the necessary competence. In addition, as nursing practice in the aged care setting is stressed due to time constraints and heavy workloads, as stated in Section 2.6.2. There is a need to investigate whether a combination of lack of the necessary skills to operate NIS and lack of efficiency of traditional training programs or ad-hoc training strategies increases the cognitive load of nurses. Finally, the concept of cognitive load in human-computer interaction will be briefly discussed.

Cognitive load in using NIS

Few studies have explored the relationship between nurses' cognitive load, acceptance, and use of technology. Cognitive load is defined as a multidimensional construct representing the mental load and mental effort that a particular task imposes on the trainee's cognitive system at an instance in time (Paas & van Merriënboer, 1994a, p. 353).

Kjeldskov, Skov and Stage (2010) used a NASA task load index (TLX) test to assess the subjective workload (i.e., cognitive load) of seven novices and seven expert hospital nurses when using an electronic patient record system in a longitudinal study. The evaluation was conducted when the system was being deployed. Another evaluation was conducted after more than one year of use (15 months) and perceived cognitive load (mental effort and mental demand) was still high post implementation. In conclusion, the novices experienced a significantly higher cognitive load and frustration than the experts. The results of the study

demonstrated that using the system over time may not heal the usability problems associated with high cognitive load regardless of whether the users become familiar with the system or uses the system over time. Further, if nurses lack skills to learn fundamental operations and functions of the system they will experience high cognitive load. The learning processes and training materials are aimed at supporting knowledge and skills acquisition.

However, there are limitations to how the Kjeldskov et al. (2010) study results can be generalised. Firstly, the respondents are representative of the workforce in hospital settings in terms of their work expertise and demographic profile, and as such are not representative of other health domains such as RACHs. Secondly, the system evaluated was similar to expert systems for complex data management in a hospital setting and not necessarily in an aged care setting.

Most studies exploring workload focused on interface design or reengineering of the NIS. To our knowledge, limited studies have been undertaken in nursing practice internationally assessing the nursing cognitive load when interacting with computers and no study has been conducted in nursing homes in the Southern Hemisphere. The focus of this study is not to redesign the introduced system interface. Rather, part of the study is to investigate cognitive load effect on human-computer interaction after nursing staff had used the system in their daily work for five years.

Based on the gap identified, cognitive load may play a significant role in nursing staff computer interaction leading to either significant frustration with the NIS or its reduced use. Cognitive load plays a central role in cognitive load theory, which is the theoretical framework used to guide part of this investigation. Cognitive load and cognitive load theory literature is presented in the Chapter 3. That chapter provides a discussion of the definition of cognitive load, how it works, how it affects learning, and discusses how it impacts nursing experiences in learning to use NIS.

2.7 Research gap, aim and research questions of the study

This literature review has examined the relevant literature for the proposed study. Three categories of technology-related, organisational and individual factors are well documented across hospitals and general practice settings. Previous studies have investigated and defined these categories to a certain extent in the healthcare setting. However, there is no consensus

on the categories of barriers and facilitators related to information systems use as most studies investigated these factors from a specific angle. The barriers and facilitators are characterised. Therefore, one key contribution of this study is to explore and describe the factors according to the lived experiences of nursing staff working with NIS in RACHs.

In addition, there is a lack of specific contextual knowledge of how technology-related, organisational, and individual factors influence nursing staff in the aged care setting to use NIS. Detailed contextual knowledge that provides insight into RACH nursing staff perceptions about NIS and the issues that hinder and facilitate NIS use in RACHs is missing and this study addresses this gap.

In addition, the literature review presented in this chapter has identified limited investigations in peer-reviewed publications, conducted internationally and in Australia, of the factors that facilitate the use of NIS in RACHs. Cherry et al. (2008) and Cherry et al. (2011) suggest that further studies are required to gain insight into facilitators or barriers to using NIS productively. They argue that these insights might assist in addressing the identified barriers and, most importantly, RACH managers, RACH industry leaders, government policy makers for aged care and health services researchers would benefit from such information.

As discussed above, studies exploring the relationship of individual factors and nurses' computer use have mostly focused on the demographic variables (i.e., age, job position, nursing experience and education levels), nurses' attitudes toward computerisation and computer competencies (i.e., computer knowledge and computer experience). This thesis contends far too much attention has been focused on demographics and attitudes rather than the cognitive impact of NIS on nursing staff. To our knowledge, limited investigation has been conducted to understand the cognitive load for nurses in learning to use NIS and no study has been conducted in Australian aged care settings. In order to address this gap, this is the first study to assess the influence of cognitive load on the use of NIS by nursing staff in Australian RACHs.

2.8 Summary of the literature review

In nursing, NIS are viewed as a way to address the challenges of nursing documentation. It is believed that with the use of NIS nursing staff will be able to capture, retain and access information that will enable them to meet accreditation standards. In addition these systems

help maintain a high quality of information that is readily accessible to facilitate timely care decisions.

On the other hand, implementation and adoption of NIS have not achieved the intended benefits because nursing staff do not use the systems as productively as intended. The factors that emerge from reviewing the literature are technological-related, organisational, and individual factors. However, the results of these studies are inconclusive. Hence, it is not clear whether the findings of these studies can be generalised to the use of NIS in RACHs. Residential aged care homes are different from the hospital setting as detailed in Section 2.5.

The present chapter aimed to provide a review of previous research on factors influencing the use of NIS. It focused on how technology-related, organisational, and individual factors affect the productive use of the NIS. The next chapter outlines the second topic area, being cognitive load and cognitive load theory, which offer explanations of the conditions that facilitates or impede knowledge acquisition in learning to use the computer to complete daily nursing tasks. Chapter 3 provides an overview of cognitive load theory research.

Chapter 3 Literature review on cognitive load theory

3.1 Introduction

This chapter primarily seeks to investigate the veracity of cognitive load theory and the construct of cognitive load in order to decide its contribution to the research aims of the thesis. It is necessary to distil the fundamental ideas of cognitive load and its underpinning theoretical context in which nursing staff-computer interactions in RACHs can be systematically investigated. The first part of the chapter provides a description of the human cognitive system, which is the foundation of cognitive load theory. In noting, how information is processed in these systems, the thesis proceeds to describe cognitive load theory and the concept of cognitive load as an analytical construct to analyse research data in later chapters. The chapter concludes with the articulation of the research questions that are used to guide the subsequent collection and analysis of research data.

3.2 Human cognitive system

Based on numerous studies focusing on the cognitive structures and their relations we have become more aware of how humans process information. These studies have focused on the conceptualisation of human cognitive structures: sensory memory, working memory and long-term memory.

Sensory memory is the initial place that transforms incoming stimuli from the environment into information so that an individual can make sense of them (Eysenck & Keane, 2010; Woolfolk & Margetts, 2007). Secondly, a working memory has limited capacity to process and maintain information before it transfers this information to long-term memory. Thirdly, long-term memory provides a massive storage capacity for organised information.

The following is a discussion of the roles of working memory and long-term memory in the human ability to process information.

3.2.1 Working memory

Working memory is both the primary memory and immediate memory (Klatzky, 1975), and is used to temporarily store and deal with the conscious processing of information (Sweller, van Merriënboer, & Paas, 1998) necessary to perform cognitive processes such as learning and reasoning (Baddeley, 1992, p. 556). This is the cognitive structure where current mental

activity takes place. Consequently, humans are only conscious of what is inside working memory and nowhere else at any given time.

However, working memory has limited capacity when dealing with new information, but it can process intricate, previously learned information without limitations (Sweller, 1999). With this limited capacity it is believed to be capable of only processing three to five new elements (data that needs to be learned) at a time (Baddeley, 1992; Miller, 1956). The inability to hold many more items that are new decreases its effectiveness of processing such novel information.

Information enters working memory in two ways. New information enters working memory via the sensory memory, whereas previously stored information enters via long-term memory (Sweller, 2004). The way information is processed depends on where it comes from and this has instructional design implications. If trainees are presented with novel information, instructional design has to compensate for the limited capacity and duration of working memory; if not it will overload it or be lost within 20-30 seconds (Peterson & Peterson, 1959).

On the other hand, information retrieved from and stored in long-term memory is processed without overloading working memory.

3.2.2 Long-term memory

Long-term memory is a secondary memory that, in contrast to working memory, is not restricted in the same way. Firstly, long-term memory has vast capacity, capable of holding an almost unlimited amount of organised information. Secondly, long-term memory is "a relatively permanent store for a lifetime's worth of knowledge and experience" (St Clair-Thompson, Overton, & Botton, 2010, p. 134). These massive amounts of stored information previously learned are necessary for everyday cognitive tasks or problem solving.

Long-term memory rather than working memory is a major contributing factor in the development of human intellectual capacity. As long-term memory develops, information is received, it is processed and added to form larger complex structures which allow humans to negotiate very complex environments. Further, long-term memory has an unlimited capacity

for organised information due to its ability to construct and automate cognitive structures known as schemas.

3.2.3 Schemas

Cognitive load theorists suggest that long-term memory comprises highly interconnected schemas. What is a schema? According to the Merriam-Webster Encyclopaedia Britannica, the word schema originates from the Greek word "schema," which means form or structured framework. Hence, schemas are viewed as complex interacting conceptual structures of knowledge rich with previous knowledge and experiences (Murphy & Medin, 1985; Sharifian, Rochecouste, & Malcolm, 2004). They are used to recognise and translate casual explanations about how the world operates (Murphy & Medin, 1985), as well as how to deal with the complexities of everyday objects and events, and are critical to remembering and learning (Rumelhart, 1980).

Marshall (1995) describes schemas as a structure of memory that permits organisation of similar experiences for an individual to:

a) identify new experiences (identification knowledge),

b) access a conceptual framework that holds critical elements of similar experiences (elaboration knowledge),

c) draw out inferences, make estimates, set goals and create plans using conceptual framework (planning knowledge), and

d) execute rules, procedures using necessary human abilities required when faced with a specific problem (execution knowledge).

According to Marshall, schemas are basic structures that have flexible structures with no fixed size and can be assimilated with others to varying degrees of strength and accessibility. In order to create schemas conscious effort and selective processing is required.

With regard to using a new NIS, nursing staff that have had prior experience with using similar information systems will have a conceptual framework (elaboration knowledge) that facilitates understanding and learning of the new system's procedures. In contrast, novices will be unlikely to have relevant schemas and therefore their ability to use the system is limited. The concept of a limited capacity, limited duration in working memory is relevant to

them because it limits the manner in which they process novel information about NIS procedures and functions.

To demonstrate the validity of the concept of schema, Bartlett (1932) conducted an experimental study on the nature of remembering, where British university students were given a Native American Indian folktale, "The War of the Ghosts," to read. Thereafter, they were requested to write up their recall of the story after some time had elapsed. Then the new written version of the story was handed to the next participants to read and write out. This procedure was repeated several times. In the end, the study showed that the folktale was progressively getting shorter and more incoherent than the original story and adopted into the culture familiar to the participants. The results indicated that the participants read the American folktale from their English cultural perspective and thus infused a modification derived from their own culture. This, according to Bartlett highlights that when individuals encounter novel information, they attempt to relate that new information to what they already know. In short, people try to interpret new information into their existing schemas.

De Groot (1965) demonstrated the importance of schemas in learning by performing experiments to observe a number of players with varying degrees of chess expertise from amateur to expert (chess masters). In his study, he demonstrated the critical functions of schemas by illustrating that chess masters defeated amateur players owing to their ability to identify the chessboard movements they have encountered in the past. The chess masters had amassed and assimilated more chessboard patterns into the long-term memory compared to the amateur players. This enabled them to recall and activate stored schemas resulting in superior performance. This study altered the way the human cognition was previously understood because it demonstrated the importance of memory in distinguishing an "expert" from a "novice." Subsequent research reproduced similar results demonstrating the significance of schemas (see Chase & Simon, 1973; Gobet & Simon, 1998), particularly in learning and problem solving, and as such, it has been postulated to explain differences between novices and experts.

In summary, there is consensus on the basic principle and structure of schemas. It is apparent that schemas:

a) are organised cognitive constructs, that provide the basis of all learning

b) are stored in long-term memory, which provides the link between what we already know (prior knowledge) and what we need to know about the new information, and
c) allow us to combine multiple related elements into a single unit.

The single unit takes less working memory capacity and thus frees working memory (Sweller, 2003) to handle other cognitive tasks relevant for the learning process. During learning, it is critical to limit opportunities of overloading the working memory capacity. The more schemas an individual stores in long-term memory, the more they are likely to show a superior memory and performance in certain areas (Sweller, 2003) and less likely to be overloaded. Therefore experts with access to schemas are able to outperform individuals with less developed or no schemas.

A number of schemas stored in long-term memory may be required at a single instance in order to perform a specific task. Consequently, chunking of these schemas is necessary for such action.

3.2.4 Chunking

Each schema loaded into working memory can be treated as a single "chunk," where multiple pieces of related information are held together. The process of chunking refers to collecting two or more nominally independent pieces of information into a meaningful single familiar unit (Miller, 1956). These pieces can be a concept from a single letter to paragraph, process, or idea. Only information elements having strong association with one another can be chunked.

De Groot (1946; 1965) initially proposed the traditional view of the chunking concept from studies of problem solving based on perception and memory. Miller's (1956) key contribution to the concept of chunking was the suggestion of information measure in human cognition systems. He pointed out that human cognitive capacity limits the number of chunks that humans can memorise to seven (plus or minus) items or chunks at a given time (but this number restriction is irrelevant to the size of each chunk). Through recoding and organising multiple pieces of information into chunks, one is able to circumvent the limitation of the cognitive system's capacity for processing information.

Other studies continued the attempt to refine the construct of a chunk and various hypotheses regarding the number of elements a chunk could hold. For instance, Newell and Simon (1972) suggest that the smallest units of information held in the long-term memory are symbols, which then act as inner representation for stimulus patterns, and these patterns are chunks comprehensible as specific symbols through learning. Klatzky (1975) claimed the inconsistent description of a chunk complicated our understanding of chunks owing to conflicting views of chunks; some define it as whatever memory holds seven of, while others claim the span of immediate memory is seven chunks. Klatzky then argues this makes "seven of whatever working memory hold seven of" indefensible. In spite of this, Anderson (1985) views chunks as cognitive units that join a set of elements in specific relation and postulates that chunks are made of more than five elements. Further, Cowan (2001) argues that the number of chunks was meant more as a rough estimate and a rhetorical device than as a real capacity limit. This working memory capacity can be conceived to be limited to no more than five elements of new information (Sweller & Chandler, 1994).

The chunking proposition has been used to provide the basis for a general model of human learning and is a major component of theories of cognition including cognitive load theory (Laird, Rosenbloom, & Newell, 1984; Sweller, 2003). It enables working memory to efficiently store and process novel information. Theoretically, chunking would be an important performance determinant in any complex NIS task in which the capacity of working memory is severely restricted. Expert NIS nursing staff users are able to chunk schemas without discernible working memory load. These staff perform NIS tasks efficiently due to the capability of their rich long-term memories.

Once the schemas are constructed, to process and use them effortlessly is achieved through the process of schema automation.

3.2.5 Schema automation

Schema automation refers to the ability to process information without conscious working memory control (Sweller, 2003). This is the assumed status of any knowledge that can be activated from long-term memory (Clarke, Ayres, & Sweller, 2005). For example, initially when we learn to drive a manual car we must master changing of gears. This involves a series of unsophisticated movements by the feet to release the accelerator and press the clutch pedals. The movements should be neither too fast nor too slow with one hand on the gear

lever. It involves the smooth release of the clutch pedal, while simultaneously pressing of the accelerator smoothly. These tasks must be performed in parallel with non-driving tasks, for example observing other vehicles on the road or listening to instructions from the driving instructor. Initially these processes would require great attention, as well as conscious controlled monitoring to successfully drive the car. At the beginners stage we are unable to group these multiple interacting elements of information from various tasks into a single element. These processes overwhelm our cognitive resources thus driving the car becomes a difficult task.

On the other hand, once thoroughly practiced we perform the required driving tasks in an automated process, which is effortless and not limited by working memory resources because once initiated it is not under our conscious direct control (Shiffrin & Schneider, 1977).

With automation, the tasks we are familiar with are performed quickly and accurately, whereas the unfamiliar tasks are likely to be performed slowly and inaccurately (Sweller et al., 1998). As automation of constructed schemas is gradual, it is possible for different schemas to be at various phases of automation and thus are more likely to utilize different amounts of working memory resources. Familiar tasks are performed successfully even without automation, but the procedure of problem solving is likely to be prolonged and disorderly, because novices will revert to random generation and testing moves in an attempt to attain the solution. For unfamiliar tasks, it is more likely to be impossible to complete them.

To sum up, an unlimited long-term memory, a limited working memory, and learning procedures that involve schema construction and schema automation are key parts of our cognitive system (Sweller et al., 1998).

However, to further our understanding of the way human cognition handles different types of information, recent developments have linked our architecture to a natural information processing system that is similar to evolution by natural selection (Sweller, 2003, 2010a).

3.3 Human cognitive system and natural information processing systems

The principle of natural selection was proposed by Darwin and Wallace (1858), commonly known as the Darwinian principle. The premise of the recent research linking human

cognitive systems to evolutionary framework (Laird, Newell, & Rosenbloom, 1987; Sweller, 2003, 2006a) is based on the claim that species such as human beings select and choose systems that ensure their survival. This provides the tenet of a human cognitive architecture in which, through evolution by natural selection, humans have evolved to perform a range of cognitive activities of varying complexity and differing levels of cognitive consequences (Sweller, 2006a; Sweller, Ayres, & Kalyuga, 2011). The evolution framework categorises knowledge into two different forms: biologically primary knowledge and biologically secondary knowledge (Geary, 1995, 2010).

Biologically primary knowledge refers to the competencies that can be acquired without awareness and with no direct instruction because humans have evolved to attain that knowledge (Geary, 2007). Primary knowledge is the inherent know-how acquired automatically over a period of time as a simple result of being in a functioning society (Geary, 2008). Consequently, humans are able to acquire large amounts of biologically primary knowledge without an apparent working memory load and the acquisition of this type of knowledge is not restricted by the human cognitive system structures outlined above (Paas & Sweller, 2012).

The manner in which we learn to recognise people (e.g., Bentin, Deouell, & Soroker, 1999) and learn to speak (e.g., Kühl, Scheiter, Gerjets, & Gemballa, 2011) demonstrates our ability to learn and acquire large amounts of complex information without explicit instruction. Concerning speaking, we learn to shape our lips, tongue, utter sounds, or words simply by immersion in a listening or speaking society. This learning is unconscious, effortless and rapid. The concept of a limited capacity and limited duration of working memory is irrelevant in processing various elements in biologically primary information (Paas & Sweller, 2012).

Biologically secondary knowledge is related to knowledge and expertise that humans have not evolved to deal with in an unconscious way. For example, nurses have not evolved the skills of understanding HTML programming language or interacting with NIS without being taught. Therefore, in order to learn biologically secondary knowledge usually explicit teaching or training is required. Direct and clear instruction acts as a replacement for the biological programming that is present when dealing with information that we have evolved to acquire (Sweller, 2009).

Geary's differentiation between biologically primary and secondary knowledge has some insightful instructional implications. For instance, trainees can construct knowledge without getting extensive help from others. Indeed, humans acquire a huge bulk of information without direct instruction. On the other hand, we often face difficulty in attaining biologically secondary knowledge in learning. The logical reason for this is due to the unsuitable instructions used to train trainees. Hence if we train nursing staff using the same instructional approach that emulates the way we are exposed to the external world, then learning would be more effortless and rapid. However, evidence does not support this view.

According to Sweller (2004), the human cognition natural information processing system is characterised by five principles, that explain the functions and processes a trainee engages to acquire biological secondary knowledge:

- Information store principle
- Borrowing and reorganising principle
- Randomness as genesis principle
- Narrow limits of change principle
- Environment organising and linking principles.

3.3.1 Information store principle

The ability that most living organisms have is to develop a cognitive action in a response to environmental stimuli. This is driven by natural information processing systems, which are reliant on the contents of an enormous information store to govern their actions. Because of the complex and large environment, there is an inherent need to store massive amounts of information to handle numerous activities of the system as they arise (Sweller & Sweller, 2006). As a consequence, the information storing principle is equally important when dealing with either primary or secondary knowledge (Sweller et al., 2011) as it provides a way to store information for human cognition.

In the case of evolution by natural selection, it is presumed that the genome stores large amounts of information that govern various activities. While there is no scientific consensus on the genome size, let alone an agreed system for measuring its size, it is widely accepted that a genome has a large capacity to deal with the complexity of any natural environment.

It is in this regard that long-term memory is therefore perceived as equivalent to a genome in genetic evolution. The long-term memory stores the entire amount of information gathered by humans.

3.3.2 Borrowing and reorganising principle

According to Sweller (2010a), the genome or long-term memory stores all the information that governs most cognitive activity, whereas borrowing and reorganising principles explain how that information is acquired into long-term memory. Secondary information in long-term memory is mostly borrowed from long-term memory of other individuals, for example in the context of NIS by replicating what they do in NIS, listening to what they say, or reading training manuals. In this way, information is reorganised and assimilated with the previous information in long-term memory (Sweller, 2009).

The information processing system of an expert in a specific domain, relies on the presence of an enormous amount of information stored in their long-term memory (Ericsson & Charness, 1994). The large store requires a mechanism to efficiently acquire, catalogue and withdraw information. The borrowing and reorganising principle is the mechanism that enables individuals to process, reorganise and store enormous amounts of information into long-term memory (Sweller & Sweller, 2006).

3.3.3 Randomness as genesis principle

The human cognitive architecture stores information in long-term memory mainly through borrowing and reorganising principles. In spite of that, this principle is not the basis of novelty. Two questions then arise. Firstly, how is novel information that has never been stored in the long-term memory initially generated since the borrowing and reorganising mechanism is not available to acquire new knowledge? Secondly, once created, how do we decide which new information is permitted to enter human memory for storage?

To answer these questions, according to Sweller (2006a), novel information enters our system though the randomness as a genesis principle. This mechanism facilitates our understanding of novel information. New information transfer involves randomly creating various combinations of new as well as existing information whereby useful information is kept while useless information is discarded (Sweller, 2003; Sweller & Sweller, 2006). Because there is no guarantee of the effectiveness of a particular combination there would be

adaptation and reorganisation followed by tests of effectiveness to determine whether the new information can be added to existing knowledge.

Randomness as genesis principle is commonly seen in means-ends analysis. Means-ends analysis is a general search strategy often used by novices in problem solving. Heyworth (1999) refers to it as a form of backward reasoning that involves:

(a) finding the problem's goal statement,

(b) identifying differences between the goal and the current state/information,

(c) generating moves or ways to reduce this difference,

(d) attempting to carry out the moves to decrease the gap between the current and goal states, if this does produce the desired results,

(e) repeating steps (b), (c) and (d) recursively with a series of sub-goals until a solution is found.

In this strategy, if the related information exists in the long-term memory, we use the test of effectiveness to reduce the gap between problem and desired results. Thus, eventually, creating new knowledge is through assimilation and it is later stored. In the case whereby new information is created and no related information is available, the NIS novice needs to randomly generate and test moves for effectiveness. The undesirable effect with this strategy is that novices can be overwhelmed given the possible long sequences of iterative actions to be attempted to reduce the difference between the problem and the desired state.

3.3.4 Narrow limits of change principle

The borrowing and reorganising, and the randomness as genesis principles as described above are the main mechanisms determining how novel information is acquired and altered in human cognition systems. The randomness as genesis is the first place of novel information. Then the borrowing and reorganising principle takes novel information acquired via the randomness principle and assimilates it with information previously held in long-term memory. However, the narrow limits of change principle states that only small changes to novel information obtained via randomness as genesis principle can be processed at any given time, due to a limited working memory (Kissane, Kalyuga, Chandler, & Sweller, 2008; Kyun, Kalyuga, & Sweller, 2013).

Studies by Miller (1956) and later by Cowan (2001) demonstrated the limited capacity of working memory when trainees dealt with more than one element of information at any given time. For that reason, if a trainee is to deal with disorganised novel information with multiple elements at any given time their working memory is likely to be overloaded (Sweller et al., 2011). This constraint limits the amount of "generate and test" of novel information that can be processed in working memory and passed into the long-term memory. Likewise, experts have enormous domain knowledge and when presented with information that has random components via borrowing and reorganising principles, such information processing would be impeded by working memory limits. These limitations reduce novel information entering long-term memory thus learning in humans is slow and incremental (Sweller, 2009; Sweller et al., 2011; Sweller & Sweller, 2006).

3.3.5 Environment organising and linking principle

Once novel information is stored in long-term memory, the working memory constraints with its narrow limits of change principles vanish. Therefore, any large amounts of information can be rapidly processed if it is from the long-term memory. This means prior knowledge is organised without the need for a trainee to apply the random "generate and test" process. The organised information retrieved from long-term memory to working memory allows trainees to perform cognitive activities without conscious effort. The environmental and organising mechanism is the underlying human cognition principle linking the trainee's environment to their cognitive functions and abilities.

The environmental organising and linking principle is summarised as the ultimate way that allows humans to transmit an enormous amount of information from long-term to working memory to support our cognitive system function in a complex environment (Sweller, 2004).

The five principles provide a base for human cognitive architecture via natural information processing systems. Based on this architecture, the primary function of instruction is to build or alter schemas in long-term memory. If there is no change in long-term memory, nothing has been learned. The knowledge held in long-term memory can be generated via the borrowing and reorganising principle. When information is presented, we should keep in mind the narrow limits of change principles. Finally, that knowledge or information can be used to efficiently direct cognitive activity and solve problems via the environmental organising and linking principle. This status therefore grants trainers, instructors, and new

learners an understanding of how human cognition works and its likely implication to the approach, delivery and conduct of effective training programs.

In short, according to Sweller (2006), the above principles are the foundation for cognitive load theory. Sweller argues that the role of instruction according to the above principles are the foundation of learning. Learning often occurs through the borrowing principle, as such, instructional design must focus on how information is presented to trainees and new learners (Sweller 2006). Approaches to learning that focus on discovery and inquiry are not particularly effective because of the nature of the randomness as genesis principle. Approaches to instruction may need to be in cognisance of the narrow limits of change principles imposed by the limits of working memory. In addition, information organised through the environmental organising and linking principles in the long-term memory provides the basis for further interaction with the environment.

The above five principles of the natural information processing system provide the basis of the functioning of human cognitive architecture and underpin cognitive load theory.

3.4 Cognitive load theory

Cognitive load theory (Chandler & Sweller, 1991; Sweller, 1988; Sweller et al., 1998) is an instructional theory developed over three decades within the domain of cognitive psychology. The fundamental assumption of cognitive load theory is that knowledge acquisition depends on the efficient use of the available limited capacity of working memory. Learning is likely to be impeded when the limit of working memory is exceeded due to the failure to align instructional design with the basic operational principles of the human cognitive architecture. Furthermore, the theory postulates that this failure consequently tends to result in a heavy cognitive load, with the risk of overwhelming limited working memory. Thus, the theory's main purpose is to provide a framework for effective instructional designs (Sweller et al., 1998) that optimise learning performance by managing working memory load effectively.

The prime goals of learning during a training program is to facilitate the construction and automation of the schemas, so that trainees and learners obtain new knowledge and skills to apply to new situations (Paas, Renkl, & Sweller, 2003). Schemas do not only allow storage of learned information in long-term memory but also reduce the burden on working memory. Cognitive load theory research mainly investigates and evaluates designs of instructional

methods better suited to our cognitive functions and its limitations. This theory recognises the concept of cognitive load as a crucial factor in learning of complex tasks (Paas, Tuovinen, Tabbers, & Van Gerven, 2003).

3.4.1 Cognitive load

Cognitive load is defined as a multidimensional construct representing the mental load and mental effort that a particular task imposes on the trainee's cognitive system at an instance in time (Choi, van Merriënboer, & Paas, 2014; Paas & van Merriënboer, 1994a).

Mental load is part of cognitive load instigated by interaction between task and trainee characteristics and imposed by instructional parameters such as task structure, sequence of information and environmental demands (see Figure 3.1). Mental load is used to provide a prediction of the anticipated cognitive capacity demands.

Mental effort refers to the amount of capacity that is allocated to the actual instructional or task demands (Paas, 1992, p. 429) and it is considered to indicate the actual cognitive load. In fact, mental effort can be considered to be the amount of working memory that is assigned by the trainee to the learning process or to task performance.

Performance is a reflection of mental load, mental effort and causal factors (Paas & van Merriënboer, 1994a). Causal factors are the characteristics of the trainee (i.e., general computer skills, knowledge of the specific domain or computer system, attitude and many more), the task, the environment, and their relationships (Paas & van Merriënboer, 1994a). Performance here is described in terms of trainee accomplishments, such as number of correct task steps, number of errors, and time on task. It can be determined while a trainee is working on a given task or post completion.

In this study, the term cognitive load refers to the amount of mental effort and demands placed on a human's working memory resources by (a) the task that is currently being engaged, (b) any other task(s) being performed simultaneously, and (c) distraction caused by various aspects of their work environment at an instance of time. Cognitive load is considered as a construct indicating the working memory resources required to learn specific novel information materials or to perform a specific given task.

These concepts and models indicate that there is a limit to how much novel information a trainee's cognitive system can attend to and process at any one time. As discussed in Section 3.2, humans have a limited working memory capacity for new information and an unlimited long-term memory. Thus, if the learning task demand exceeds the working memory capacity, it is likely to result in cognitive overload.

Cognitive load can be a result of the inherent nature of the novel information, the manner in which that novel information is presented or by the actions required of trainees. Cognitive load (or the risk for overload), needs to be managed in order to support meaningful learning because when the necessary cognitive processing exceeds the capacity, learning will be disrupted (Bradford, 2011).

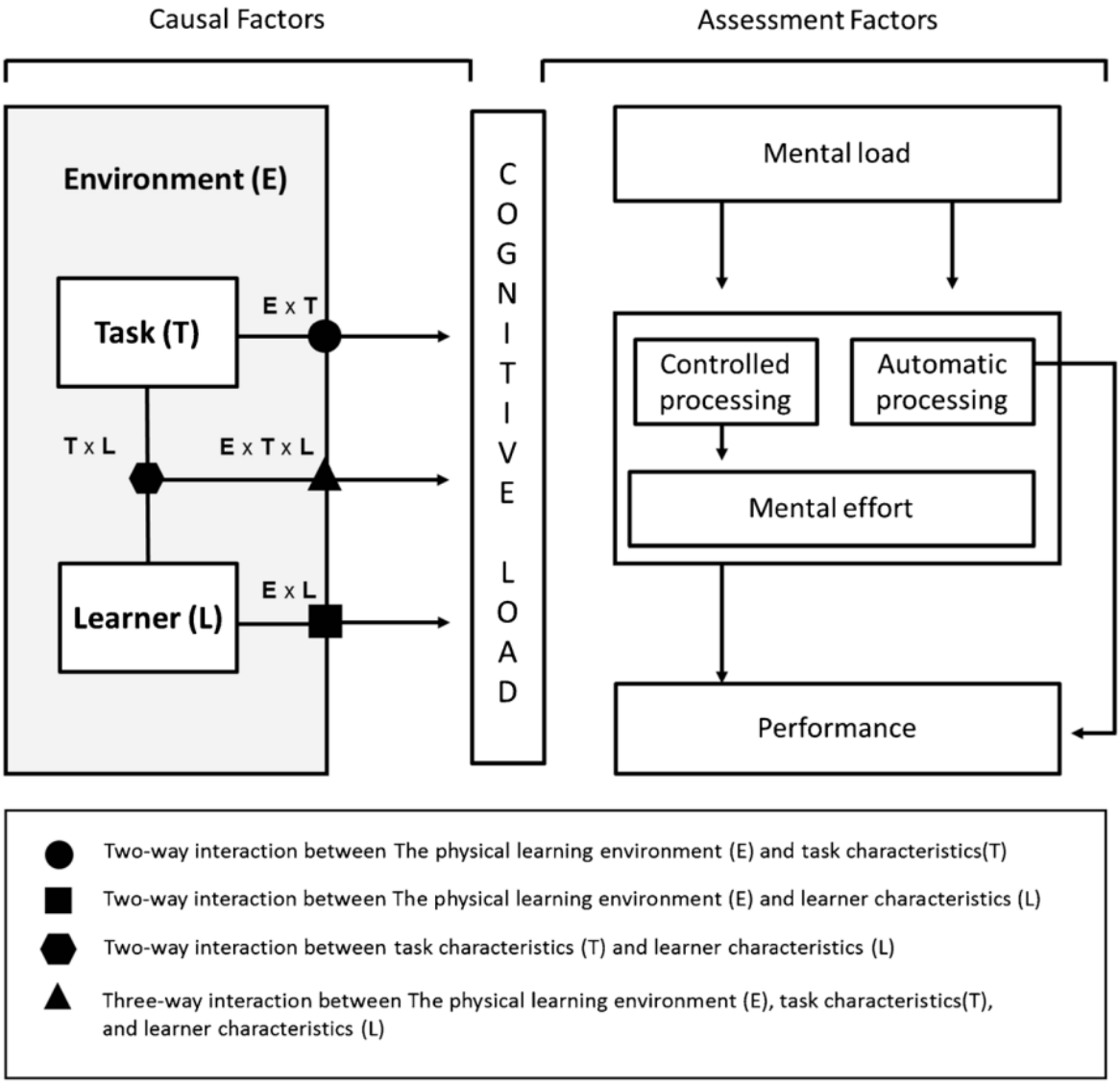


Figure 3.1 The factors determining the level of the cognitive load (Source: original model adapted from Paas & van Merriënboer 1994 and current model above revised by Choi, van Merriënboer & Paas 2014).

3.4.2 Sources of cognitive load

Cognitive load theorists characterise three sources of cognitive load during learning: intrinsic cognitive load, germane cognitive load and extraneous cognitive load.

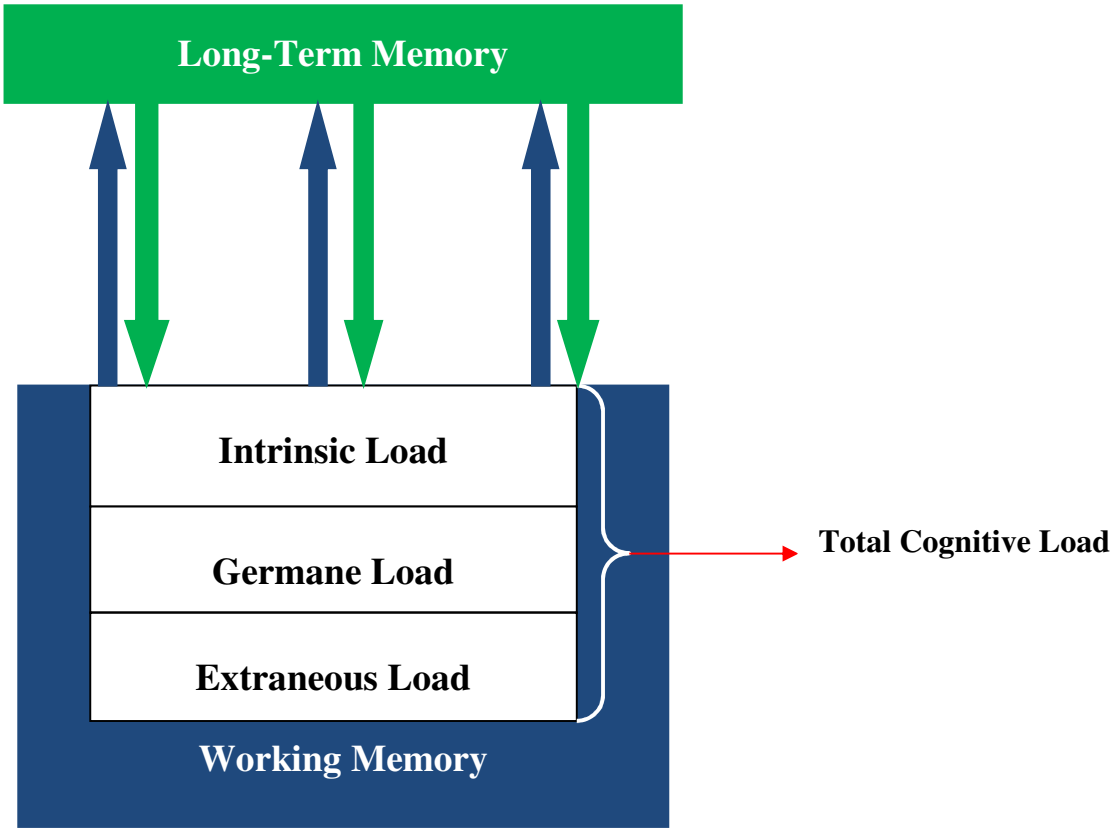


Figure 3.2 Cognitive Load Theory and visual representation of the assumptions underlying cognitive load theory (Paas, Tuovinen, et al., 2003; Sweller et al., 1998).

Intrinsic cognitive load

Intrinsic cognitive load is the result of the inherent difficulty of the content of the learning material or task. The magnitude of the intrinsic cognitive load experienced by a trainee is caused by the degree of association between crucial elements of information which need to be considered to understand new information (Paas, Renkl, et al., 2003).

The Element Interaction of the to-be learned Material

The crucial factor after giving trainees learning materials is the complexity of the information a trainee receives (Pollock, Chandler, & Sweller, 2002). Because training materials are made up of components or a number of "elements", and if a relationship between them exists, the elements may "interact", and it is this interaction that can lead to increased complexity of the materials (Sweller & Chandler, 1994). That is, related elements need to connect and interact with each other in order for learning to occur (Sweller, 1999). In this situation, elements "must be processed simultaneously in working memory because they are logically related" (Sweller et al., 2011, p.58). This phenomenon is known as *"element interactivity."*

Many tasks would involve the processing of many interacting elements. The higher the number of interacting information elements processed simultaneously, the higher intrinsic cognitive load imposed on working memory. Novel information with high element interactivity often makes understanding the new complex information extremely difficult. In Figure 3.3, in order for a nurse to learn to record patient data in the vital signs chart, one must be familiar with the quantity of information presented: the NIS module, the location of this module in the NIS menu and how to manipulate all the various elements in their working memory to successfully understand the information presented or to be recorded.

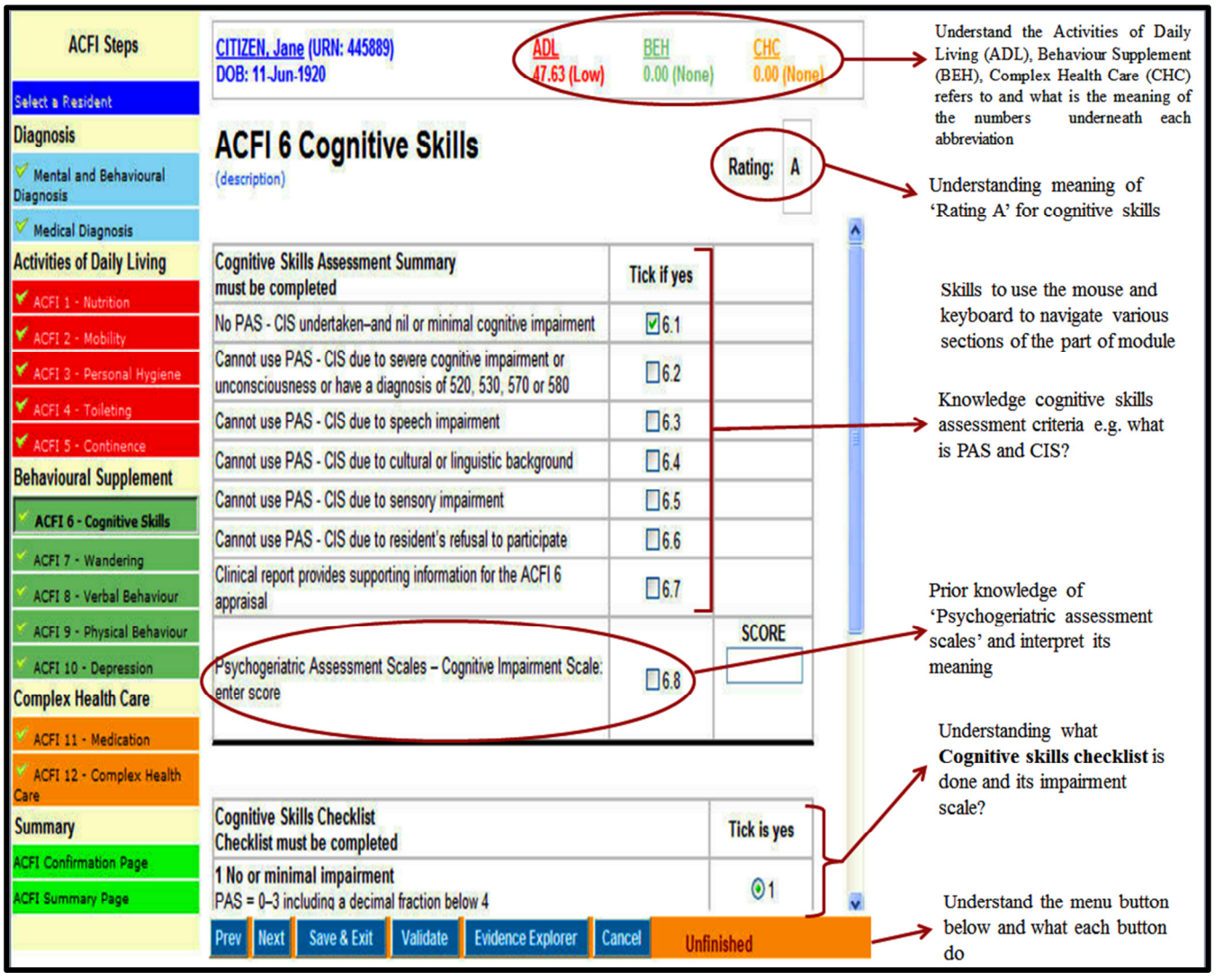


Figure 3.3 Numerous related elements that lead to a high level of interactivity.

Learning to perform a task in the NIS requires the interaction of multiple elements simultaneously, thus the intrinsic cognitive load is likely to be high. If the element

interactivity is high, there is less probability that such novel information will be easily understood. In fact, understanding, as asserted by Sweller (2004; 1994) and Pollock et al. (2002), is a function of processing all necessary elements simultaneously in working memory. In other words, highly interactive material cannot be understood unless the relations between them are learned simultaneously.

However, Sweller et al. (1998) argue that for effective learning, a number of connected elements must be considered concurrently rather than in isolation. Certain elements that can be learned in isolation can be chosen in order to reduce the load on the working memory. At the same time, simple instructional material and tasks that have few interacting elements are found not to impose an unnecessarily high cognitive load (Chandler & Sweller, 1996). For example learning to read a body thermometer scale is a low element interactivity task as such it is easier to process and understand. Reading the number scale of a thermometer is learnt serially rather than simultaneously. As a result, trainees can accommodate simple instructional material within working memory limits with less effect on the learning outcome even with ineffective instructional design (Sweller & Sweller, 2006).

However, higher intrinsic cognitive load does not only occur due to element interactivity. It also depends on the level of expertise of the trainee. Certain tasks or learning material can exert high element interactivity for some trainees, since they have not developed sophisticated schemas. In addition, as the expertise increases so does the development of more complex schemas. Thus, creation and modification of schemas is dependent on the expertise of the trainee and the extent of prior knowledge (Kalyuga, Ayres, Chandler, & Sweller, 2003).

Intrinsic cognitive load is assumed to be reduced when suitable schemas are already constructed and stored in long-term memory. Efficient use of schemas is critical for the trainee to reduce the load on working memory. For instance, novice NIS users are presumed to face high cognitive burden relative to more expert NIS users. The schema construction is more complex for novices, as they need to deal with more and more interacting elements. Trainees are likely to quickly overload their limited working memory.

Thus, according to cognitive load theory, intrinsic cognitive load is generated by the inherent element difficulty of the information to be learnt (i.e., the difficulty involved in learning the

functions of a new NIS) (Hasler, Kersten, & Sweller, 2007). Learning success is dependent on how new element interactivity affects existing prior knowledge (schemas) held in the long-term memory. By systematically minimising element interactivity, we may be able to temporarily minimise high intrinsic cognitive load by introducing elements in a staged format. Thus, novel information or problems need to be pitched at the appropriate level of difficulty so it can be easy to develop cognitive strategies necessary to facilitate schema construction without overburdening the working memory.

Germane (effective) cognitive load

Germane cognitive load "refers to the working memory resources that the trainee allocates to managing the intrinsic cognitive load associated with the information" (Sweller, 2010b, p. 126). It is the result of devoting working memory resources to skills acquisition and automation of schemas from active processing of novel information (Paas & van Merriënboer, 1994a; van Merriënboer & Sweller, 2005). This load assists in learning by creating logical mental representations of novel information in working memory and linking them with existing schemas (Kalyuga, 2007; van Merriënboer, Kester, & Paas, 2006).

The attention dedicated to the learning process subsequently increases germane cognitive load, and this is due to the increase in mental effort as cognitive resources are devoted to the task. In the recent conceptualization of cognitive load, germane is regarded as limited by intrinsic cognitive load (Sweller et al., 2011). Therefore, intrinsic cognitive load is the load needed to learn new materials, whilst germane cognitive load is the actual load devoted directly in understanding and learning novel information.

In designing the instructional strategies to increase germane cognitive load it is crucial to understand the level of the trainee's prior knowledge. Trainees use prior knowledge as building blocks to develop appropriate problem solving strategies and understanding of the procedures required to carry out NIS tasks appropriately. Also utilizing any techniques aimed at building trainees' prior knowledge (pre-training) before actual learning of the novel information has been shown to have a positive effect on intrinsic cognitive load and enhanced subsequent learning (see Clark & Mayer, 2011; Mayer, Mathias, & Wetzell, 2002).

Clearly, any cognitive activity contributes to improving a trainee's experience and knowledge of a particular NIS, thus leading to a greater understanding of that system's functions.

Germane cognitive load does not constitute an independent source of cognitive load but refers to the working memory resources available to handle element interactivity associated with intrinsic cognitive load (Sweller, 2010b). This load is directly related to the cognitive processing directed toward the construction of schemas.

Extraneous (ineffective) cognitive load

Any information related to instructional design factors, which is unrelated and unhelpful to the learning, is caused by factors extraneous or not internal to the learning tasks such as poor instructional design.

Specifically, high extraneous load can be a result of an instructional design approach which ignores the limitation of working memory (Sweller & Sweller, 2006) or it can be due to the presentation format of the learning materials making information elements difficult to integrate with each other or understandable. Extraneous cognitive load obstructs the construction and automation of schemas and interferes with learning; it is ineffective cognitive load (Paas, Renkl, et al., 2003).

Most instructional materials developed without considering the structure of human cognitive architecture produce ineffective cognitive load (Paas, Renkl, et al., 2003). For example, NIS training materials are often cluttered with text next to self-explanatory diagrams. Staff then experience extraneous load when they divide their attention between physically separated information sources. Hence, nursing staff are likely to exhaust much of their cognitive capacity in trying to digest these different information sources, leaving less capacity for actual learning.

In addition, extraneous cognitive load is trainee dependent. For example, novice trainees may need multiple examples or different information (i.e., a diagram and text description of the same problem) to aid their understanding and establish an appropriate approach to solving given problems. For experienced trainees multiple examples would be unnecessary to enable identification of the necessary cues given in one example. To the experienced trainees the extra information can lead to high extraneous cognitive load or confusion but this may not be so for novices.

In summary, intrinsic cognitive load is the inherent difficulty level of the to-be-learned information. Germane cognitive load and extraneous cognitive load both can be manipulated by the design of the learning material as they are associated with how information is presented and how we directly learn.

Total cognitive load

Cognitive load theory recognises three types of cognitive load that must be managed in any learning situation. Extraneous cognitive load is imposed by poor instructional design. Intrinsic cognitive load is caused by innate complexity of the learning material. Appropriate instructional designs must keep the total of the extraneous and intrinsic cognitive load below the total capacity working memory capacity for effective schema construction (i.e. learning) and comprehension of a given task (Sweller, 2010b). Working memory resources devotes to dealing with intrinsic cognitive load is referred to germane cognitive load.

The main concern of cognitive load theory is that the most important consideration when developing instructional materials should be the reduction of unnecessary extraneous cognitive load on working memory (Chandler & Sweller, 1996; Sweller, 1999). The freed working memory capacity allows the trainee to acquire more schemas and so create an efficient learning environment.

3.4.3 Approaches to measure cognitive load

Understanding how to measure the multidimensional construct of cognitive load is a fundamental challenge for cognitive load theorists. This is mainly because how to support claims that performing a particular task imposes specific cognitive load and to demonstrate that causal cognitive load construct is due to the interaction between the trainee's characteristics and the task at hand (Paas, Tuovinen, et al., 2003).

In human-computer interaction, measurement of cognitive load is important to understand a user's interaction and further aid in identifying tasks that induce high or low levels of cognitive load that negatively affect a user's performance. In any case, there must be an empirical way to measure cognitive load, which is an important factor that determines the success of an instructional design. In the Paas and Van Merriënboer (1994a) model (Figure 3.1), cognitive load can be determined by measuring mental load, mental effort, and the performance of a trainee.

Previous research on measuring cognitive load is not direct, but inferred from performance measures such as the trainee's task success, which may be recorded in terms of the number of errors, correct or incorrect responses, or task completion times. Sweller (1988) initially attempted to measure cognitive load in his study by recording where errors were made on a secondary task. Numerous other studies used secondary task performance as a cognitive load measure (see Brünken, Plass, & Leutner, 2003; Chandler & Sweller, 1996; Marcus, Cooper, & Sweller, 1996). One major criticism of secondary task use is that it may interfere with the primary task (Paas, Tuovinen, et al., 2003).

Many research studies have identified different ways to assess the users' cognitive load, with each using different individual techniques and features or measures. These approaches have been classified into two dimensions based on objectivity (subjective and objective), and causal relationship (direct or indirect) (Brünken et al., 2003).

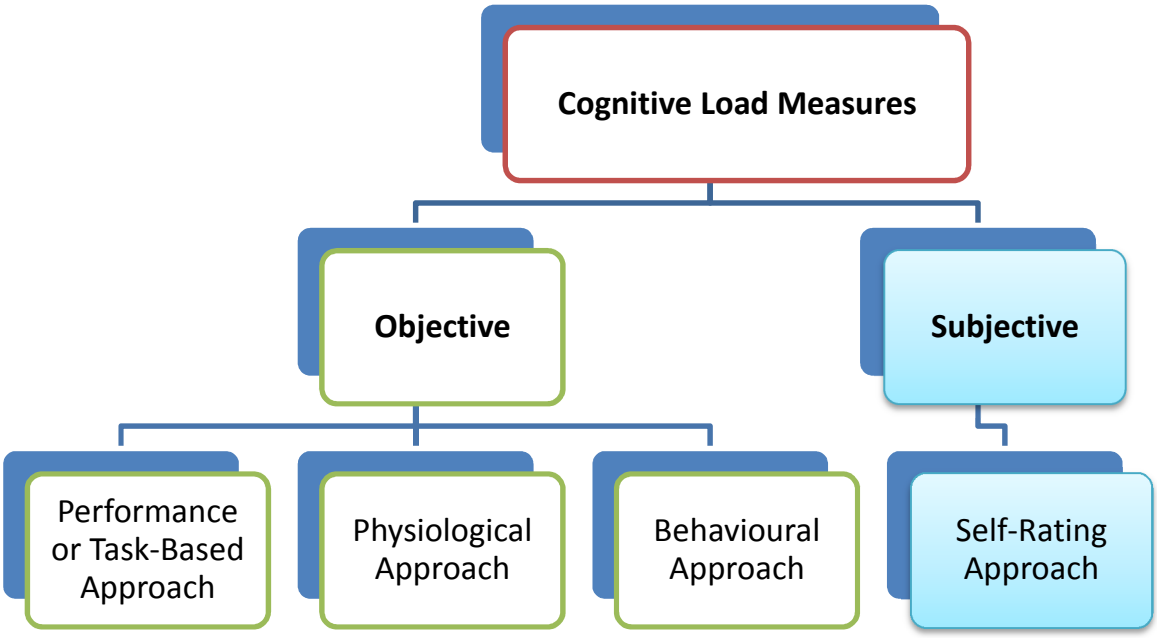


Figure 3.4 Cognitive load measurement approaches.

The subjective dimension describes whether the method uses subjective indicators for cognitive load. These are based on the assumption that people are able to reflect on their cognitive processes and report the amount of mental effort expended on a task (Paas & van Merriënboer, 1994a). The widely used approaches are the subjective self-reported rating scale of perceived mental effort developed by Paas (1992); a modified version of the NASA-Task Load Index (NASA-TLX) (Hart & Staveland, 1988) which has been used to measure different aspects of cognitive load; and the recent facet-specific measures suggested by DeLeeuw and Mayer (2008) which suggest that different load indicators tend to show different sensitivity to different types of load (Beckmann, 2010).

The first subjective cognitive load scale which was developed by Paas (1992) was based on Bratfisch, Borg and Dornic's (1972) rating scale for measuring perceived task difficulty. Pass demonstrated that participants are capable of rating their own levels of mental effort (Paas, Tuovinen, et al., 2003). In his rating scale, learners had to report their invested mental effort on a unidimensional nine-point symmetrical category scale, where 1 = "very, very low mental effort" and 9 = "very, very high mental effort". Follow-up studies by Paas and van Merriënboer (1994b) and Paas, Van Merriënboer, & Adam (1994) replicated the findings of Paas (1992) and found this subjective measure was valid, reliable and nonintrusive. Because

of this, Paas's (1992), nine-point unidimensional mental effort rating scale has been widely used for measuring cognitive load (for reviews: Paas, Tuovinen, et al., 2003; Van Gog & Paas, 2008).

Another type of indicator is related to objective observations in which participants cannot overtly manipulate cognitive load. These measures include observations of physiological changes, behavioural measures or performance measures (such as test scores, error rates, and completion times).

Empirical methods especially subjective rating scales, psycho-physiological, and task performance, have received a lot of attention (Paas, Tuovinen, et al., 2003) lately. Each method has a number of individual assessment techniques.

High cognitive load can evoke involuntary changes in human physiology. These changes are induced by cognitive functioning and are accompanied by varying levels of cognitive load (Brünken et al., 2003). Different techniques have been used to capture physiological variables. These are known as physiological measures and they include eye-movement behaviours (papillary dilation, and blink rate), heart activity (heart rate variability), and brain activity (task-evoked brain potentials) (see Antonenko, Paas, Grabner, & van Gog, 2010; Chen, Epps, Ruiz, & Chen, 2011; Kennedy & Scholey, 2000; Tungare & Pérez-Quiñones, 2009).

Physiological measurement is considered useful because it is continuous, data can be captured at a high rate and at smaller gradual increments, much more than could be achieved by self-reports where participants report an overall impression of the task. Most important, is the fact that this data collection measure does not require an explicit reaction from the participants as is apparent in self-report or performance measures. Psychological measures have been found to be intrusive and likely to disrupt the normal way participants interact with a task which is likely to minimise the chance of real-time assessment of the level of cognitive load experienced.

In the human-computer interaction community, behavioural measurement tests have been widely used to observe feature patterns of interactive behaviours. These measures include capturing mouse speed and pressure, mouse clicking, keyboard key-pressing, linguistic or

prosodic changes in speech and disfluency in speech as they are affected by fluctuations in cognitive load (see Ark, Dryer, & Lu, 1999; Marshall, Pleydell-Pearce, & Dickson, 2003; Oviatt, 2006; Ruiz, Taib, Shi, Choi, & Chen, 2007).

3.5 Cognitive load theory effects

Cognitive load theory research has developed numerous instructional techniques (effects) targeted at reducing extraneous cognitive load that could be used to improve the effectiveness and usability of NIS. For instance, in training nursing staff to learn to use a new NIS, a nurse must not only process the instructional material but also pay attention to the keyboard, mouse, and computer screen at the same time. Cognitive load theorists indicate that this poses two potential risks: split attention and redundancy. In addition, for new information to be acquired it must be carefully structured to ensure working memory is not overloaded. Worked examples, split-attention, and redundancy effects which are some of the techniques purposely structured to meet the above goal, are discussed in the next sections.

3.5.1 Split attention effect

Spilt-attention occurs when trainees are required to split their attention between, and mentally integrate, several sources of physically or temporally unrelated information, where each source of information is necessary for understanding the information (Ayres & Sweller, 2005; Chandler & Sweller, 1991, 1992). Trainees must then divide their attention and mentally integrate these multiple sources of information.

For example, most training programs present information in various forms: printed screen shots, animations and diagrams with text (Adaskin et al., 1994; Ashtari & Su, 2013). Figure 3.6 demonstrates a NIS training manual that does not present procedural information in an integrated format. The graphic image is presented at the top of the screen, and the instructional information is presented underneath it, as items e to h. If a trainee focuses his/her attention on the text data only, he or she will find it difficult to understand without linking it to the graphic image. Thus, in order to understand these multiple sources of information the trainee must hold the corresponding graphic image and text in working memory at the same time. Some nurse trainees may find this difficult and therefore be unable to build the connections among these sources and develop the necessary schema.

In addition, during the mental integration process, a portion of working memory is unnecessarily needed to integrate multiple sources, which is then not available for the learning process nor is it directly related to learning (Kalyuga, Chandler, & Sweller, 1999). These processes would increase extraneous cognitive load (Kalyuga et al., 1999), thereby causing unnecessary cognitive overload (Chandler & Sweller, 1991).

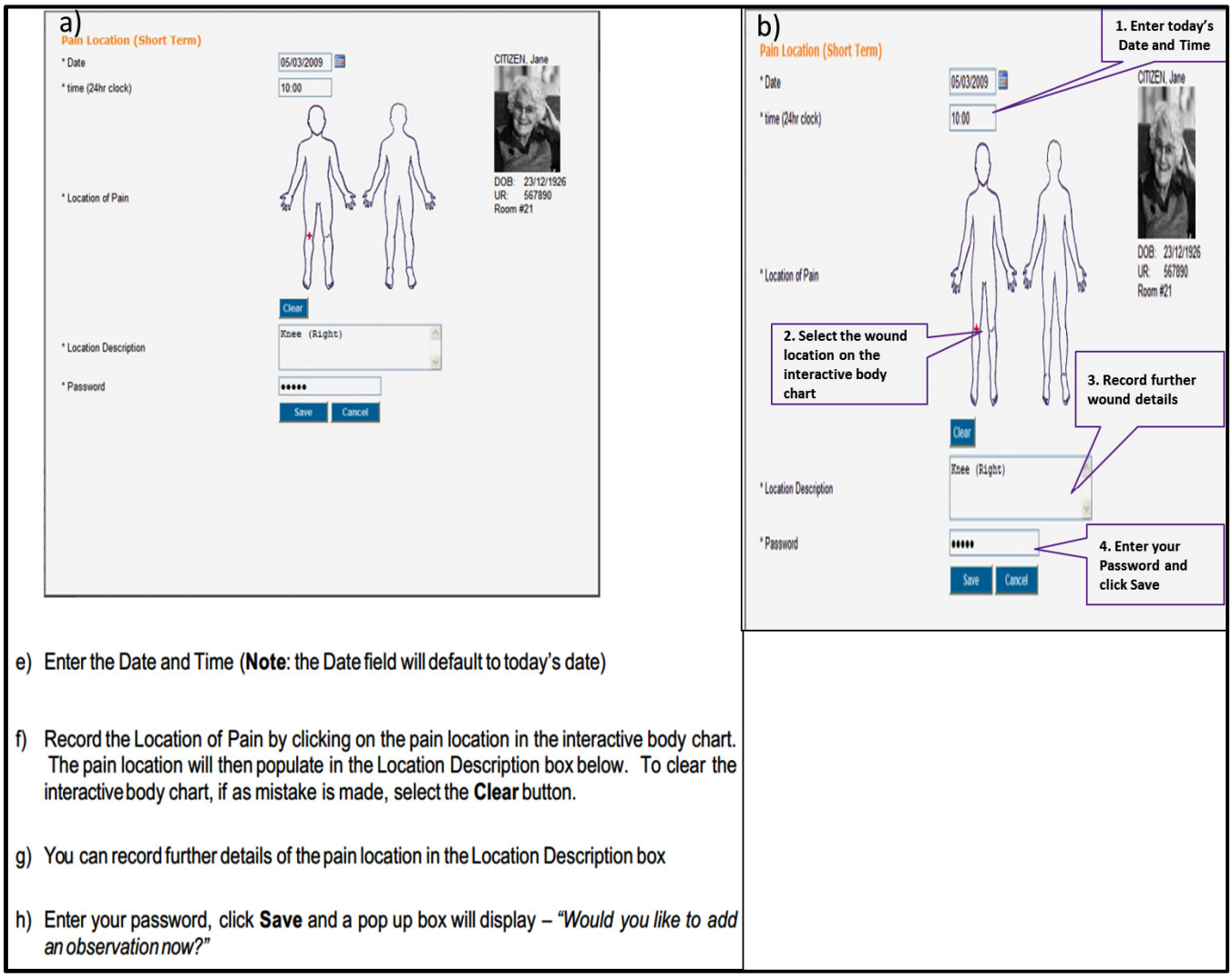


Figure 3.5 Training modules with text and picture a) conventional split-attention format and b) an integrated format.

Studies have explored various ways to minimise the split-attention effect by physically integrating split sources of information. Chandler and Sweller (1996) conducted a series of experiments in the 1990s to show the adverse effect of split-attention encountered by students when learning to use a new computer program. Students were divided into groups and each group presented with different instructional material using on-screen delivery or from a

manual. Some students were found to split their attention between the computer screen, the keyboard, and the manual. This study concludes that efficient learning occurred in the group, which utilised the manual only, while those with access to both manual and on-screen delivery experienced the split-attention effect. Similar research has demonstrated that information presented with diagrams and text restructured so that they are physically located together is easier to understand (Chandler & Sweller, 1996; Kalyuga et al., 1999; Mayer, Heiser, & Lonn, 2001) as demonstrated in Figure 3.6b.

An increase in extraneous cognitive load due to splitting attention leaves less working memory capacity available for the learning processes. Learning materials such as charts, documentation (text), computer program manuals, self-help programs, or diagrams can impose a varying degree of cognitive load. However, instructional formats with physically integrated related elements lessen working memory load in a way that avoids or at least minimises the split-attention effect. An instructional design that keeps extraneous cognitive load low would free up more working memory capacity for learning. Split-attention formats are particularly load bearing and a hindrance to learning.

3.5.2 Redundancy effect

The redundancy effect occurs when the same information is presented to a trainee in different forms, e.g., when identical spoken and written text are provided concurrently (Kalyuga et al., 1999). The study of Chandler and Sweller (1991) was one of the first to demonstrate this effect, using conventional learning materials (consisting of text and diagrams that were unintelligible without mental integration) vs. integrated materials. Their results indicated that the introduction of nonessential explanatory material could have adverse effects even when presented in an integrated format. The presentation of such information was not beneficial and decreased learning rates (Chandler & Sweller, 1991). For trainers and designers intending to present information in multiple sources, such as diagrams with text, these may not always offer an effective method as some information might be unnecessary or redundant.

Previous research has shown trainees learn better from multimedia lessons containing integrated graphics and narration (see Figure 3.6b) than from graphics, narration and redundant on-screen text (see Figure 3.6a) (Kalyuga et al., 1999). For example, in Figure 3.6b, the training module provides minimal text and ample diagrams, which reduces redundancy. It provides an example of an integrated instructional design where different

types of integrated information are in one screenshot of an NIS module. The amount and the content of the information in the integrated format is the same as that in Figure 3.6a, but because the information presented is in close proximity and clearly linked to the relevant features of the NIS module, this design avoids split-attention and minimises redundancy. The integrated format can be effective at reducing cognitive load when dealing with multiple sources of information that are unintelligible in isolation.

Results from these studies (see Chandler & Sweller, 1991; Kalyuga et al., 1999; Mayer, Bove, Bryman, Mars, & Tapangco, 1996; Pociask & Morrison, 2008) indicate that trainees who rely on a single reduced version of information performed better than those who integrated all the given information from multiple formats. In this situation the elimination, rather than integration of redundant information is useful to the learning process. The presentation of repeated information from multiple sources induces an increase in cognitive load, as the trainee unnecessarily attempts to process the same information "twice" (Chandler & Sweller, 1991). This forces the trainee to use valuable resources in an attempt to incorporate redundant information into essential information and consumes the trainees' limited cognitive resources. As a result, fewer resources are free for the essential learning processes: schema construction and schema automation.

3.5.3 Worked example effect vs. problem solving

The worked example effect is a technique used to reduce cognitive load through the demonstration of each step of a task or of solving a problem (Sweller, 1988). That is, learning from worked-out example is commonly characterised by the explicit demonstration of one or more domain principles (e.g., rule for data set or physical laws) after which trainees are provided with multiple examples rather than a single example showing the full sequence of steps leading to the solution of a problem or reaching a given goal (Reisslein, Atkinson, Seeling, & Reisslein, 2006; Renkl & Wittwer, 2010). Each example contains clear steps to the solution. The success of the methodology depends on the trainee's self-explanation and the effectiveness of the student's abilities to focus cognitive resources on problem solution and the solution steps of the task (Mayer et al., 1996; Renkl, 2002). The details provided in the instructional explanations also have an effect on the success of the worked-out examples.

In a problem solving approach such as means-ends analysis, the trainee must simultaneously consider the current problem state, the goal state, the differences between the current problem

and goal state, the relevant operators and their relations to the differences between the current state and goal state and then solve the problem (Kalyuga, Chandler, Tuovinen, & Sweller, 2001). The worked examples technique is purposefully designed to counteract the interference with learning caused by certain strategies of the problem solving approach. Unlike solving problems through the search process, in worked examples the attention of a trainee is directed to the problem and solutions steps.

Worked-out examples are the ultimate instantiation of the borrowing principle while problem solving is equally the ultimate instantiation of the randomness as a genesis principle (Sweller, 2006a). This genesis principle, when integrated into cognitive load theory, can be used to predict, that learning by novices using worked examples will be superior to learning via problem solving because of the reduction of random processes (Sweller, 2006b). Worked examples should not be used to entirely eliminate randomness, in order not to precipitate an over-dependence on worked examples. However, the use of worked examples leads to an increase in the probability of successful learning compared to learning solely through problem solving. Solving problems can take longer than studying examples but results in less time to solve the problem.

The worked examples approach has been criticised, especially by constructivists, with the suggestion that it is a form of knowledge transmission, lacking active learning and devoid of problem solving experience. According to cognitive load theory, problem solving is mental activity that is important for learning and this is a direct consequence of the activity to the human cognitive systems. To avoid passivity in learning, example-problem pairs, completion, and guidance fading can be employed.

Anyone who attempts to solve problems in the initial phase of use of NIS before becoming proficient is more likely to use general problem solving search strategies. They tend to focus their attention on specific features of the problem rather than on schema-relevant features. In addition, this new user rarely considers other possible solutions options. This approach can lead to an increased cognitive load.

The worked-out examples approach aims to counter the general search strategies and the evidence pointing to beneficial learning using this approach have been well documented (see Cooper & Sweller, 1987; Paas & van Gog, 2006; Renkl, Atkinson, & Große, 2004). These

studies established that learning from worked-out examples is more efficient, requires less time, and leads to better problem solving. Training individuals from worked-out examples is an important source of learning (Renkl, Atkinson, Maier, & Staley, 2002), and it is the learning mode preferred by novices (van Gog, Paas, & van Merriënboer, 2004).

Learning materials in which explicit explanations of concepts and procedures are provided is an effective method for productive problem solving because it allows the trainee firstly to acquire the necessary basic domain knowledge. Worked examples provide understanding of a skill domain in the beginning of cognitive skill acquisition. The presentation of a problem along with the provision of worked examples offers incentive for a trainee to actively learn from the worked examples. This is critical for trainees for whom the materials may not necessarily contribute to relevant schema construction (Sweller, 2006b). In addition, worked-out examples allow trainees to learn the consequences of particular problem solving approaches rather than only learning the conditions.

3.6 Application of cognitive load theory in training nursing staff use of NIS

The cognitive load theory offers a unique and plausible way to view training and how nursing staff interact with information systems. It is unique in that cognitive load theory postulates testable predictions distinguishable from other cognitive models.

Learning occurs when a schema is constructed, automated, and assimilated within the existing schemas. The existing schemas refer to prior knowledge that one holds in long-term memory. For novice NIS end users, activities such as navigating different menus, finding various forms and chart tools, typing in various input data types, importing and exporting different files. can be overwhelming. Further, a trainee would attempt to connect new concepts to previous held knowledge and experiences. To minimise misconceptions of the novel information and allow novices to acquire necessary domain knowledge, training has to be carried out in a systematic and efficient manner. This is not to say that a trainee needs always to be familiar with novel information before they can learn it but rather learning is demonstrated to be efficient when there is some prior knowledge linked with the new knowledge.

In addition, it has been suggested that a novice in a particular system needs to be provided with a pre-training session before approaching full learning procedures. Clarke and

colleagues (Clarke et al., 2005) found that a pre-training session provides trainees with prior knowledge before the actual learning. In effect, this strategy corroborates the argument for slowing constructing schemas to minimize intrinsic cognitive load. Furthermore, the degree of cognitive load (intrinsic) is dependent on the trainee's familiarity with the new system and domain specific knowledge (nursing knowledge) to be learned. Therefore, utilizing prior knowledge is crucial (Ayres, 2006a).

In general when introducing a specific NIS, many different types of interventions can be used. The most common is training and this intervention can vary from general instruction to intensive training sessions with different time lengths. Training has a direct effect on numerous factors that influence trainee use of NIS. These are perceived usefulness or relative advantages, ease of use, familiarity with system, attitudes, motivation to use the IT (resistance to change), self-efficacy (trainee's belief in one's competence to use the IT) and factors associated with peers (attitude of colleagues towards IT) (Gagnon et al., 2012). Nevertheless, training interventions during implementation have revealed mixed results. Amongst many reasons for these mixed results, one critical reason may be the misalignment of training to the human cognition system.

Research has demonstrated that certain instructional techniques are effective for novice trainees but can have negative effects on expert trainees. The effectiveness of a training method will be highly dependent on the expertise of the learner and their level of schema development.

3.7 Conclusion

In summary, this chapter provides an overview of the research on cognitive load theory and some of the cognitive load effects related to the current thesis. Since its inception, the theory has evolved and recently has included the biological evolution perspective to underpin its principles. The generated research has demonstrated the depth of its implication for instructional design and the importance of understanding the impact of human cognitive architecture on instructional design. Different ways are highlighted in the literature on how to minimize ineffective cognitive load to assist the learning process.

Therefore, this study draws upon the cognitive load theory to create a foundation for studying the effects of cognitive factors in nursing staff use of an NIS in an RACH and, specifically, to

answer Question 4 and related sub-questions. These cognitive factors can help to understand and explain why nursing staff may or may not use the system effectively or as productively as intended. Further, this study was conducted in a realistic user or natural setting where it captured data to reveal both the broad context and micro details of NIS use by nursing staff in their natural workplace setting. By focusing on a workplace setting, this study is one of few attempts to address the concern about the external validity of cognitive load theory results of studies mostly conducted in various educational institutions.

Further, this study seeks to investigate the application of subjective measures of cognitive load of respondents in a natural environment. Both self-reported and objective measures of cognitive load were used and compared in this investigation. The next chapter presents the methodological approach to addressing the research questions and gaps identified in Chapter 2.

Chapter 4 Research Methodology

4.1 Introduction

The adoption of NIS into Australian RACHs is a complex process. As outlined in Chapter 2, an analysis of the literature identified a number of factors on which further research could enable better understanding of strategies to improve the ability of nursing staff to use these systems productively. These factors are technology-related factors, organisational factors, and individual factors and these factors are defined in four research questions. It is anticipated that a comprehensive response to those questions will support RACHs in optimising implementation strategies and use of NIS to maximise its benefits.

The goal of this chapter is to explain the research design that was developed to address the four research questions. The research questions are divided into two parts (see Table 4.1 and Table 4.2). Research Questions 1-3 aim to identify the technology-related, organisational, and individual factors that influence the use of NIS using an in-depth interview approach. Research Question 4 aims to identify factors that influence the use of NIS and their effects on nursing staff's computer interaction efficiency and effectiveness, in order to assist the aged care industry to understand and find ways to promote productive use of NIS. Question 4 is answered through answering four further questions.

The procedures carried out in this chapter to select a suitable design for the research commence with the discussion of the study context and case study research design. The research design that draws on both qualitative and quantitative methods is reasoned to best address the four research questions. This is followed by a discussion of the methods used for data collection and the techniques by which data was analysed and then reported (see Section 4.4.1 and 4.4.2). Finally, the ethics application process is described.

4.2 Study context

The case study was conducted between 2011 and 2014 in two Australian RACHs. Residential aged care homes are primarily designed to provide accommodation, personal and nursing care to frail older people whose overall care support needs cannot be adequately met in the general community and who will stay here until the end of their life (Department of Health and Ageing, 2006). People living in RACHs are cared for by their medical practitioners and by the nursing staff in the facility.

4.2.1 Context

The main investigation was conducted at Warrigal Care Albion Park Rail and Warrigal Care Coniston. The Warrigal Care Coniston RACHs is a one-house facility comprised of 60 beds. The residential aged care home employs a total of 11 registered nurses, 2 enrolled nurses, and 34 personal care workers to provide care for residents. The facility has two nursing stations, both with NIS terminals. Other computer terminals are found in the kitchen and staff common room to provide access to the system. There are 10 computer terminals in total in this facility. Nursing information system training was conducted at the facility and off-site. This facility does not have NIS support staff.

The initial recruitment of participants was carried out at Albion Park Rail due to the potential access to a large number of nursing staff, particularly registered nurses. The RACH has six houses with approximately 183-beds. Each house has its own nursing stations with computer terminals to access the NIS.

Albion Park Rail, a 110-bed RACF has a total of 17 registered nurses, 6 endorsed enrolled nurses and 109 personal care workers, care service employees, or assistants in nursing to care for the residents. Registered nurses have completed a 3-year baccalaureate program (nursing degree) whereas enrolled nurses have undertaken an 18-months/2-years diploma in nursing. Personal care workers have either a certificate IV/III in aged care or proof of current studies toward enrolled nurse/registered nurse qualifications. Medical doctors are not directly employed by the facility but visit their nominated residents regularly or are called in emergencies.

Registered nurses are team leaders in a work shift, while enrolled nurses work under the direction and supervision registered nurses. Registered and enrolled nurses are responsible for medication documentation, preparing shift handover reports, developing and updating residents' care plans, and completing information on the Aged Care Funding Instrument (ACFI) tool. Personal care workers provide basic care to the residents such as showering, toileting etc. They work under the direction and supervision of a registered/enrolled nurse. Personal care workers are responsible for writing progress notes, and completing charts and forms for basic services provided in the NIS.

4.2.2 The NIS at both Warrigal Care RACHs

A commercial web-based (online) clinical and care management system was implemented in 2009. The system was widely used in all Australian states and territories. The system was used to capture information about residents' occupancy details, assessments, progress notes, incident and accident reports, care plans, funding of care, administrative, and 24-hour shift handover reports. Moreover it is designed to automatically integrate information entered on forms, charts and progress notes into nursing care plans, calculation of funding and management reports. It is compulsory for every staff member to use the system.

The entire nursing staff was trained on how to use and operate the system during its implementation. The initial training sessions were held 3 months before the introduction of the system. Each worker received a 30 min one-on-one training session. Subsequently, a train the trainer strategy was used. Staff members who showed better basic computer skills as indicated in the computer basic skills test were chosen as "**super-users"** to receive a one-week training provided by a trainer from the software vendor. These **"super-users"** would then train the rest of the health care workers on how to use the system especially newly employed healthcare workers or those who did not attend the training sessions. Currently the majority of healthcare workers rely on peers with greater experience to learn how to use the system or troubleshoot any problems encountered. All newly recruited workers usually undergo some form of ad-hoc, one-on-one training and are expected to learn on-the-job until they are fully confident in using the system. Ongoing training is provided on an individual needs basis or after identification of weakness in documentation records.

4.3 Research design

The design covers the identification of appropriate methods, the collection of research data, analysis of research data and reporting of this analysis. Data was collected via a single case study with interviews and observations of the participants, that is, selected nursing staff in an aged care setting.

4.3.1 Case study and its justification for this study

According to Benbasat, Goldstein, and Mead (1987, p.370), a case study is an examination of "a phenomenon in its natural setting, employing multiple methods of data collection to gather information from one or a few entities". Entities can be people (in this research it is nursing staff), groups, or organisations (two nursing homes were examined). Creswell (2014) further

added that the detailed, in-depth collection of information afforded by case study research is often rich in context and collected over time. The case study's usefulness stems from the expectation that it catches the complexity of a single case in order to understand its activity within its own important circumstances. For example, Yin (2009) argued that the case study approach is appropriate for contemporary events where the researcher has little control over the events being observed.

The work by Walsham (1993) highlighted an interpretive in-depth use of case study research. Yin (2009, p.18) contends that the case study research is "an empirical inquiry that investigates a contemporary phenomenon within its real-life context, especially when the boundaries between phenomenon and context are not clearly evident". In other words, the case study required boundaries to limit the scope of the inquiry in order to create a distinct identity in what the researcher was trying to find. Further, clear boundaries are required to assist the researcher to define what is included and excluded from the case (Denscombe, 1998).

In this study, the boundaries are the technology-related, organisational and individual factors, which hinder or facilitate nursing staff use of NIS, and the research restricts itself to RACHs in Australia. The examination of these phenomena over an extended period of time will provide useful insight into the use of NIS in this setting.

This study combined qualitative interviews and human-computer interaction observation in a single case study with selected nursing staff (see Section 4.4).

4.4 Research methods

The research methods are standardised sets of techniques for building scientific knowledge by allowing the researcher to answer research questions. The research questions and the methods used are presented in Table 4.1. In this study, there were two phases of the investigation to answer research questions. The following section describes first phase of the investigation.

Table 4.1 Thesis research questions – part 1.

Research Questions Part 1: From the first phase of the investigation	
	Method to address the question
Q1 What **technology-related factors** influence nursing staff use of NIS in RACHs?	Interview
Q2 What **organisational factors** influence nursing staff use of NIS in RACHs?	Interview
Q3 What **individual factors** influence nursing staff use of NIS in RACHs?	Interview

4.4.1 First phase of the investigation

The first phase of the investigation was directed at answering Research Questions 1-3 (see Table 4.1).

4.4.1.1 Data collection

Data collection was carried out using an interview at three separate data points: pre-implementation; six months post implementation; and two years post implementation. While the interview questions were pre-defined, flexible open-ended questions were used in order to explore the emerging issues in the implementation of the aged care NIS. The next section discusses and presents the justification for using interviews as a data collection instrument to capture these various issues.

Interview

Interviewing staff has the potential to provide comprehensive data from the study participants, because they are able to verbally articulate information in response to the questions asked by the researcher. This allows the respondent the opportunity to express what they deemed important freely during the interview (Bell, 2010). Hence, it can promote more in-depth understanding and clarification because the researcher can probe for more details and seek more reflective replies to explore issues as the interviewees raise them (Walter, 2013). This belief is supported by Yin's claim that interviews are important sources of case study information because such studies are about people and their activities and will provide important insight and identify other sources of evidence (Myers & Newman, 2007; Yin, 2009).

Justification for the interview as a data collection method

The main purpose of an interview as means of data collection, is to record and analyse what respondents feel, think, and believe (Patton, 2002). Hence, it provides fundamental insights into the various perspectives and contextual knowledge about factors that affect people's actions in aged care settings. The use of the NIS involves people. Often people are complex, and there is no single truth. Therefore, the advantage of the interview technique is that it enables direct and immediate interaction with the nursing staff (Allan & Skinner, 1991) who are the stakeholders of the system. This allows the researcher to examine them in their natural environment without manipulation and this gives the researcher a vital source of evidence (Yusof, Stergioulas, & Zugic, 2007). In addition, interviews are a widely preferred and effective method of obtaining primary data.

4.4.1.2 Participants and sampling

For this study, 30 nursing staff from Warrigal Care Albion Park Rail and Warrigal Care Coniston participated in the interviews. For a detailed description of the nursing homes' characteristics, refer to Section 4.2. The interviews were conducted at pre-implementation, six months post-implementation, and two years post-implementation of the NIS in RACHs. This interview study is part of a large project conducted between 2008 and 2011 evaluating the success of the aged care NIS.

The number of nursing staff that were finally interviewed was determined by the method of theoretical sampling as described in Corbin and Strauss (2008). Two theoretical criteria were used to choose the participants. Firstly, the end users were representative of all positions of nursing staff in order to fully capture and understand their perceptions. These include personal care workers, endorsed enrolled nurses, registered nurses, and managers. Nursing staff that were salaried at the same level as personal care workers were categorised under the personal care worker level. These included assistants in nursing, care service employees, and other employees who had double roles such as personal care workers and physiotherapist assistants. Secondly, participants had varying demographics that could shape their perspective or influence their experiences with the NIS. These included years of nursing experience, computer skills before using the NIS, and previous computer experience.

4.4.1.3 Data analysis

Content analysis

To identify factors that influence nursing staff use of NIS in RACHs, themes in the interview data were examined by means of content analysis. Content analysis is "a research technique for the objective, systematic and quantitative description of the manifest content of communication" (Berelson, 1952). Since its inception, a wide range of researchers in many areas and disciplines (Krippendorff, 2013; Weare & Lin, 2000) have used it with text data coded into explicit categories. Further, its use and definition has evolved and been expanded to also include qualitative interpretations of overt communication behaviour of selected communicators (Berelson, 1952; Graneheim & Lundman, 2004). Krippendorff (2013) further argues that content is a flexible research method for making replicable and valid inferences from text data to the context of their use. More recently, the potential of content analysis as a valuable and distinctive component of qualitative research for health researchers has been recognised, resulting in its increased application and popularity (Hsieh & Shannon, 2005; Nandy & Sarvela, 1997).

The goal of content analysis is "to provide knowledge and understanding of the phenomena under study" (Downe-Wamboldt, 1992, p.314). Hsieh and Shannon (2005, p.1279) indicated the use of a conventional content analysis approach is "appropriate when existing theory or research on a phenomenon is limited". This allows the researchers to immerse themselves in the data to gain insights directly from the text data without preconceived theoretical perspective or categories imposed (Elo & Kyngäs, 2008; Hsieh & Shannon, 2005). Research using qualitative content analysis techniques seeks to identify characteristics of the discussion or communication with attention to the content or contextual meaning of the text (McTavish & Pirro, 1990; Moretti et al., 2011). Text information might be verbal, print or in electronic form and may have been obtained from narrative responses, open-ended survey questions, interviews, focus groups, observations, or print media such as newspaper articles, books, or manuals (Kondracki, Wellman, & Amundson, 2002; Walter, 2013). The technique's analysis goes beyond merely counting words to substantiating and establishing the presence of concepts, themes, phrases, or sentences in order to classify text data into an efficient number of categories with similar meaning (Weber, 1990). These categories represent inferred meaning or explicit communication.

Qualitative content analysis was chosen for this study based on the research aims, questions, and nature – to gain an in-depth understanding of technology-related, organisational, and individual factors that influence nursing staff use of NIS in Australian RACHs.

The conventional qualitative content analysis method was adopted for this study because it allows for the subjective interpretation of the content of text data through the systematic classification process of coding and identifying themes or patterns from interviews. The data analysed was collected through interviews, open-ended questions and it contained probes that were open-ended or specific to the participants' comments rather than to a pre-existing theory, for example, "That is very interesting, can you tell me more about that?"

Microsoft Excel IS used to conduct content analysis

There are two widely utilised ways, which IS qualitative researchers can select to analyse and process the qualitative data: use computer-assisted qualitative analyses software (CAQDAS) or manually categorise information themes (Shin, Kim, & Chung, 2009). Computer-assisted qualitative analysis software, such as Atlas.ti, NVivo and Nud.ist (MacMillan & Koenig, 2004) are commonly used to handle large and diverse data sources. Alternatively, a number of researchers adopt manual analysis which may utilise a computer but not CAQDAS (Webb, 1999). Manual analysis includes copy/cut and paste as well as colour-coding the text to categorise data (Webb, 1999). The limited quantity of data that needed to be analysed did not justify the cost of CAQDAS so manual analysis was therefore used.

Content analysis allowed the researcher to abstract significant categories from the interview data aligning with the main themes identified in the literature: technological-related, organisational, and individual factors. The detailed steps undertaken to achieve this are described below.

Content analysis steps

Although there is no single method for the content analysis of interview data, Downe-Wamboldt, (1992, p.315) suggests the following general steps:

1. Selecting the unit of analysis
2. Creating and defining the categories
3. Pretesting the category definitions and rules
4. Assessing reliability and validity
5. Revising the coding rules if necessary
6. Pretesting the revised category scheme

7. Coding all the data
8. Reassessing reliability and validity

The following sections discuss the detailed procedures for content analysis. First is a description of what guided the selection and identification of the unit of analysis, followed by a discussion of the tool used to analyse and process the data, a description of how reliability was ensured, and finally a statement of the coding process for the identification of the various factors from the interview data.

1. Unit of analysis

The selection of unit of analysis was guided by the questions to be answered. The research questions (not the interview questions) about nursing staff perceptions about what factors influence the use of NIS were:

- What technology-related factors influence nursing staff use of NIS in RACHs?
- What organisational factors influence nursing staff use of NIS in RACHs?
- What individual factors influence nursing staff use of NIS in RACHs?

The above questions assisted the researcher to identify the appropriate information from the individual interview data as the unit of analysis. Hence, the phrases or sentences, and themes from the interviews describing each group of factors (i.e., technology-related, organisational, and individual factors) were grouped separately.

2. Creating and defining the categories

The nursing staff comments were copied from a Word document and pasted into a Microsoft Excel workbook. Various functions of Excel such as highlighting, data sorting, filtering, cell counting and PivotChart were used for data analysis. Each theme was inserted in a specific column (see Table 4.2). In other words, one comment or quotation with a single concept was recorded in its own cell. In some cases, long sentences, which described multiple factors or concepts, were subdivided in such a way that a relevant section was recorded in one cell and the irrelevant part was replaced with ellipses "…". On the other hand, if the sentence lost clarity due to the ellipses, it was decided to record the long sentence into multiple cells and to colour code the information that represented the concepts.

A number of categories of factors that influence nursing staff use of the NIS were selected based on previous studies (see Section 2.6). Under the technology-related factors ease of use, usefulness of the NIS, design and technical constraints were selected. The categories of organisational factors were training, work-related time constraints and staffing levels, availability and access to computers, and peer and IT support. Individual factors were demographic characteristics, computer experience, and attitudes towards the NIS. These sub-categories of each factor were developed based on the researcher's understanding of the transcripts and emerging themes from the interview data.

Defining categories

The common list of factors influencing the adoption of NIS by healthcare professionals that emerged from the literature (see Gagnon et al., 2012) includes the following:

- **Technology-related factors:** design and technical constraints, perceived usefulness, ease of use/complexity, compatibility, triability, observability, system reliability, legal issues, costs issues, and interoperability;
- **Organisational factors:** work structure, time constraints and workload, work flexibility, skills and staff, resource availability, training/lack of or inadequate training, presence and use of champions, management, participation of end users in the design or implementation or lack of participation, communication, readiness, organisational culture aspects;
- **Individual factors:** knowledge (awareness of the existence and or objectives of NIS, and familiarity with NIS), attitude, and socio-demographic characteristics (age, gender, experience, other);

In this study, a number of factors did not find supporting evidence in the transcripts such as work flexibility, participation of end users in the design, organisational culture, observability and triability. Other factors were not applicable in the study setting or nursing staff did not face them such as legal issues, cost issues of the system and interoperability as there was no legacy system. Staff also did not participate in the design or implementation strategy.

Therefore those retained and supported by the transcripts are the following:

- **Technology-related factors** are design and technical constraints, perceived usefulness, ease of use;

- **Organisational factors** include work-related time constraints, staff levels, availability and access to computers, training/lack of or inadequate training, peer and IT support;
- **Individual factors** were knowledge (awareness of the existence and or objectives of the NIS, and familiarity with the NIS), attitude, and socio-demographic characteristics (computer experience and skills, nursing experience and job level).

3. Pretesting the category definitions

A pre-testing process (Downe-Wamboldt 1992) of coding the transcripts was conducted and further refined based on the feedback of two other researchers (Ping Yu and William Tibben) (see Appendix H). The content analysis was refined a number of times to fully code the technology-related, organisational and individual factors. All these factors and their sub-categories were recorded in an Excel spreadsheet. The spreadsheet had the same format to retain consistency throughout the analysis process.

4. Assessing reliability and revising the coding rules

To increase inter-coder reliability (Walter, 2013), the tentative coding and sub-categories of factors were discussed among three individual researchers (Ping Yu, William Tibben and the researcher) (see Appendix I) and revised based on the consensus. Further, comparison, aggregation, and classification generated further expansion of the sub-categories from a description of each factor.

Finally, the process of content analysis constant comparison, aggregation, and classification was iterated for four months to finalise the category system for the various factors and the themes about each factor.

5. *Pretesting the revised categories*

Sometimes interviewees may describe what they perceive as factors in different ways. A technique to handle this is condensation, which refers to the shortening of description while still retaining the core concept (Graneheim & Lundman, 2004). Therefore, this study generated and identified tentative codes for each factor. Thereafter, a constant comparison (Glaser, 1967) and aggregation process (Graneheim & Lundman, 2004) led to the abstraction and refinement of the coding which depicts the various factors. To further ensure consistency the following rules were observed in the coding process (Walter, 2013):

- Explain the meaning of the first-level codes;

- Examine into which categories or higher level codes the first-level codes should be grouped;
- Identify those cases where the quotations could be translated from an implicit meaning to an explicit concept.

6. Coding all the data

Table 4.2 demonstrates a sample of four entries in the spreadsheet. The information shown in the table indicates the file name of the transcript, the date of the interview, the facility the interviewee worked for, the NIS used, the interviewee's position, a direct quotation of what the interviewee stated about a specific factor and the sub-category of the said factor. At the end of the analysis, a PivotChart was generated automatically based on the data recorded in the spreadsheet indicating the number of participants and times that each category and sub-category was referenced. Similar files were constructed for other factors.

7. Reassessing reliability and validity

Building on the refined category system, coding was carried out for all the transcripts. The technology-related, organisational, and individual factors that influence the nursing staff use of NIS in RACHs were analysed and reviewed within the context of the entire data set for each participant. The goal was to detail the factors using both latent and manifest content analysis to describe the meaning and number of references to a specific factor in order to provide insightful and meaningful results (Downe-Wamboldt, 1992). The reassessment was discussed among the three researchers and revised based on the consensus.

Table 4.2 An excerpt of content analysis of the transcripts

Organisational factor: Training										
						Sub-categories of training [details describing issues about training]				
Entry	**File Name**	**Collect time**	**Facility**	**IS**	**Position Category**	**How was training timetabled**	**Training strategy**	**Did the training meet your needs**	**The length of time it would take to be comfortable using the NIS**	**Is there any way training could be improved**
6months	PCW_01	10/2009	Albion Park	NIS	PCW	Probably half a dozen different days where they train people that they got to train us…They would have specific days half an hour allotments for us staff so that is how we would learn. I have never done care plans on the computer so I have a meeting with [trainer A] tomorrow for two hours and he is going to show me how to do that	I was trained by one of the train-the-trainer	No	Well we had like probably 6 different days	
6months	PCW_02	10/2009	Albion Park	NIS	PCW	Now I only really had one go at training [train-the-trainer] and people still use my support. Almost each day [I train other people]	I attended train-the-trainer			
6months	PCW_03	10/2009	Albion Park	NIS	PCW	We have little groups of, so there was plenty of time to learn.…were all trained in small group training	Was the trainer from train-the-trainer	I am happy with what I have learned so far…	Now that it is going faster, I think in a couple of months that will be fully used to it	
6months	RSM_01	10/2009	Albion Park	NIS	Manager	We did have documentation training for staff and we did case studies but it does not sink in. So I started to do it	was trained by train-the-trainer	Yes it met my needs	Probably another four months I reckon [already took me four	I do not think so. We could have more sessions if

						by picking another person go through their progress notes and if there are any issues we bring it up on a one-to-one basis and give them examples			month to where I am now]	we wanted to.

6 months = six months post-implementation, PCW = personal care worker

4.4.2 Second phase of the investigation

In order to answer Question 4 and its sub-questions (see Table 4.3 below) the second phase of the investigation was conducted. In particular, individual factors, such as cognitive factors, which consist of computer competence, cognitive load, and expertise, and causative effects were verified through hypothesis testing. Hence, to test these hypotheses on cognitive load and expertise the human-computer interaction observation study was necessary.

The two phases of the investigation, in Section 4.4.1 and in Section 4.4.2 were carried out sequential to one another in an attempt to elaborate further on the cognitive factors findings from the qualitative first phase of the investigation.

Table 4.3 Thesis research questions – part 2.

Research Questions Part 2: From the second phase of the investigation	
	Method(s)
Q4.1 Are there differences in cognitive load between lower expertise and higher expertise nursing staff? ▪ Hypothesis 1: Experienced users will experience lower cognitive load (i.e. invest less effort) than inexperienced users as they are more efficient when interacting with the computer system.	Cognitive load self-report rating scale Video-based observation
Q4.2 Are there differences in task completion efficiency between lower expertise and higher expertise nursing staff? ▪ Hypothesis 2: Experienced users will demonstrate more relevant keystrokes or presses (mouse clicks) and engage more frequently in activities that are efficient to complete a given task than inexperienced users.	Questionnaire survey, Video-based observation
Q4.3 Are there differences in task performance in completing simple and complex tasks between lower and high expertise nursing staff? ▪ Hypothesis 3: Experienced users will achieve higher performance than inexperienced users on both simple and complex tasks when performing these tasks on the computer system. This	Questionnaire survey, Video-based observation

difference will be more pronounced for complex tasks than for simple tasks.	
Q4.4 What is the relationship between cognitive load, as measured by subjective task ratings (e.g., self-reported cognitive load measures), and one identified by human-computer interaction study (e.g., errors made, number of mouse clicks and keystrokes, and sub-tasks completely solved)? Based on this question, the research propose to test the following hypothesis: ▪ Hypothesis 4: Self-reported cognitive load rating scores will be positively correlated to the number of errors made during task performance. ▪ Hypothesis 5: Self-reported cognitive load rating scores will be positively correlated to the number of mouse clicks made during task performance. ▪ Hypothesis 6: Self-reported cognitive load rating scores will be negatively correlated to the number of keystrokes made during task performance. ▪ Hypothesis 7: Self-reported cognitive load rating scores will be negatively correlated to the number of sub-tasks completely solved.	Cognitive load self-report rating scale Video-based observation

This section, therefore, provides a description of the experiment design, data collection design, justification of data collection instruments, a discussion of the participants and sampling strategies used and data analysis approaches adopted.

4.4.2.1 Experiment and data collection design

Daily nursing tasks were used for the computer interaction observation study and were manipulated in terms of task complexity, (simple task, and complex task) and expertise (nursing staff were divided into experienced and inexperienced groups).

Task complexity refers to task characteristics that affect information-processing demands of the individual, which is often caused by the presence of multiple potential paths to the solution, multiple desired end-states, conflicting interdependence among paths to multiple outcomes, and uncertainty as to a meaningful solution (Campbell, 1988; Wood, 1986).

The level of end user expertise was determined based on the three dimensions related to the level of a user's experience, according to Nielsen (1993): the user's knowledge about the domain; the user's experience with computers in general; and the user's experience with the specific computer system being evaluated (see Section 4.4.2.3 Survey instruments for further details on how it was measured).

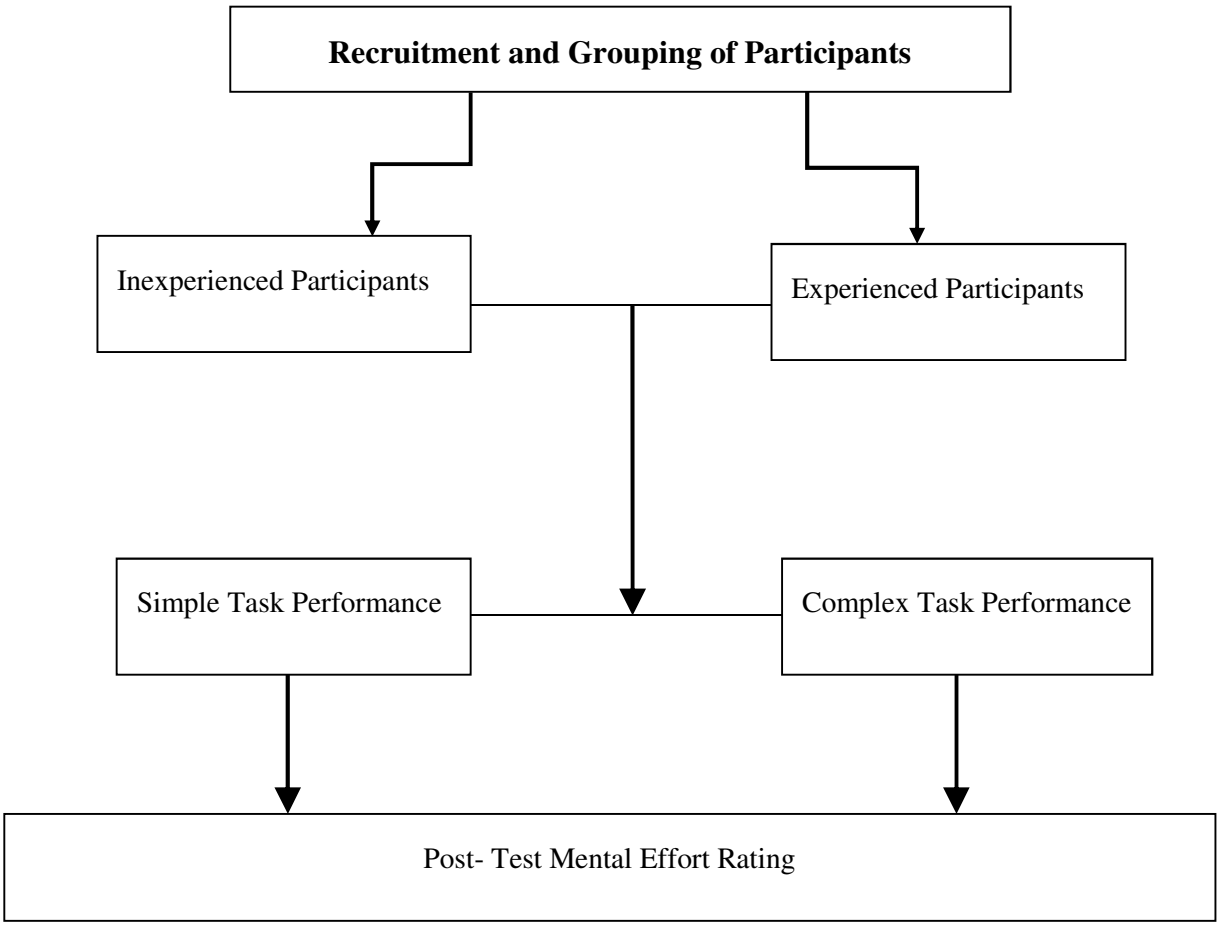
To determine the effects of the two conditions, task complexity and expertise, an experimental within-subject design was implemented with nursing staff performing all tasks (see Figure 4.1 below). One of the advantages of such a within-subject design is that each nursing staff member is effectively their own control, receiving both simple and complex tasks. The human-computer study was conducted five years post-implementation and all participants had received training offered by the organisation.

In this study, the simple task consisted of smaller numbers of sub-tasks than the complex task, and there was only one way to perform the task, that is, with the information provided all staff members were expected to successfully carry out the task. On the other hand, complex tasks had more sub-tasks, the sub-tasks had significant variations, no cues were specified and there was a lack of input-to-output relations (Wood, 1986). It was expected that nursing staff would rely heavily on their domain expertise to perform better.

The observation study was designed to reveal what, when and how nursing staff performed given tasks or reacted to encountered problems or challenges when using the NIS. The study was able to investigate mental effort invested by the experienced or inexperienced staff members in performing a given task. The varying task complexity offers insight into task efficiency, task effectiveness, challenges, and the needs of end users for optimal use of NIS.

Figure 4.1 illustrates the design of the data collection plan for the second phase of the investigation, which followed the detailed description of the data-gathering processes.

Figure 4.1 Design of data collection plan



4.4.2.2 Data collection instruments

Questionnaire survey

According to Polit and Hungler (2004), a questionnaire is a tool to gather self-reported information from respondents regarding their perceptions about attitudes, knowledge, belief and feelings. There are a number of advantages of using a questionnaire as a tool for gathering data. Some of the key ones are: firstly, the standardised format makes it easier to deliver; secondly, it is a much quicker and more efficient mode for data-gathering; and thirdly, it allows the researcher to reach a larger sample size in short period of time (Allan & Skinner, 1991). For further discussion on tool development, see Section 4.4.2.3, sub-heading "Survey instruments."

Justification for the questionnaire survey as a data collection method

In the second phase of the investigation of this study, a questionnaire survey was used to gather demographic information, nursing staff's perception on general computer experience, the NIS used by the RACHs and nursing knowledge. These perceptions would later help categorise the users in to either the experienced or inexperienced group.

Video-based observation

Video-based observation is a useful tool that has become commonplace for studying how people interact with technology in a healthcare setting (Borycki, Kushniruk, Kuwata, & Kannry, 2011; Britto et al., 2009; Kushniruk & Patel, 1995; Qui & Yu, 2007). The method commonly offers audio, video and screen recorded data that facilitates the micro-analysis of behaviours and interaction patterns to help gain insight and develop in-depth descriptions of behaviour (Paterson, Bottorff, & Hewat, 2008). Instead of directly "shadowing" people in their naturalistic environment, a researcher sets up video cameras to capture data on how participants use computers. It provides a complete, continuous and real time record of the behaviour from both the system and end user (Prasse, 1990), creating a permanent record for later analysis instead of relying on real-time note taking or self-reported perceptions.

Justification for video-based observation as a data collection method

The most important advantage in using video-based observation in the field is that it unobtrusively, collects rich, empirical data on individual NIS-user interactions in their natural work environments. Further, screen recording, which was utilised in the second phase of the investigation of this study, provides digital video that adds to the value of video-based data collection, with the ability to annotate clips, find them easily, select, or create clips to use, and edit the video. Screen recording also captures a much more detailed record of the user's interactions than a diary or journal study (e.g., Czerwinski, Horvitz, & Wilhite, 2004) and with less user effort.

4.4.2.3 Participants and sampling

All of the participants who took part are nursing staff at the two RACHs. The participants included registered nurses, endorsed enrolled nurses, and care service employees who had been using the NIS after they had been trained before first use.

Sampling strategy and size

The study was designed to assess cognitive load (mental effort) and its effects on computer users' performance between two groups: experienced and inexperienced. It was necessary to have participants who were representative of the targeted population than a simple random sample. A stratified sampling strategy was used. Stratified sampling is a technique where a random sample is taken in which the researcher at first identifies some significant characterisations known (exactly or approximately), divides the sample by the characterisations and then uses random selection to select cases for each group (Neuman, 2006). The stratifying factor in this study was NIS expertise. Nursing staff in the two RACHs were grouped into two expertise groups. One group specifically included participants with low expertise and the other with high expertise based on their proportionality to the total population. The procedure in obtaining the required participants was facilitated by the residential service manager (RSM) who provided the list of staff members categorised according to their level of expertise. The residential service manager list was informed by the individual's history of nursing information system interactions and work experience. Thereafter the researcher triangulated the list from RSM with the list of pre-test screening questionnaire survey results to produce stronger evidence to group each worker to a specific stratum. After drawing each stratum the researcher would draw a random sample from each subgroup.

Survey instruments

There are two self-administered questionnaire survey instruments used in the study. The first instrument, a modified Staggers nursing computer experience questionnaire (SNCEQ), as developed by Staggers (1994) was used as pre-test screening questionnaire for each stratum. The SNCEQ (Appendix A) is a self-report that was primarily created focusing on the computer competence of healthcare professionals. The questionnaire is widely used in healthcare literature (Balen & Jewesson, 2004; Cho, Park, Chung, & Lee, 2003; Liu, Pothiban, Lu, & Khamphonsiri, 2000). The instrument has been assessed for content validity and has content validity indexes for items ranging from 0.83 to 1.00 (Hobbs, 2002; Koivunen et al., 2009; Staggers & Kobus, 2000). The instrument consists of six scales describing computer experience: past or present use, knowledge of general computer applications, specific RACHs NIS past or present use, and knowledge, and the user's knowledge about the domain (nursing/healthcare setting). In this study the modified survey consisted of 13 five-point Likert-type items (0 = none; 4= extensive). The rating described the participant's

experience with computers in general (such as word processing, windows, email, and social media) whether minimal or extensive and then their experience with the specific system was also evaluated (such as progress notes, observations and charting tools, care plans, handover tool, and ACFI management tool) as to whether they were novice or expert. Moreover, the rating described the participant's knowledge about the domain and it included items on basic demographic information. After modification the face validity of the modified questionnaire was verified by the two residential service managers, two registered nurses, and three enrolled nurses at the facility.

Another survey used in the study is a self-report rating, which requires a participant to reflect and introspect on their perception of cognitive load. Although the subjectivity of a self-report has been criticised due to its degree of individual variability (participants may exaggerate or under-report the load), it has been found that subjects are consistently and accurately able to determine on a nine-point scale the level of load induced by a particular task when tested several times (Gopher & Braune, 1984; Paas, 1992; Paas et al., 1994). Most important, participants must be able to do an objective introspective analysis of their experienced load and rate it accurately across tasks.

Self-report measures are usually administered after task performance. These measures are relatively easy, straightforward, and cost-effective but require deliberate participation from the subject. Uni-dimensional scales of self-report are advantageous for giving a simple, global reading of cognitive loads (see Appendix B). Their distinct straightforward structure is easier for participants to complete. In this study, nursing staff were required to report on the mental effort they expended when interacting with the NIS. Thus, cognitive load self-rating was used in this study.

Survey and observation study procedure

In collaboration with the RSM at each facility, the pre-test questionnaire was used to understand the level of expertise and was distributed to eligible staff members. Eligible nursing staff members refers to anyone working at the facility either as part-time, full-time, or full-time casual. An introductory letter (information sheet) about the purpose of the study and assurance of confidentiality accompanied the questionnaire. Only after a consent form was signed and returned, was further follow up with the staff member conducted. The nursing staff either were instructed to complete the survey and return to the clerk offices or put it in a

drop-box in the common room/kitchen marked “iCare Questionnaire”. Each survey was provided with an empty envelope in which participants were to seal and return the survey in order to ensure confidentiality of the information provided. The clerk securely stored the survey before its collection by the researcher. The box in the kitchen was securely locked and sealed.

In the studies, participants conducted two concurrent tasks in each human-computer interaction observation study session. Each participant was randomly assigned to perform a task. There were 12 inexperienced and 12 experienced participants. The cognitive load self-report rating measure was given and instruction was provided to the participants to self-report their mental effort immediately after completing each task (there were two tasks performed by each participant) for each experiment.

Participants and data collection

The criterion for taking part in the test session was first that they were selected participants from the stratified sample. Within each subgroup random sampling was used to choose a participant. The selected participant was asked to provide a date and time when they could perform the test session. All participants (from both sub-groups) had participated in traditional instructor-led NIS training during initial training or if they joined the organisation after its implementation they would have been trained within two or three days of working in the RACH.

The video-based recordings were held over a four-month period at two Warrigal Care RACHs. Each recording took about 45-60 minutes in a training room at an RACH. In each recording, the participant completed one simple and one complex task. Immediately after completion of the task the participants were given a cognitive load self-report measure to record how much mental effort they believed they invested (Brünken et al., 2003). The test sessions were captured using the computer-based video software called Morae® produced by TechSmith. The information captured included film of the participants and recording of their voice and computer screen.

The next section describes the study environment and the data collection process.

4.4.2.4 Data analysis

Questionnaire data analysis

The pre-test-screening survey responses were first coded and entered into MS Excel 2007. The score for each dimension item was calculated using Excel by adding the scores measuring past or present use of general computer application by nursing staff and each person's knowledge level of each general computer application, then dividing the sum by the number of measurement items (i.e., divided by five for overall general computer applications). This was also performed for the NIS, which had similar response questions as general computers (see Appendix A).

The nursing staff self-report responses to cognitive load survey (see Appendix B) were first entered into MS Excel 2007. Data were then exported to Statistical Package for Social Sciences (IBM SPSS Statistics) version 19. Descriptive statistics and parametric statistical methods (Shapiro-Wilk test, two-way ANOVA (general linear model) and Spearman Rank Order correlation test were used for data analysis. The hypothesis tested was that "inexperienced users will experience a higher mental load (effort) than more advanced users due to engaging inefficient activities when interacting with a computer system". Statistical significance was assumed when a p value was less than 0.05. For the expertise vs. cognitive estimated marginal means, 95% confidence interval was assumed.

Video-based observation data analysis

Performance measures such as task completion times, number of keystrokes and mouse clicks, number of tasks completely solved, completion rates and error numbers were recorded on MS Excel 2007 for each participant. These measures were obtained manually and where possible extracted from the recording software. Excel data were exported to IBM SPSS, version 19. The same statistical tests as those on cognitive load measures were performed.

4.5 Ethical considerations

The University of Wollongong Human Research Ethics Committee approved the study (ethics number HE08/263). The purpose of this process is to ensure that the interview participants' rights are protected and has a number of measures that are designed to avoid possible harm to respondents. The research process follows the approved research protocol. For example, to maintain the confidentiality and anonymity of the research participants in the study, names of the participants were replaced by codes known only by the investigator (a

number and three letters were assigned to each participant). All data collected was stored in locked files and only accessed by the principal investigator (MG) during the study period. At the end of the study, the principal supervisor (PY) securely stored the data on their password-protected computer and disposed of it safely according to university policy.

All the participants received a letter that described the study objectives, procedures and the steps taken to maintain anonymity of the subjects. Each participant was asked to sign a letter of consent before participating in the study. Participants were notified in both letters (consent and information sheet) that they were free to withdraw from the study at any time. In the event the participant withdrew, all the data collected from such an individual were destroyed. Feedback to the participants was communicated in the study results in a brief thank you letter sent to all. RACHs were given feedback regarding training needs, problems, and suggestions for further development of training procedures. Copies of consent, information sheet and ethics approval can be found in Appendix C - E.

4.6 Summary

This chapter provided a detailed description of the issues that were instrumental in guiding the data collection, the analysis of data and the reporting of this analysis. In doing so, the thesis does acknowledge that the methods used exist within broader scientific contexts. In acknowledging the mixed methods used in conjunction with interpretive approach that this thesis has adopted, a number of reason for this approach have been detailed. Further, because, the role of the participants is important in this study, recruitment and ethical consideration were discussed. In addition, there is a detailed explanation of data analysis procedures and the efforts made to increase reliability and validity of data analysis.

In Chapter 5 and 6, the evidence-based results are presented in detail. Chapter 5 presents the technology-related factors, organisational factors, and individual factors. Chapter 6 discusses the cognitive factors that influence the use of NIS in RACHs.

Chapter 5 Individual, technology-related and organisational factors influencing nursing staff use of NIS in RACHs

5.1 Introduction

This chapter reports on the in-depth analysis of qualitative data. As discussed in Section 4.4.1 the first phase of the investigation provides insights into the contextual knowledge about the factors that affect nursing staff use of NIS in RACHs. The findings addressed Research Questions 1-3 (see Table 5.1):

Table 5.1 Three research questions addressed by this research

Q1 What **technology-related** factors influence nursing staff use of NIS in RACHs?
Q2 What **organisational factors** influence nursing staff use of NIS in RACHs?
Q3 What **individual factors** influence nursing staff use of NIS in RACHs?

These questions were addressed using the methodology outlined in Chapter 4. Thirty nursing staff at two non-profit RACHs operated by one organisation had participated in interviews carried out at three points in the implementation of the NIS. Three technology-related and four organisational factors emerged from the 606 entries from the coding of the transcripts.

Data are presented in descending order of number of mentions from both technology-related and organisational factors: usefulness of the NIS, training, design and technical constraints, ease of use, time constraints and staffing levels, peer and IT support needs, and availability and access to computers (see Figure 5.1).

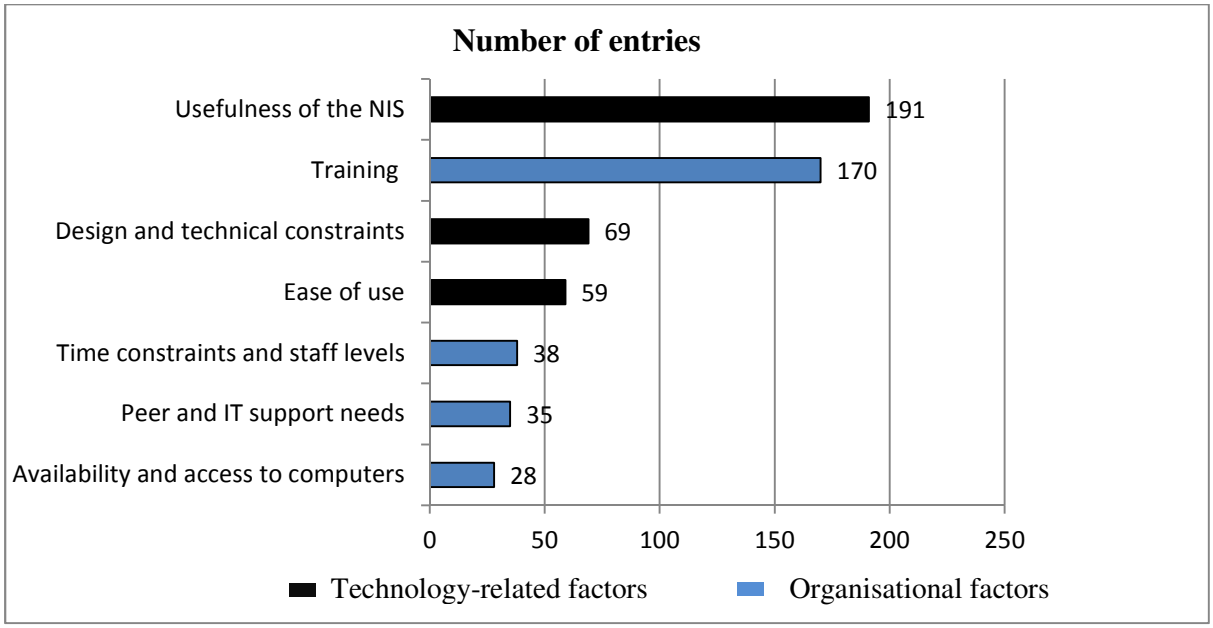


Figure 5.1 Top mentioned sub-categories of technology-related and organisational factors influencing nursing staff use of NIS in RACHs

In Chapter 2, technology-related factors identified were perceived usefulness, perceived ease of use, design and technical concerns; while organisational factors were training, time constraints and workload, access and availability of resources to support NIS, as well as NIS technical support.

The following sections will present the individual factors first, then discuss the technology-related factors and the organisational factors afterwards. The individual factors contain basic demographic characteristics and attitudes. The technology-related factors include usefulness of the NIS, ease of use, design, and technical constraints. The organisational factors are training, work-related time constraints and staffing levels, availability and access to computers, peer and IT support.

5.2 Individual factors influencing staff use of the NIS in RACHs

This section addresses the individual factors that impact on nursing staff interaction with the NIS, with a focus on demographic characteristics and nursing attitudes towards computers and computer based learning packages. The demographic information included nursing experience, job level (nursing position), computer skills before using the NIS in the RACHs, and previous computer experience.

The researcher analysed 31 interview transcripts. One interview transcript was excluded because it was incomplete and only one page long, leaving 30 interview transcripts remaining that were obtained from 30 nursing staff. Table 5.2 presents the demographic information of these staff members.

Table 5.2 Participants' demographics

Characteristics	*N*	*%*
Nursing experience		
3 to 11+ months	2	6
1 to 2+ years	3	10
3 - 4+ years	4	13
5 - 9+ years	12	39
10+ years	3	10
Not stated	7	23
Job level		
Personal carer or assistant in nursing	15	50
Endorsed enrolled nurse	3	10
Registered nurse	6	20
Manager or deputy manager	6	20
Computer skills (before using the system)		
Poor	3	10
Below average	3	10
Average	8	27
Above average	9	30
Good	3	10
Not stated	4	13
Previous computer experience		
No experience	3	10
Minimum experience	4	13
Regularly used	11	37
Extensive	12	40

5.2.1 Nursing experience and job level

There was a wide range of nursing experience, with 39% of the nursing staff having worked in aged care nursing for 5 to 10 years, 13% had worked for 3 to 4 years, and 10% had worked

for 10 years and above. The remaining 10% had worked for 1 to 2 years. Thus, the majority of the interview participants had between 3 and 10 years' nursing experience (63%).

In terms of job role, 50% of the participants were personal care workers or assistants in nursing (n =15). Registered nurses represented 20% of the respondents (n = 6), whereas 20% of the participants were nursing managers (n = 6) and only 10% of the nursing staff were enrolled nurses (n = 3).

5.2.2 Computer skills before using the current NIS

Ten percent of the participants reported their ability to use computers before starting to interact with the introduced NIS as "poor," similarly another 10% stated "below average," this meant that 20% of the participants' self-assessment of computer skills was below average or poor. The rest of the participants perceived their computer skills as average (27%), above average (30%), and good (10%). If taking self-rating responses of average, above average and good as an indication of nursing staff having sufficient computer skills to competently use the NIS, 67% of participants can be expected to use the NIS application after undergoing training and receiving ongoing support (Yu et al., 2009).

5.2.3 Previous computer experience

Ten percent of the respondents suggested that they had "no experience" with computers, 13% as "minimum experience," meaning that 23% of the respondents' self-reported computer experiences were minimum or none. The remaining nursing staff self-reported their previous computer experience as "regularly used" (37%) and "extensive" (40%). Based on the above one can argue that 77% of the respondents would be able adapt to a new NIS with reasonable training and support (Yu et al., 2008).

5.2.4 Positive nursing staff attitudes towards the NIS

Positive attitudes toward NIS were extracted from the nursing staff perceptions about the system. These included their feelings about whether the NIS offered improved access to nursing data, saved time by eliminating certain daily tasks previously performed in a paper-recording system, improved communication and reduced paper work, made the jobs of nursing staff easier and overall self-reported satisfaction with system usage. Two hundred and twenty-two entries of positive attitudes towards the NIS identified these nursing staff attitudes.

5.2.4.1 Belief that NIS use was more of a help than hindrance to providing care

Thirty five entries from 15 nursing staff members (50%) reported that, compared to a paper-based recording system, it is easier to access nursing data stored in the NIS, and that, further, it helps one to remember to document all patient care details. This easier access brought obvious satisfaction to nursing staff.

> *I think so [it is easier now] because bowel charting some days were forgotten, particularly when there were on paper. This was because there was so much paperwork to go through. So now, it is all there in front of you. You get access straightaway and further you can easily see if someone has not had his or her bowels opened. Other days, because of the busy nature of nursing care where all sorts of things can happen and sometimes you did not even get a chance to document as required. Thus, it was often overlooked before when in paper whereas [now] it is easier to do* [in computer] *and the last person's notes are in front of you. So yes, you can see charting progress is a lot clearer and it encourages you to record too. – Personal care worker 14 at six months post-implementation*

One staff member expressed her satisfaction that electronic documentation would promote precise and concise description of nursing activity because on paper there was too much "waffling." Further, use of electronic nursing documentation enabled them understand and follow recorded instructions and hence improve care delivery.

> *... yes I feel people are not waffling on so much because in the computer they are just writing what they need to write and they are more explicit. … it is straight to the point and a lot better I think than* [before on paper] *– Personal care worker 14 at six months post-implementation*

Furthermore, easier access to data encouraged a more positive attitude to record keeping that, in turn, contributed to better care provision. One registered nurse self-reported that data from the past months or year was readily accessible could be used to identify any emerging pattern.

> *I feel that there is more detail entered on* [the NIS]. *– Manager 20 at six months post-implementation*

I reiterate. I feel it is easier to go through the electronic notes. When we are doing monthly review, I prefer to go into each resident's record and read everything that occurred in the last two months so I can find out if there is any emerging pattern. – Registered nurse 17 at six months post-implementation

Staff members perceived that use of the NIS enabled them to monitor the charting progress, encourage documentation, promote precise and concise description of nursing activities, and enhance care provision and thus increased their satisfaction with the system.

5.2.4.2 Belief that NIS use saves steps compared to paper-based procedures

There were 29 entries from 19 nursing staff members (57%) who believed that using the NIS to perform daily nursing duties saved time. This was because certain unnecessary steps or activities previously carried out in a paper-based recording system were eliminated, such as searching for residents files in bookshelves whenever there was an enquiry, double recording of data because of poor file management, moving from one place to another looking for specific forms or data and many others. Therefore, they were of the opinion that using the NIS for most nursing daily activities took less time.

I think that it will be less time-consuming. Because previously you had to find the file to write up the notes and sometimes somebody has the files or forms and you cannot find them. Now that we are using computers, you just sign in and do it any time that you like. – Enrolled nurse 3 at pre-implementation

Before we had to search from folder to folder or you had to wait for a person who had taken the file. Sometimes there out there caring for a resident and must wait. Most of the time, the file gets misplaced and because of this, we have missed reports or unrecorded bowels charting, but now over here [in the NIS]*, it has everything. I think it also encourages staff members to get on and use the technology – Personal care worker 18 at six months post-implementation*

One personal care worker reported that in the new system, it was not necessary for every nursing staff member to write a progress note and if one is required to do so, it was easier and took less time to do on a computer.

> *The part I am happiest about* [the NIS] *is that you do not have to write progress notes. That is what I find is the best thing. However, if you had to write one, it is just easier on the computer and does not take much time. For me if it is required I feel I can do it fast because I am a fast typist. – Personal care worker 16 at six months post-implementation*

Nursing staff reported that they believed performing nursing tasks in the NIS took fewer steps and eliminated certain redundancies thereby saving time. Nursing staff at both sites had a similar high level of satisfaction with their electronic documentation compared to when they used paper-based documentation particularly time savings.

5.2.4.3 Belief that using NIS improves communication and reduces paperwork

Twenty-six (87%) nursing staff members, including 6 (20%) managers, 6 (20%) registered nurses, 3 (10%) enrolled nurses and 11 (37%) personal care workers believed that there was improved communication and less paper since the introduction of the NIS. Of the 54 entries recorded from these staff members, they believed it would be easier to learn more about the residents quickly as the notes are legible and easy to understand since doctors' notes on paper were often difficult to read (i.e., because of poor handwriting).

> *They* [doctors] *will be able to access it here. At least then, we will be able to understand what they are writing because at this stage it is really hard to read the doctor's note … – Manager 1 at pre-implementation*

This belief was evident also at six months post implementation.

> *… it is easier to retrieve doctor's notes, because you can get doctors notes and they are legible. I guess it is part of the communication process. – Manager 15 at six months post-implementation*

Four personal care workers and one manager believed another benefit of using the NIS was that there was going to be a reduction in paperwork and paper savings.

… it is all stored electronically so they would not be files and paperwork all over the place. It is there in one place on the computer. I think it will make my life easier in terms that often I meet with residents and relatives here and need to able to have resident's records and record information quickly in order to share with resident's relatives. – Manager 12 at pre-implementation

Only there is less paperwork [impact of the NIS]. *For me I think it is easier just to go and use the computer … - Personal care worker 27 at two years post-implementation*

5.2.2.4 Overall nursing staff NIS use satisfaction

The satisfaction expressed was not associated with any specific features but was a general expression of happiness or liking the NIS. Twenty-six nursing staff (87%) expressed their satisfaction with the impact of the NIS on nursing documentation. Others stated that they just liked it because individually they liked to try new things and therefore they enjoyed using it and felt positive about their experiences. This included 4 (13%) managers, 3 (10%) registered nurses, 4 (13%) enrolled nurses and 15 (50%) personal care workers.

Excellent, I love it. I think it is neat. I think it is also going to tell us the value of timing and writing because we are using [the NIS] *and that is where my interest grew. – Personal care worker 7 at pre-implementation*

Beautiful and I like it. It is one of the best systems I think I have ever used so far. I can go anywhere in the facility and at a click of a button I can pick up any information. – Personal care worker 18 at six months post-implementation

… [It is] *fantastic as well … I just love it. It is even better now than it was before. I think it was due to the most recent upgrade. It made it so easy you only have to click a button to see the last five days progress notes. – Manager 25 at two years post-implementation*

The satisfaction of these users was an important element in their intention to use and gaining of confidence in the system's utility. On the other hand, some other nursing staff held a negative viewpoint or attitudes towards the NIS. It is this attitude that might provide insights

on why the system might be somewhat less used and associated negative attitudes. Presented next are the negative expressions of the staff about the NIS.

5.2.5 Negative nursing staff attitudes towards the NIS

The negative attitudes of nursing staff were expressed based on their familiarity with the NIS and thoughts of what might impede its use in RACHs. The beliefs were sub-divided into four themes. These themes were generated from frustrations derived from design flaws, the mindset that using the system does not affect making judgements about residents' care, and slow software response. Seventy-eight entries, including 13 at pre-implementation, 48 at six months post-implementation and 17 at two years post-implementation from 25 nursing staff (83%) reported negative attitudes toward the system.

5.2.5.1 Belief that certain NIS forms had increased the nursing workload

As described in the narrative responses, some nursing staff felt that certain forms and functionalities including bowel charts, personal care showering, washing, and wounds charting forms did not meet their end user needs. As such they found them frustrating and time-consuming. There were 3 mentions at pre-implementation, 21 mentions at six months post-implementation and 6 mentions at two years post-implementation, frustrations expressed by a total of 14 (47%) staff members. The most widely noted responses were that staff members were spending more time on these forms and charts and expressed their willingness to revert to a paper-based recording system.

> *You go around, "it takes too much time", "I would rather do this on paper" especially the bowel charts and the personal-care charts." To me if you can have one thing on the computer you should do it all in the computer. The staff members would rather have half part of the charts on computer and other half on paper. – Manager 20 at six months post-implementation*

> [Interviewer: Is there anything that frustrates you about the NIS?] *Yes, have to try and work out an easier way of getting into the bowel charts….it is a hassle to use. It is very time-consuming and difficult to use. But apart from that is probably the only hiccup with* [the NIS] *that I probably got. – Personal care worker 13 at six month post-implementation*

There were fewer mentions at the pre-implementation stage because the reported experiences were based on the few hours' interaction during training sessions. At six months post–implementation, the nursing staff had full experience of noted forms and charts. The nursing staff then reported dissatisfaction and disappointment that their preconceived expectations about the use of these computerised forms and charts were not met. Eventually, certain NIS forms were discontinued and the nursing homes reverted to paper and this explained the lower number of mentions at two years post-implementation.

5.2.5.2 Using the NIS does not affect making judgements about nursing care

Some nursing staff believed that using the NIS did not help with any judgements nor help them make better decisions relevant to residents' continued care. For this aspect, they did not believing using the system helped at all. Fifteen mentions were extracted from 13 nursing staff (40%) expressing this view. This included 6 (46%) personal care workers, 6 (46) registered nurses, and 1 (8%) manager.

A personal care worker suggested that the system does not help make better judgements, because if she does it means they are not doing their jobs appropriately. Other care workers' positions were that decision-making and the use of NIS are two different things with no connection.

> [Interviewer: Would the NIS affect nursing judgement at all?]. *No. I do not think that is true because we would not be doing our job properly if I said yes! Then again, it is just me. – Personal care worker 13 at six months post-implementation*

> [Interviewer: How might the NIS affect your judgement in the care you provided to residents does it have an impact?]. *I do not think so. I cannot think how it would. – Registered nurse 29 at two years post-implementation*

The point of view indicated the NIS was seen as a separate entity that was parallel to continued care or did not help provide better care. This point of view is interesting because of the positive attitudes expressed in Section 5.2.4 and reported usefulness in Section 5.3.1. In both sections the majority of the staff members were very positive about the NIS hence it was expected that they perceived its use would facilitate making judgements about nursing care. If not, further investigation is necessary to find out if cognitive load might be a factor

contributing to this negative viewpoint because if learning and use of the NIS imposes heavy cognitive load on its end users they are likely to view it as creating extra workload (O'Connell et al., 2007) and a separate entity not related to the processes of nursing judgement. The second phase of the investigation of this study examined these issues (see Section 6.3 to 6.6).

5.2.5.3 Frustration with slow response of the NIS

Some nursing staff complained about having to enter data and read charts and forms in the NIS, which were frustrating to use. Fifteen entries were recorded from 7 nursing staff (23%) who stated that the slow response of the NIS led to them or their colleagues delaying its use. A manager reiterated this frustration of slow speeds, which affected staff ability to use the NIS, and often accompanied by the application "freezing" or "crashes." Therefore, staff members became impatient and returned to the floor to continue with non-computer nursing care activities.

> *It often crashes … as the application freezes and it is often very slow, I think that it is probably a broadband problem. I think that it gives the [staff] that does not want to document often an excuse – Manager 15 at six months post implementation*

> *It was heaps slower … Just the slowness* [is the frustrating thing about NIS] – *Personal care worker 16 at six months post implementation*

The above stated attitudes offer insight into why some staff members are not motivated to document more often or as productively as intended particularly at six months post-implementation. For instance, the design of the system did not fit with the nursing workflow for certain tasks. In addition, most staff members did not seem to believe this system would improve their decision-making about resident care and the slow system problems discouraged others to document in a timely fashion.

Section 5.2 presented the individual factors influencing staff use of the NIS which were nursing experience, job level, computer skills and experience, positive and attitude attitudes towards the NIS. The next section present results about the technology-related factors.

5.3 Technology-related factors influencing staff use of the NIS in RACHs

Most nursing staff reported their satisfaction with the NIS, particularly the way it was implemented. Thirty nursing staff suggested 336 times that, compared to paper-based records, the system was useful and easy to use but pointed out that there were some design issues and technical constraints that impacted their ability to use it.

5.3.1 Usefulness of the NIS

Usefulness of the NIS describes the way in which staff believed that NIS had enhanced their job performance by making their daily nursing duties easier. Thirty nursing staff reported 191 times that they believed using the NIS had made it easier to carry out their daily nursing duties in relation to nursing documentation. Specific aspects of nursing documentation that were mentioned were: data entry and retrieval, improved task effectiveness and efficiency, and improved communication among nursing staff and other health professionals. These themes are further discussed in the following sections.

5.3.1.1 Data entry

Twenty-nine nursing staff (97%) reported that the NIS was a useful tool that supported their daily nursing activities in data entry. This usefulness was mentioned 73 times. A manager reported that a computer made it easier to access and store information than a paper-based recording system.

> *I think it is good to record progress notes using a computer and store them in* [the NIS] *rather than have paper files everywhere. – Manager 20 at six months post-implementation*

The data in a computer was reported to be at the "click of a button" compared to searching for a file in stack of folders in a filing cabinet. In particular, the functions of "bowel charts" in the NIS were reported much more useful than paper-based forms for sharing of information.

> *Previously, we used to get bowel charting forgotten when it was on paper because there was so much paperwork to go through. Now it is all there in front of you in the computer and you get charting done straightaway. – Personal care worker 14 at six months post-implementation*

Other data entry functionalities including progress notes, forms, and charts and ACFI were perceived to be useful. Hence, nursing staff and other health professionals would document more or record more details of care provided.

> *I feel that there is more detail entered on* [the NIS] *and there is more documentation done. – Manager 20 at six months post-implementation*

From a managerial point of view, the system was useful as it allowed constant and on-time monitoring of the data entered. Therefore, the management team used the system to identify any weakness in the documentation so as to develop targeted strategies to improve documentation.

> *… if* [one of the management team members] *wants to see who logged in, and how many* [data] *entries they made of you, we can check that easily. This is helpful because we can actually identity potential weakness in documentation ... I guess the degree of supervision that nursing staff now gets from management over the documentation is much more thorough. – Manager 15 at six months post-implementation*

5.3.1.2 Data retrieval

Twenty-one nursing staff (70%) reported that data retrieval from the NIS was much easier. 21 nursing staff expressed these perceptions 48 times in all three phases of data collection.

For instance, because the information needed for nursing care was easier more easily retrieved compared with paper records, one manager reported that using the NIS made it easier to deliver care to residents.

> *It is easier to retrieve* [data in the NIS] *because when you have paper, one page can go there and another page on different room, simply scattered all over the place. – Manager 15 at six months post-implementation*

In addition, if the staff member did not work every day, or if the information they needed was recorded in the previous shift, they were able to retrieve from the records, which nursing actions had been performed and which had not.

You have the person's picture and you have the details at your fingertips. I can check if everything has been done very easily or if it has not been done. It is easy for me to do that using the [NIS]. *– Manager 25 at two years post-implementation*

In summary, 70% of the interviewed staff members reported that ease of data retrieval when compared to paper charts was a significant reason for them to have developed positive impressions about the NIS.

… in resident management, if I login into it I can [retrieve data about] *the resident details, care plans, progress notes, forms and charts so on … I would had never be able to do this* [previously on paper record]. *– Registered nurse 21 at six months post-implementation*

5.3.1.3 Enhanced task effectiveness and efficiency

Most of the nursing staff perceived that the NIS would or had enhanced the effectiveness of their nursing practice thereby improving their job performance. Thirty-nine entries from 24 staff members across all the data collection stages mentioned factors pertaining to task effectiveness. These were related to improved step completion and efficiency.

A manager reported that she preferred nursing documentation in the NIS because once the information was recorded in the progress notes it was picked up by various functions in the system to generate the relevant indicators that would remind the nursing staff about the care needs of the resident. According to a manager, these indicators included falls, slips, trips, medication errors, various kinds of incidents or accidents that the resident/s might have had.

The fact that the information, once it goes on the progress notes, the system's indicators will then pick it up and various alerts are generated. [These indicators are for] *falls, slips, trips, medication errors, any sort of incident/accident that the residents have …* [Because previously to set clinical indicators] *you have to obtain these information transcribed from paper sources such as memos* [etc] *... – Manager 1 at pre-implementation*

Two other staff members stated that the NIS reminded the staff members to update care plans regularly in order to meet the needs of residents which was not always the case when paper-based records were in use.

> *I am probably thinking that their care plans and their needs will be updated a lot more regularly than they are on the paper-based ones now ... That is a lot more updated information for the nursing staff. – Personal care worker 9 at pre-implementation*

> [Using the NIS] *is quicker because we do not have paper work everywhere. We are more in tune with their* [for example] *bowel charts for a start. I think it is better and faster. I think … everybody is* [keen] *to get in and do a little bit more to* [complete] *documentation. – Personal care worker 13 at six months post-implementation*

One nurse reported that NIS made it efficient to record care provided to the residents. The same recorded information was faster to find, which saved time in a super busy work environment. Therefore, more time could be spent with residents.

> *… There should be a bit more time to spend one-on-one with your residents.* [In addition], *probably more things will be documented about residents which are probably are not being done now because it is efficient to use the system to work. – Registered nurse 2 at pre-implementation*

> [Interviewer: Has the way you do documentation … changed before and after the introduction of the NIS?] *It is more efficient. It* [is] *faster to go through the notes. I am doing second monthly review, I prefer to go through and read everything that has happened in the last two months so I can see if there is an emerging pattern, and I can note it appropriately. - Registered nurse 17 at six months post-implementation*

Staff cited automated prompts for information and greater efficiencies in recording information as examples of greater task effectiveness in the work they do.

5.3.1.4 Facilitated communication

One of the most significant contributions to perceptions of NIS usefulness has been improved communication between healthcare workers. All levels of nursing staff, including 15 (50%) personal care workers, 4 (13%) enrolled nurses, 5 (17%) registered nurses, and 6 (20%) managers from the two nursing homes reported that the NIS improved communication among staff members as well as with other health professionals. These suggestions were mentioned at pre-implementation (7 mentions), six months post-implementation (17 mentions) and two years post-implementation (9 mentions). At the pre-implementation stage, nursing staff reported their perceptions based on their experience of interacting with the NIS during the period of training.

At the pre-implementation stage, a registered nurse reported that the system would improve the communication amongst nursing staff within the nursing home, as it would be quicker to retrieve and read information instead of catching-up with the person physically to clarify what had been written.

> *On paper-based records you had to ask staff about something that is not clear on the care plan or if you cannot read their notes. But, in* [the NIS] *in a way it will be good because if you cannot find a person or the said staff member or whatever, you can always go to the computer and look up the information you want. – Registered nurse 3 at pre-implementation*

At six months post-implementation, they reported that information recorded in the system was quicker to transmit and share with the other health professionals.

> *Doctors like* [the NIS]. *Because it is seen as more professional … we are* [able] *to e-mail them* [information to their surgery]. *For instance, Dr* [X] *came in yesterday so I e-mailed all that his notes that he wrote in* [the NIS] *to his computer in his general practice clinic. That is good - Personal care worker 13 at six months post-implementation*

> *Yes we have access to a dietician, I am saying yes* [it helps with communication with outside health providers]. *The physio and their assistant have access to* [the NIS] *and she will write in* [it]. *The physiotherapist and physio assistant come in three days a week. - Registered nurse 17 at six months post-implementation*

At two years post-implementation, others mentioned that the NIS had enhanced continuity of care because it was easier to follow doctors' instructions as their notes were legible and understandable. This legibility had minimised misinterpretation or possible miscommunication brought about by bad handwriting. Further, doctors were able to read what nursing staff noted and used that information to enhance continuity of care.

> *The doctors are able to read* [previous care records written by us] … *They can actually go back read their notes if they want to or they can read all* [including nurses'] *notes. To me it is useful because it is actually more legible. You are not trying to read different handwriting and it is all in the one script. Therefore, they can read their notes properly. They do not have the trouble trying to decipher somebody's handwriting. – Registered nurse 28 at two years post-implementation*

> *It is quite easy to read instructions compared to previously when you are looking at doctors handwriting. My handwriting is not the best either it is pretty scrawly.* [However]*, there are some people with pretty untidy handwriting so it is not easy to access information that you need … So* [in the NIS] *it is quite easy for me to look back and see what's occurred, at her with a dressing or doctors visit or something that I have missed when I have not been here. - Registered nurse 29 two years post-implementation*

In summary, the system's usefulness was reported in terms of its ability to facilitate data entry and retrieval, enhanced task effectiveness, and improved communications among staff members within the nursing home and with other healthcare workers.

5.3.2 Ease of use

Twenty-two nursing staff (73%) reported their perceptions about the system's ease of use for 59 mentions at the different stages of system's introduction. The reason for ease of use was that different electronic forms and menus were easier to locate than paper forms. Nursing staff thought it was easier even for an individual who had never used a computer before to use the system. One personal care worker who had never used a computer before, thus with limited typing and mouse movement skills, reported that:

> *It is so much easy to use. I was somebody that had never used a computer until I was shown how to use* [the NIS]. *I am very pleased with it. - Personal care worker 14 at six months post-implementation*

Ease of use is also manifested by the system's simplicity, intuitiveness where staff members easily learnt by doing and perceived that it was straightforward.

5.3.2.1 Simplicity

Fifteen nursing staff (50%) reported about how they in general perceived the NIS to be somewhat easier to use in their daily practice. These comments were not directed to specific functionalities or a specific performance of a given task. These 15 staff members made 15 statements describing this perception.

> *I think* [the NIS] *is a lot easier to use. Once everyone knows how to use it, they will find it is easy. – Personal care worker 9 at pre-implementation* [this comment based on training they received before system went live]

> *...it is very easy to do anything in* [the NIS] *and it is a very user-friendly program* [as such] *it was not hard to teach most people... - Manager 25 at two years post-implementation*

This perception was found at the pre-implementation stage to two years post-implementation. At the pre-implementation stage every staff member was trained (on how training was conducted see Section 5.4.1) on how to use the new NIS and a training module was set-up for him or her to continue practising what he or she had learnt. Hence, the perceptions expressed above at pre-implementation stage were based on these experiences.

5.3.2.2 Intuitiveness – learning by doing

Twenty-four nursing staff (80%) reported that they learned how to use the system based on intuitive knowledge and required less assistance in learning to operate it. This was reported throughout the different time intervals of the data collection. For instance, there were 6 mentions at pre-implementation, 13 mentions at six months post-implementation and 4 mentions at two years post-implementation from 24 nursing staff including 11 personal care workers (37%), 3 enrolled nurses (10%), 5 registered nurses (17%) and 5 managers (17%).

One personal care worker reported that at first, she was doubtful if she would be able to learn and operate the system because she did not know how complex it would be, but after 1-day training, she simply logged in and was able to use it without further assistance.

> *At first, I was thinking I might not be able to learn the skills* [to operate the system]. *I did not know what was going on* [during training] *but on the second day, I was just* [able to] *login and get going. – Personal care worker 7 at pre-implementation*

Others stated that understanding how the NIS worked was quite easy even though they needed more time to learn other features such as care plans.

> *Yes, I am still learning about it … Understanding how* [the NIS] *works was fairly immediate … – Registered nurse 21 at six months post-implementation*

Moreover, some nursing staff reported that phased implementation of the system features was too slow for them because they actually learnt much quicker than was planned. They suggested the functions of the system could be introduced much faster than they were actually introduced.

> *I am still learning how to use it. Because they been introducing one section of the system at a time. I think we could do that bit quicker because I tend to get a bit impatient. - Registered nurse 17 at six-month post-implementation*

The positive end user experience had led to their increased confidence with the system.

5.3.2.3 Straightforward

Despite having limited practice with the system prior to its introduction, using the NIS was considered straightforward and easier to adapt to by the nursing staff after its implementation. There were 9 mentions from 7 nursing staff (23%) who stated that they there were able to use the system straight away without any difficulties. For instance, at pre-implementation stage one personal care worker described her interaction experience as follows:

> *They* [staff with poor computer skills] *probably get nervous you know because they are not really good with computers. They are not really good with computers, but* [the NIS] *is pretty straightforward once you get used to it. - Personal care worker 4 at pre-implementation*

One registered nurse said:

> *I did not have a problem with it for what I use it for. I do not seem to have a problem with it and it is straightforward. – Registered nurse 28 at two years post-implementation*

5.3.3 Design and technical constraints

Even though many staff were generally positive about the NIS, there were some who raised significant issues in relation to the design and technical constraints of the system. In total, 69 entries from 21 nursing staff (70%) reported concerns about the design of certain modules of the NIS and the technical infrastructure that supported the system. These concerns mainly centred on the difficulty of inputting data and retrieving information caused by the interface design and some functionalities of the NIS. In addition to this, the design of the network as well as system failures figured in the responses from the participants.

5.3.3.1 Difficulty of inputting data and retrieving information

Despite the positive endorsement, many staff reported problems with data entry when it was required for twenty or more patients at a time. Sixteen entries from 12 nursing staff (40%) reported the problem of an inability to enter and retrieve information necessary for provision of continuity of care that were supported by the system in several electronic forms. Two problems were suggested as the cause of this difficulty: interface design and inadequate functionalities. The majority of staff who expressed these frustrations were personal care workers who were primarily responsible for entering patient data into the system. Further, managers reiterated that these workers have stated these frustrations to them.

Interface design

There were 24 entries from 10 nursing staff (33%) who mentioned that the interface design of "bowel chart" electronic forms were inadequate and must be improved, even though these same forms were described positively in Section 5.3.2, particularly in the way they organised

stored data compared to paper-based records. On the other hand, here the complaints focused on the way the designed forms captured data compared to the paper-based forms. A manager reported that when they used the paper-based system staff members had one sheet for each resident and simply made "ticks" in the appropriate checkboxes. However, using the NIS one must open each resident's record, put in your password to each individual record, input the required information, close that record, and repeat the same process for the next resident. This was suggested to be slow and frustrated staff members, especially if one had 35 residents' to record.

> *Nursing staff are complaining that they are spending too much time for example on bowel charts, especially in low care were they got 20 residents to look after. They have to enter 20 bowel charts. Previously you have each sheet for a resident and you would go to tick! Tick! Tick! Tick!. But in* [the NIS]*, you must open each resident and you have to put your password in to each individual entry and hit the enter button. In that time, they make entry for one person they would have probably have done ten in paper.* [Also] *it is a fairly lengthy process to get your print out. – Manager 15 at six months post-implementation*

> *We have to try work out an easier way of getting into the bowel charts.* [For instance] *two* [nursing staff] *on a daytime, one does zone one, and the other does zone two. In each zone you probably got roughly 35 people to provide care for and then you have to enter data for them individually, that is a hassle and it is very time-consuming. - Personal care worker 13 at six months post-implementation*

At the post-implementation stage, staff suggested that getting into "bowel charts" forms was difficult to use and strongly felt these forms were time consuming and unnecessarily complex. The design offered inefficient support to enable quick entry and finding of relevant information. They recommended that the forms or the way these forms recorded data should be updated or redesigned to fit the daily recording of data.

> *Forms and charts* [could] *speed it up or make them much better to use.* [However]*, what is a hassle is the bowel charts. When they first came in, because we were one of the first ones to use it, at* [Age Care Home X] *they tried to use it, it was a different software program, but when we tried to do the bowels on the computer, one of the*

registered nurses said, "No, the bowel book is a bible." I agree with that, there are frustrating. - Registered nurse 19 at six months post-implementation

Is it worth mentioning here that the personal care workers carried the burden of this limitation of interface design. It seems that managers, on the other hand, use the system to retrieve this data so were not inconvenienced by this limitation.

Lack of key functions

Two managers and one registered nurse mentioned their concern with the lack of certain key functions on the NIS. These functions included lack of forms or data fields to record a resident's specific condition. Others complained about the lack of a spell-checker.

The problem of missing forms and data fields in which to enter the relevant information was raised by both managers and nurses. Some highlighted the lack of flexibility in entering important information specific to their needs. For instance, one manager reported that no suitable text fields existed in the NIS to record specific problems about a new resident on respite care.

Well with the drop-down menu, I can tell you a couple of weeks ago a resident who might be coming for respite with us shortly. She had problems with her skin and she uses this particular thing. We had to supply it for her and there is nowhere to write this in [the NIS]. *I could write it in progress notes but it is best if this information is in care but there is nowhere actually to record it in the care forms. When it came to her diet because her mother had bowel cancer, there are certain kinds of meals that she does not tolerate, for instance what she likes and dislikes. When you go to food people, we can tell them but there is no room to document all this* [in the NIS]. *– Manager 15 at six months post-implementation*

Others managers mentioned that there was a lack of functionality for retrieval of certain resident information.

When it comes to the individualised care documentation, there is not enough opportunity to access, set, and retrieve individual information. – Manger 15 at six months post-implementation

Three personal care workers suggested that they would like to have a spelling checker function in the NIS. One reason is that the spelling checker would assist personal care workers from non-English speaking backgrounds spell accurately or save time in searching and rewriting certain words. Arguably, this would be an advantage to all staff members who need to enter information.

> *I would prefer spelling checker. Incorrect spelled words, a bit of a worry. – Personal care worker 8 at pre-implementation*

> *The only thing I do not like about* [the NIS] *is that does not have a spelling checker on it. – Personal care worker 13 at six months post-implementation*

User-interface design and lack of certain functionalities were cited as the reasons for the difficulty in entering and retrieving data from the NIS. The significance of these negative comments needs to be considered in balance with the positive comments reported earlier. Certainly, the issue of interface design is more prominent as a negative feature as there were relatively few positive comments reported about interface design. On the other issue of functionalities, the ledger is more balanced where numerous positive comments were made about the functionalities of the NIS. On the other hand, there were network constraints or failures, which also were reported to hinder the use of the NIS. This is discussed in the next section.

5.3.3.2 Network constraints or failures

Network infrastructure that is designed to support the optimal functioning of the NIS was reported to often fail or run slowly. The failures and constraints were caused by the network's inability to support or cope with increasing numbers of users at peak hours, power outages, computer malfunctions, server breakdowns, and the system "freezing." Most of these causes were due to the third-party products and other service providers, which were not under the direct control of the RACHs.

On the local area network, the constraints were due to the infrastructure's limited capacity to support increased traffic over a specific period. It was reported that the system was incredibly slow and did not respond quickly enough during the afternoon or midday onwards. Nursing

staff became impatient and clicked a number of buttons repeatedly, which often led to a system malfunction (crash) or data being entered numerous times.

> [The NIS] *slows down in the afternoon. Yes, it happens often.* [It starts] *at about three o'clock* [and until] *I go home about half past four, five* [I do not know when it returns to normal speed]. *– Manager 20 at six months post-implementation*

> *I think some of the weaknesses are that some* [nursing staff] *are saying* [the NIS] *is just so slow. They have to wait* [as it hangs or freezes] *and eventually they get impatient and hit the enter key many times. Then this enters the data three or four times. Therefore, they have to go through [the record] and delete things. – Registered nurse 17 at six months post-implementation*

Situations of complete NIS failures were caused by temporary power outages. During these outages, nursing staff reverted to paper-based data entry.

> *The continues crashing and the power going out that is basically about it the only time there is an issue. – Enrolled nurse 26 at two years post-implementation*

Other complete system failures were associated with computer hardware breakdowns and server malfunctions. The server malfunction or slowness to respond was widely reported as frustrating amongst most staff members. This led to limited or no use of the system and doubled workload as nursing staff had to handwrite the documentation and later enter the data once the NIS was restored to normal function.

> *From time to time, is one of the frustrations when there hardware computer breakdown and staff cannot record any information. Therefore, they have to hand write notes, and then when the computers are back on again they then have to enter them into* [the NIS]. *So that is double work. That is a bit of a problem. We have had quite a few breakdowns in the last couple of months. – Manager 30 at two years post-implementation*

The only time I get frustrated with is if the server goes down and I cannot use the system. We cannot get into the resident notes when the doctor comes in, and we do not know what is happening. – Manager 25 at two years post-implementation

Other nursing staff reported that the NIS could "freeze" and last for hours in that state. In addition, combined with slowness of the NIS and server problems it was difficult and frustrating to enter data and staff members had to delay documentation of care.

It freezes a lot that is quite frustrating to do anything on it. For instance, I forgot to [to save as I was creating care plan] *for one resident a few weeks ago, I had written about five or six pages of care plan and then when I realised that it had frozen and I lost a good hour and a half's work. – Registered nurse 17 at six months post implementation*

A couple of weeks ago, everything was moved to a different provider, different server it was supposed to be faster but it is slower than ever. Yes, it [slowness] *happens across* [the facility]. *It is not an* [the NIS] *application problem. It is the server and the broadband. It also often crashes … and as in the application freezes … Well I think we also experience the slow network that probably counts too … Manager 15 at six months post-implementation*

Section 5.2 presents the results of the technology-related factors that influenced the use of the NIS in RACHs, which were usefulness of the NIS, ease of use, design and technical constraints. The next section presents results relating to the organisational factors.

5.4 Organisational factors influencing nursing staff use of NIS in RACHs

Various organisational factors were reported that affected nursing staff's utilisation of the NIS in RACHs. These factors were training, time constraints, staffing issues, access to computers, peer and IT support needs. The next sections discuss nursing staff reports about these factors.

5.4.1 Training

One hundred and seventy entries were collected from 30 nursing staff (100%) about the NIS training. The main themes that emerged from these comments were the strategy used to train

staff, how training was timetabled, whether the training met trainee's needs, how long it took staff members to be comfortable with using NIS and how training could be improved.

5.4.1.1 Training strategy used in the RACHs

Training strategy defines the approach for the education and training of the workforce in the workplace chosen by the trainers or employing organisation. Staff members stated the various approaches they underwent during their training. Thirty nursing staff underwent one or more of the following training models: train-the-trainer or one-on-one training provided by trainers, and small numbers of group training. The trainers were those co-workers selected to attend the comprehensive train-the-trainer training provided by a trainer of the vendor offsite at the pre-implementation stage, who then came back to the workplace to conduct training for the rest of the team members. About half of the nursing staff (15 people) were trained as trainers, these included personal care workers, enrolled nurses, registered nurses and managers in each of the aged care homes. These nursing staff members were perceived as having relatively higher computer skills than others.

> *First, we wanted to get people that were sort of computer literate/savvy. We got those people trained up specifically to do the train-the-trainer and then return to train other people. This was done on voluntary basis. – Manager 30 at two years post-implementation*

Some group training was reported. Both, train-the-trainer and one-on-one training were hands-on. One-on-one training was offered on a needs basis until the trainee was fully comfortable in using the NIS.

5.4.1.2 The way training was timetabled

Twenty-nine nursing staff (97%) commented on the way training was organised and supported across all three phases of implementation. Training was reported to have been scheduled as a five day training workshop either conducted offsite or individualised training on specific functionalities on different days on-site after the system went live. Fifteen nursing staff, 10 personal care workers (33%), 2 enrolled nurses (7%), 2 registered nurses (7%) and 3 managers (10%) reported that they attended a comprehensive 8-hour training session for 5 days off-site before the system was implemented.

I did the five-day [training] *workshop and I have not used it since though. - Manager 1 at pre-implementation*

Another 15 nursing staff including 8 personal care workers (27%), 1 enrolled nurse (3%), 3 registered nurses (10%) and 3 managers (10%) revealed that they were timetabled to attend training sessions that ranged in length from one to four hours. These sessions focused on one function at a time.

We had six different days where they train people. They would have specific days half an hour allotments for us staff so that how we would learn. - Personal care worker 13 at six months post-implementation

Other training sessions were scheduled on an individual needs basis, which focused on specific functionality. The staff members stated that a trainer was present to facilitate the learning and address any difficulties.

Some care staff members reported that they had learned the functions of the NIS through direct observation of others or just learning on their own, instead of the formalised training. They reported that help was available if they needed it.

As I said, I learn by fiddling. - Manager 15 at six months post-implementation

I was working with another partner, that partner would do her progress notes so I would go up and say "I can stand beside you and look at what you are doing and how you get into the computers and that is how I learnt". Even sometimes mucking around yourself you know. - Personal care worker 27 at two years post-implementation

5.4.1.3 Meeting the trainees' needs

Nine personal care workers (30%), two enrolled nurses (7%), 3 registered nurses (10%) and 3 managers (10%) believed that the training met their needs. The way training was done was "good," straightforward, made the learning process easy and enjoyable too.

[Interviewer: Do you think that the training met your needs?] *Yes, definitely! Because I think the others would be able to get on the computer at home and do all sorts of things … - Manager 1 at pre-implementation*

[Interviewer: Did the training you have received meet your needs?] *Yes.* [Interviewer: So you found it pretty straightforward] *Yes, it was pretty much easy. - Personal care worker 4 at pre-implementation*

Two personal care workers stated that training did not meet their needs because it was too rushed, which made it difficult to understand the content and certain information was not given.

It was too rushed so I think it was not as clear as you want it to be. Things would be left or were missed more easily. - Personal care worker 5 at pre-implementation

5.4.1.4 Time required for familiarising themselves with the NIS after training

Most nursing staff reported varying periods of how long it took them to be comfortable using the system after being trained. The periods varied from six days to some months.

One personal care worker stated it would take about six different days to reach a comfortable level, whereas the next care worker suggested it would take her about four or more months. After two years' experience with the system one personal care worker revealed it took her 12 months to reach a comfortable level in using the NIS. A registered nurse stated it would be more than a "couple" of months to reach the same level.

How long did it take me to feel confident in using [the NIS]*? It probably it would take me six more days. - Personal care worker 13 at six months post-implementation*

Well, probably took me four months to be at the current level of confidence in using [the NIS]. *But I am still learning it will take me probably another four months I reckon* [to reach the level where I will be making the best use of it] – *Personal care worker 14 at six months post-implementation*

I need 12 months to reach the desire confidence level in using the system, because I was not confident. That is not worker [trainer] fault or anything. That is partly my fault because I am not a computer person. When it comes to a computer, I will skip it, go to a pad, and write. – Personal care worker 27 at two years post-implementation

5.4.1.5 Suggested improvements to training

Twelve entries from 9 nursing staff (30%) made mention about whether training should be improved or not. Most of the nursing staff did not think there was anyway training could be improved. They suggested that the way training was conducted was adequate and was well organised. Some suggested that there was support if they required extra training sessions or any assistance on how to use the NIS.

We could have more sessions if we wanted to … if you [do not have] *enough knowledge in that section. We do a little section* [at a] *time and if you did not have enough knowledge you could just go and talk to* [the trainer] *he would teach you. – Personal care worker 13 at six months post-implementation*

However, two personal care workers and one enrolled nurse reported that they were trained on functions that were not relevant to their job role. Hence, they suggested that they should only focus on functionalities specific to their daily nursing activities.

We learnt the whole system but some of the stuff we were taught was more for managers. So I personally thought that perhaps we did not need to know all of that and it would have been better to spend a bit more time refreshing the functions that we going to be using all the time, rather than going into stuff that we are probably not going to use. Perhaps, maybe the people in those managerial roles should be trained separately because there are certain functions in the [NIS] *that are only available to managerial level. – Enrolled nurse 2 at pre-implementation*

We only really needed learn certain things only. For example, I do not really know how to do care plans and I do not do them but I did training in them. We just do bowel charts, the progress notes, and the accident reports not a great deal. – Personal care worker 16 at six months post-implementation

In summary, the evidence above indicates the training strategy and how training was timetabled worked well in these RACHs. Most staff suggested that the training met their needed and did not think there was anything wrong or need to be improved about the training. Despite this positive expression towards training, interestingly the same staff responded that it would take them between 6 days to 12 months to be familiar and comfortable with the NIS after training.

This is something that warrants further investigation in order to understand what it is that makes some individuals take so long to be familiar with the system and what factors affect absorption of new IT skills. Furthermore, the results suggest an investigation on whether these people take longer than the stated period to be competent users (progress from novice to expert within a reasonable time). If so, the introduction of the NIS could have been further optimised to take account of the impact of cognitive load in staff, particularly those with less experience with computers (see Chapter 6).

5.4.2 Work-related time constraints and staffing levels

Thirty-eight entries from 19 nursing staff (63%) mentioned that lack of time and insufficient staff numbers had affected documentation of care.

A manager stated that the biggest challenge to the delivery of good quality care to the residents in aged care homes is lack of time. Time was an issue even before the introduction of the NIS. Fourteen staff members (47%) reported that they had little time to document or use the computers because they were busy carrying out other nursing activities. Three registered nurses also reported that they did not have adequate time to practise using the NIS even after using the system for two years.

> *The biggest challenge with delivering quality care to the residents is time … So* [we] *do not have enough time to do everything that our job requires … We are always doing extra time, everybody does extra time. - Manager 1 at pre-implementation*

> *… the biggest challenge in my case in delivering good care to residents is time. I would have to say no I do not think* [the NIS] *will not help in solving this time issue - Registered nurse 29 at two years post-implementation*

A manager and a nurse mentioned inadequate staff levels. This problem was prominent in the afternoon shift (2.15 pm to 10.45 pm), thus making it difficult for one care worker to provide care for about 70 residents alone, as well as document their care. One personal care worker stated:

> *Especially on afternoon shift, if we do not have extra short shift in the afternoons, it makes for a long night. Very busy night for the one girl that is there to look after 70 something residents ...- Personal care worker 11 at pre-implementation*

> *One of our biggest challenges in resident care, concerning quality resident care, it is having enough registered nurses.* [The NIS] *cannot help with that one. It is the general human resources problem. – Manager 15 at six months post-implementation*

Work-related time constraints and staffing shortages were stated as barriers to productive use of the NIS in these RACHs because some staff members were not able to gain sufficient opportunity to use and familiarise themselves with the NIS because they were required to attend to their residents. This is caused by declining numbers of registered nurses in RACH settings as those remaining have many nursing tasks to complete in a given shift. Of concern, 11(mainly managers and registered nurses) staff do not believe the introduced NIS would help to minimise the effect of inadequate staffing levels.

5.4.3 Availability and access to computers

Fourteen (46%) nursing staff, including 2 (7%) managers, 1 (3%) registered nurse, 2 (7%) enrolled nurses and 7 (23%) personal care workers from pre-implementation to two years post-implementation of the NIS reported there were inadequate computers. Despite this perception noted at pre-implementation, the same concerns were still expressed at two years post implementation. This was an indication that the number of computers remained insufficient even though at pre-implementation nursing home management was aware of this concern.

Such problems were particularly felt in the morning and afternoon shifts, when there were many staff members working. Personal care workers had to wait around for computers since registered nurses and enrolled nurses had priority of computer access. This is perhaps ironic given the crucial role personal care worker's play in entering patient data. Most of the

personal care workers documented during break or at end of the shift. However, this was not always achievable.

> [Interviewer: Do you ever have trouble getting access to a computer to enter information?] *Yes! A lot. Because there are only five computers on the morning shift, there are eight of us. The registered nurses get priority access. So now, there is a certain room for them. It leaves us with six of us against three computers, and if someone is heaps slow, you have to wait around for it. Yes, so I reckon there is a need for more workstations. – Personal care worker 16 at six months post-implementation*

> *We have three computers and they have allocated our time to do 20 minutes or so of documenting, but the way the computers are now, if you do not document in time, you do not go home in time. At times, some of the staff leave [without documenting] and saying I cannot afford to stay back. - Personal care worker 18 at six months post-implementation*

There were nine nursing staff (30%) who suggested that there was need for more space to place computers. Two personal care workers expressed their concerns about the offices or nursing stations where computers were not enough. The frustration of these care workers was that registered and enrolled nurses and doctors were given two offices to use whereas they only had one office space with three computers to be used by six personal care workers.

> *They are going to buy extra computers and laptops and put them in the corridors and other rooms where the staff will have to stand to have a computer to use. - Personal care worker 7 at pre-implementation*

> *The other thing that frustrates me is we do not have computer spaces, like before we had two offices to do* [the NIS]. *Now that office is being given to the registered nurses and enrolled nurses, and this office there is only three computers, each staff sitting behind waiting for the computers. But if they give both offices to the staff then the registered nurses are frustrated. - Personal care worker 18 at six months post-implementation*

5.4.4 Peer and IT support

Thirty-five entries from 18 nursing staff (60%) suggested they required support in order to be confident using the NIS. Most nursing staff felt that peer support from colleagues and supervisors was sufficient. Those staff members who attended the train-the-trainer training at pre-implementation stage assisted their co-workers in solving usage problems with the system. Others reported that if they could not get help from co-workers, they would direct the queries to the IT support personnel. The IT support person was reported to be exceptionally helpful and able to solve most problems.

> *We* [train-the trainers] *always leave the door open for the staff to see if anyone if they want to ask us questions. They can come to us... Whoever has time at night shift, afternoon shift or somebody is running late, one of us has to stay back for half an hour… so that we* [know] *the staff are doing* [OK before going home]. - *Personal care worker 7 at pre-implementation*

> *I mean* [IT personnel staff X] *is really good and provide necessary help. If I want something on* [the NIS]*, that he is happy to do it for me or show me how, I just have to ring him. - Manager 15 at six months post-implementation*

However, the competent and helpful IT support personnel were not available after hours. One personal care worker reported that she got frustrated with the lack of support, especially on the afternoon shift (2.15 pm to 10.45 pm) and weekends because there was no one to provide immediate support.

> *I do not always get the help when I need it because I work afternoon shifts and weekends. That is the only stumbling block if I get a stuck I can't ring up* [IT personnel staff X] *because he is home. - Personal care worker 14 at six post-implementation*

5.5 Discussion

The results indicate that there are apparent contradictions in the research findings. It can be noted that the attitudes of staff (found under individual factors) were not always consistent with the themes of usefulness and ease of use (under technology-related factors). This is best exemplified in the use of the bowel charts where staff members were effusive in their praise

in the pre-implementation phase but were critical at post implementation stages (six months and two years).

There are two possible explanations for these apparent contradictions. Firstly, the shortcomings of the NIS in relation to the bowel charts forms were not apparent during the pre-implementation phase. The shortcomings became apparent later when nursing staff had greater practical experience with the system. A second explanation relates to the level of experience of nursing staff that are tasked with the bowel charts. Bowel charts are the preserve of the least experienced staff. These are personal care workers, they form the largest occupational group (68%) in RACHs and the majority have a baseline qualification (Department of Health and Ageing, 2013). In addition, they are likely to have no or minimal computers skills and computer experience.

When such staff members are faced with the functional problems of the NIS their ability to carry on with normal nursing care in aged care is severely compromised. In this case, the functional problems were severe to the extent that RACH management opted to revert to paper-based recording of care and the electronic bowel charts were abandoned. This may be due to low experience and having not acquired the necessary skill to operate the system, which leads one to wonder whether nursing staff perceptions are a true reflection of how they will use the system. Hence, the researcher decided to conduct a further quantitative human-computer interaction study to complement the qualitative phase.

In the broader context, clearly NIS implementation was a success on many levels, but the bowel charts example provides a window on a potentially critical flaw in any potential NIS introduction when considering the staff with the least or minimal experience. This raises the issue of cognitive load and the implication it may have on the ability of nursing staff to carry out the expected nursing care activities when faced with an NIS that has functional flaws.

In addition, the training results indicate most staff members stated that it would take them a longer time period to familiarise themselves and be competent using the NIS after undergoing training. Surprisingly, the majority of staff members were satisfied with training strategies and how it was timetabled. Most believed the training met their needs and was suitable. Therefore these contradictions, from training and attitudes may indicate there is another factor that influences the use of the NIS.

The researcher is of the view that cognitive factors, particularly cognitive load could explain these apparent contradictions. Because, the traditional training approach uses conventional methods it imposes a heavy cognitive load when least experienced users attempt to learn to use the system. These users cannot pay attention to relevant procedures necessary for learning, resulting in the failure of the users to acquire the appropriate NIS skills due to a high cognitive load and inappropriate approaches to training. This led to the second phase of the investigation.

5.6 Summary

This chapter presented the individual factors, technology-related factors and organisation factors that influenced nursing staff use of the NIS in RACHs. The results were derived from content analysis of the archived interview data.

The **demographic information** indicated that 63% of the interviewees had worked in aged care nursing for 3 to 10 years and above. In terms of job role, 50% of the participants were personal care workers and the other 50% were managers, registered nurses and enrolled nurses. Since 67% reported their computer skills as "average" and above, it would mean they would be able to adapt to using the NIS after undergoing reasonable training and appropriate support. A similar percentage was reported for previous computer experience. Research results imply that the majority of end users were knowledgeable about nursing, with average and above experience with computers and with the NIS being used. On average, they would be able to adapt and use the systems as intended with appropriate training and support.

In terms of the **attitudes**, most staff reported positive attitudes toward the NIS because they believed that using it was more of a help than hindrance to care, perceived that NIS use saved steps compared with manual procedures, thought its use improved communications and were overall satisfied with its use. On the other hand, there were negative attitudes expressed towards the NIS, particularly in the post-implementation phases. Some felt that certain NIS forms had increased the nursing workload, using the NIS did not affect making judgements about nursing care and were frustrated with the slowness of the NIS. This attitudinal shift is significant as it may potentially lead to avoidance, resistance and less frequent use of the NIS.

There were three categories of technology-related factors: **ease of use**, **usefulness**, **design and technical constraints** related to the NIS.

Four major themes emerged under the factor of **usefulness of the NIS**: (1) data entry, (2) data retrieval, (3) enhanced task effectiveness and efficiency, and (4) facilitated communication. The majority of staff members paid great attention to how use of the NIS would improve their job. The results indicate they believed that the system was useful in their daily nursing activities in RACHs and it enhanced their job performance.

Ease of use was manifested in three sub-themes: (1) simplicity, (2) intuitiveness, and (3) straightforwardness. On this aspect, 73% of nursing staff found that most of the features of the systems were "very easy" and straightforward to use. The analysis revealed this belief might positively affect the way they use and integrate it in their practice because of the view that it requires less effort and is "somewhat" not difficult.

Two themes that emerged which can be grouped into factors of the **design and technical constraints** were (1) difficult to input data and retrieve information and (2) network constraints or failures. The difficulty to input data and retrieve it as suggested by some staff members was because of lack of key functions and interface design issues. Other difficulties reported as making it harder to use were due to third-party product failures and others service providers' inability to provide stable service. These were not directly under the control of the RACHs but were associated with increased dissatisfaction and less frequent use of the NIS.

The organisational factors identified were **training, time constraints, and staffing levels, inadequate number of computers or limited access to computers in the RACHs, and, peer and IT support**.

Five major themes reflecting the organisation's **training strategies and practices** were: (1) the way training was timetabled pre and post-implementation stages; (2) training strategy used; (3) assessment of whether training met the trainee's needs; (4) length of time for nursing staff to familiarise themselves with the NIS after receiving training; and (5) suggested improvements to training. The results indicate that nursing staff were satisfied with training strategies and the learning by doing approach utilised. On the other hand, most of staff reported a longer length of time would be required for them to fully familiarise

themselves with the NIS after training. Some considered that training could be improved. The results indicate the need for systematic approaches to training.

The next chapter describes an investigation into the cognitive factors that influence the use of the NIS in aged care settings.

Chapter 6 Cognitive factors influencing nursing staff use of NIS in RACHs

6.1 Introduction

This chapter reports the results of the second phase of the investigation. It reports answers to Research Question 4. What cognitive factors influence nursing staff use of NIS in RACHs? This question is answered by answering the following four questions: Are there differences in cognitive load between lower expertise and higher expertise nursing staff? This is followed by three further questions. Are there differences in task completion efficiency between lower expertise and higher expertise nursing staff? Are there differences in task performance in completing simple and complex tasks between higher and lower expertise nursing staff? What is the relationship between cognitive load, as measured by subjective task ratings (e.g., self-reported load measures), and one identified by human-computer interaction study (e.g., errors made, number of mouse clicks and keystrokes, and sub-tasks completely solved) (see Table 6.1)?

The answers to the above questions indirectly addressed the three issues that affect nursing staff's interaction with NIS: computer competency, cognitive load and task complexity. The last question explored the difference between self-reported measures and observational study.

The evidence used to answer these questions was collected from the data of a human-computer interaction observation study with the nursing staff five years post implementation of the NIS. Section 4.4.2 provides the methods used to collect the data.

This chapter is divided into five major sections. The first section presents the demographics information about the respondents. The second section presents the statistical analysis responding to the first two Research Questions 4.1-4.2. The third section presents the results of the hypothesis to answer Research Question 4.3 and the fourth the results of testing hypothesis 3 to answer Research Question 4.4. The last section presents the findings of the comparison of subjective and objective measures of cognitive load, Research Question 4.4.

Table 6.1 Research Question RQ 4

Q4.1 Are there differences in perceived cognitive load between lower expertise and higher expertise nursing staff?

- Hypothesis 1. Experienced users will experience lower cognitive load (i.e. invest less effort) than inexperienced users as they are more efficient when interacting with the computer system.

Q4.2 Are there differences in task completion efficiency between lower expertise and higher expertise nursing staff?

- Hypothesis 2. Experienced users will demonstrate more relevant keystrokes or presses (mouse clicks) and engage more frequently in activities that are efficient to complete a sgiven task than inexperienced users.

Q4.3 Are there differences in task performance in completing simple and complex tasks between lower and high expertise nursing staff?

- Hypothesis 3. Experienced users will achieve higher performance than inexperienced users on both simple and complex tasks when performing these tasks on the computer system. This difference will be more pronounced for complex tasks than for simple tasks.

Q4.4 What is the relationship between cognitive load, as measured by subjective task ratings (e.g., self-reported cognitive load measures), and one identified by human-computer interaction study (e.g., errors made, number of mouse clicks and keystrokes, and sub-tasks completely solved)? Based on this question, the research propose to test the following hypothesis:

- Hypothesis 4. Self-reported cognitive load rating scores will be positively correlated to the number of errors made during task performance.

- Hypothesis 5. Self-reported cognitive load rating scores will be positively correlated to the number of mouse clicks made during task performance.

- Hypothesis 6. Self-reported cognitive load rating scores will be negatively correlated to the number of keystrokes made during task performance.

- Hypothesis 7. Self-reported cognitive load rating scores will be negatively correlated to the number of sub-tasks completely solved.

6.2 Individual factors from the second phase of the investigation

The second section presents results from the computer interaction study from Phase Two of the investigation. These provided the results of the cognitive load, nursing task completion efficiency, and effectiveness metrics as measures of performance for nursing staff members who used the NIS, five years post-implementation.

6.2.1 Characteristics of nursing staff participating in human-computer interaction study

Table 6.2 presents the demographic data of the nursing staff who participated in the human-computer interaction study. The demographic variables included nursing staff's gender, age, job level, nursing knowledge, NIS skills, computer skills, length of time using the NIS, job level, and residential aged care work experience. There were 11 (92%) females and 1 (8%) male in both the inexperienced and experienced groups who participated in this computer interaction evaluation.

Table 6.2 Demographic information of nursing staff who participated in the human-computer interaction study

Characteristics	Inexperienced	%	Experienced	%
Sex				
Male	1	8	1	8
Female	11	92	11	92
Age				
Under 20	1	8	0	0
21-30	2	17	2	17
31-40	3	25	2	17
41-50	1	8	2	17
51-60	4	33	5	42
61 and above	1	8	1	8
Job level				
Personal carer or assistant in nursing	10	84	5	42
Endorsed enrolled nurse	1	8	3	25
Registered nurse	1	8	3	25
Manager	0	0	1	8
Residential aged care work experience				
3 to 11 months	2	17	0	0
1 to 2 years	4	33	2	17
3 to 4 years	1	8	1	8
5 to 10+ years	5	42	9	75
Length of time using the NIS				
4 to 11 months	2	17	0	0
12+ months	10	83	12	100
Computer skills				
Below average	3	25	2	17
Average	3	25	1	8
Above average	2	17	6	50
Advanced	4	33	3	25
NIS skills				
Average	10	83	0	0
Above average	1	8	6	50
Advanced	1	8	6	50
Nursing knowledge				
Beginner	1	8	0	0
Below average	2	17	1	8
Average	3	25	0	0
Above average	5	42	5	42
Experienced	1	8	6	50

The following sections describe the distinct classification of the chosen participants for each group with respect to parameters such as their demographic profile (age, job level) and their level of experience (residential aged care work experience, nursing knowledge, computer

skills, NIS skills and experience). Refer to Section 4.4.2 for a detailed description on three different dimensions used for profiling the inexperienced and experienced group.

6.2.1.1 Age and Job level

In the inexperienced group, 10 were personal care workers or assistants in nursing, one endorsed enrolled nurse and one registered nurse. On the other hand, the experienced group had five personal care workers or assistants in nursing, three endorsed enrolled nurses, three registered nurses, and one manager.

The largest age group of participants were aged between 51 and 60 (33% for the inexperienced group and 42% for the experienced group).

6.2.1.2 Residential aged care work experience and nursing knowledge

The personal care workers or assistants in nursing, enrolled nurses and registered nurses had similar lengths of RACH work experience of from 5 to over 10 years in both groups.

Eight percent of the respondents ranked their nursing knowledge level as "poor," and 17% as "below average." The nursing knowledge of 25% of the inexperienced respondents was below average or poor. The rest of the respondents self-reported their nursing knowledge as average (25%), above average (42%) and experienced (8%).

In the experienced group, all nursing staff saw their nursing knowledge level as average (8%), above average (42%) and experienced (50%). By taking any response of "average", "above average" or "experienced" as an indication of having sufficient competencies for their job roles, experienced nursing staff had higher nursing knowledge compared to inexperienced nursing staff.

6.2.1.3 General computer skills

Nursing staff were asked to self-estimate their past or present use and knowledge level of general computer applications.

Twenty five percent (25%) of the inexperienced participants ranked their ability to use general computer applications as "below average". The rest of the group's self-reported computer skills were average (25%), above average (17%) and advanced (33%). By taking

self-reported skills from average and above, as an indication of possessing the basic skills to enable them to quickly familiarise themselves with and use the new NIS software, it appears that 75% of inexperienced NIS users should have been able to adapt to using an NIS with reasonable training and support (Yu et al., 2009).

Within the experienced group, 17% of the participants ranked their ability to use computers as "below average." The remaining respondents self-estimated their skills as average (8%), above average (50%) and advanced (25%). Thus, in this group 83% of the participants indicated their ability to use computer applications as average and above. As such, these nursing staff were likely to be competent in the use of the NIS.

6.2.1.4 Information systems skills and length of time using RACHs' NIS

Eighty three percent of the inexperienced participants rated their ability to use the NIS as "average," 8% as "above average" and the same percentage for "advanced." Of the experienced group, 50% self-estimated to be "above average" and 50% "advanced." No participants regardless of the group regarded their skills to be below average or worse.

Two percent of the respondents (2%) had been using the NIS for less than six months. The rest of the participants in the inexperienced group had used the NIS for more than 12 months. At the same time, all of the experienced participants had used the software application for more than 12 months.

6.3 Cognitive factors influencing nursing staff use of NIS in RACHs

To test the three hypotheses (see H1-3 listed below) and determine the effects of task complexity and expertise on staff-computer interaction, a 2 X 2 mixed design with repeated measures on task complexity was used for the study.

The independent variables for H1-3 were expertise, which had two levels (inexperienced nursing staff members vs. experienced nursing staff members), and task complexity, which had two levels (simple task vs. complex task).

The dependent variables for H1-3 were the number of keystrokes, task completion time, composite cognitive load, number of errors made, number of mouse clicks made, and number of sub-tasks successfully completed per task.

In order to identify the determinants of performance, particularly the impact of cognitive load when carrying out a given task, a composite measure was formed. A composite measure is one way of assessing relevant cognitive load outcome by combining two or more measures into a single measure. Kalyuga and Sweller (2005) combined the mental effort rating of each task and performance measure on the same task to provide an indicator of cognitive efficiency. Similarly Paas, Tuovinen, van Merriënboer, and Darabi (2005) and Darabi, Nelson and Paas (2007) combined the learners' mental effort invested in the learning task and the cognitive load imposed by the performance of that task. In the current study, it was assumed that lower task completion time represents lower mental effort. Hence, a composite measure of cognitive load score was created for each participant from the self-reported mental effort rating score of each task divided by completion time on the same task.

To ease interpretation, dependent variable task completion was converted from seconds to hours. Hence, inexperienced nursing staff's composite measure values are expected to appear small because they are postulated to have spent more time on each task. In the current study, we needed cognitive load measure experienced in real time during the experiment, and so this study's composite measure differs slightly from Kalyuga and Sweller's (2005) measure particularly that there is no actual performance indicators involved (both indicators used are interpreted as associated with cognitive load. In fact, the conception of efficiency (mental efficiency, instructional efficiency etc) used in Kalyuga and Sweller (2005), Darabi et al. (2007) and other researches vary and there is little consensus as to how to define, measure, and interpret the efficiency construct.

The measurement of cognitive load remains problematic in much published research (see de Jong, 2010), the discussion on the measurement of cognitive load remains perplexing and an area of considerable debate.

The goal of the human-computer interaction study was to examine the relationship between dimensions of task complexity and expertise. The hypotheses are:

> H1: Inexperienced users will experience higher mental load (i.e. invest more effort) than experienced users due to the inefficient activities they engage in when interacting with the computer system.

H2: Inexperienced users will demonstrate more irrelevant keystrokes or presses (mouse clicks) and engage more frequently in activities that are not efficient to complete a given task than experienced users.

H3: Experienced users will achieve higher performance than inexperienced users on both simple and complex tasks when performing these tasks on the computer system. This difference will be more pronounced for complex tasks than for simple tasks.

The overall design of the test sessions consisted of an acquisition phase, where both nursing staff groups had received traditional training instruction on how to use the system. This was followed by an extensive practice of solving basic NIS interaction problems at pre-implementation stage. Training of staff members joining post-implementation of NIS was provided, and then the training module was setup and made available to them.

The observation study's simple and complex tasks were made up of problems identical to those encountered during training, and daily use of the NIS. It was predicted that the inexperienced nursing staff using general problem-solving strategies would most likely not be effective on both simple and complex task problems. Most nursing staff had used the NIS for more than one year. It was expected that there would be a difference between the two groups when they interacted with the system.

Table 1 shows the mean and standard deviations of the results of the task completion time, mouse clicks, number of keystrokes, errors made and sub-tasks completely solved across all tasks.

Table 6.3 The means and standard deviations for the different variable

	Inexperienced (*N=12*)		**Experienced (*N=12*)**	
	Mean	*SD*	Mean	*SD*
1. Simple Task Composite Cognitive Load	31.92	14.81	49.83	19.22
Complex Task Composite Cognitive load	32.50	12.15	57.08	25.71
2. Simple Task Mean Completion Time *(seconds)*	497.45	185.02	357.80	75.41
Complex Task Mean Completion Time *(seconds)*	652.97	211.97	450.30	142.84
3. Simple Task Mouse Clicks	127.33	98.33	62.42	27.88
Complex Task Mouse Clicks	194.83	94.87	146.25	41.94
4. Simple Task Keystrokes	659.25	27.67	643.83	31.73
Complex Task Keystrokes	522.58	319.50	544.42	227.61
5. Simple Task Errors	6.92	5.58	2.00	.953
Complex Task Errors	7.83	6.61	2.00	1.13
6. Completely Solved Sub-tasks from Simple-Task	4.25	1.49	5.25	.52
Completely Solved Sub-tasks from Complex-Task	8.58	4.52	13.17	.94

6.3.1 Cognitive load findings (Hypothesis 1)

Cognitive load is a multidimensional construct representing the mental load that a particular task imposes on a trainee's cognitive system. Indicators of cognitive load include mental load and mental effort (Paas & van Merriënboer, 1994a, p353). In this study, self-reported mental effort was used as the primary indicator of cognitive load and the scale was developed by Paas (1992). Mental effort ratings were sought from participants at the completion of the given task. For example, "Circle the number that indicates how much effort you invested in implementing the scenario in this electronic system – NIS?" (see Appendix B).

The ANOVA performed on the composite cognitive load revealed a significant main effect for expertise, $F(1, 22) = 10.180$, $p < .004$, which indicates that the experienced nursing staff members reported less cognitive load during the period of task performance than inexperienced nursing staff members. The main effect for task complexity was not significant, $F(1, 22) < 1.0$. The interaction between expertise and task complexity was also not significant, $F(1, 22) < 1.0$.

6.4 Task efficiency findings: experienced and inexperienced users (Hypothesis 2)

Efficiency is the relation between (1) the accuracy and completeness of achieved goals and (2) the resources expended in achieving them (Frøkjær, Hertzum, & Hornb, 2000). Indicators of efficiency in human-computer interaction often include **task completion time** and this measure was used in this study. In addition, this study included the number of **mouse clicks** and **keystrokes per second** as other indicators of efficiency (Hickman, Rogers, & Fisk, 2007; Salmeron-Majadas, Santos, & Boticario, 2014).

6.4.1 Completion time

The ANOVA performed on the mean completion time revealed a significant main effect for expertise, $F(1, 22) = 9.557$, $p < .005$, which indicates that the experienced nursing staff members completed the tasks faster than the inexperienced nursing staff members. The main effect for task complexity was also significant, $F(1, 22) = 11.650$, $p < .002$, which indicates that the complex task took more time to complete than the simple task. The interaction between expertise and task complexity was not significant, $F(1, 22) < 1.0$.

6.4.2 Mouse clicks

Similar to the mean completion time, the ANOVA performed on the mouse clicks revealed a significant main effect for expertise, $F(1, 22) = 4.436$, $p < .047$, which indicates that the experienced nursing staff members made fewer mouse clicks than the inexperienced nursing staff members. The main effect for task complexity was also significant, $F(1, 22) = 36.320$, $p < .001$, which indicated that nursing staff members made more mouse clicks in a complex task than in a simple task. The interaction between expertise and task complexity was not significant, $F(1, 22) < 1.0$.

6.4.3 Number of keystrokes per second

The ANOVA performed on the number of keystrokes per second showed a significant main effect for expertise, $F(1, 22) = 6.082$, $p < .022$, which indicates that the experienced nursing staff members pressed more keystrokes per second (typed faster) than the inexperienced nursing staff members. The main effect for task complexity was also significant, $F(1, 22) = 28.930$, $p < .001$, which indicated that in performing a complex task nursing staff members made fewer keystrokes per second than in a simple task. The lesser number of keystrokes in a complex task represents incomplete sub-task/s, as nursing staff intentionally left out mandatory text fields when it became difficult for them. The interaction between expertise and task complexity was not significant, $F(1, 22) < 1.0$.

Overall as predicted, inexperienced nursing staff spent more time on both simple and complex tasks, and made more mouse clicks compared to experienced nursing staff. Inexperienced nursing staff members were less efficient in pressing keyboard keys compared to experienced nursing staff. All the indicators of efficiency confirmed hypothesis H2, which predicted that experienced nursing staff members would be more efficient by spending less time on a given task, typing faster and making fewer mouse clicks to complete a given task. In the final analysis, the completion time, mouse clicks and number of keystrokes per unit of time related-variances in the level of efficiency between the two groups was attributed to their level of expertise.

6.5 Task effectiveness findings: experienced and inexperienced users (Hypothesis 3)

In this study, effectiveness in human-computer interaction is based on the accuracy and completeness with which users achieve certain goals. Indicators of effectiveness include

quality of solution (i.e., number of **sub-tasks completely solved**) and **error rates** (Frøkjær et al., 2000).

6.5.1 Sub-tasks completely solved

The human-computer interaction study distinguished between completely and partially solved tasks. The ANOVA performed on the sub-tasks completely solved showed a significant main effect for expertise, F(1, 22) = 13.781, p < .001, which indicates that the experienced nursing staff members completely solved more sub-tasks than the inexperienced nursing staff members did. The main effect for task complexity was also significant, F = (1, 22) = 8.594, p <. 001, which indicates that more sub-tasks in complex tasks were not completely solved compared to sub-tasks in simple tasks.

Results of the ANOVA revealed a significant interaction as the number of sub-tasks completely solved differed from simple task to complex task based on expertise. Inexperienced nursing staff members solved significantly fewer sub-tasks, $F(1, 22) = 7.581$, $p < .012$) from simple task to complex tasks than experienced nursing staff. This indicated that the difference in sub-tasks completely solved between simple and complex tasks was more pronounced in experienced than in inexperienced nursing staff members. Hence, the post hoc results indicated that the mean numbers of solved tasks for the experienced nursing staff members were significantly higher on complex tasks ($M = 13.17$, $SD = .94$) than the inexperienced nursing staff members ($M = 8.58$, $SD = 4.52$).

6.5.2 Errors Made

The numbers of errors made by inexperienced nursing staff was higher in both tasks. The ANOVA performed on the number of errors made revealed a significant main effect for expertise, $F(1, 22) = 10.894$, $p < .003$, which indicates that the experienced nursing staff members completed tasks with fewer errors than inexperienced nursing staff members. The main effect for task complexity was not significant, $F(1, 22) < 1.0$. The interaction between expertise and task complexity was not significant either, $F(1, 22) < 1.0$.

In conclusion, the experienced users were more effective than inexperienced users. Experienced users solved significantly more sub-tasks and made fewer errors than the inexperienced users.

6.6 Self-reported cognitive load measure comparison with cognitive load measures identified by human-computer interaction study (Hypotheses 4-7)

In Research Question 4.4, the study sought to identify the measure of cognitive load that would be most effective in predicting cognitive load impact on nursing staff use of the NIS. Hence, cognitive load obtained from human-computer interaction study and subjective self-reported cognitive load were compared to determine whether they were associated. The comparison is used to determine whether nursing managers can rely on staff members' self-reported cognitive load and use it to identify NIS use challenges.

The question is, what is the relationship between cognitive load, as measured by subjective task ratings (e.g., **self-reported cognitive load measures**), and one identified by a human-computer interaction study (e.g., **errors made, number of mouse clicks** and **keystrokes**, and **sub-tasks completely solved**)? A high correlation between subjective task ratings and human-computer interaction study measures would be an indication that both methods were able to detect the cognitive load experienced.

A Spearman's Rank Order correlation test was done to determine if subjectively reported cognitive load related to the objectively identified human-computer interaction cognitive load. Non-parametric methods, such as the Spearman's Rank Order correlation test, are most appropriate when the sample sizes are small (Hill & Lewicki, 2006). Further, the authors state a small sample size is considered to be less than 100. For that reason, the Spearman's Rank Order correlation test was deemed the most appropriate for use in this study, as the participant number of 24, was less than 100.

6.6.1 Subjective cognitive load measure and errors made

Hypothesis H4 states that self-reported cognitive load rating scores will be positively correlated to the errors made on task performance. The data analysis using Spearman's correlation test results revealed there is no correlations between participants' self-reported cognitive load and the number of errors made when performing either simple tasks, $r_s = -.392$, *n.s* or complex tasks $r_s = -.020$, *n.s*.

6.6.2 Subjective cognitive load measure and number of mouse clicks

Hypothesis H5 states that self-reported cognitive load rating scores will be positively correlated to the number of mouse clicks made during task performance. The data analysis

using the Spearman correlation test results revealed there is no correlation between participants self-reported cognitive load and the number of mouse clicks made when performing either simple tasks, r_s = -.270, *n.s*, or complex tasks r_s = -.209, *n.s*.

6.6.3 Subjective cognitive load measure and number of keystrokes

Hypothesis H6 states that self-reported cognitive load rating scores will be negatively correlated to the number of keystrokes pressed during task performance. The data analysis using the Spearman correlation results indicated participants' high ratings of self-reported cognitive load were associated with low numbers of keystrokes pressed when performing simple tasks; the correlation was significant, r_s = -.457, $p < .05$. On the contrary, the results using the Spearman correlation analysis for complex tasks was not significant, r_s = -.296, *n.s*

6.6.4 Subjective cognitive load measure and number of sub-tasks completely solved

Hypothesis H7 states that self-reported cognitive load rating will be negatively correlated to the number of sub-tasks completely solved during task performance. The data analysis using the Spearman correlation results revealed that the nursing staff's high self-reported cognitive load ratings were associated with the high number of sub-tasks not completely solved when performing simple tasks. The correlation between subjective and objective cognitive load measures was significant in simple task performance, r_s = .505, $p < .05$, but it was not significant for complex task, r_s = -.098, *n.s*

6.7 Discussion

The results of the cognitive load H1 analyses show that nursing staff with low expertise reported high levels of cognitive load during task performance. Expertise makes a difference in the amount of cognitive load a particular task imposes on an individual. This is possibly because an individual with the relevant domain knowledge and experience would process domain information with minimal cognitive effort (Sweller, 1999). Information processing is automated in experts and this reduces the need for more working memory resources (Clarke et al., 2005) and enables problem solving during NIS task interaction to occur without significant conscious effort.

In this study, as described in Section 4.4.2 user expertise is a multidimensional construct representing the user's domain knowledge (nursing), the user's experience with computers in general, and the user's experience with the specific system being evaluated (Kjeldskov et al.,

2010; Nielsen, 1993). Although, it is expected inexperienced users will experience high cognitive load, it is necessary to identify what contributes to this high load.

The results of this research indicated that inexperienced users had experienced high cognitive load as expected, but interestingly in this domain, the load was not caused by task complexity. Further, the majority of the inexperienced cohort (83%) were not new staff members but had been using the system for more than 12 months, 50% had RACH work experience of more than 3 years and were predominantly personal care workers.

Given the above, the results may suggest that the learning needs of inexperienced nursing staff to use this NIS were not sufficiently addressed. The problems experienced were significantly more severe for the inexperienced (for example, more incomplete sub-tasks, errors rates, and higher completion time), so the problems remained after more than 3 years' of use. This may suggest that nursing staff will continue to struggle, as they did not progress from novice to advanced proficiency levels in using the NIS.

In addition, cognitive load findings provided a window on the extent to which the use of the NIS negatively influenced these staff members in their computer interaction during documentation. The problem cannot be dismissed as one that would be resolved as workers adapt to an initial learning curve because the results indicated that twelve months after the system's implementation, the computer interaction was still not used effectively and efficiently. When more cognitive resources are used by attempting to solve a problem or search for a menu to enter, fewer resources will be available to actual record the nursing care information resulting in longer time to complete a task (Brünken, Plass, & Leutner, 2004; Chandler & Sweller, 1996).

Additional analyses were conducted in order to best ascertain cognitive factors influencing nursing staff use of the NIS in RACHs; both subjective and objective measures were used to provide a reading of cognitive load when users interacted with the system. Further, analysis was conducted to assess whether the scores from both measures were associated. The following paragraphs present discussion of the findings of Hypotheses H4 – H7.

Based on the results discussed in Section 6.6, there was no correlation between subjective ratings scores and objective measures in all complex tasks. However, the results indicated a

negative correlation between subjective cognitive load and two objective measures: keystrokes and sub-tasks completely solved only on simple task, meaning that nursing staff with high self-ratings scores made fewer number of keystrokes and completed fewer sub-tasks.

While the results on complex tasks indicated no correlation, this is in contrast to previous studies that have found that individuals often make errors due to high cognitive load (Ayres, 2006a, 2006b). The result of this research shows the opposite of the expected. There may be three reasons for this.

First, the meaning of the scale end-points, or all points in fact, is different from user to user. All users may not always understand the scale the same way. Second, the scale may have suffered lack of sensitivity (DeLeeuw & Mayer, 2008), because nursing staff provided a single rating score for the entire task after it was completed, however, the effort expended may have varied at different points during task performance. Third, the self-assessment is based on the assumption that nursing staff are able to accurately introspect and give a numeral indication of their perceived mental load. Studies in education settings have shown that these subjective measures are reliable. However, in naturalistic setting as in this study, participants may invest a high amount of cognitive load on a specific task and instead of finding a solution to a problem, they may opt to skip it and continue to another sub-task in the NIS form. The system design allows omitting of tasks and makes it difficult to ascertain the amount of effort one invested.

The nursing information system did not restrict users from skipping or omitting incomplete sub-tasks. In summary, in this setting where the NIS is used for recording nursing care, errors made and cognitive load correlation can be bi-directional; that means it can be either positive or negative correlation. This is because nursing staff when faced with difficult task/s may attempt to solve it via trial and error. In this case, errors made may reflect the cognitive load expended. In contrast, other staff members invested a shorter time in studying a task perceived difficult and opted to skip it.

Hypothesis 5 was rejected because there is no correlation between self-reported cognitive load scores and the number of mouse clicks made. This result suggests that mouse clicks may not be reflective of the invested cognitive load. Further research may be needed that

combines the use of mouse-tails and mouse clicks. This may provide useful insight into an individual's cognitive load.

Hypothesis 6 based on the results was accepted. As expected, when nursing staff invested a high amount of cognitive load on specific task they pressed fewer keystrokes, whereas on complex tasks, the number of keystrokes was expected to be fewer because nursing staff did omit most sub-tasks they found difficult. In many instances, they had long pauses without any input before moving to the next sub-task.

Hypothesis 7 was accepted for simple tasks. As expected, a high score for self-reported cognitive load was positively correlated with high number of sub-tasks completely solved. In complex tasks, because numerous difficult sub-tasks were omitted, the self-reported cognitive load may have been underreported.

6.7 Summary

This chapter presented individual factors from the staff computer interaction study, particularly cognitive factors. The basic background information of the interview participants were presented to further provide insight into what hinders or facilitates use of the NIS in RACHS.

As expected, experienced nursing staff self-reported lower cognitive load than inexperienced users, indicating cognitive load is a factor that influence staff members' use of the NIS. The ability of lower expertise staff members to perform daily nursing care activities was compromised when confronted with functional problems of the NIS. Inexperienced staff spent more time on a given task, typed very slowly, made more unnecessary mouse clicks, completely solved a significantly lower number of sub-tasks than the experienced staff, and made more errors.

Further, additional comparison between subjective and objective measures of cognitive load revealed that self-rating scores were not associated with mouse clicks. In contrast, errors made, number of keystrokes and task completely solved were correlated to self-reported cognitive load only in the simple task. This indicated that mouse clicks could not be considered as a true representation of cognitive load.

The next chapter presents the contribution of this research, discusses the results, and concludes this inquiry.

Chapter 7 Discussion

7.1 Introduction

The main aim of this research was to present evidence to identify how technology-related, organisational, and individual factors may hinder or encourage nursing staff use of NIS in Australian RACHs. The study investigated nursing staff use of NIS at the pre-implementation phase, six-month post-implementation, two years post-implementation, and five years post-implementation using a mixed methods approach to collect both qualitative and quantitative data. The aims and objectives of the research have been met by conducting a two phased investigation approach. This chapter presents a summary of the study's findings, the contribution of this research and its implication for future implementation of NIS in RACHs. The chapter concludes with limitations of the study and recommendations for further research.

7.2 Summary of study findings

The academic literature addressing the factors affecting the use of IS was analysed to gain in-depth understanding of the context of the research topics, to formulate research questions, and support the investigation in the NIS at Warrigal nursing homes in Coniston and Albion Park Rail. The following sections examine the results of this study in comparison with other findings in previous studies in this area. As indicated in the research design, this literature comparison phase was the last stage in the investigation.

In the literature review, it is argued why this study is situated in the aged care setting. To recap, aged care is dissimilar to other healthcare settings in a number of ways. Firstly, it is estimated that over 50% of people living in RACHs to have dementia (Australian Institute of Health and Welfare, 2013). Secondly, safe effective healthcare for those with other aged-related conditions besides dementia depends upon recruitment and retention of qualified nursing staff. However, RACHs are faced with a severe shortage of skilled staff (i.e., since 2007 the number of registered nurses has fallen from 17% to 15%) (King et al., 2014). With the declining number of registered nurses within the aged care workforce, the greater part of the care for these chronic diseases is provided by personal care workers (an estimated 68% of RACHs workforce) (King et al., 2014) whose education and training in dementia and other aged-related chronic conditions are often inadequate to provide the appropriate standard of care services required.

Thirdly, the complex care conditions of the demographic means more responsibility falls on declining numbers of registered nurses working in RACHs. Fourthly, there is a high turnover and failure to retain qualified staff because direct aged care services for people with dementia and chronic health conditions are labour intensive, however the employment terms and conditions of nursing staff in RACHs are generally less favourable than for public healthcare staff (Australian Government Productivity Commission, 2011). Lastly, there is limited after-hour access to and some communication problems with general practitioners (Chaudhry et al., 2006). In addition, hospitals and general practices have been most active in implementing information systems. For instance, a total of 98% of Australian general practices (GPs) and hospitals have a computer on their desk, which they use for clinical purposes (Mclnnes, Saltman, & Kidd, 2006) while it is believed that the aged care setting lags behind. Hence, this single case study may provide insight into the rest of the aged care nursing homes.

The study identified the following factors that may facilitate or impede nursing staff in their use and adaption to the NIS in RACHs.

7.2.1 Technology-related factors

The productive use of NIS in aged care services is not a simple process of installing and enforcing the mandatory use of such technology. Certain characteristics of the system as perceived by its users are fundamental determinants in predicting whether they will use it. The main system characteristics that emerged from the results of this study were **ease of use**, **usefulness of the system**, and **design and technical constraints** as perceived by nursing staff before and after its introduction in RACHs.

The most evident theme from the interview data was **ease of use**. There were 59 mentions reported by 73% of the nursing staff. Staff described the ease of use by stating that they were able to instinctively learn to use and understand the system's features. Equally importantly, they were able to do so without great effort. Consequently, they perceived it as an easy-to-learn application and were able to perform tasks in it with ease. Others expressed this in similar terms when they stated that using the NIS was simple and straightforward. These findings suggest that the majority of nursing staff believed that the NIS required little effort to use. Therefore, these users were positively disposed to accept and use the NIS.

Although this was the predominant view, other staff members faced challenges. Thirteen percent expressed a negative perspective regarding ease of use. The system was not simple or straightforward to them. This was consistent with the nature of the heterogeneous population examined in this case study. This means that staff with higher computer competence were more positive toward using the systems while others who had never used a computer before struggled with it and perceived it negatively.

The above findings are consistent with the comparative study conducted by Yu, Hailey and Li (2008) in two Australian nursing homes which also investigated nursing staff acceptance of NIS. Yu et al. (2008) examined the acceptance of NIS at one point in time: 11 weeks after implementation of the system. This research investigated the use of the NIS at four different points in time, which made it possible to gain an in-depth understanding of both context and phenomenon over a longer period of time.

Similarly, the system was reported to be **useful**. In this study, the research detailed nursing staff perceptions and a lived experience of what they found useful about the NIS in the Australian aged care setting. The usefulness of the NIS was most apparent when staff spoke of documentation compared to paper-based records. For instance, in regards to carrying out nursing care tasks in NIS, they believed it was a useful tool. The majority of staff perceived that it supported their core nursing activities, such as facilitating data entry and retrieval, and enhancing task effectiveness and efficiency.

In a similar vein, others stated that NIS made it easy to carry out nursing activities in RACHs. The majority of respondents indicated that it resulted in improved communication between nursing staff within the organisations and with other healthcare professionals. Hence, they felt more empowered because the NIS enabled them to read doctors notes and act accordingly. In addition, respondents indicated that it was easier to share and faster to transmit data to other healthcare providers. The majority of the respondents preferred recording data in a computer to writing it on paper. Perhaps it is this perception that played a crucial role in improving nursing staff perception about the system's usefulness.

Yu, Li, and Gagnon (2009) in a quantitative cross-sectional study investigated antecedents that influence behavioural intention to use health IT applications pre-implementation in the aged care setting. This study found that both perceived usefulness and perceived ease of use

significantly affect nursing staff acceptance and use of NIS. While, Yu et al. (2009) provide only a snapshot of a pre-implementation insights into acceptance to use if the system is implemented, this case study offers an observation of the factors affecting use conducted at four different points, from pre-implementation, to six months post-implementation, two years post-implementation, and five years post-implementation.

Another recent qualitative study that investigated the benefits of NIS in RACHs reported similar results on perceived usefulness of the system (Zhang et al., 2012). The focus of that study was to identify the benefits and to examine how the benefits have been achieved, whereas the focus of this research was to identify what staff members perceive as useful about the NIS over an extended period of time at the same RACHs.

Further, this study detailed lived experiences and perceptions of RACH nursing staff about the ease of use and usefulness of the system as described above. Consequently, this study provides a more detailed insight of these phenomena conducted at four data points: at pre-implementation, six months post-implementation, two years post-implementation, and five years post-implementation.

Design and technical constraints were linked to the limited use of the NIS at pre and post implementation in this study. These concerns and challenges expressed by 67% of staff members (most of them personal care workers) included difficulty to input data and retrieve information, problematic interface design, lack of certain functionalities, and network failures. It affected nursing staff ability to enter data in a timely manner and thus they often decided to assign themselves other non-documenting duties. For example, in Section 5.3.3.1, this was strikingly illustrated when it came to light that the bowel chart in the NIS was problematic. In this case, the paper-based system represented a more efficient use. The deleterious effect was manifested in less documentation of resident data and the RACH was forced to revert to a paper-based recording system. This was a clear example of a design constraint that led to less efficient use of the NIS.

Similar negative scenarios of NIS design can be found in the literature. These findings are consistent with the results by Yeh et al. (2009), whose quasi-experimental design study at Taiwanese long-term care facilities assessing obstacles to using a Nursing Process Support System in Chinese (NPSSC) pre and post-implementation, found that poor interface design

and lack of required functionality to support normal functions were some of the concerns that hindered the use and led to less use of the system. Another study by Yu et al. (2008) in an aged care setting reported the opposite results, where all nursing home nursing staff members interviewed stated they were happy with the design of the system. The system in Yu et al. (2008) differs from the system used in Yeh et al. (2009) and to the NIS examined in the current case study. These findings confirm that design concerns are system specific. On the other hand, this finding may be useful to NIS developers to help design products that accommodate the needs and work processes for various nursing staff roles in aged care settings.

In summary, technology-related factors indicate that much of the NIS implementation was well planned and contributed to a generally positive disposition of staff to further adopt the NIS into their work routines. However, technology-related factors also revealed aspects of design that may hinder the use of NIS in aged care settings. It will be revealed that these factors had an inordinate effect on attitudes of staff - see individual factors below. In total, the results of this study suggest that these factors are indeed antecedents of NIS use patterns by nursing staff in this environment as indicated in previous studies. The improved level of detail of this study provides greater clarity on how technology-related factors can be used qualitatively to understand how these factors benefit some levels of staff and not others depending on their level of computer experience.

7.2.2 Organisational factors

Research Question 2 investigated the organisational factors that influence the use of the NIS. Organisational factors were manifested in four sub-themes: **training, work-related time constraints and staffing levels, availability and access to computers, peer and IT support needs.**

From the interview data, themes about **training** that emerged from staff comments were about how training was timetabled. Training was organised either as an off-site five-day training workshop, onsite individualised training or an ad hoc approach addressing specific needs. The training strategy used was train-the-trainer, provided by a trainer from the software vendor conducted offsite and those who attended train-the-trainer came back to the workplace to conduct one-on-one training to the rest of the nursing staff. Fifty seven percent of staff expressed the view that training met their needs. This group reported a high level of

satisfaction with training, believed it was straightforward, and made learning the NIS functions easy.

On the other hand, others indicated that training did not meet all their needs because it was rushed, making it difficult to comprehend various functions of the NIS (13%). They were overwhelmed and frustrated at the end of the training. The majority of the respondents who expressed this view were personal care workers.

This study for the first time details nursing staff perceptions about the length of time it would take to be fully comfortable in using the NIS after training. The time reported was from six days to over twelve months. Although the reason for this view might be due to a number of factors, the findings indicated that over 43% of staff members stated that the onsite ad-hoc training did not meet their needs. Further, onsite trainers were not monitored and advised how to train mixed abilities staff members and the training materials are not designed to guide them to gradually learn to use the system without being overwhelmed.

Other related comments of significance to training were suggestions from staff of a need to improve the training strategy. One notable example suggested that individuals' should be trained on the NIS functions relevant to their roles instead of learning all its functions.

Many prior studies have found that training positively influences nursing staff use of NIS in aged care settings (Alexander et al., 2007; Cherry et al., 2008; Fossum et al., 2011; Yeh et al., 2009; Yu & Comensoli, 2004; Yu et al., 2008). Most of these studies merely mention that training is essential and should be improved without detailing the shortcomings of the training approach itself as detailed in this study. For instance, Fossum et al. (2011) identified staff training was frequently mentioned by focus group members as either a barrier or facilitating factor to the use of NIS in nursing homes. The focus group included nursing staff and corporate executives. Executives may offer us little insight into the exact impact of training at the individual level of nursing staff.

The insights generated in this thesis explored whether the training strategy used addressed trainee's needs, and perceptions that staff had about improving the training approach and how long they believed it would take them to be comfortable in using the NIS after receiving

training. The single case study with chronological data points adopted allowed an observation of the influence of training strategy and approach on the use of the NIS.

The single most important finding in this aspect of the study is that most staff stated it would take them more than four months or more to get to a level where they would be comfortable with using the NIS. This is an indication that training did not achieve the desired effect. Staff members still struggled past six months post-implementation. This is despite the fact that the majority of the respondents expressed satisfaction about the training approach, training timetabling, training perceived to have met their needs, and professed the system as easy to learn.

Lack of time was reported as one of the factors that hindered productive use of the NIS in RACHs. Forty-seven percent of staff members indicated that they had little time to enter data in the NIS because they were busy with other nursing tasks.

Twenty-seven percent of staff noted that without **adequate staff levels,** documenting care as required would remain an ongoing challenge in aged care. Mostly, registered nurses and managers stated that insufficient staff is a limiting factor to how much documentation could be done by staff on the floor. These findings suggest that aged care nursing staff are most likely to enter data in NIS less frequently than intended.

This finding is consistent with studies conducted by Cherry et al. (2008) and Yu and Comensoli (2004), who also note lack of time and insufficient staffing levels as obstacles to using electronic documentation systems in aged care. The weakness of the study by Cherry et al. (2008) however, is the use of both participants who are currently using NIS and employees in aged care homes that do not use NIS. Perceptions from non-users do not provide any insight in understanding how staff levels influence the use of NIS. The objective of the study by Yu and Comensoli (2004) was to identify key factors contributing to the low adoption of IT in aged care, and hence it does not focus on the use of the introduced IT applications. In this case study, respondents are all users of the NIS, and the investigation was conducted at four data points. In addition, in this study lack of time is also associated with difficulty in accessing the training necessary to learn how to use the NIS.

Another organisational factor that emerged from the end users is **adequate access and sufficient number of computer terminals**. The results indicate that there were insufficient computers. Furthermore, personal care workers particularly expressed frustration with lack of access because nurses and managers were given priority in computer access. As such, most personal care workers could not use the NIS as and when they needed. At other times, they documented during breaks or at the end of their shift, although this was also not always possible. These findings indicate that there is need for more spaces to provide more computers. More interesting is the priority given to more senior staff by the system designers and the apparent lack of understanding of the impacts of the system design oriented towards managerial staff (including nurses), disregarding personal care workers who have the least experience or competencies.

These findings are practical issues and organisation specific. However, they are consistent with prior findings (Alexander et al., 2007; Fossum et al., 2011; Yeh et al., 2009). Direct effects from a lack of computers are an increase in overtime work and minimal documentation of care. Furthermore, limited computer use may affect individual attitudes and NIS competence due to limited access. In contrast to the current study, none of the previous studies reveals the different impacts of insufficient computer access on different levels of staff such as personal care workers to senior managers where the least experienced staff were impacted to a greater extent.

Nursing staff recognised the value of **peer and IT support** to address their NIS interaction challenges and technical queries. The majority of staff members expressed that peer-support from co-workers, IT support personnel and managers was sufficient. These findings might explain why most staff felt the system was easy to learn, and felt no need to improve the training strategy.

Other studies have also identified support (from either peers or IT personnel) as a critical factor in the implementation of NIS in aged care settings (Alexander et al., 2007; Yeh et al., 2009; Yu & Comensoli, 2004). However, some studies link training and support but do not sufficiently discriminate between IT support and training. In this thesis, these two are differentiated by investigating IT and training separately from pre-implementation to two years post-implementation.

Summing up, findings identified by this case study demonstrate that staff members were generally positive and happy about the training strategy and its timetabling. However, further analysis indicates that this positive perception did not mean the training was effective. Some nursing staff reported it would take them significantly more time to reach comfort levels and to be competent NIS users. Despite this, they indicated there was no need to change either the training approach or its strategy.

In addition, these findings necessitate further investigation into what other factors could be hindering acquisition of skills, particularly since most respondents said that they were satisfied about the training, and perceived the system as easy to use but stated they needed more time (i.e., four months and more) to be comfortable and competent users of the NIS. This leads to an investigation of their individual factors.

7.2.3 Individual factors

Various individual factors have been explored to determine whether they affect nursing staff use of NIS. In this study, participants self-reported their nursing experience and job level, computer skills before using the current NIS, previous computer experience and attitude toward the system.

Of the interviewees from the first phase of the investigation, 67% had a self-rating of average and above in basic **computer skills**, which is perceived as a good indication of having sufficient skills. In addition, 77% of the same group had sufficient **previous computer experience** with ratings of average and above, indicating that staff members would be able to adapt to using NIS after undergoing reasonable training. This finding is consistent with the study conducted by Yu et al. (2009), which examined the pre-implementation factors determining the acceptance of NIS applications in long-term care facilities, and found that computer skills had a positive impact on the intention to use NIS.

In terms of attitudes towards the NIS, the results were mixed but the overall attitude towards using the NIS was positive at both nursing homes (see Section 5.2.4), which is consistent with prior findings (Yu et al., 2008).

For instance, some believed that access to electronic data offers potential to improve care, it saves time, improves communication between healthcare workers and within the nursing homes, and makes the job easier by reducing paper work.

On the other hand, after the system was implemented, most personal care workers were frustrated by problems they encountered when using the system. The frustrations were due to design flaws or the slowness of the system, which drove some of them away from using it frequently to document care activities as they occurred.

A significant number of respondents believed it had not helped when asked whether the new NIS had affected their confidence to make judgements. Hence, the majority believed the system did not affect making judgements about resident nursing care. These findings are significant to RACHs as it may indicate lack of appreciation of the significance of the system, or more seriously, it may suggest that the system is pitched at the needs of senior staff as opposed to personal care workers on the floor.

Summing up the individual factors from the qualitative data analysis, the results indicate that over 60% had sufficient computer skills and experience and it seemed that with adequate training and support they would adapt to using the NIS. Despite this, if the training is insufficient to equip staff members with new skills to operate the system it is unlikely they will use it effectively. Further, the negative attitude toward it would increase.

In the qualitative data analysis, there are apparent contradictions. Firstly, the staff attitude was not always consistent with the perceived usefulness and ease of use themes (both under technology-related factors). This was best exemplified by use of bowel charts where they were very positive in the pre-implementation phase but were critical at the post-implementation (six months and two years after implementation) phase. Secondly, in general, there was positive satisfaction expressed toward training approaches and most believed it addressed their needs. Nevertheless, staff members stated varying time periods (four months and more even at six months post-implementation) that it would take for them to be comfortable and competent users of the NIS.

This had a pronounced impact on junior level staff with basic computer skills. The implication of these findings is that the quality of work required of staff may suffer if systems

such as the NIS impose an additional level of cognition that is not directly relevant to the nursing staff at hand leading to negative attitudes because of stress. In such circumstances, the efficiency that the NIS introduced at more senior staff levels is not realised at lower functional levels. The study suggests that this situation may be more serious than previously known and the NIS has the potential to reduce the effectiveness of staff with the least or minimal experience in carrying out their duties.

The researcher conducted a further probe into individual factors, particularly cognitive factors using a quantitative approach. Another reason for this approach was that training results indicated that some staff members were overwhelmed. The quantitative approach offered insight on the extent to which cognitive factors influence the use of the NIS.

7.2.4 Cognitive factors

As indicated above, quantitative data analysis was conducted to examine individual factors particularly cognitive factors. These include cognitive load, expertise, and task complexity generated from the human-computer interaction study. The following summarises the findings in relation to cognitive factors guided by the use of cognitive load theory.

The cognitive load construct of cognitive load theory refers to a multidimensional construct representing the load that a particular task imposes on an individual carrying out the task. According to cognitive load theory if a task imposes a high cognitive load on an individual it overwhelms the limited cognitive resources, and thus disrupts task performance. In this study, cognitive load was found to be a factor influencing nursing staff use of NIS.

To test for any effects, the nursing staff were classified into two groups: inexperienced and experienced. The categorisation was based on three dimensions considering user's domain knowledge (nursing), the user's experience with computers in general, and the user's experience with the system being evaluated (Kjeldskov et al., 2010; Nielsen, 1993).

In addressing Research Question 4.1, as to whether there were differences in perceived cognitive load between lower expertise and higher expertise nursing staff, the study found that experienced staff members self-reported less cognitive load during task performance than inexperienced staff members. The effect was attributed to expertise and not to task complexity, since this variance was not due to task complexity.

Similar results have been found in various other studies in educational classroom settings (Heyworth, 1999; Reisslein et al., 2006) and there is consensus within the cognitive load field that little work has been conducted in other domains that could add legitimacy to cognitive load measurement techniques such as self-reporting. This case study was conducted in a nursing care domain in aged care settings, which is a naturalistic research setting. Further, cognitive load was measured as a function of time and was measured by taking into account the time the participant is working on a task.

In Question 4.2 examined the task efficiency and effectiveness between the two groups. Task efficiency was measured by the completeness of achieved goals and the resources expended in achieving them was indicated by task completion time, mouse clicks, and keystrokes per second made. As expected, task completion time, mouse clicks and number of keystrokes per second varied substantially between groups. Experienced staff members completed the tasks faster, with fewer mouse clicks and pressed more keystrokes per second (typed faster) than the inexperienced nursing staff members. Nursing staff completed both simple tasks and complex tasks but these measures did not differ by task.

Task effectiveness was indicated by accuracy and completeness by which users achieved certain goals. Indicators of effectiveness were quality of solution (e.g., number of sub-tasks completely solved) and number of errors made. The results indicate that the number of sub-tasks completely solved were substantially different by group and tasks (between complex and simple tasks). However, the number of errors was only significant between groups not between tasks. The experienced users solved significantly more sub-tasks and made fewer errors than the inexperienced users. Nursing staff made errors in both simple tasks and complex tasks but the numbers were not significant.

In order to infer the implication of cognitive load to task efficiency and effectiveness as demonstrated above, additional analyses were conducted to better understand whether objective cognitive load identified during the human-computer interaction is associated with the self-reported cognitive load by nursing staff. These analyses offered insight into whether nursing staff were able to accurately report the cognitive load experienced.

The question related to the relationship between cognitive load, as measured by subjective task ratings (e.g., self-reported cognitive load measures) and one identified by human-computer interaction study (e.g., errors made, number of mouse clicks and keystrokes, and sub-tasks completely solved). Subjective cognitive load measures were correlated to the number of keystrokes and sub-tasks completely solved. However, mouse clicks and errors made were not correlated to cognitive load.

To the researcher's knowledge, this is the first study to assess the effect of cognitive load in the ability of nursing staff to use an NIS in an Australian aged care setting. Most importantly, self-reporting cognitive load and objective cognitive load captured in the human-computer interaction were assessed to see if there was any correlation. If they were associated, it meant that managers and researchers could trust that what nursing staff were telling them were true reflections of the cognitive loads they experienced. The main issue is whether staff will objectively report the areas in which they experienced high cognitive load in order for nursing managers to provide relevant training and support.

The findings showed that cognitive load plays a crucial role in people's ability to use NIS. The results confirmed that staff with less practical experience and competency in using the system had higher cognitive load during computer interaction. The majority of the inexperienced staff (83%) were not new staff members but had been using the system for more than 12 months, 50% had RACHs work experienced of more than 3 years and were mostly personal care workers. As discussed in section 5.5, it means these workers lacked the experience and skills to use this specific NIS.

In addition, the traditional instruction that is didactic, focusing on known learning goals using predetermined and directed learning activities, may not have achieved the desired goals. In most cases, this instruction is based on the assumption that solving a wide range of practice problems is an effective way for novices to build expertise. In fact, according to cognitive load theorists, such a strategy provides fewer opportunities for novices to acquire the requisite skills to operate the NIS. The results of this study confirmed this view as most of the inexperienced group had used the system for more than 12 months but still faced challenges in using it.

Cognitive load theory literature has demonstrated that novices find themselves engaging frequently in activities that are inefficient to task performance because of unguided practices when learning various functions of the system. For inexperienced users, such unguided strategies typically represent a situation that is close to the limits of their capabilities. Inefficient and ineffective ways impose a high load on their cognitive system leading to less effective learning, frustration and eventual resistance to using the system.

In summary, the analysis using the cognitive load theory was a useful framework for predicting cognitive load effect on nursing staff use of NIS. It further helped understand and explain the pattern identified amongst individuals who reported high cognitive load. For instance, with high cognitive load it is expected that users will make more errors, take longer to complete tasks and have fewer sub-tasks completely solved. Based on cognitive load theory, tasks that impose high load overwhelm the person trying to carrying out the task.

The cognitive load approach also helped to clarify apparent contradictions in the research as it can be seen that the perceptions of staff were not always consistent with the theme of usefulness and ease of use perceptions, as discussed in detail in Section 5.5. In addition, staff were satisfied about the training strategies and how it was timetabled. However, they reported they needed more time (four months or more at both six months and two years post-implementation) after training to familiarise themselves with the NIS. The results indicate that the fact that people with less competence (nursing, computer, and the NIS knowledge) reported high cognitive load may explain these contradictions.

7.3 The contributions of this study

To date, there has been very little in-depth systematic analysis of the factors that might facilitate and hinder nursing staff to fully adapt to using nursing information systems in aged care. This was established in Chapter 2 where it was found that most studies were focused on healthcare settings such as hospitals and physician practices rather than aged care. Therefore, our study helps to fill this knowledge gap.

Another contribution is that this single case study provided further detailed contextual knowledge about technology-related, organisational, and individual factors that may facilitate and hinder the use of NIS in aged care settings. This case study provided in-depth understanding of the problems faced when using NIS, because no research had previously

had the opportunity to examine these factors in this context, although these problems were common across the aged care settings. Supporting evidence of these factors were obtained by studying the same single case at four different points in time: pre-implementation, six months post-implementation, two years post-implementation and five years post-implementation.

In addition, these factors are well defined in the literature and were demonstrated to affect an individual's intention to use information systems, mostly using a quantitative approach. The quantitative research focuses on causality, hence it does not provide explicit contextual meaning or views on what nursing staff perceived, for example what is ease of use or the system's usefulness to them. In this study, under each factor are themes that were generated by nursing staff without predefined suggestions by the researcher. The study allowed respondents to express their lived experiences and perceptions in open-ended interviews.

In terms of the contribution to cognitive load theory, this investigation is the first of its kind conducted in an Australian aged care setting, to examine the role cognitive load plays in influencing nursing staff use of NIS to document care in an aged care setting. The research assessed whether self-reported cognitive load is reliable in settings outside the educational classroom. The findings of this study indicated that self-reported measures are to be used with caution. For instance, self-reported cognitive load scores were useful when they were treated as composite measures. In comparing cognitive load, during a simple task the number of keystrokes and sub-tasks completely solved were correlated as measured by self-reported cognitive load ratings and objective cognitive load captured during the human-computer interaction study. There was no correlation between errors made or mouse clicks to self-reported cognitive load scores.

These findings suggest that nursing home managers and trainers should not rely solely on self-reported cognitive load in order to provide the training and support required. Nursing staff self-ratings on cognitive load did not appear to be a true reflection of what they were experiencing. Therefore, cognitive load indicated by human-computer interaction study may be the best strategy for now to identify learning needs in nursing homes. This is in contrast to numerous cognitive load theory studies conducted in educational settings using the same self-rating scales (for an overview see Kyun et al., 2013; Paas, Tuovinen, et al., 2003; Tasir & Pin, 2012).

On the other hand, measuring the multidimensional construct of cognitive load is a fundamental challenge facing cognitive load theorists and they concur that there is a need for continual refinement of ways to measure the load (Brünken et al., 2003; Gerjets, Scheiter, & Cierniak, 2009; Leppink, Paas, van der Vleuten, van Gog, & van Merriënboer, 2013; Martin, 2014; Paas, Tuovinen, et al., 2003). In addition, the majority of cognitive load theory studies are found in educational settings and there has been little work conducted in other domains to add further legitimacy to this measure, particularly self-rating. This research addresses this gap of testing the external validity of cognitive load theory self-rating measures in an aged care setting.

Another contribution of the study, which is explained by cognitive load, is that the majority of nursing staff were satisfied with the training strategies, believed the system was easy to learn, and suggested little to improved training during the pre-implementation phase. Surprisingly, post implementation most staff stated it would take more time for them to reach a comfortable level in using the system after receiving training. This suggests that post implementation of the NIS it was uncovered that further training was required, particularly to further facilitate acquisition of skills necessary for productive use of NIS.

Further, some staff members who reported they felt overwhelmed and frustrated as they struggled to fully adapt and use the system to carry out daily nursing activities indicated support for a cognitive load effect. One study has argued that trainers need to understand how high cognitive load affects trainee's ability to acquire new knowledge when learning to use new systems (Galani, Yu, Paas, & Chandler, 2014) and this study demonstrated the effect of cognitive load.

The apparent contradictory perceptions brought together in the bowel charting example provides insight for any potential implementation of NIS, particularly considering when staff with the least or minimal competence are involved. In the Australian aged care setting, 68% of nursing staff in aged care have baseline qualification (Department of Health and Ageing, 2013) and likely have least computer skills and experience. This raises the issue of training and its implications in respect of the ability of nursing staff to carry out expected aged care functions using an NIS that has functional flaws or design issues. For trainers to design effective training strategies and materials, they must consider the adverse effect of high

cognitive load and seek to use instructional design strategies that facilitate learning without exerting an unnecessary extra cognitive load.

Lastly, another contribution in relation to research design that this study establishes is the importance of mixed methods driven research while examining the introduction and use of NIS over a period of time. This approach allows for an in-depth enquiry to better understand the multifaceted problems facing the nursing staff in using information systems in the aged care setting. The need for this type of research approach is crucial because the introduction of NIS in all aged care facilities is inevitable.

7.4 Impacts of individual, technology-related, organisational, and cognitive factors on interaction with the NIS

In this study, both factors that hinder or facilitate the use of the NIS were identified. Ease of use, system usefulness, training, IT and peer support, nursing knowledge, computer skills and experience, NIS skills (ability to use NIS), and positive attitudes were found to support productive use of the system in RACHs. The majority of staff members perceived the system to be easy to use, useful, and their overall attitudes were positive towards the introduction of the system. A significant number of staff had sufficient nursing knowledge, general computer skills, and experience. These self-reported competencies suggest that they would be able to adapt to using the NIS with reasonable training and necessary IT support. The majority of staff members were satisfied with the training strategy and believed it met their needs.

However, factors such as design and technical constraints, time constraints, insufficient staffing levels, inadequate number of computers, negative attitudes towards the system, inadequate training and limited IT support personnel may hinder the productive use of the system. Organisational factors such as time constraints, staff levels, hiring of IT support staff and acquisition of sufficient numbers of computer are organisation specific but limits staff access to and use of NIS. Lack of a systematic approach to training is one of the problems identified. The ad-hoc approach to training did not address staff learning needs and instead they became overwhelmed and frustrated. This may lead to staff members viewing the introduction of a new NIS as adding to their workload, consequently they may resist it and be fearful of it or perceive it as time consuming. Further, the difficulty in comfortably interacting with the system generated negative attitudes toward the systems. Design and

technical constraints were found to impede intended use. To varying degrees, nursing staff will resist the system if it is slow, as they will perceive it to be time consuming.

7.5 Implications for the introduction of NIS in RACHs

This study also has many practical implications not only for the two Warrigal RACHs, but other RACH administrators and IT managers planning to introduce NIS. Two overall themes emerged from this study. These themes include resource allocation and training recommendations.

7.5.1 Resource allocation

While there are invariably limitations on the resources available to aged care homes, some judicious additions can better support a more successful NIS introduction. Firstly, the research finds there was limited computer access. For instance, day and afternoon shift nursing staff were less inclined to document during their shift because there was an inadequate number of computers on the floor. They reported that enrolled nurses and registered nurses had priority to use the computers, so sometimes it was difficult for personal care workers to access the NIS. Therefore, the recommendation is to have more computers in order for personal care workers to use them. The computers can be positioned in various places in the nursing homes e.g. training room, corridors, or other places where there are network ports for connections.

Furthermore, managers and registered nurses seem oblivious to the reality that the data they need for their work may in fact be deficient because personal care workers do not have sufficient terminals to enter the latest information. This highlights the crucial role of personal care workers and the need to remedy the access and training challenges, detailed above. Additionally, the opportunity for improved access that the NIS provides to information that was historically was restricted to RACH managers and administrators have pay-backs for a larger number of RACHs employees. This includes less-skilled workers as they are enabled to carry out their tasks in a more convenient and less time consuming ways.

Furthermore, it is suggested that IT help desk support should be outsourced when the full-time staff member is off-duty. On afternoon, evening and weekend shifts staff members indicated that when they faced difficulties or required help, the IT help personnel were not available. They would have to wait until the help desk employee was next on shift. Alternatively, experienced “super users” who are

well trained on the IT help desk should be placed on all shifts to address the need for out-of-hours IT expertise.

The super users' structure utilised in the training of co-workers was perceived effective in supporting others and for disseminating information throughout the RACHs regarding the NIS, thus leading to less resistance even amongst those who had never before used a computer. The residential managers of both RACHs were able to authorise super users to have time slots during each shift post-implementation to help the other nursing staff to better learn and operate the system. The RACH managers appear to have budgeted for this extra and intensive training of super users; other aged care homes should be encouraged to follow this model.

However, the recurring theme from this study is the unequal benefits that the NIS conferred on senior level management staff compared to personal care workers who did not see the NIS as assisting with their day-to-day documenting of care. This is a significant issue where more attention seems to have been placed on the requirements of managers in the design of the NIS as opposed to those working on the floor. This may be a strategic marketing decision that software vendors are likely to employ but those with the buying power are not entering data into bowel charts. However, in order for NIS to realise its full potential in the delivery of effective nursing care to residents in aged care nursing homes there is a critical need to address the lack of value that the NIS provides to personal care workers, particularly those with minimal computer experience.

7.5.2 Training recommendations

Nursing staff in aged care are different from other healthcare professionals in hospital settings and general practice setting; as such, computer use and experience can vary significantly. Those without proper training, as shown by the results of this research, may find learning to use the system stressful and are likely to be frustrated with the system, become fearful of it, and perceive it as time consuming. Eventually, some will resist using it and take longer to adapt to using it in their daily practice. Therefore, it is suggested that trainers understand how information overload or cognitive load affects a trainee's ability to acquire new knowledge and what instructional design strategies can be used to facilitate learning without exerting an unnecessary extra mental load.

To help NIS trainers design effective training strategies and materials, it is suggested that cognitive load theory design principles should be incorporated in training materials and activities to promote effective learning without overloading nursing staff with unstructured and cognitively overloading information. There are three instructional design strategies that emerged from cognitive load theory literature. The first strategy reduces the split-attention effect by integrating related information sources. The second strategy eliminates redundancies from instructional sources. The third strategy is to provide novice users with worked-out examples to gain the necessary basic knowledge and skills of how to operate an NIS, then gradually to lead them to learn to use it via trial and error. Pre-training nursing staff in basic computer skills and simplifying some tasks can assist novices who struggle in their initial attempts at learning NIS.

In order not to misuse the time of those that have high computer experience, nursing staff should not be trained in a heterogeneous group but they should have the option to trial the system with less assistance. Furthermore, more efforts should be made to ensure systematic training is a continuous process particularly after each system upgrade. This would help nursing staff to build new skills and become familiar with the latest system changes. Ad-hoc training of new staff members in RACHs should also be minimised. In addition, extra training opportunities must be provided to those who lag behind. Along with training staff members on the NIS, there are additional opportunities for communicating the importance of the system to the staff.

7.6 Limitations of the study

Firstly, this study identified a number of relevant technology-related, organisational, and individual factors that are likely to be faced by other aged care settings introducing NIS. In addition, this study was conducted during the pre-implementation, six months, two years and five years post-implementation. Therefore, it provided rich data generated from a natural setting over a long period, which gives valuable insights into factors influencing nursing staff use of NIS that has not been found in the literature to date.

Generalisation to all areas of nursing will be limited due to the sample population representation from the RACHs. The study will also be limited by use of one organisation specific NIS. The study focuses on nursing staff perceptions and does not include general

practitioners (medical doctors or physician) or ancillary personnel or other allied health personnel.

However, a number of strategies were employed during the research to address the limitations of a single case in order to derive the full benefits of this case. First, this case study used a variety of data collection and analysis (both qualitative and quantitative), which provided a comprehensive research approach (Yin, 2009). These mixed methods data sources maximise the range of data that contributed to the researcher's understanding of the RACH setting. In addition, outcomes of objective video-based recording of the system interaction data supported and offset the associated weakness of subjective interviews and questionnaires. Secondly, this case study examined the same single case at four points in time in order to determine how certain factors changed over time (Yin, 2009), for instance, attitudinal change observed at the post-implementation phase, which was dissimilar to the pre-implementation phase. This allowed the researcher to observe and analyse a phenomenon over time.

Another limitation is that the researcher did not categorically assess whether all the participants' views varied across different data collection phases, that is, from pre- to two years post-implementation. Such differences may be relevant in understanding why some staff members have more success at adapting and using the system more efficiently than others. This is an area for possible future research.

7.7 Future research directions

Research in this field is continually evolving, allowing numerous research studies to be conducted. The same goes for the current study that has identified technology-related, organisational, and individual factors that hinder or facilitate the use and full adaptation to the NIS in RACHs through a mixed methods approach. Further research in this context should be conducted using a longitudinal study design. This approach will allow a rigorous analysis about causality inferences. Graphical networks can be applied to demonstrate the relationships of the identified factors and this can lead to in-depth understanding of the emergent factor structures in an aged care setting.

In addition, the possible next steps based on the findings of this study include performing an assessment of the impact of cognitive load theory-based training on systematic acquisition, development and transfer of the knowledge, skills, and attitudes required by nursing staff to

adequately and productively use NIS. To allow deeper understanding of the impact of systematic training, cognitive load theory-based training performance has to be evaluated in comparison with the traditional NIS training approach. Cognitive load theory-based training promotes the development of instructional design approach in ways that do not overload a trainee's processing capacity of working memory thus lessening resistance towards the use of a new NIS.

Further, a redesign of the study should seek to make a distinction between different types of professionals such as general practitioners, allied health professionals, and nursing staff. Australian general practitioners are reported to have achieved near-universal clinical computerisation (Mclnnes et al., 2006), where drug prescribing, ordering laboratory tests and recording progress notes are generated and recorded electronically. Despite this, evidence shows that general practitioners visiting the RACHs did not use the NIS. Hence, a study may focus on investigating factors influencing their use of NIS in RACHs because their effective use of these systems would significantly enhance the importance of the system and eventually increase the probability of achieving the desired benefits of electronic documentation.

Finally, the mixed-methods approach utilised in this study could potentially be applied to other studies within this field of research.

7.8 Conclusion

This study sought to identify **technology-related, organisational, and individual** (e.g., cognitive**)** factors that hinder or facilitate the use of NIS in RACHs. An understanding on how these factors can affect productive use of NIS is needed. This is particularly so with the aged care organisations introducing NIS into RACHs in an effort to improve aged care, enhance documentation, reduce time needed to do routine paperwork and enable nursing staff to spend more time with their residents (Fossum et al., 2011; Zhang et al., 2012) and thus the need to find ways to achieve the intended benefits. Furthermore, the majority of the factors influencing the use of NIS studies are mostly focused on hospitals and primary care settings which tends to be better funded, to have highly skilled nursing staff and do not provide long-term care for aged people with complex chronic conditions.

Summarising, the focus of this research has been particularly on factors influencing nursing staff use of NIS in RACHs, asking:

1. What technology-related factors influence nursing staff use of NIS in RACHs?
2. What organisational factors influence nursing staff use of NIS in RACHs?
3. What individual factors influence nursing staff use of NIS in RACHs?
4. What cognitive factors influence nursing staff use of NIS in RACHs?

It also ascertained the causes of these problems and examined how to promote factors that facilitate nursing staff adoption and use of the system productively in their daily nursing practice. It also found ways to minimise the impact of factors that hinder productive use of the system.

In order to address these research questions, the current study used an innovative mixed methods approach, which included qualitative content analysis of interviews with staff and human-computer interaction methods involving video-based analysis, and questionnaire surveys.

In the first phase of the investigation, data was collected using interviews from two RACHs and analysed via content analysis. The analysis of the interview data identified, question 1-3, the technology-related, organisational, and individual factors that hinder or facilitate the use of the NIS. The findings confirmed that ease of use, usefulness, adequate training, availability of peer and IT support, adequate level of nursing knowledge, computer skills and experience, basic NIS skills and positive attitude facilitated productive use of the system. At the same time, design and technical problems, time constraints, insufficient staffing levels, inadequate numbers of computers, negative attitudes toward the system, inadequate training approach and limited peer and IT support personnel may hinder the productive use of the system.

Video-based recording and questionnaires were used for the second phase of the investigation. The analysis of data in this phase addressed the question 4 hypotheses (see Section 1.1). Cognitive load was identified as a major factor affecting inexperienced nursing staff. Inexperienced staff members were found to be less efficient and less effective when using the system than experienced staff members. In particular, they took more time to complete a given task, made more errors, and completed fewer tasks. The results indicated that expertise of nursing staff was an important factor (Kalyuga et al., 2003). Hence, it should be noted that the benefits would be unlikely to be achieved because of low use of NIS and this may negatively affect the quality of care. Further, self-reported measures of cognitive

load must be used with caution as workers under-reported the cognitive load they experienced.

As NIS will be commonplace and required in the future of aged care, it is necessary to appreciate the factors that influence the use of NIS in RACHs, because improved implementation strategies and introduction of NIS may lead to faster realisation of better health outcomes and lowered health costs to the aged care organisations. Also, in a recent International Journal of Medical Informatics article, Zhang, Yu, and Shen, (2012) stated the significant challenges and improvements to be learned to optimise benefits and improve system use. These include practical implications of these study findings such as allocation of resources to address shortage of computers and hiring of additional IT support staff or retraining super users to act as support staff. Further, improvement requires a systematic approach to training to address the shortfall of the current traditional NIS training widely used and finding ways to communicate the positive implications of NIS for resident care.

The discussion presented here is based on systematic observations, which provide insight into why NIS might not be used productively. It is hoped that this thesis can offer further insights into interpreting the intricate phenomena of nursing staff's adaptation and use of NIS in aged care.

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Peer reviewed publications

Galani, M, Yu, P, & Chandler, P. (2011). *Using cognitive load theory to guide the design of training strategies that facilitate care staff members to learn to use clinical information system.* Paper presented at the Health Informatics Society of Australia - HIC 2011, Brisbane, Australia (abstract submission).

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Appendix A

Pre-test screening questionnaire SNCEQ

NIS Training and Computer Experience Questionnaire

The purpose of this instrument is to determine your computer and NIS experience. Completing this questionnaire will take approximately 5 minutes. Please consider each item carefully and circle the number most closely corresponding to your use, knowledge of, or participation in computer-related activities.

A. General Computer Application and NIS

Please read the Instructions Carefully: Each item should be rated in two ways using the sets of numbers. The first rating describes your past or present computer use. The second rating describes your knowledge level of the named computer applications and iCare functions.

	Past or Present Use Scale: 0 = none 4 = Extensive	Knowledge Level Scale: 0 = none 4 = extensive
General Computer Applications		
1. **word processing** (Writing reports, papers, documents, or other text)	0 1 2 3 4	0 1 2 3 4
2. **Windows** (deleting, changing directories, finding files, etc)	0 1 2 3 4	0 1 2 3 4
3. **Email** (Sending messages to others)	0 1 2 3 4	0 1 2 3 4
4. **Using Excel**	0 1 2 3 4	0 1 2 3 4
5. The **use of** Facebook, MSN etc. **(social media)**	0 1 2 3 4	0 1 2 3 4
NIS		
6. Using **progress notes**	0 1 2 3 4	0 1 2 3 4
7. Using **Forms & Charts**	0 1 2 3 4	0 1 2 3 4
8. Using **care plans**	0 1 2 3 4	0 1 2 3 4
9. Using **observation and charting** tools	0 1 2 3 4	0 1 2 3 4
10. Using **Handover sheet** tool	0 1 2 3 4	0 1 2 3 4
11. Using the **Management Reporting** tool	0 1 2 3 4	0 1 2 3 4
12. Using **ACFI management** tools (ACFI calculator, print submission, file/photo upload)	0 1 2 3 4	0 1 2 3 4
13. Using **resident details** functions	0 1 2 3 4	0 1 2 3 4

B. Experience Rating

Please rate your ability to use NIS (please circle): novice **1 2 3 4 5** experienced
Please rate your general computer skills (please circle): novice **1 2 3 4 5** experienced
Please rate you nursing knowledge level (please circle): beginner **1 2 3 4 5** experienced

C. Basic demographics

1. Your age: ☐21-30yrs ☐31-40yrs ☐41-50yrs ☐51-60yrs ☐Above 60yrs
2. Please state your highest level of education completed.....
3. How long have you worked in this facility? ☐less than 3months ☐3-11months ☐1-2yrs ☐3-4yrs ☐5-10yrs or above
4. How long have you been using your facility's NIS? ☐ 0-3month ☐4-6months ☐7-11months ☐12 months and above.
5. When using NIS what do you find difficult to use? (*Tick more than one if applicable*)
☐Typing ☐ Keyboard ☐ Familiarity with the software ☐ describing it in nursing language
6. Do you seek or get help from your co-workers when having problems using NIS? ☐ Yes ☐No
7. If Yes, what kind of help do you often ask for?
State.....
.....
.....
.....

Your name: ..... **You are employed as:** .....

Thank you for your participation and for taking the time to complete this survey.

Appendix B

Self-report cognitive load survey

Your Name:..... Your current Position:..... Date:.....

TASK.....

Circle the number that indicates how much effort you invested in implementing the scenario in this electronic system - NIS?

very, very low |------|-------|-------|-------|--------|--------|---------|--------| very, very high
1 2 3 4 5 6 7 8 9

Appendix C

Consent sheet

University of Wollongong 

Consent to Participate in a Research Project

Factors affecting nursing staff's use of nursing information systems in residential aged care homes.

I have been given information about the research project **Factors affecting nursing staff's use of nursing information systems in residential aged care homes** and have discussed this with Dr Ping Yu / Professor Paul Chandler, and Malatsi Galani or other students conducting this research on behalf of the School of Information Systems and Technology at the University of Wollongong.

I understand that, if I consent to participate in this project, I will be observed conducting my daily duties, asked to participate in an interview or focus group discussion which will be taped or notes taken.

I understand that my participation in this research is voluntary. I am free to decline to participate and I am free to withdraw from the research or withdraw my data at any time. My refusal to participate or withdrawal of consent will not affect my relationship with my employer or my relationship with the University of Wollongong.

I have been advised of the potential risks and burdens associated with this research and have had an opportunity to ask the research team any questions I may have about the research and my participation.

If I have any enquiries about the research, I can contact Dr Ping Yu, Tel: 02 42215412, at the University of Wollongong. If I have any concerns or complaints regarding the way the research is or has been conducted, I can contact the Complaints Officer, Human Research Ethics Committee, University of Wollongong on 02 42214457, email: rsi-ethics@uow.edu.au.

I, _____, consent to participate in the self-administered observational study, interview or focus group for the project entitled "Battling the challenges of continuous training of nursing staff members to use clinical IT systems through self-management of cognitive load" led by Dr Ping Yu as it has been described to me in the information sheet and in discussion with the research team.

I understand that the confidential data collected from my participation will be used for thesis writing and publication. I consent for it to be used in that manner.

Signed ..... Date ...../...../.....

Appendix D

Information sheet

University of Wollongong 

Research Project: Factors affecting nursing staff's use of nursing information systems in residential aged care homes

Participant Information Sheet

You are invited to participate in this research project being undertaken by the University of Wollongong, in collaboration with Warrigal Care.

Aims of the research: 1. An investigation into challenges that nursing staff members face in learning to use clinical IT systems. 2. Assess factors that either increase or decrease cognitive load for caregivers to interact with computers in nursing homes. 3. Developing training strategies and materials that will facilitate caregivers to learn to use clinical IT systems.

The research objectives:

- Theoretically interpret the processes nursing staff members take to learn clinical IT applications.
- According to the learning processes, design the best training strategy mode of delivery, pace of delivery that will facilitate nursing staff members learn to use a clinical IT system.
- Identify factors that affect the continuous training and self management of cognitive load for nursing staff members.

Demands on participants: If you agree to participate, you will be asked to participate in observational study for which your interaction with computers may be observed by a researcher. The observational process would involve the researchers observing you interacting with the electronic documentation system NIS. You will be encouraged to think aloud (saying out loud what you are thinking when interacting with NIS) when you enter information in NIS. The duration of the observations is 60 minutes or less per day during care staff members' interaction with NIS. Observation will be conducted 2 or 3 days a week over 4 months. You may also be interviewed or be asked to participate in a focus group discussion or questionnaire survey for approximately 15 to 30 minutes. The conversation may be taped / notes being taken. The action of returning the questionnaire form without signing consent is seen as an indication of agreement to participate in the study. There is likelihood of researchers requesting you participate in training of NIS. You will be expected to participate in the study for three (3) years.

Sample statements and questions: In the questionnaire survey, you will be asked to circle the number on the descriptive scale for statements such as:

- When did you start to use NIS? Can you describe your experience with NIS? From your experience, is NIS used well? Are there any changes in work practices that are brought about by using NIS compared with the paper-based documentation?

The questions to be asked in the interview or focus group include:

- "Which aspects of the system were you most happy with and why? What are the difficulties that you have encountered in learning to use the software? What lessons can be learned from implementing NIS in your home? If you were to do it again, what would you do differently?

Possible risks and inconvenience: Apart from the time involved, the study poses minimal inconvenience or risk to the participants. Your involvement is voluntary and you may withdraw your participation and data at any time. You have the right to choose to participate in the study anonymously or to give your identifiable information (name). Your identification information will allow the researchers to track the change of your responses at different data collection points. This identification information will be kept separately from the data used for analysis, on password protected computers. The documents and recordings generated from the study will be securely locked in a file cabinet in the researchers' work place. The researchers guarantee that these documents and recordings are safe from exposure to people outside the research team.

Ethics review and complaints: This study has been approved by the Human Research Ethics Committee of the University of Wollongong. Any questions you may have concerning the research and procedures will be welcomed and answered by the researchers. If you would like to discuss this research further, please contact the Chief Investigator, Dr Ping Yu, on 02 4221 5412, ping@uow.edu.au. If you have any concerns or complaints about the ethical conduct of this research, please contact the Ethics Officer, University of Wollongong on 42214457.

Thank you for your interest in this research project.

Appendix E

Ethics approval

University of Wollongong

AMENDMENT APPROVAL
In reply please quote: HE08/263
Further Enquiries Phone: 4221 3386
MR:SH

19 April 2012

Dr Ping Yu
School of Information Systems and Technology
Faculty of Informatics

Dear Dr Yu

I am pleased to advise that the amendment requested to the following Human Research Ethics application has been approved.

Ethics Number:	HE08/263
Project Title:	Introducing computer-based documentation to Residential Aged Care: a multi-method evaluation of success
Researchers:	Dr Ping Yu, Mr David Hailey, Ms Esther Munyisia, Mr Ning Wang, Mr Zhenyu Zhang, Dr Karin Garrety, Mr Kieren Diment, Professor Mary Barrett, Yiting Zhang, Siyu Qian, Malatsi Galani, Dr Madeline Cincotta
Amendments:	iCare Training and Computer Experience Questionnaire
Approval Date:	25 September 2011
Expiry Date:	24 September 2012

Please remember that in addition to reporting proposed changes to your research protocol the HREC requires that researchers immediately report:

- serious or unexpected adverse effects on participants
- unforseen events that might affect continued ethical acceptability of the project.

The University of Wollongong/ Illawarra and Shoalhaven Local Health Network District (ISLHD) Social Science HREC is constituted and functions in accordance with the NHMRC National Statement on Ethical Conduct in Human Research.

A condition of approval by the HREC is the submission of a progress report annually and a final report on completion of your project. The progress report template is available at http://www.uow.edu.au/research/rso/ethics/UOW009385.html. This report must be completed, signed by the appropriate Head of School and returned to the Research Services Office prior to the expiry date.

If you have any queries regarding the HREC review process, please contact the Ethics Unit on phone 4221 3386 or email rso-ethics@uow.edu.au.

Yours sincerely

A/Professor Garry Hoban
Chair, Social Sciences
Human Research Ethics Committee

Research Services Office University of Wollongong NSW 2522 Australia
Telephone +61 2 4221 3386 Facsimilie +61 2 4221 4338
research_services@uow.edu.au www.uow.edu.au/research

Appendix F

Simple task

Test: Participant Name: .....

Your current position: .....

Observer: .....

Time: .....

NIS: http://icare/

Before opening the online nursing documentation system

- iCare version used: .....

Please complete the following tasks step by step. Consult any help menu or training manual if you get stuck. We will be asking you to 'Think Out Loud' – explaining what you think about, what you are seeing and doing to help us understand what you are thinking about as you perform these tasks.

It will require 10-20 minutes to complete these tasks. When you have finished, please complete all the questionnaires provided.

Everyday Tasks
Scenario 1 Log into NIS, enter the Progress Note for Ms Pamela Lissett on what happened to her in the shift as described below. You are requested to type in all the necessary information based on your knowledge of nursing care knowledge and observation. Pamela had an episode of hypoglycaemia during this shift. At about 5.00 pm, a nursing staff member reported that Pamela looked drowsy when being attended to while having her dinner in the lounge. An immediate assessment of Pamela was conducted: Pamela was alert, sitting in her chair, looked pale and her skin was clammy. A glass of milk was offered and taken by her. Pamela had a moderate amount of her drink when the condition improved. RN was informed to review the resident. Pamela was monitored for vital signs and any changes with her condition to be recorded.

Appendix G

Complex task

Test: Participant Name: .....

Your current position: .....

Observer: .....

Time: .....

NIS: http://icare-training/

Before opening the online nursing documentation system

- iCare training version used: .....

Please complete the following tasks step by step. Consult any help menu or training manual if you get stuck. We will be asking you to 'Think Out Loud' – explaining what you think about, what you are seeing and doing to help us understand what you are thinking about as you performing these tasks. Please read carefully the scenario provided below. After 3 minutes the scenario will be taken away. You are then expected to complete the tasks based on the scenario you just read.

It will require 8-10 minutes to complete these tasks. When you have finished, please complete all the questionnaires provided.

Everyday Tasks
Scenario 2 In your day shift you are part of the nursing staff assigned to perform additional rounds for 86-year old Ms Joyce Thomas. Ms Thomas is identified as having a high risk of fall due to low mobility. Your team leader assigns you to provide close supervision for Ms Thomas (1:1 care). During the shift you briefly left her alone to complete another nursing task. You hear a loud bang and you quickly return, only to find that Ms Thomas has fallen off the bed. She cannot stand on her own. You ask Ms Thomas, what happened and she stated she fell off the bed. Ms Thomas has sustained minor injuries including minor laceration and skin tear to her left arm and a hematoma causing small swelling to the forehead. Your task: Document this fall incident into NIS. Complete the progress note, if necessary, to record any additional information on what happened. Describe the severity of the injuries, the resident status after the incident, how you treated it, how you got the resident back in bed, note any new interventions needed to prevent recurrence of this type of fall incident, inform the resident doctor and family on the required form/s. Follow the required documentation procedures based on your investigation of this incident.

Appendix H

Coding test – A sample of the initial code testing showing the results of the researcher and the two researchers

PY	WT	Phrase	Researcher
Training needs	Training	Yes, training definitely met my needs. Because I think the others would get on the computer at home and play, and do all sorts of things…	Training needs
Training Improvement	Training improvement	No, when I reflect back, I do not think there is anything that we would have done differently in training staff	Training improvement
Training strategy	Training strategy/ Training timetabling	Yes, I was one of the EHR trainers and I attend the five day training by vendor people	Training strategy
Training timetabling	Training timetabling	The training and support was organised pretty good, although I like I said I do not think had much to do with it. I have noticed people saying there are going off the floor and going to training that kind of thing	Training timetabling
Training improvement	Training improvement	I sort of felt that perhaps maybe they should have perhaps been trained as a separate unit. That is just my opinion. A couple of the days I thought we were doing stuff that I felt I had never likely to be probably going into anyway.	Training improvement
Training strategy	Training strategy/ Training timetabling	Well, the trainer Dylan is trying to organise everyone to train, but I have not trained anyone yet. I am one of those trained as trainer. It has been good though we been getting everyone off the floor and getting them trained. So it is good.	Training strategy
Training timetabling	Training timetabling	Yes had them with Dylan and I just remembered last week I went to Sydney where we had the training with EHR people. It was about the new module on occupancy and some changes with charts and forms.	Training timetabling
Training timetabling	Training timetabling	Well we had like probably 6 different days, probably half a dozen different days where they train people that they got to train us. They would have specific days half an hour allotments for us staff so that is how we would learn. Tomorrow I have never done care plans on the computer so I have a meeting with Dylan tomorrow for two hours and he is going to show me how to do that.	Training timetabling

Appendix I

Coding test after discussion of the themes/categories with other researchers

PY	WT	Phrase	Researcher
Training needs	Training needs	Yes, training definitely met my needs. Because I think the others would get on the computer at home and play, and do all sorts of things…	Training needs
Suggested Training Improvement	Suggested Training improvement	No, when I reflect back, I do not think there is anything that we would have done differently in training staff	Suggested Training improvement
Training strategy	Training strategy	Yes, I was one of the EHR trainers and I attend the five day training by vendor people	Training strategy
Training timetabling	Training timetabling	The training and support was organised pretty good, although I like I said I do not think had much to do with it. I have noticed people saying there are going off the floor and going to training that kind of thing	Training and support
Suggested Training improvement	Suggested Training improvement	I sort of felt that perhaps maybe they should have perhaps been trained as a separate unit. That is just my opinion. A couple of the days I thought we were doing stuff that I felt I had never likely to be probably going into anyway.	Suggested Training improvement
Training strategy	Training strategy	Well, the trainer Dylan is trying to organise everyone to train, but I have not trained anyone yet. I am one of those trained as trainer. It has been good though we been getting everyone off the floor and getting them trained. So it is good.	Training strategy
Training timetabling	Training timetabling	Yes had them with Dylan and I just remembered last week I went to Sydney where we had the training with EHR people. It was about the new module on occupancy and some changes with charts and forms.	Training timetabling
Training timetabling	Training timetabling	Well we had like probably 6 different days, probably half a dozen different days where they train people that they got to train us. They would have specific days half an hour allotments for us staff so that is how we would learn. Tomorrow I have never done care plans on the computer so I have a meeting with Dylan tomorrow for two hours and he is going to show me how to do that.	Training timetabling