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Chemistry Experiences of First-Year Nursing Students: The Interplay of Self-Efficacy, Anxiety, Prior Chemistry Experience and Academic Performance - A Mixed Method Approach

Kerrie Boddey
Avondale College of Higher Education, kerrie.boddey@avondale.edu.au

Chemistry experiences of first-year nursing students: The interplay of self-efficacy, anxiety, prior chemistry experience and academic performance – a mixed method approach

Kerrie Ann Boddey

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Statement of Original Authorship

I, Kerrie Boddey, hereby declare that

- this thesis is my own work
- all persons consulted, and all assistance rendered are fully acknowledged
- all references used are indicated in the text and accurately reported in the listed references
- the substance of this thesis has not been presented, in whole, or part by me to any other institution for a degree.

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Acknowledgements

Firstly, I want to acknowledge God as the source of all good things, the giver of talents and abilities, and whose incredible love has sustained me throughout the ups and downs of the research process.

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This thesis is dedicated to all of you.

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ABSTRACT

Previous research has established that students with a limited science background find chemistry difficult, with many nursing students experiencing anxiety and a lack of confidence when faced with studying chemistry as part of their degree. One strategy employed by the institution where this research was conducted to help alleviate stress and build confidence in students with a poor chemistry background has been to offer a non-compulsory, 3-day chemistry bridging course prior to the beginning of the semester.

With Social Cognitive Theory and Cognitive Load Theory acting as a theoretical framework and employing a mixed method approach operating within a pragmatic paradigm, the purpose of this research was to investigate the chemistry experiences of first-year nursing students enrolled in a chemistry course in order to determine relationships between the key variables of self-efficacy, anxiety, prior chemistry experience, perceptions of chemistry and academic performance. The effectiveness of a 3-day chemistry bridging course was examined in light of these findings.

A pilot study was conducted to develop appropriate chemistry self-efficacy and anxiety instruments. In the first phase of the predominantly explanatory sequential design of the main study, quantitative data (N=101) from the Chemistry for Nurses Self-efficacy Scale (CNSS) and Chemistry for Nurses Anxiety Scale (CNAS) obtained at the beginning and end of the chemistry component of Health Science I and qualitative data in the form of focus group interviews based on prior chemistry experience (N=27) were collected in parallel. During phase two, individual interviewees (N=6) reflected on the integrated findings from Phase 1.

Factor analysis revealed four chemistry dimensions: cognitive self-efficacy (CS), laboratory self-efficacy (LS), test anxiety (TA), and laboratory anxiety (LA). The laboratory dimensions and demographic variables proved to be of little predictive use, but significant correlations were found between CS, TA, prior chemistry experience, perceptions of chemistry and academic performance. t-tests showed an increase in CS and enjoyment for all academic performance and prior chemistry experience groups as a result of studying chemistry in Health Science I. Further, TA decreased for the total cohort. Hierarchical regression showed that CS and TA measured at the end of the course accounted for an additional 20.4% of the variance in academic performance after controlling for cognitive capacity and prior knowledge. A path model for academic performance was derived. In addition, themes of 'connectivity', 'reductivity' and 'reflexivity' emerged from the qualitative data, giving rise to a dynamic and interactive model for 'learning and academic performance' in chemistry. The 3-day bridging course was shown to be successful in raising CS due to the acquisition of foundation knowledge allowing participants to begin the semester at a level comparable with students who studied senior chemistry. Benefits in academic performance were noted for bridging course attendees when the distribution of scores in the low, average and high achievement groups was examined.

These findings have implications for chemistry educators, particularly of the novice student, and recommendations for implementation are made.

1 INTRODUCTION

This research project aims to investigate the chemistry experiences of first-year nursing students at a private Australian higher education institution from 2010 to 2012. As a lecturer in this field over a number of years, it became apparent to me that there existed a spectrum of confidence and anxiety levels with respect to chemistry, some of which appeared to impede academic success. A variety of perceptions amongst nursing students about the learning of chemistry, including its relevance to nursing, has always challenged the lecturers presenting this subject to nurses.

Two significant and recurring issues are noted in the nursing education literature in relation to science: generally, many students find science too difficult to understand, and many fail to recognise the relevance of science study to nursing. This appears to be particularly true of chemistry. It is from these perspectives, along with my interest in developing the chemistry curriculum for nurse education, that this study evolved.

This chapter begins with a brief history of chemistry in nurse education in this institution followed by an introduction to those factors selected for investigation. Research questions are stated and the significance and nature of the inquiry are outlined. The definitions of key terms used in this thesis are provided and the chapter concludes with an outline of the organisation of the thesis.

1.1 Background to Physical Science Education in Nursing at an Australian Higher Education Institution

Prior to 1974, nursing education in Australia involved hospital-based training programs supervised by senior nurses (Russell, 1990), a direction developed from the Nightingale school of thought (Parker, 2006). Nurses exemplified “the feminine ideal” (Parker, 2006, p. 40). The transition of nurse education to Higher Education institutions began around 1974 (Caon & Treagust, 1993) in response to increases in scientific knowledge and technological advancement (Cree & Rischmiller, 2001). Levels of responsibility with respect to patient care increased, with nurses being more autonomous in decision-making (Friedel & Treagust, 2005). Nursing as an independent discipline of study emerged along with its own scientific and professional base (Parker, 2006). The need for a common knowledge foundation became evident as nurses became a key part of multidisciplinary teamwork (Fenton, 2010). In 1984, the federal government recommended a full transfer from the hospital-based system to the tertiary sector (Russell, 1990) where all undergraduate nurse education currently occurs (Sellers & Deans, 1999).

In conjunction with a city private hospital, the institution commenced a 3-year 'Diploma of Applied Science (Nursing)' in July, 1980. First semester classes were taught on the rural campus, with subsequent classes conducted on the city hospital campus. The 'Bachelor of Nursing' degree has been offered since 1991.

The depth of content, delivery and relevance of undergraduate science education for nurses has evoked much debate, not only in Australia, but world-wide (Fenton, 2010; Jordan, Davies, & Green, 1999; Thornton, 1997; Wilkes & Batts, 1998), especially in the area of physical science (chemistry and physics) with many nursing staff, particularly staff with non-bioscience degrees, claiming that too much time is allocated to the teaching of science (Davies, Murphy, & Jordan, 2000). Additionally, numerous researchers point out the disproportionate difficulty of the science subjects in a nursing course (Caon & Treagust, 1993; Davies, et al., 2000; Jordan, et al., 1999; Nicoll & Butler, 1996; Whyte, Madigan, & Drinkwater, 2011), particularly chemistry (Caon & Treagust, 1993; Fenton, 2010). The objections raised about bioscience are exacerbated with physical science. While most curriculum developers recognise the need for a foundation in physical science in nursing education (Wilkes & Batts, 1998), they have struggled with the selection of what constitutes 'appropriate content' for inclusion. In fact, the struggle over science in curriculum design can be "fraught with power conflicts and subject to personal influences and perceptions" (Fenton, 2010, p. 276). After classifying nursing activities on the ward, Wilkes (1992) concluded that, at the very least, a fundamental understanding of chemistry and physics was required for effective nursing practice. Fenton (2010) also concluded that the fundamental knowledge and skills afforded by science, including an awareness of basic chemistry, are required to support clinical decision-making.

The institution at which this project was conducted has, in the past, considered physical science to be a crucial component of nurse education. In 1980, 'Physical Science' was introduced as part of the inaugural first semester program to provide what was considered fundamental principles of chemistry and physics. The unit was taught by staff from the Faculty of Science and senior school chemistry was assumed knowledge. Therefore, a 5-day bridging course was made compulsory for those students without the necessary prerequisite. In response to the introduction of the degree program, the unit was later reviewed and renamed 'Biophysical Bases of Health Care IB'. In 2002, the physics component was removed from the first semester program and replaced by microbiology. This was due to pressure from nursing authorities to reduce student exposure to physical science in a first semester course of study. The subject was then renamed Health Science I.

The chemistry component remained relatively unchanged until semester 2, 2008. At this time, the subject was offered on the city campus without providing the opportunity for students to complete a bridging course. Consequently, the curriculum for Health Science I was modified to accommodate this possible lack of chemistry background knowledge and discussion relating to the viability of continuing with the compulsory bridging course resulted. In keeping with other universities, the 2009 bridging course was reduced to 3 days and was listed as highly recommended, but not compulsory, for those without senior chemistry.

An examination of the first-year content of nursing degree programs in Australia indicates that relatively few institutions currently allocate significant course time to chemistry. The institution at which this study took place is shortly to fall in line with this trend by eliminating a specific chemistry component.

1.2 Course Description

1.2.1 Health Science I

Chemistry made up approximately 60% of the unit, the remainder being microbiology. Health Science I is a core unit taught in the first semester of the degree program and all students taking this unit were enrolled in either the Bachelor of Nursing degree or the Diploma of General Studies with a view to entering the degree program.

The chemistry component of Health Science I was delivered face-to-face in the first part of the semester, consisting of 20 lectures, seven tutorials and 4 two-hour laboratory sessions over a period of 7 weeks. Topics covered included basic atomic structure and ion formation, writing chemical formulae, ionic and covalent bonding, basic organic molecules and polarity, solutions (including concentration, diffusion and osmosis), acids and bases, equilibrium and buffers, biomolecules and reaction rates. There was no prerequisite for the unit so no prior chemistry knowledge was assumed in the presentation of lectures. A schedule for this unit can be found in Appendix 1.

The depth of chemistry material covered in Health Science I is atypical of most Australian nursing degrees where generally, a small number of chemistry lectures are included as part of a bioscience component in the first semester of study.

1.2.2 The Bridging Course

The bridging course was intended to improve self-efficacy and reduce anxiety by providing nursing students with an elementary factual and conceptual base of chemistry through addressing the most significant source of self-efficacy – mastery learning. Designed for students who have not taken chemistry in senior high school, it introduced principles necessary to solve simple chemical problems and gave participants a brief introduction to the laboratory and the opportunity of working collaboratively in both laboratory experiences and tutorial sessions. All content from the bridging course was repeated in Health Science I but at a faster presentation pace. The 3-day course was conducted in the week prior to the start of semester 1. It comprised of seven, 50-minute lectures each followed by a 50-minute tutorial where students worked through exercises related to the preceding lecture material. In addition, an 80-minute laboratory session designed to familiarise students with the safe use of chemicals and equipment was conducted on the second and third days. A schedule for the bridging course can be found in Appendix 2.

1.3 Factors Selected for Investigation

It has been mentioned that many chemistry educators and researchers note that chemistry is widely perceived as being difficult (Abendroth & Friedman, 1983; Billington, Smith, Karousos, Cowham, & Davis, 2008; A. H. Johnstone, 2000; McCarthy & Widanski, 2009), and particularly so for nursing students with a non-science background (Davies, et al., 2000; Dori, 1994; Fenton, 2010).

Many non-cognitive variables have been identified in the literature as impacting academic performance. Two have been selected for this study: chemistry self-efficacy (the belief one has in one's ability to perform a given task) and anxiety. Research has identified self-efficacy as a pivotal, non-cognitive construct influencing engagement and achievement in science at the tertiary level. Anecdotal evidence from observing Health Science I students indicated that students without some prior experience in chemistry struggled with the content of Health Science I and experienced significant levels of anxiety. Indeed, Udo, Ramsey and Mallow (2004) found acute levels of science anxiety amongst nursing students. Anxiety towards chemistry causes disinterest in the subject (Kurbanoglu & Akin, 2010) which can influence academic performance. Furthermore, both the literature and personal experience indicates a significant disparity in the chemistry background, levels of anxiety and self-efficacy and attitude towards the subject in a typical first-year intake of nursing students. Having been involved in the design of the 3-day Chemistry Bridging Course and subsequent curriculum modifications to Health Science I, I was interested in exploring the potential of the bridging course to reduce the 'prior chemistry experience' gulf, enhance chemistry self-efficacy and reduce chemistry anxiety.

1.4 Purpose and Associated Research Questions

The purpose of this study was to develop, trial and administer a chemistry self-efficacy and anxiety instrument for a cohort of nursing students in a health science course. Along with data from focus group and individual interviews, it was planned to determine what factors influenced chemistry self-efficacy and anxiety. The purpose also included an examination of how self-efficacy, anxiety and prior chemistry experience might impact academic performance. The effectiveness of a 3-day bridging course was examined in the light of these findings.

The following research questions guided the investigation.

1. What role do demographic variables play in self-efficacy, anxiety and academic performance?
2. How does self-efficacy, anxiety and student perceptions of chemistry change over the course of the semester?
3. What relationships can be established between self-efficacy, anxiety, prior chemistry experience and academic performance?
4. To what extent has a 3-day bridging course been beneficial to nursing students studying Health Science I?

1.5 Significance of the Inquiry

As noted, previous research has established that students with a non-science background find chemistry difficult. With a significant number of nursing students reporting no experience in chemistry past Year 10, this investigation will provide a voice for those who struggle through the chemistry component of Health Science I. This study will focus on the investigation of the specific constructs of chemistry self-efficacy and chemistry anxiety in a nursing education course, distinguishing it from other related studies reported in the literature.

While several studies have considered self-efficacy, anxiety and chemistry background, the interplay of these factors has not been investigated in a cohort of first-year nursing students. Therefore, research into the interaction of these cognitive and non-cognitive variables over the chemistry component of the first semester course should add to the knowledge of science educators in the nursing sphere. This research should provide insight for educators into the perceptions of first-year students and contribute to discussions concerning not only course curriculum, but the way in which chemistry is taught, particularly to the novice student. In turn, improved practices should impact motivation and subsequent achievement levels of nursing students.

Many universities conduct short science bridging courses before the commencement of the semester. This study provides evidence relating to the role played by such courses in supporting students with a poor chemistry background and describes strategies to improve their delivery.

1.6 Nature of the Inquiry

This study investigates the chemistry experiences of first-year nursing students in a small private tertiary institution with a proud heritage of nurse education. From a pragmatic paradigm, a sequential explanatory design has been chosen from the mixed method methodology where quantitative and qualitative data are collected in two phases. Firstly, quantitative data obtained from questionnaires will be used to present correlations between demographics, self-efficacy, anxiety, prior chemistry experience and academic performance. Focus group interviews will provide parallel qualitative data in this phase. In the second phase, qualitative and quantitative models derived from phase one data will be explored through individual interviews. As a result, a more comprehensive picture of the chemistry experiences of first-year nursing students can be built.

1.7 Definition of Terms

The following terms are used throughout this thesis and require definition.

- **Chemistry Self-efficacy**: "beliefs in one's capabilities to organise and execute a course of action required to produce given attainments" (Bandura, 1997, p. 3) in chemistry.
- **Chemistry Anxiety**: a fear of chemistry with respect to learning, assessment and laboratory procedures that may lead to problems in the construction and use of chemistry knowledge and skills (Britner & Pajares, 2006; Eddy, 2000).
- **Chemistry Bridging Course**: a 3-day chemistry workshop designed for students with poor chemistry background. The course consists of lectures, tutorials and laboratory exercises and is conducted in the week prior to the start of Semester 1.
- **Poor Chemistry Background (PC)**: students who have not studied chemistry beyond Year 10 (or equivalent) and did not complete the bridging course.
- **Bridging Course Chemistry (BC)**: students who have attended the 3-day bridging course. Generally, these students have not studied chemistry past Year 10. This group may contain some who have studied Year 11 Chemistry or mature-age students who have studied chemistry at the senior level some time in the past.
- **Senior Chemistry Background (SC)**: students who have studied chemistry in Years 11 or 12 and have not attended the bridging course.
- **Prior chemistry experience**: three levels have been defined in this study - PC, BC, and SC.

Additional definitions, abbreviations and acronyms used throughout this thesis can be found in the Glossary in Appendix 3.

1.8 Organisation of the Thesis

This chapter has provided a brief background to the place of chemistry in the Bachelor of Nursing program at the institution where the investigation was conducted, along with the purpose and research questions. Chapter 2 outlines two key theoretical perspectives that underpin chemistry education before reviewing the literature on self-efficacy, anxiety, academic performance, some perceptions of chemistry and bridging courses. Chapter 3 presents the pragmatic paradigm framing this inquiry and the mixed method methodology used to conduct this research. It details the development of instruments used to measure self-efficacy and anxiety and outlines the methods employed to collect both quantitative and qualitative data. In chapter 4, techniques for the analysis of the quantitative data are described, along with the themes and model that emerged from the analysis of interview data. Issues associated with data evaluation are also considered.

Chapters 5, 6 and 7 each describe specific results and present an integrated discussion of quantitative and qualitative aspects of self-efficacy, anxiety and academic performance respectively. Conclusions from each chapter are made in light of the four research questions. Chapter 8 considers other pertinent aspects of the bridging course, allowing Research Question Four to be addressed more completely. Chapter 9 concludes the thesis by reviewing the unique findings of this inquiry, making recommendations for pedagogical practice, outlining the limitations of the research and suggesting directions for future research.

2 LITERATURE REVIEW

This section begins with an examination of two key theoretical perspectives concerning the main constructs under consideration involved in learning chemistry: Cognitive Load Theory and Social Cognitive Theory. This is followed by a review of the literature that describes key cognitive and non-cognitive components that may impact academic performance for a cohort of first-year nursing students in chemistry, in particular, self-efficacy, anxiety, prior chemistry experience, bridging course attendance, some perceptions of chemistry and selected demographic variables. The paucity of studies conducted in chemistry education in nursing means it is necessary to consider relevant research findings in other areas of tertiary education, such as other academic areas of nursing outside physical science, general chemistry courses, and tertiary studies in other areas of science. Analysis of the literature is largely confined to the tertiary setting, but pertinent studies of science in the high school setting are alluded to in the review where appropriate.

An inherent problem associated with a review of literature relating to self-efficacy, anxiety and academic performance is the varied definitions of these terms and methods employed to measure them. Differences in the definitions of self-efficacy and anxiety are considered in the following literature review but the problems associated with their measurement are addressed in the methodology section of Chapter 3. Interpreting the results of studies relating to academic performance can also prove difficult because of the different criterion measures used. For example, achievement may be based on results from a particular subject or all subjects. This may have been conducted over a whole course, part of a course or just one semester. It may have involved grades or marks, progression to the next semester or even completion of a degree program. The way in which grades are determined will also vary enormously based on institution and discipline. In addition, Dalgety, Coll and Jones (2003) point out that achievement is a subjective term, where 60% could represent a good or bad result, depending on ability. Therefore, where possible, the nature of the academic performance studied in the literature will be identified.

2.1 Theoretical Perspectives of Learning

2.1.1 Cognitive Load Theory

Cognitive load theory (CLT) has become very influential in educational psychology over the last two decades, with research confirming its validity and usefulness in implementing effective instructional design (de Jong, 2010; Paas, van Gog, & Sweller, 2010). It relates memory characteristics with instructional effectiveness, taking into account both the characteristics of the information and of the learner (van Merriënboer & Sweller, 2005). The theory is concerned with the "learning of complex tasks, in which learners are often overwhelmed by the number of interactive information elements that need to be processed simultaneously before meaningful learning can commence" (Paas, et al., 2010, p. 116). Based on this theory, there are two key components of human cognitive architecture: long term memory (LTM) and working memory (WM).

Long-term memory (LTM) is essentially unlimited and stores huge amounts of acquired information as structured schemata. Expertise is built as a consequence of two processes. Firstly, schemata become more complex as a result of the combination of lower level schemata. Secondly, extensive practice leads to the development of automaticity. Note that an expert does not necessarily possess superior general problem solving skills but rather has access to a complex schema (Sweller, van Merriënboer, & Paas, 1998; van Merriënboer & Sweller, 2005). The processes by which knowledge can be structured to allow this to occur are central to the theory and inform teaching practice.

Unlike LTM, working memory (formally known as 'short term memory') is limited in both capacity (storing 7±2 elements known as 'chunks', processing 2-4 ±1 elements) and duration (unrefreshed < 20-30s), particularly for the novice (Paas, et al., 2010; van Merriënboer & Sweller, 2005) and carries out two main functions: it holds both task-relevant and irrelevant information and processes information either prior to entering, or as it is retrieved from, the LTM. As such, it can be thought of as a 'thinking-holding space' (A. H. Johnstone, 1997). In educational terms, "it is where the learner thinks, understands, makes sense of information, and solves problems" (Reid, 2009, p. 132). As new elements are taken in, the number of possible combinations when trying to organise the information increases exponentially (van Merriënboer & Sweller, 2005). WM limitations do not exist when processing cognitive schemata retrieved from the LTM because even a highly complex schema will be treated as one element in the WM. Consequently, these limitations apply in particular to new information and as such, the implications for learning cannot be overestimated (Sweller, et al., 1998). The premise of CLT is that "learning is hampered when working memory capacity is exceeded in a learning task" (de Jong, 2010, p. 106). This is referred to as cognitive overload, leaving learners overwhelmed by the number of elements that must be processed simultaneously (Paas, et al., 2010) affecting learning (Reid, 2008).

Three sources of cognitive load which affect working memory are considered in this theory. Firstly, *intrinsic cognitive load* is attributed to the inherent complexity of the task. It is dependent on the degree of simultaneous element interactivity, with high levels difficult to understand because of problems in developing cognitive schema (Paas, et al., 2010; van Merriënboer & Sweller, 2005).

Secondly, *extraneous cognitive load* results from the interaction of the learner with the instructional environment. Poor pedagogy and irrelevant material divert WM space from schema acquisition. Consequently, "carefully considered instructional design is particularly important when teaching difficult subject matter" (van Merriënboer & Sweller, 2005, p. 151) and where time and cognitive capacity are limited (Paas, 1992). For example, guided instruction procedures, including the use of worked examples, have been shown to be more effective for novice science students than unguided procedures such as inquiry learning (P. A. Kirschner, Sweller, & Clark, 2006). Other studies in science have demonstrated that when teaching materials are designed to lower WM demand, attitudes to studying science improve (El-Farargy, 2009) and academic performance increases (Chu, 2008; Danili & Reid, 2004; Hussein & Reid, 2009). The mental effort required (i.e. "the amount of capacity that is allocated to the instructional demands" (Paas, 1992, p. 429)) to overcome poor instruction is a consequence of extraneous cognitive load.

Finally, *germane cognitive load* is produced by the learner's efforts to process, interpret and construct information in an attempt to make meaning and produce schemata, that is, it considers resources required to deal with cognitive load. Jung and Reid (2009) have demonstrated that science students with a high WM capacity will attempt to understand science concepts whereas those with low WM capacity rely on rote learning of knowledge.

Principles for instructional processes emerge from these three sources of cognitive load: prior knowledge should be considered (intrinsic load), extraneous information should be avoided (lower extraneous load) and pedagogical techniques that allow for deep knowledge should be applied (increase germane load) (de Jong, 2010; Paas, et al., 2010).

Information Processing Model

It has been suggested that elements of the working memory framework could prove fruitful for science education (Niaz & Logie, 1993). In an attempt to give direction to chemical education research, Johnstone (1997) developed a model based on cognitive load theory which incorporates the frameworks of Ausubel and Piaget (El-Farargy, 2009), noting that the most important factor in learning is prior knowledge (A. H. Johnstone, 2006). Johnstone named his model The Information Processing Model (IPM) and it has been used to explain a number of research findings in science and, more particularly, in chemistry education (reviewed in St Clair-Thompson, Overton, & Botton, 2010). Johnstone has demonstrated both its explanatory and predictive power (A. H. Johnstone, 2006), with St Clair-Thompson, Overton and Botton (2010, p. 141) concluding that the model "continues to provide a useful framework for integrating various cognitive variables that are related to education."

There are three key components to the IPM (see Figure 1). The working memory (referred to as the working memory space - WMS) and long term memory components are essentially the same as outlined in CLT. It incorporates a third component - the 'perception filter'. Since it is impossible to attend to all the incoming stimuli, it is filtered by what we already know and understand – prior knowledge, preferences (importance, interest) and beliefs (A. H. Johnstone, 1997, 2000). These experiences stored in the LTM act as a feedback loop and interact with the perception filter. The sieving process of an expert chemist and a novice will be very different because of the matrix of information that exists in the LTM. Filtered material can then enter the limited WMS where it is matched with what is known and either modified for storage in the LTM or rejected. As in CLT, there is an interaction between the WMS and LTM with information passed on for storage in the LTM and being retrieved to assist in processing in the WMS (A. H. Johnstone, 1997).

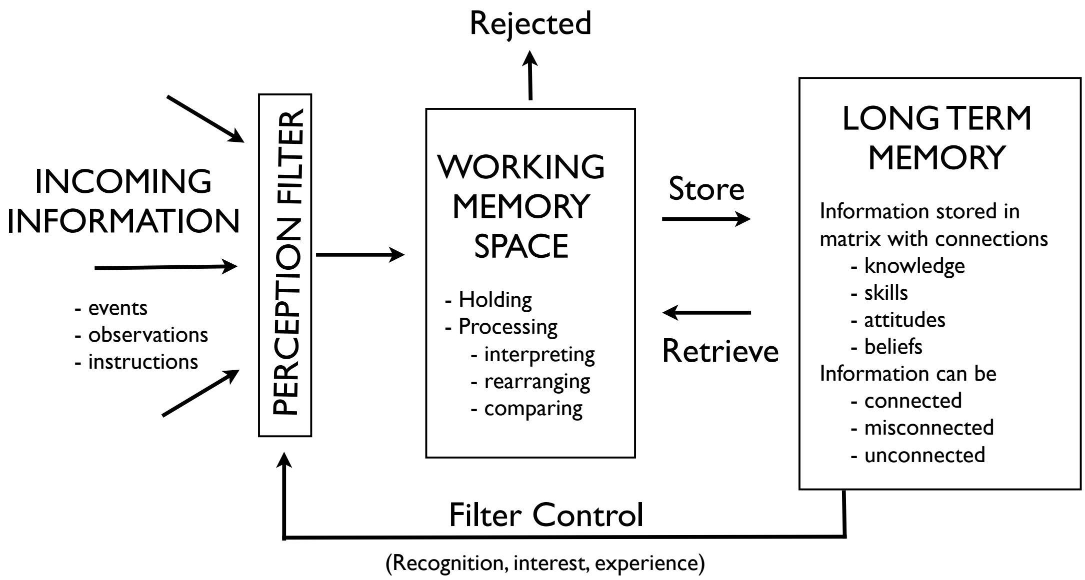

Figure 1. Information Processing Model: Adapted from Johnstone (2006), Johnstone & Selepeng (2001) and St Claire-Thompson et al. (2010)

Model of the Nature of Chemistry

Another paradigm developed by Johnstone is the notion that the nature and learning of chemistry is multi-levelled, consisting of three components: macro (tangible), sub-micro which is abstract (atoms, molecules, ions, structures) and representational (symbols, formulae, equations, mathematical manipulation and graphs) (A. H. Johnstone, 2000, 2006) (see Figure 2). These three levels represent significant problems for the novice learner, generally resulting in cognitive overload,

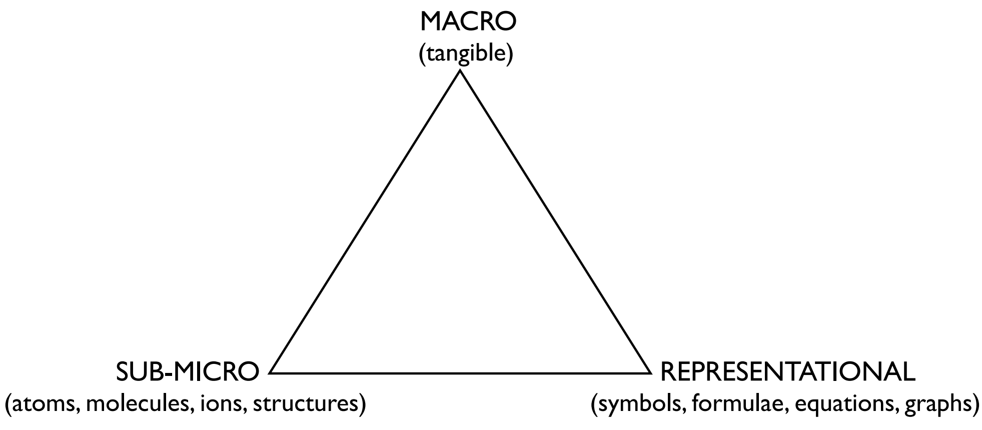

Figure 2. Model of the nature of chemistry - three conceptual levels (A. H. Johnstone, 2006)

making it difficult to make attachments to information in the LTM. While the experienced chemist is comfortable working at all levels simultaneously, this represents "the weakness of the subject when … beginners (students) try to learn it" (A. H. Johnstone, 2000, p. 11). Research has shown that the novice chemistry student experiences difficulty understanding the role and relationships between the conceptual levels, and that significant depth of understanding requires the simultaneous use of the levels (Chittleborough & Treagust, 2007; Treagust, Chittleborough, & Mamiala, 2003). The symbolic nature of chemistry poses significant problems for the novice (Chittleborough & Treagust, 2007; Marais & Jordaan, 2000) as does the unique language, which may appear alien (A. H. Johnstone & Selepeng, 2001; Logan & Angel, 2011; Ver Beek & Louters, 1991). These problems are further confounded when students attempt to make sense of the relationship between chemistry and their real world (Bodner, 1992).

Reid (2009) explains that the origin of much of the difficulty experienced in science is that, by its very nature, it is conceptual. In order for concept development to occur, much information must be held at the same time. Johnstone's model demonstrates that intrinsic cognitive load in chemistry is not only because it is more difficult than other learning domains, but because difficulty is enhanced due to the need for learners to change ontological categories (de Jong, 2010). Consequently, the novice chemistry learner is particularly prone to cognitive overload.

Cognitive Load Theory, the Information Processing Model and the Model of the Nature of Chemistry are largely concerned with the cognitive factors involved in learning, including prior chemistry knowledge. de Jong (2010) notes that even if intrinsic and extraneous loads are low, learning is not guaranteed. Indeed, Johnstone (2006) does not profess to deal with attitude and motivation in the IPM, both of which have been identified as important influences on learning, except for acknowledging their role as part of the perception filter. In order to appreciate the role that non-cognitive factors such as attitudes and beliefs play, an additional framework is required.

2.1.2 Social Cognitive Theory

Albert Bandura's Social Cognitive Theory (SCT) appeared in the late 1970s and was originally applied to phobias. It has since been used to explain behaviour in many fields including sport and the workplace and increasingly in education, particularly with respect to academic motivation (Pajares, 1996). According to SCT, "human agency [i.e. intentional acts] operates within a triadic interdependent causal structure" (Bandura, 1997, p. 6) where internal personal factors (cognitive, affective and biological), behaviour and environmental events have a bidirectional influence on each other, referred to as 'reciprocal causation', the relative strength of which will vary according to circumstances (see Figure 3). It may take time for the causal effect to be felt and there will be personal variation in the interpretation of, and reaction to, the three components. Consequently, individuals are proactive rather than simply reactive to environmental forces and are viewed as both products and producers of their environment. Through self-referent processing of social influences and accomplishments, individuals can exercise some control over their thoughts, feelings and actions. The extent of this control will depend on whether the environment is imposed, selected or created and how modifiable it is. In the context of education, teachers can assist students by acting on any of the triadic factors (Pajares, 2002).

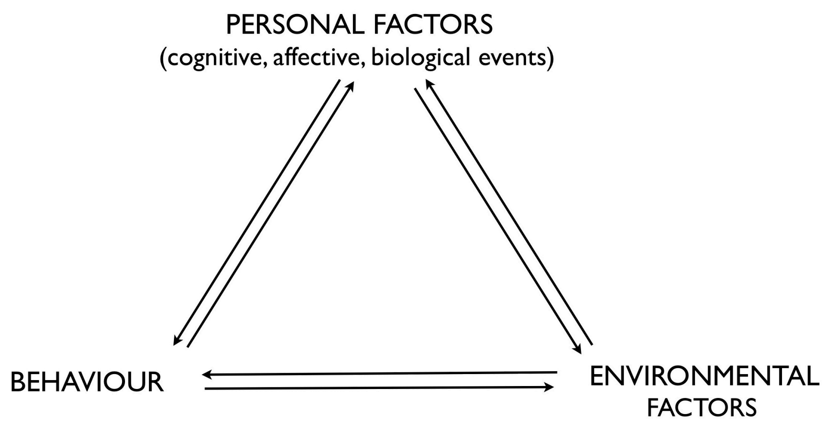

Figure 3. Relationship between the three major classes of determinants in Bandura's triadic reciprocality (Bandura, 1986, as cited in Bandura, 1997)

The Concept of Self-efficacy

People's judgments of their capabilities to exercise control over life events play a major role in determining behaviour. Self-efficacy, defined as the "beliefs in one's capabilities to organise and execute a course of action required to produce given attainments" (Bandura, 1997, p. 3), is embedded in social cognitive theory and plays a paramount role in how an individual will organise, create and manage the environment in order to bring about desired changes. Self-efficacy is the belief or confidence one has to successfully perform or complete a given behaviour. Note that it involves one's judgment about *capacity* to perform rather than *intention* to perform a given task. By definition, self-efficacy will be task-specific and this orientation has led to self-efficacy studies in general academic activities and in domain-specific activities such as science and mathematics. Self-efficacy influences the way an individual interprets environmental facts and in turn, exerts an effect on the environment.

Perceived self-efficacy will influence choices, effort expended, duration of perseverance, emotional reactions and accomplishment (Bandura, 1997). Bandura asserts that without belief in the power to achieve, a person will not make an attempt. A highly efficacious student will perceive difficult tasks as a challenge and remain relatively calm, set challenging goals, maintain commitment and effort in the face of adversity or failure, rebound from setbacks and attribute failure to insufficient effort or lack of acquirable skills. However, a highly efficacious student may show a lack of persistence if the task is perceived to be too easy (Salomon, 1984). In contrast, a student who lacks confidence in his/her ability to accomplish a challenging task will dwell on personal deficiencies, display low commitment, give up quickly, believe things are tougher than they really are, view failure as a deficiency in aptitude, be more susceptible to stress, anxiety and depression and simply try to avoid the task (Bandura, 1994; Pajares, 1996).

Self-efficacy is considered one of a series of constructs that motivate individuals. Various motivation theories, including attribution theory and expectancy-value theory, reinforce the widespread presumed influence of self-efficacy (Pajares, 1996). Schunk (1990) views self-efficacy and motivation as interacting mechanisms. A number of key components of motivational processes based on the social cognitive framework can be found in studies involved in the teaching and learning of science at the college level (Glynn & Koballa, 2006; Pintrich & De Groot, 1990; Zusho, Pintrich, & Coppola, 2003). Along with self-efficacy, a number of other constructs have been identified as playing a crucial role in motivation (Pintrich, 1994), including measurements of outcome expectancy, task value, goal orientation (learning vs performance), self-determination (perceived degree of control), origins of motivation (intrinsic vs extrinsic), interest, and anxiety.

Motivational beliefs influence, and are influenced by, contextual variables and each other. Behaviour is modified and in turn, influences beliefs (Bandura, 1997). The antecedents of self-efficacy as proposed by Bandura are now explored.

Sources of Self-efficacy

Bandura (1994, 1997), recognising that self-efficacy is responsive to changes, has hypothesised the existence of four antecedents of self-efficacy beliefs. He explains that it is the way information is interpreted through cognitive processing and reflective thought from these antecedents that is of significance. The most influential source is enactive *mastery experiences*. Successful experiences that come as a result of persistent effort will build robust self-efficacy resulting in participation in subsequent tasks. Failure undermines self-efficacy, particularly if a strong sense of self-efficacy has not yet been established. Judgment of perceived competence will be revised based on attainment in such a task. Mastery experiences provide the most authentic evidence of one's capabilities.

Secondly, self-efficacy can be affected by *vicarious experiences* provided by social models. Observing other individuals similar to oneself succeed in a task by sustained effort enhances the belief that one can also succeed in that task. Individuals assessed as being more capable than oneself are usually discounted as irrelevant. While this is a much weaker source of self-belief than mastery experiences, it can be very significant when there is limited prior experience and the role model possesses similar characteristics to the learner.

Self-efficacy beliefs are also informed by the *social persuasion* that occurs when a respected person considered credible and trustworthy, verbally or non-verbally persuades the student that they possess the capabilities to master the task. In an educational setting, teachers play a crucial role as credible persuaders in providing evaluative feedback in the form of encouragement and suggestions for improvement. As with vicarious experiences, this source will be more powerful if experience is limited.

Finally, *emotional and physiological states* contribute to self-efficacy. Feelings such as anxiety, stress, fatigue and mood that occur as a result of contemplation or engagement are interpreted in light of the complexity of the task and existing self-efficacy. It is not so much the strength of these reactions, but how they are perceived and interpreted that is important. Arousal may be viewed as energizing or debilitating depending on whether it is perceived as originating from a common reaction or personal inadequacies, facilitating judgments of confidence accordingly.

Hence, self-efficacy is not merely a "mechanical audit of one's performances," (Bandura, 1997, p. 81) but is also molded by socially-mediated experiences such as mastery experience, vicarious experience, social persuasion and emotional and physiological states. It is the cognitive processing of selection, interpretation, and integration of information through reflective thought that determines self-efficacy judgments. As such, judgments of personal efficacy can be used to assess instructional intervention along with differences between individuals and groups.

Self-efficacy and Related Constructs

While many theories of human behaviour contain self-referent thought processes, Bandura (1997) draws the distinction between personal efficacy and other closely related constructs such as self-esteem and self-concept. Indeed, terms such as self-concept, self-esteem, task-specific self-concept, self-concept of ability, expectancy beliefs, expectancy of success, performance expectancy, perceptions of competence, perceived ability, perceived control, and confidence are often equated with self-efficacy (Pajares, 1996). The most common confusion centres around self-concept and self-esteem.

Whereas self-efficacy is a judgment of capability, self-esteem and self-concept are judgments of worth based on social and self-comparisons, generally concerned with global self-images (Bandura, 1997, 2006; Pajares, 1996). Bandura (1997) contends there is little relationship between beliefs about one's capabilities and whether one likes oneself. For example, a person may not be efficacious in a given activity, but suffer no loss in self-esteem because little worth is invested in that activity. In addition, since these alternative conceptions cannot be task specific, they are not as predictive of behaviour as self-efficacy, having less influence on goal setting and the level of performance. As such, self-efficacy and self-concept represent different phenomena.

The confusion between self-efficacy and self-concept or self-esteem is further illustrated in a number of studies. For example, Lawson, Banks and Logvin (2007), in support of their conclusion that improving achievement by boosting self-efficacy is misplaced, quote Baumeister, Campbell, Druiegar and Vohs (2005). Examination of the latter article reveals the construct under examination is in fact self-esteem, not self-efficacy, with the authors drawing attention to the futility of efforts to increase academic performance by improving self-esteem, a notion supported by social cognitive theory. Lawson et al. appear to have inadvertently equated self-esteem with self-efficacy in this case, drawing invalid support for their findings. Similarly, Thomas, Iventosch and Rohwer (2008) appear to inappropriately use the term 'self-efficacy' in their research. Their definition encompasses self-concept with respect to academic ability, combining self-worth and locus of control. They used a modified version of the Self Concept of Academic Ability Test (SCAAT) to assess self-efficacy. This instrument was developed in 1967 by Brookover, Erickson and Joiner (1967, as cited in G. Thomas, et al., 2008) prior to Bandura's social cognitive theory and, as the name suggests, measures academic self-concept rather than self-efficacy. Self-efficacy is conceptually and psychometrically different from related constructs such as self-concept, and care must be exercised not only when assessing and interpreting research, but constructing instrument items to ensure they accurately reflect the construct.

2.1.3 Summary

By considering both Social Cognitive Theory and the Information Processing Model in the context of Cognitive Learning Theory, the interplay of self-efficacy, anxiety, prior chemistry experience and the academic performance of the individual in a social context can be considered. A review of the literature in each of these areas follows.

2.2 Self-Efficacy

The previous section examined self-efficacy in the context of Bandura's Social Cognitive Theory and other related constructs. The literature will now be examined to determine the relationships between self-efficacy and several other constructs relevant to this study. Instruments developed to measure self-efficacy are evaluated in Chapter 3in light of the theoretical perspectives previously discussed in Section 2.1.

2.2.1 Demographic Factors and Self-efficacy

The research linking the influence of gender and age with self-efficacy is inconsistent. In nursing studies, gender findings are hampered by the low numbers of male candidates which make generalizations statistically hazardous. An Australian study of over 500 first-year nursing students where 88% of the students were female (Harvey & McMurray, 1994), found no gender differences in either academic or clinical skill self-efficacy. Another Australian study (*N*=81) conducted by Andrew (1998) also found no gender differences using a comprehensive science in nursing self-efficacy instrument, except for the 'Physics Applied' factor where the 11 males had, on average, higher self-efficacy. This finding with respect to physics is supported by Cavallo, Rozman & Potter (2004) where males were found to have higher academic self-efficacy in a college physics course. Some studies have shown males to have higher self-efficacy in a first-year chemistry (Obrentz, 2011) and biology course (Glynn, Taasoobshirazi, & Brickman, 2009). Other studies at the college level indicate little gender bifurcation in self-efficacy in undergraduate science courses (Aydin, Uzuntiryaki, & Demirdogen, 2011; Lent, Brown, & Larkin, 1986; Smist, 1993; Witt-Rose, 2003) and for problem solving in chemistry (Taasoobshirazi & Glynn, 2009).

Few studies have considered the link between age and self-efficacy. Findings generally indicate that younger college students have higher academic self-efficacy (Ofori & Charlton, 2002; Zeegers, 2004). However, this is not supported by Witt-Rose (2003) who found no relationship between the age of 260 tertiary students and self-efficacy for anatomy and physiology.

2.2.2 Self-efficacy and Academic Performance

Bandura (1997) hypothesized that elevated self-efficacy would result in better academic performance because of elevated levels of effort and persistence. The link between self-efficacy and performance is a flourishing area of research and has been explored in a multitude of studies at all levels and in all domains. These studies have established that self-efficacy is a significant predictor of academic achievement (Pajares, 1996; Schunk, 1990).

In the field of nursing, there have been surprisingly few studies investigating self-efficacy and academic performance and none have been found specifically in chemistry. However, in a cohort of Australian nurses (*N*=81) studying physical science, Andrew (1998) found that self-efficacy for science contributed 24% of the variance in academic performance in physical science and 18.5% in bioscience. In a more extensive cohort of first-year Australian nursing students (*N*=303), Andrew and Vialle (1998) used three different self-efficacy scales (academic self-efficacy, science self-efficacy and self-efficacy for learning and performance) and found that each correlated significantly with academic performance measured by grade. Other nursing studies have also demonstrated the important contribution academic self-efficacy can make to academic performance (Chacko & Huba, 1991; Silvestri, 2010; Tutor, 2006). Contrary to much of the literature, Ofori and Charlton (2002) found that in their path model, academic self-efficacy had no direct effect on academic performance in Psychological Perspectives in Nursing.

The relationship between self-efficacy and academic performance has been well established in studies involving chemistry for non-nursing students at the college level (Garcia, 2010; Obrentz, 2011; Smist, 1993; Turner & Lindsay, 2003; Uzuntiryaki & Aydin, 2009; Zusho, et al., 2003). When measured at the end of the semester, Zusho et al. (2003) found academic self-efficacy to be a better predictor of grades than SAT-maths scores in an introductory general chemistry course.

For studies in fields other than nursing and chemistry at the tertiary level, findings are generally supportive of a significant positive correlation between self-efficacy and academic performance (Al-Harthy, Was, & Isaacson, 2010; Cavallo, et al., 2004; Hargroder, 2007; Klomegah, 2007; Lent, et al., 1986; Pajares & Miller, 1994; J. W. Thomas, Iventosch, & Rohwer, 1987; Witt-Rose, 2003). In research involving college students, a meta-analysis of 109 studies found academic self-efficacy to be the best psychosocial predictor of grade point average (GPA) (Robbins, et al., 2004). Brown et al.'s (2008) path analysis on this study found that at a bivariate level, academic self-efficacy strongly correlated with college academic performance. Similar findings have been found in high school investigations, with self-efficacy research confirming a correlation with academic performance in science (Britner, 2008; Britner & Pajares, 2006; Lau & Roeser, 2002; Pintrich & De Groot, 1990; J. E. Williams, 1994).

However, not all studies have found a significant relationship between self-efficacy and academic achievement. In a study involving college biology students (*N*=459), Lawson et al. (2007) found that item-specific biology self-efficacy accounted for, at best, 2% of the variance and found reasoning ability to be a much better construct for achievement prediction.

While Brown et al. (2008) found that academic self-efficacy had a direct effect on academic performance, it has been suggested that self-efficacy plays a mediator role with respect to academic performance (Multon, Brown, & Lent, 1991; Pintrich & De Groot, 1990; Schunk, 1990). Support for these findings can be found in the numerous studies showing that highly efficacious students are more likely to use cognitive and self-regulatory strategies in their study (Pintrich & De Groot, 1990; J. W. Thomas, et al., 1987; Zimmerman & Martinez-Pons, 1990) and superior problem solving strategies (Lawson, et al., 2007; Taasoobshirazi & Glynn, 2009).

In summary, self-efficacy has been found to be the most significant non-cognitive factor in predicting academic performance (Klomegah, 2007; Lau & Roeser, 2002; Robbins, et al., 2004; Turner & Lindsay, 2003; Tutor, 2006), with some studies placing its predictive strength above academic aptitude (Zusho, et al., 2003). Schunk (1990, p. 6) concluded that "studies differ in many ways, but they are united in their emphasis on motivation & efficacy as central constructs in explanations of achievement behaviours."

2.2.3 Self-efficacy, Prior Knowledge and Ability

Since self-efficacy is significantly shaped by mastery experiences (Bandura, 1997), one would expect to find a correlation between prior academic achievement and self-efficacy. As postulated, a strong link between self-efficacy and high school GPA (r=0.70) was found among college students by Robbins et al. (2004) and later confirmed by Brown et al. (2008). Gretsy and Cotton (2003) found a significant correlation between previous biology experience and the confidence to pass module tests in a nursing cohort in the UK and Pajares and Kranzler (1995) demonstrated using path analysis that 3.9% of the variance in high school maths self-efficacy could be explained by the level of exposure to maths content in previous courses. An unexpected finding by Andrew (1998) was that science self-efficacy in first-year nursing students was not influenced by whether or not science had been studied at high school. In fact, very few studies have considered the relationship between prior experience and self-efficacy in a particular domain, with the focus generally on academic performance.

Positive correlations between various types of self-efficacy and general ability measures such as the American university entrance tests (e.g. SAT - Scholastic Assessment Test, ACT - American College Testing) and Cube comparisons test have been demonstrated in high school students (Lau & Roeser, 2002; Zimmerman & Martinez-Pons, 1990) and at the college level (Chacko & Huba, 1991; Robbins, et al., 2004). Meta-analysis studies show that the effect size for the relationship between self-efficacy and cognitive ability is not as strong as for prior academic achievement measures (Multon, et al., 1991; Robbins, et al., 2004).

2.2.4 Change in Self-efficacy

Self-efficacy is a dynamic construct, constantly being reassessed by perceptions of the environment and will change over a lifespan (Bandura, 1994). While many researchers administer a self-efficacy instrument on only one occasion for a particular group, some studies have investigated changes in self-efficacy over a semester. An array of findings has been reported in relation to changes in self-efficacy over a semester for the tertiary sector. While both Obrentz (2011) and Zusho et al. (2003) found a decrease in self-efficacy (chemistry and academic self-efficacy respectively) in a general chemistry cohort, other researchers have found no change for academic (Bresó, Schaufeli, & Salanova, 2010; Cavallo, et al., 2004; Lent, et al., 1986) and chemistry self-efficacy (Smist, 1993) while others have noted an increase for chemistry (Dalgety & Coll, 2006; Garcia, 2010) and biology self-efficacy (Lawson, et al., 2007). Increases in bioscience self-efficacy over the duration of a three-year degree in New Zealand have also been reported (Friedel & Treagust, 2005). Zusho et al. (2003) and Obrentz (2011) found that the degree of change in academic self-efficacy was dependent on the level of academic achievement, with low achievers experiencing a pronounced decline over the semester.

2.3 Anxiety

While an extensive number of studies exist on self-efficacy across many domains and ages, there are relatively few studies that focus on anxiety as a separate phenomenon in the tertiary field. Only a small number have focused on anxiety in science education, with even less specifically addressing chemistry anxiety.

Not only do studies describe different measures and types of anxiety, they also differ in the approach taken. A number of studies include an investigation of anxiety, generally some measure of assessment anxiety, but focus on motivation or some other construct. Very few education studies claim to measure a fundamental state of anxiety, instead utilising several items with a similar response pattern on a questionnaire labelled as 'anxiety' (Bauer, 2008). As such, Bauer (2008) suggests that an anxiety scale is most informative when used in one of two ways: to compare groups (Akabş & Kan, 2007; Britner, 2008; Britner & Pajares, 2006; Brownlow, Jacobi, & Rogers, 2000; Chiarelott & Czerniak, 1987; Driscoll, Evans, Ramsey, & Wheeler, 2009; Eddy, 2000; Lo, 2002; Mallow, 1994; Mallow, et al., 2010; McCarthy & Widanski, 2009; Misra & McKean, 2000; Udo, et al., 2004) or in a before and after design (Abendroth & Friedman, 1983; Oliver-Hoyo & Allen, 2005; Olupide & Awokoy, 2010; Udo, Ramsey, Reynolds-Alpert, & Mallow, 2001). A number of these studies also investigate correlations with other variables, such as self-efficacy.

Because of the relatively few studies addressing chemistry anxiety, several types of anxiety will be considered from the literature to determine how others have studied the phenomenon of anxiety in an academic setting.

2.3.1 Definitions and Approaches to Research in Anxiety

Bandura (1997) defines anxiety as "a state of anticipatory apprehension over possible deleterious happenings" (p. 137) and is conceptualized as fear resulting in "physiological arousal or subjective feelings of agitation" (p. 138). In an academic setting, anxiety can be considered as "general worry and negative emotions about doing well in class" (Zusho, et al., 2003, p. 1083). When examining research, it is important to consider what type of anxiety is being measured. An outline of the three types of anxiety related to this research project follows. Irrespective of the type of anxiety, it is widely believed that while some degree of anxiety can be helpful and contribute to motivation, excessive levels can have an adverse affect on learning and impede performance (Akabş & Kan, 2007; Cassady & Johnson, 2002; Udo, et al., 2004).

Test/Evaluation/Assessment Anxiety

Evaluation anxiety has been investigated for decades by educational psychologists with two emerging dimensions: emotionality (physiological response during testing) and worry, also referred to as cognitive test anxiety (cognitive reactions prior to, during and after tasks) (Cassady & Johnson, 2002). The debilitating effect of anxiety can result in cognitive interference leading to poor conceptualisation, organisation and information retrieval when preparing for and undertaking a test (Cassady & Johnson, 2002; Naveh-Benjamin, McKeachie, & Lin, 1987; Pintrich, 1994). Chapell et al. (2005) recommend the incorporation of assessment anxiety in studies relating to academic performance. Test anxiety has been included as one of the affective variables in numerous studies linking aspects of motivation with self-regulated learning strategies and/or academic performance (Glynn, Taasoobshirazi, & Brickman, 2007; Obrentz, 2011; Pintrich & De Groot, 1990; Zusho, et al., 2003). Of particular relevance to this inquiry is a finding by Driscoll, Evans, Ramsey and Wheeler (2009) indicating significantly greater levels of high test anxiety in the nursing student population (30%) of an American university compared with students in other courses (17%).

Science Anxiety

The term “science anxiety” was coined by Mallow in 1977 (Mallow, 1978, 2006) in response to students exhibiting anxiety in science classes but calm in non-science courses. Science anxiety is the fear of science concepts, scientists and science-related activities resulting in problems with construction and use of science knowledge and skills (Britner & Pajares, 2006; Mallow, 2006). It can paralyze students who would otherwise perform well based on intelligence (Udo, et al., 2004) and may manifest itself as panic in a science exam (Alvaro, 1978, as cited in Mallow, et al., 2010). It has been demonstrated in both school (Britner & Pajares, 2006; Chiarelott & Czerniak, 1987) and tertiary students (Brownlow, et al., 2000; Mallow, 1994; Udo, et al., 2004; Udo, et al., 2001).

There is much evidence that reveals the existence of high levels of anxiety towards science units amongst nursing students, particularly in physical science and amongst those with poor science backgrounds (Dori, 1994; Jordan, et al., 1999; Logan-Sinclair & Coombe, 2006; Nicoll & Butler, 1996; Sherrod, et al., 1992; Treblow, Daly, & Sarquis, 1984).

Chemistry Anxiety

Given that college students can distinguish between attitudes in the various science disciplines (Bauer, 2008), chemistry anxiety has emerged as a construct which has been studied separately from science anxiety. The earliest study found to date specifically on chemistry anxiety was conducted in 1981 (Abendroth & Friedman, 1983). More recently, in a study which compared chemistry anxiety with trait-anxiety in an introductory chemistry course at college level, Eddy (2000) concluded that there “really is something unique about chemistry that makes students anxious” (p. 515). Indeed, several researchers have used the term ”chemophobia” to represent this unique form of anxiety (Berdonosov, Kuzmenko, & Kharisov, 1999; Billington, et al., 2008; Eddy, 2000; McCarthy & Widanski, 2009). Various dimensions of chemistry anxiety have also been investigated. Eddy (2000) found that three subscales of chemistry anxiety were substantiated by factor analysis - learning chemistry, evaluation of chemistry and handling chemicals - which were subsequently explored by Oliver-Hoyo and Allen (2005) and McCarthy and Widanski (2009). Others have investigated various dimensions of chemistry laboratory anxiety (Bowen, 1999; Kurbanoglu & Akin, 2010) and test anxiety in a chemistry setting (Ellis, 1993; Obrentz, 2011; Zusho, et al., 2003).

2.3.2 Factors Contributing to Anxiety

Many factors contribute to anxiety (Brownlow, et al., 2000) and Mallow (2006) outlines several that could furnish science anxiety in tertiary students. Foremost, there is a prevailing belief that science is difficult, with success attainable by only an elite few. Both primary and secondary school education contribute significantly to negative messages about science, and students come to the tertiary setting with “baggage ... [which is] both cognitive and emotional” (Mallow, 2006, p. 10). Many have been exposed to bad experiences in science classes where approaches to teaching science have emphasised memorization to the detriment of analytical thinking. In addition, many primary teachers are science anxious themselves which is transmitted to the students. In a broader context, socialisation by adults plays a role (Brownlow, et al., 2000) and stereotypes of scientists as male, intelligent and boring still persist in the media (Mallow, 2006).

Following is a discussion of studies that have investigated specific factors related to various types of anxiety.

Demographics and Anxiety

Traditionally, females have been found to be more anxious than males. Misra and McKean (2000) propose that despite more effective time management, females experience higher levels of self-imposed stress with more physiological reactions. Further, using the General Health Questionnaire, female nursing students have recorded lower levels of well-being, indicating a greater tendency to stress-related illness (Gibbons, Dempster, & Moutray, 2011). In this section, both chemistry and science anxiety will be considered with respect to gender and age.

While research on chemistry anxiety is limited, gender effects have been studied at the tertiary level. Using the DCARS (Derived Chemistry Anxiety Rating Scale), Eddy (2000) found females in an introductory chemistry course experienced higher overall chemistry anxiety, and scored higher on each of the three subscales: learning, evaluation and handling chemicals. However, in a subsequent study on a similar cohort and using the same instrument, McCarthy and Widanski (2009) only found gender bifurcated responses for the evaluation subscale, with females reporting higher anxiety. In contrast, possibly due to a different chemistry anxiety scale, gender bifurcation was not evident in a study on introductory chemistry students in Turkey (Aydin, et al., 2011).

When general test anxiety has been assessed, undergraduate females reportedly exhibit higher levels of anxiety (N=4000) (Chapell, et al., 2005). This has also been shown to be the case in general chemistry cohorts (Eddy, 2000; McCarthy & Widanski, 2009; Obrentz, 2011; Zusho, et al., 2003)

While studies reporting gender bifurcation with respect to science anxiety in nursing cohorts could not be found, possibly due to the small proportion of males making statistical generalizations difficult, numerous undergraduate studies on science anxiety have been conducted. Research using the Science Anxiety Scale has generally shown gender to be the second most significant predictor of science anxiety after ‘non-science anxiety’ in undergraduate students studying science, including a small cohort of nursing students (Mallow, 1994; Udo, et al., 2004; Udo, et al., 2001). However, Brownlow, Jacobi and Rogers (2000) found no gender bifurcation in science anxiety, even when students were placed in high and low science anxiety groupings. Supporting the claim by Brownlow et al (2000) that other factors may covary with gender, Udo et. al. (2001) found that female science anxiety decreased when the content of an introductory physics course was taught by a female. On reviewing recent research, Mallow (2006) stated there was little likelihood of a "natural" female tendency toward science anxiety, a conclusion supported by subsequent research with US and Danish university students which demonstrated a closing of the "anxiety gender gap" (Mallow, 2010; Mallow, et al., 2010)

There seems to be limited research investigating the relationship between age and anxiety in academic settings. It has been suggested that science anxiety begins as early as nine years of age (Chiarelott & Czerniak, 1987). Generally, in tertiary students, there appears to be no correlation between age and academic stress (Misra & McKean, 2000) or science anxiety (Brownlow, et al., 2000). However, Chapell et al. (2005) did report a small, but statistically significant positive correlation between age and test anxiety (r=.16, p<.001) for undergraduates across all courses of study.

Prior Chemistry/Science Experience and Anxiety

As expected, a negative correlation between the factor 'learning chemistry anxiety' and previous chemistry experience has been found in students enrolled in introductory chemistry courses (Eddy, 2000; McCarthy & Widanski, 2009). This finding is supported by studies that show the level of science anxiety is related to the type of major studied, where students studying a science major would generally have studied more science at school. Science majors were found, therefore, to be less anxious about studying science compared with non-science majors (Bauer, 2008; Mallow, 1994; McCarthy & Widanski, 2009; Udo, et al., 2004). However, this was not the case for a Turkish general chemistry cohort, where no significant difference in chemistry anxiety between majors and minors was observed (Aydin, et al., 2011). Interestingly, while Eddy (2000) found that tertiary students with less than three years of chemistry experience at school or college suffered higher levels of chemistry anxiety than those with more experience, there was no significant difference in anxiety between those studying chemistry as a major compared with those undertaking chemistry as a minor course of study. Udo et al. (2001) also found that the course major was not a significant predictor of science anxiety, possibly due to the relatively small number of non-major students in the study.

Other Factors Contributing to Anxiety

In terms of general factors that may contribute to science anxiety, several possible influences suggested by Mallow (2006) have already been outlined. Learning styles have been studied in relation to anxiety. In a study of Australian first and third-year science students, Zeegers (2004) demonstrated that a surface approach to learning correlates with test anxiety. Various educational factors have also been shown to be significant in anxiety reduction, such as cooperative learning programs (Oliver-Hoyo & Allen, 2005; Olupide & Awokoy, 2010) and effective high school science teaching (Brownlow, et al., 2000). In addition, chemistry anxiety has been shown to correlate strongly with maths anxiety (Eddy, 2000). For the highly anxious students interviewed in Eddy's study (2000), factors such as chemistry in general, answering questions in class, the pace of the course, lack of relevance to life, lack of information on test structure, unstructured laboratories, lighting a Bunsen, acid burns and explosions were all sources of anxiety.

With respect to general anxiety in nursing students, the academic program has been shown to be one of the most significant sources of stress (Beck & Srivastava, 1991; Lo, 2002; Nicoll & Butler, 1996). Science subjects, in particular physical science, have been reported as amongst the most difficult to study (Caon & Treagust, 1993; Gibbons, et al., 2011; McCabe, 2007, 2009b; Nicoll & Butler, 1996; Penman, 2005). In addition, anxiety exists at higher levels among nursing students with part-time work (Beck & Srivastava, 1991; Lo, 2002). In a survey of Bachelor of Nursing students in Australia, 87% worked either full or part-time, with 63% classifying their work as essential (Rella, Winwood, & Lushington, 2009). Mature-age Australian nursing students in particular find the balance between study, work and family stressful (Lo, 2002). Further, the highest levels of stress have been reported in first-year nursing students (Lo, 2002).

2.3.3 Anxiety and Academic Performance

While the relationship between self-efficacy and academic achievement across a wide range of domains and age levels has been clearly demonstrated, the same cannot be said for anxiety and academic performance. Comparatively few studies have investigated the link between academic performance and science anxiety, but even less have examined chemistry anxiety in this context. In the field of psychology, several researchers support the conclusion that test anxiety has a negative impact on academic performance (Cassady & Johnson, 2002; Zeidner, 1995) by interfering with the activation of appropriate knowledge (Pintrich, 1994). In a cohort of 4000 undergraduate tertiary students, lower assessment anxiety was associated with higher GPA (Chapell, et al., 2005). A number of researchers in science education have found evidence to support this claim. Negative correlations between anxiety and achievement have been found with students in high school science (Pintrich & De Groot, 1990) and introductory chemistry (Obrentz, 2011; Zusho, et al., 2003). In contrast to these findings, an Australian study involving first-year tertiary science students (*N*=118) found that test anxiety had no direct effect on annual GPA (Zeegers, 2004). These disparities could be explained by the finding that anxiety has an indirect effect on academic performance when other variables are considered (Meece, Wigfield, & Eccles, 1990), such as non-causal covariation largely due to the effect of self-efficacy (Pajares & Kranzler, 1995).

Only one study to date has been found that considers chemistry anxiety specifically and academic achievement in a tertiary setting. Abendroth and Friedman (1983) found that the group of students who received psychological treatment for chemistry anxiety had significantly higher grades. However, generalisations from this study must be treated with caution because the classes were taught by different teachers and the sample size was small (*N*=17 in the treatment group and *N*=23 in the control group).

Finally, it is important to note that while there appears to be a link between high science anxiety and low academic performance, the "converse link … may not be warranted" (Chiarelott & Czerniak, 1987, p. 204). Similarly, highly science-anxious students do not necessarily do poorly (Mallow, 1986, as cited in Udo, et al., 2001). Bandura (1997) claims that students with low self-efficacy are more vulnerable to experiencing anxiety, with the effect of anxiety on academic performance diminishing when the influence of self-efficacy is included (Pajares, 1996). Zimmerman (2000) suggests that educators would gain better results by focusing on improving self-efficacy rather than diminishing anxiety.

2.3.4 Change in Anxiety

Emotional and physiological responses such as anxiety will change over time as a consequence of contemplation and engagement, yet very few studies have considered changes in anxiety over a semester. However, changes in test anxiety have been investigated in two general chemistry cohorts over this time frame. No change was reported when measurements were compared at Weeks 10 and 15 of the semester (Obrentz, 2011; Zusho, et al., 2003) and the increase in test anxiety from Week 5 to 15 in the Obrentz (2011) study was largely attributed to the increase experienced by the low performing group, with no change for the average and high performing groups.

2.3.5 Relationship Between Anxiety and Self-efficacy

In the context of Social Cognitive Theory, self-efficacy is central to the regulation of anxiety. Bandura (1997) purports that individuals will experience anxiety if they do not believe they possess the skills required to manage detrimental events. Despite the apparent close relationship between self-efficacy and anxiety, there is a paucity of studies linking the two constructs.

Highly efficacious first-year biology students were found to be less assessment anxious than those with low self-efficacy (Glynn, et al., 2009) and nursing students with high self-efficacy beliefs studying psychology had fewer academic worries (Ofori & Charlton, 2002). Investigations with general chemistry students also show significant negative correlations between self-efficacy and test anxiety (Aydin, et al., 2011; Obrentz, 2011; Zusho, et al., 2003) and laboratory anxiety (Kurbanoglu & Akin, 2010) where self-efficacy indirectly reduced laboratory anxiety via attitudes. The inverse link between self-efficacy and anxiety has also been demonstrated in high school maths (Meece, et al., 1990; Pajares & Kranzler, 1995) and science (Britner & Pajares, 2006; Usher & Pajares, 2006). It is interesting to note that in the study conducted by Pajares and Kranzler (1995), only maths self-efficacy was predictive of maths performance in high school students when both self-efficacy and anxiety were present in a path analysis. This illustrates the importance of multiple regression analysis when considering any causal effect of anxiety.

While the majority of research supports self-efficacy and anxiety as separate constructs, largely through factor analysis, some studies have found no clear distinction. For example, a factor analysis conducted on the Fennema-Sherman Mathematics Attitudes Scales (FSMAS) by Mulhearn and Rae (1998) indicated a six-factor structure, rather than the nine suggested by the original developers of the instrument, with the anxiety and self-efficacy scales collapsing into one factor. Glyn and Koballa (2006) modified the extensively used Motivated Strategies for Learning

Questionnaire (MSLQ) to produce The Science Motivation Questionnaire (SMQ) in order to increase relevancy to college science. Glynn, Taasoobshirazi and Brickman (2007, 2009) reported that in the second administration of the SMQ, the self-efficacy and anxiety scales collapsed into one factor which contrasted with their findings from an earlier cohort. However, different types of factor analysis were implemented in each study. The authors suggested that students with high self-efficacy are not anxious about assessment.

2.4 Other Considered Indicators of Academic Performance

A multitude of factors that affect academic performance have been investigated, not all of which can be reviewed here. Aside from self-efficacy and anxiety, other factors considered relevant and that fall within the context of this study will be examined.

2.4.1 Demographic Variables and Academic Performance

Age

A review of the literature on the relationship between age and academic performance reveals conflicting results, with some studies indicating a correlation and others finding no relationship. Adding to the confusion and interpretation of studies is the ill-defined boundary for defining mature-age that varies from study to study, making the comparison of results difficult. For example, mature-age has been defined as greater than 20 years of age (Zeegers, 2004), greater than 22 years of age (Houltram, 1996), greater than 23 years of age (Van Lanen, Lockie, & McGannon, 2000) and greater than 25 years of age (Bers & Jaffe, 1977; Kevern, Ricketts, & Webb, 1999; McKenzie & Schweitzer, 2001; Salamonson & Andrew, 2006). Furthermore, some researchers use the terms ‘mature-age’ or ‘older students’ without defining the scope (Dalziel & Peat, 1998; Ofori & Charlton, 2002). In addition, age is delineated in some studies using two categories (Bers & Jaffe, 1977; Salamonson & Andrew, 2006; Van Lanen, et al., 2000; Zeegers, 2004) while others use multiple classifications (Kevern, et al., 1999; McKenzie & Schweitzer, 2001; Wagner, Sasser, & DiBiase, 2002).

Another challenge when considering the effect of age on academic performance is due to the fact that the connection may be mediated by other factors related to maturity. It is generally believed that mature-age students outperform younger students because they possess qualities needed to succeed in an academic setting, such as increased motivation, persistence, readiness to learn and a greater willingness to seek support (Ofori & Charlton, 2002). This indirect effect of age was found in an Australian study by Zeegers (2004) where older students enrolled in first and third-year science courses had a better GPA for the year because of the deep learning approach taken.

Van Lanen, Lockie and McGannon's study (2000) (*N*=308) found age to be one of five variables contributing to chemistry success in a stepwise multiple regression analysis of data obtained from an organic and biochemistry course largely comprised of nursing majors (95.1%). Traditional students, defined as being less than 23 years of age, did not perform as well as older students in the final grade.

A number of studies involving general or introductory chemistry courses have been conducted where age has been a variable. Bers and Jaffe (1977) (*N*=120) found that students over 25 years of age were more likely to receive a passing grade (65% vs 51%) and received a disproportionate number of As and Bs. Unfortunately, no statistical analysis was reported. Wagner, Sasser and DiBiase (2002) demonstrated that, when included in a regression analysis, age helped to predict failure in a first semester general chemistry course, with increasing age predictive of a better outcome. On the other hand, Daziel and Peat (1998) found younger students had higher weighted mean averages (WAM) at the end of first semester for an Australian Bachelor of Science degree. They cited anecdotal evidence that, despite a high level of enthusiasm, some mature-age students were not sure of academic expectations and found it difficult to establish peer networks, both of which contributed to lower academic performance. Unfortunately, the paper did not indicate the age cut-off point. Age was found to be a non-predictor of overall performance in first-year science and IT courses in Australia (McKenzie & Schweitzer, 2001).

Age has also been found to be a significant predictor of academic performance in nursing studies such as the NCLEX-RN licensure exam (Daley, Kirkpatrick, Frazier, Chung, & Moser, 2003; Humphreys, 2008), the Common Foundation Program in the UK (Houltram, 1996; Kevern, et al., 1999) and specific subjects such as pathophysiology (Salamonson & Andrew, 2006) and psychology (Ofori & Charlton, 2002). In all of these studies, older students were shown to have superior academic performances. In an Australian study (*N*=250), mature-entry (enrolled in the course at least one year after the completion of high school) was found to be the second highest predictor behind UAI in a path model for bioscience and overall GPA of a nursing cohort (Whyte, et al., 2011). Interestingly, van Rooyen, Dixon, Dixon and Wells (2006) found that in the first year of a nursing program, an increase in age equated with higher performance in bioscience, but that in the second year, younger students outperformed mature-age students. In contrast, age was found to be a non-significant predictor of first-year academic performance in other nursing programs (Alden, 2008; McCarey, Barr, & Rattray, 2007).

Gender

As with age, gender findings with respect to academic performance are inconclusive. Gender has been found to be an inconsistent indicator of performance in assignments and exams over the course of a three-year nursing degree (McCarey, et al., 2007) and a non-predictor of academic performance in chemistry for nurses (Van Lanen, et al., 2000), in first-year general chemistry (Andrews & Andrews, 1979; BouJaoude & Giuliano, 1994; Glynn, et al., 2009; Hailikari & Nevgi, 2009; Seery, 2009), in science and IT courses (Zeegers, 2004), and for non-science majors studying biology (Glynn, et al., 2007). However, males have outperformed females in a number of tertiary science studies (Cavallo, et al., 2004; Dalziel & Peat, 1998; Obrentz, 2011). Conversely, females outperformed males for full-time students studying Bachelor of Health Science at the University of Western Australia (C. Mills, Heyworth, Rosenwax, Carr, & Rosenberg, 2009). While Chiarelott and Czerniak (1987, p. 202) acknowledge that a link between gender and achievement exists, they warn that it is “somewhat muted” and caution should be taken against drawing any causal relationship. The literature cited here would appear to suggest this stance.

Working Hours

In the tertiary sector in Australia, longer working hours are generally associated with lower academic achievement (James, Krause, & Jennings, 2010), yet few studies have included working hours as a variable that may influence academic performance. While Harris, Hannum and Gupta (2004) found an insignificant correlation between working hours and academic performance in anatomy and physiology, other studies have refuted this. When considering age, ethnicity and work hours for second-year Australian nursing students studying pathophysiology, time occupied by work was considered the most significant of the three factors (Salamonson & Andrew, 2006). Students with no employment had the highest academic performance while the group working more than 16 hours per week (equivalent to two shifts) had the lowest. This relationship is also supported by McKenzie and Schweitzer (2001) who found that Australian first-year students studying science and IT full-time with no work commitments had the highest GPA at the end of that year. The combination of full-time study and part-time work had the lowest GPA. While Klomegah (2007) found a negative and significant correlation between work hours and academic performance for 103 sociology students, the two were not highly correlated in the subsequent multiple regression analysis.

2.4.2 Cognitive Factors

Several cognitive factors have been shown to be predictive of academic performance. Performance in the first test for a general chemistry cohort is a robust predictor of course success (P. Mills, Sweeney, & Bonner, 2009; Seery, 2009) and the type of approach taken for learning also plays a role (Minasian-Batmanian, Lingard, & Prosser, 2005; Ofori, 2000; Thornton, 1997). University entrance criteria and prior knowledge have also been shown to be important and a discussion of studies in these two areas follows.

University Entry Qualifications – School Entrance Scores

Many universities in Australia are increasingly adopting policies to encourage alternative entry pathways in response to the increasing number of mature-age students applying for enrolment (Krause, Hartley, James, & McInnis, 2005). This is particularly true of a nursing cohort, many of whom have not completed the final year of high school and have gained entry to a Bachelor of Nursing program with Enrolled Nursing qualifications. Few studies have been found linking Australian nursing student entry qualifications to academic performance. Consequently, a review of entry qualifications in overseas studies in nursing and chemistry will be examined to explore the link with academic performance.

In Australia, the relationship between matriculation scores (an overall measure of secondary school performance) and university academic performance is well established. While each Australian state has it own matriculation score (e.g.

OP, TES, TER, UAI, ATAR), the university entrance score has been found to be the most significant contributor to academic performance for first-year science students in numerous studies (Dalziel & Peat, 1998; McKenzie & Schweitzer, 2001; C. Mills, et al., 2009; Zeegers, 2004). In nursing, there are conflicting reports of this link, with some maintaining a correlation with academic performance in first-year bioscience in New Zealand (van Rooyen, et al., 2006) and Australia (Whyte, et al., 2011), while others report no association (Kershaw, 1989).

For first-year general chemistry students in overseas studies, the relationship between high school GPA and academic achievement is mixed. Sanchez and Betkouski (1986) found high school GPA to be the best single predictor of academic performance in general chemistry. This finding is supported by a small study from Dublin where the university entrance score accounted for 17% of the variance in academic performance (Seery, 2009). In contrast, high school GPA was found to be a non-predictor in several chemistry courses (Andrews & Andrews, 1979; Karpp, 1995) along with a nursing chemistry cohort (Van Lanen, et al., 2000).

In the UK where criteria for entry to university includes the number of ‘A levels’ studied in school, researchers have generally found that students with higher entry qualifications perform better in nursing programs (Houltram, 1996; Kevern, et al., 1999; McCarey, et al., 2007). Others have found that this is not necessarily the case (Ofori & Charlton, 2002). Wharrad and Nicola (2003) suggest it is unwise to rely solely on ‘A levels’ since the academic performance of students with unconventional entry was only slightly less than students with conventional entry.

Aptitude Tests

In the US, aptitude testing using the Scholastic Aptitude Test (SAT) and/or American College Testing (ACT) is routinely administered to students beginning university to measure general mathematics and literacy ability. Of these, the SAT-maths has been prominent in many studies and found to be a significant predictor for performance in general chemistry (Andrews & Andrews, 1979; Lewis & Lewis, 2007; Obrentz, 2011; Ozsogomonyan & Loftus, 1979; Wagner, et al., 2002; Xu & Lewis, 2011; Zusho, et al., 2003). California Chemistry Diagnostic Test (CCDT) scores have also been found to be a significant predictor of general chemistry success (Karpp, 1995; Legg, Legg, & Greenbowe, 2001). In addition, ACT-maths has been predictive of success in a nursing chemistry exam (Mamantov & Wyatt, 1978).

Indeed, Brown et al. (2008) found that using ACT/SAT information had a stronger direct relation to academic performance than high school GPA. Since ACT scores were not available for transfer students, Van Lanen et al. (2000) used a Maths Placement test developed by the Science and Mathematics faculty at Saint Xavier University (the institution where the study was conducted). This was found to be the most significant predictor variable of academic performance for students less than 23 years of age. Interestingly, the Nelson Denny Test (for comprehension) was more significant for students 23+ years of age. Maths ability was also important in predicting performance in 2nd year physical chemistry (Hahn & Polik, 2004) and organic chemistry (Turner & Lindsay, 2003).

Prior Knowledge

In an extensive narrative review of 183 articles found in the literature on prior knowledge, Dochy, Segers and Buehl (1999, p. 145) conclude it is "difficult to overestimate the contribution of individuals' prior knowledge" in the context of educational performance. They suggest that prior knowledge encompasses all knowledge that is available and structured in schemata before a learning experience is encountered. They found a strong relationship between prior knowledge and academic performance, with 91.5% of the studies reviewed demonstrating the positive effect. Indeed, prior knowledge generally explained 30-60% of the variance in performance.

A number of nursing studies have considered the relationship between high school science and performance in a tertiary bioscience subject, with some tertiary benefit resulting from the study of either biology or science at school (Harris, et al., 2004; McKee, 2002; Potolsky, Cohen, & Saylor, 2003; Whyte, et al., 2011) or the level of achievement in a high school biology course (Caon & Treagust, 1992; McKee, 2002). Fenton (2010) demonstrated that nurses who attempted science in senior school found studying science in their nursing course less difficult than those who had not studied science at the senior level. An investigation into the association between high school chemistry and performance in chemistry at the tertiary level follows.

Surprisingly, few studies have considered the quality of previous chemistry background as a variable for predicting academic performance in chemistry at the tertiary level, with researchers generally using high school completion of a science course as the prior knowledge criteria. A number of researchers have found no relationship between academic performance and prior knowledge in chemistry. For example, Mamantov and Wyatt (1978) found no significant dependence on high school chemistry experience for the performance of a group of nursing students studying chemistry. Prior knowledge was measured by whether or not a previous course in chemistry had been taken and the quality of this knowledge was not considered. This appears to be supported by Bers and Jaffe (1977) who found that the one-third of the class without pre-requisites for an introductory chemistry course were just as likely to successfully complete the course as those with the pre-requisites. Similarly, Ozsogomonyan and Loftus (1979) found that students with no background in high school chemistry performed better in general chemistry than those who received a 'C' in high school chemistry. Furthermore, in a regression analysis, an 'A' result in high school chemistry was the only significant contributor to academic performance out of the high school marks. In another regression study, Smist (1993) found little predictive effect of taking high school chemistry on academic performance in a general chemistry class (adjusted R^2=.009). In a small study involving motivated students with high ability in science, researchers found that students without high school chemistry could perform as well in college chemistry as their prior knowledge counterparts (Yager, Snider, & Krajcik, 1988). The authors suggest that personal qualities such as motivation, good study habits, perseverance and general ability in maths and comprehension may be more important than the pre-mastering of specific concepts. In the 11 studies reviewed by Dochy et al. (1999) which found a negative or null effect of prior knowledge on academic performance, measures of prior knowledge were flawed or inadequate, such as in the use of familiarity ratings. In addition, it is possible that the students in the Ozsogomonyan and Loftus study (1979) who received an "A" in high school chemistry may have performed well in general chemistry even without prior knowledge because of their general aptitude.

More recent studies in general chemistry refute these findings. In one study, prior chemistry background was found to be the second best predictor of academic performance behind GPA (Sanchez & Betkouski, 1986). In another, prior knowledge (determined by the use of pre-tests containing prerequisite knowledge for the course) was the best predictor of academic performance, ahead of formal reasoning ability and demographic factors (BouJaoude & Giuliano, 1994). Wagner, Sasser and DiBiase (2002) developed an instrument to assist in the identification of students at risk of failing. Consisting of chemistry and maths questions, it was more predictive of failure than the SAT-Maths or Toledo exam (although the latter were better for course grade predictions). This finding is supported by an Australian study where researchers found the failure rate for a first-year chemistry course was lowest for students with high school chemistry - 21% compared with 40% with no chemistry background (Schmid, Youl, George, & Read, 2012; Youl, Read, George, & Schmid, 2006). In a small study where prior knowledge was based on performance in chemistry in the leaving certificate exam in Dublin, Seery (2009) found a strong positive correlation with academic performance where the inclusion of prior knowledge increased the variance in academic performance from 17% to 35%. It was the most significant factor in predicting the final exam score. In a regression study, Obrentz (2011) found the completion of high school chemistry to be the weakest of the statistically significant predictors of academic performance in a general chemistry cohort behind SAT-maths, self-efficacy, and effort regulation. Investigating the effects of four types of prior knowledge in a regression analysis, Hailikari and Nevgi (2009) found only 'application of knowledge' related positively to the final grade, adding further support to the claim of Dochy et al. (1999) relating to the importance of measurement and quality of prior knowledge in investigations. In a study of pharmacy students studying chemistry, researchers noted that almost all prior knowledge tasks correlated with the final grade (Hailikari, Katajavuori, & Lindblom-Ylanne, 2008). In addition, the deeper the level of prior knowledge, the better the grades. All researchers concluded that prior knowledge can be used to identify at-risk students in general chemistry and in addition, to "activate and motivate students" (Hailikari & Nevgi, 2009, p. 13).

Tai, Ward and Sadler (2006) used an innovative approach to prior knowledge by exploring the connection between academic success in an introductory chemistry course and the prior exposure to specific high school chemistry topics. Over 3500 students across the US were surveyed to determine the amount of time spent on eight high school topics and this was correlated with the final grade. In addition, several academic background measures were included, controlling for demographic variables. Time spent on stoichiometry was found to be an important predictor. They found that while enrolment in high school chemistry was significant for performance in college chemistry, it was not as significant as high school maths enrolment and SAT-maths scores. This could reflect the level of mathematics required in general chemistry, which is also an important component of stoichiometry.

If prior knowledge is lacking, two factors have been identified that can help overcome the deficit. Dochy et al. (1999) point out that interest can influence the relationship between prior knowledge and performance. If there is little or no prior knowledge, the level of interest seems to play an important role. They purport that the nature of this relationship appears to be inconclusive. In addition, high reasoning ability has been identified as a factor in physics students that helps to negate a lack of prior knowledge in physics (Cavallo, et al., 2004).

Prior knowledge has been shown to account for a significant proportion of the variance in academic performance, making it an important variable to consider in learning outcomes research (Shapiro, 2004). Dochy et al. (1999) posit that the various theories addressing prior knowledge

> "recognise the positive influence of prior knowledge on the selection process from the knowledge base, the capacity of working memory, the elaborations carried out on new information, the storage of new information in long-term memory, and the retrieval of new information … [and] conclude that prior knowledge is indeed an effective aid for learning new knowledge" (Dochy, et al., 1999, p. 173).

Hailikari and Nevgi (2009) point out that this is particularly important in chemistry because of the "cumulative structure of science" (2009, p. 14).

2.4.3 Additional Factors

Numerous additional non-cognitive variables have been investigated in relation to academic performance in science. In a study of 303 first-year nursing students across three Australian universities, Andrew and Vialle (1999) showed that high-achieving students reported using more metacognitive self-regulatory strategies when studying for science, while low achievers particularly failed to self-monitor when reading. Further, students who changed from the low to high achiever group in the second semester reported increasing the number and usage of metacognitive self-regulated learning strategies. This is supported by Zeegers (2004) who found that a lack of metacognitive skills in first-year science students had a direct negative effect on the use of a deep learning approach and academic performance.

Other predictors of academic performance identified in studies related to nursing programs include class attendance (McKee, 2002), willingness to seek support (Ofori & Charlton, 2002), the number of subjects studied during the semester (Harris, et al., 2004), English speaking background (Salamonson & Andrew, 2006), and reading comprehension (Alden, 2008).

While the literature concerned with qualitative studies of science learning in the nursing field is relatively scarce, nonetheless, there are several studies that have highlighted the important role the lecturer plays, particularly the ability to give clear explanations for scientific concepts (Akinsanya, 1984; Kyriacos, Jordan, & van den Heever, 2005). The way the course is structured, such as the pace of the course and the depth at which the material is covered, can also play a significant role (Davies, et al., 2000; Jordan, et al., 1999; Thornton, 1997; Walhout & Heinschel, 1992).

2.5 Perceptions of Chemistry

It is not the primary focus of this inquiry to examine in detail the role played by perceptions of chemistry or attitudes in learning, or to look for causal links to other key variables. However, based on the Information Processing model, it is recognised that attitudes do contribute to the perception filtering process and the way information is handled (Jung & Reid, 2009). For example, negative attitudes create learning obstacles for some nursing students (Fenton, 2010; McCabe, 2007; Thornton, 1997). Also, “attitudes are enduring while knowledge often has an ephemeral quality” (J. Osborne, Simon, & Collins, 2003, p. 1074), so it is pertinent to consider links between various perceptions of chemistry and self-efficacy, anxiety, learning and performance. Furthermore, it is inevitable that some perceptions of chemistry would arise in the nursing context during interviews. As such, a brief review of the literature exploring various attitudes follows. It begins by considering the broad term ‘attitude’ before progressing to more specific examples of perceptions of science and chemistry in relation to self-efficacy, anxiety and academic performance.

The term ‘attitudes’ is nebulous, often lacking conceptual clarity due to its multidimensional nature (Gogolin & Swartz, 1992; J. Osborne, et al., 2003; Rennie & Punch, 1991; Walczak & Walczak, 2009). For example, it is considered to have at least an affective dimension (e.g. science is interesting) and a cognitive dimension (e.g. science is difficult) (Gardner, 1975, as cited in J. Osborne, et al., 2003). A myriad of perceptions may form part of the affective dimension and could include feelings, beliefs, task value, enjoyment or interest, personal or professional relevance, utility, creativity, anxiety, satisfaction, expectations and self-concept, to name just a few (Bauer, 2005; J. Osborne, et al., 2003; Xu & Lewis, 2011). Further complicating the comparison of data in the literature is the plethora of instruments that have been developed to measure attitudes, with many researchers expressing concerns over the psychometric quality of such instruments and the summation of unrelated items into one scale (Gogolin & Swartz, 1992; J. Osborne, et al., 2003; Rennie & Punch, 1991; Walczak & Walczak, 2009; Xu & Lewis, 2011). In this research project, two affective perceptions of chemistry will be considered: 'enjoyment or interest in chemistry' and 'importance or relevance of chemistry to nursing'.

The goal of science education is more than just facilitating knowledge and skill acquisition. Enhancing scientific literacy and positive attitudes is also central (Xu & Lewis, 2011), with researchers demonstrating that attitudinal change is possible as a result of exposure to science at the tertiary level (Gogolin & Swartz, 1992; Walczak & Walczak, 2009). In terms of research in the broad "attitude" category, general self-efficacy has been shown to be the best predictor of 'Chemistry Course Perceptions' (Reardon, Traverse, Feakes, Gibbs, & Rohde, 2010) and high anxiety has been correlated with low 'Interest and Utility' in chemistry (Bauer, 2008). In relation to academic performance, the literature reports conflicting findings not only about the existence of a relationship between achievement and attitudes, but also with the nature of the causal link and whether attitudes or performance should be classed as the dependent variable (J. Osborne, et al., 2003). Osborne et al. (2003, p. 1072) conclude that "the only tenable position is that the two are inescapably linked in a complex interaction." Positive correlations between attitudes and achievement have been demonstrated in high school science (Papanastasiou & Zembylas, 2004; Schibeci & Riley II, 1986) and first-year chemistry (Cukrowska, Staskun, & Schoeman, 1999).

When considering the perception of interest or enjoyment, positive correlations have been demonstrated with academic self-efficacy in general chemistry (Zusho, et al., 2003). Using multiple regression, 'emotional satisfaction', representing feelings of enjoyment, accounted for 6.2% of the variance for the final exam mark in a general chemistry cohort (Xu & Lewis, 2011) and a moderate correlation between interest and performance in a general chemistry test was demonstrated by Seery (2009). No correlation between interest and prior knowledge was found in the Seery (2009) study.

As early as the 1970s, nurse educators recognized the problem of relevance when teaching chemistry to nursing students (Jones, 1976; Takacs, Bigler, Burns, & Stockham, 1976), and there has been a recognition of the need to demonstrate this relevance (Andrew & Vialle, 1998; Fenton, 2010; Jordan, et al., 1999; Treblow, et al., 1984) by linking it with clinical practice (Davies, et al., 2000). Despite the level of difficulty, most nurses and nursing students agree that bioscience is important and relevant (Andrew & Vialle, 1998; Davies, et al., 2000; Kyriacos, et al., 2005), with less relevance perceived in the physical sciences (Caon & Treagust, 1993; Kyriacos, et al., 2005; Singh, 1995). In nursing, bioscience task value has been weakly correlated with science self-efficacy (Andrew & Vialle, 1998) and a lack of perceived relevance of chemistry has been associated with increased anxiety levels (Dori, 1994). Some studies have found that nursing students with low academic performance have typically been less convinced than high performers of the importance of bioscience to nursing (Andrew & Vialle, 1998; Caon & Treagust, 1993) while others have shown no such correlation (Jordan, et al., 1999). In general chemistry research, strong correlations were found at the end of the semester between chemistry self-efficacy and relevance of chemistry to personal goals (Obrentz, 2011) and between academic self-efficacy and chemistry task value (Zusho, et al., 2003). In addition, the Obrentz (2011) and Zusho et al. (2003) studies showed no significant correlation between test anxiety and measures of relevance at the end of the semester. Furthermore, results from correlations with academic performance groups and changes in relevance over the semester were somewhat conflicting in these two research projects.

2.6 Bridging Courses

With student backgrounds becoming increasingly diverse with respect to prior knowledge and experience (Krause, et al., 2005), it is more important than ever to minimise inequalities and allow students to start their courses on a more equal footing (Botch, et al., 2007). Many different programs have been employed by various universities and colleges world-wide to aid in the transition of students into tertiary academic life.

Many universities conduct general orientation programs to help in the transition to university life. These may last from 1 day (Dalziel & Peat, 1998) to 2 weeks (Fleming & McKee, 2005). The content of these programs varies enormously, and may include any of the following: orientation to university life, career guidance, strategies for academic success, IT orientation, introduction to peers and faculty and social activities. Research generally shows positive results, with slight increases in progression for nursing students (Fleming & McKee, 2005), an increase in retention rates for engineering students (Chevalier, Chrisman, & Kelsey, 2001), and significantly higher academic performance for science students (Dalziel & Peat, 1998; House & Kuchynka, 1997). House and Kuchynka's (1997) study is noteworthy in that they controlled for the potential effects of academic ability inconsistencies between groups by using ANCOVA. Dalziel and Peat (1998) reported no significant difference between attendees and non-attendees of the 1-day workshop based on university entrance scores.

Numerous strategies have been implemented in universities in an attempt to bridge the background knowledge gap in science courses. They include in-semester programs such as supplemental instruction (da Silva & Hunter, 2009; Minchella, Yazvac, Fodrea, & Ball, 2002; Van Lanen & Lockie, 1997), peer-assisted learning (Drane, Smith, Light, Pinto, & Swarat, 2005; Parkinson, 2009), on-line resources (Cole & Todd, 2003), summer programs (Yager, et al., 1988) and bridging courses/workshops ranging anywhere from 3 to10 days (Boelen & Kenny, 2009; Penman, 2005; Rutishauser & Stephenson, 1985; Wischusen & Wischusen, 2007; Youl, et al., 2005) to a full semester (Bentley & Gellene, 2005; Mitchell & de Jong, 1994). A discussion of some of the key shorter bridging programs of significance to this study follows. Note, however, that no study has been found to date that uses a psychometrically-sound instrument to determine changes in self-efficacy and anxiety as a consequence of bridging course attendance.

2.6.1 Programs for Nurses

Only three studies have been identified that consider a bridging program designed for nursing students. With alarmingly high student failure in the first-year Human Bioscience class at the University of South Australia (Whyalla campus), Penman (2005) implemented an optional 5-day workshop, "Preparing for Sciences", for students without a science background. The aim of the course was to introduce basic science concepts necessary for nursing in a relevant and enjoyable way and impart learning skills and approaches. Surveys were distributed immediately following the workshop and at the end of the Human Bioscience course to obtain feedback on the course and its helpfulness. The response to the course was very positive but a number of students found the content overwhelming. While the small cohort (*N*=28) and low survey response rate at the end of the semester limits the generalizability of the results, Penman concluded that the course was useful in preparing students for Human Bioscience I and was worthwhile continuing as it provided essential background content.

A similar course was designed by Boelen and Kenny (2009). They conducted a 5-day compulsory bridging program, "Anatomy, Physiology and Chemistry program" (AP&C), to support the conversion of enrolled nurses to a university degree at La Trobe University. They identified the need for a course that focused on learning strategies and introduced students to underpinning biological science concepts. Students (*N*=70) were exposed to lectures, tutorials, computer laboratory sessions and practical classes. Questionnaires were administered on the first and fifth days and information on demographics, confidence with anatomy, physiology and chemistry, confidence about returning to study, and the importance of science in nursing was collected. While academic performance was not discussed in the paper, responses from 62 of the participants indicated significant increases in confidence over all areas, with anatomy, physiology and chemistry confidence levels improving 68%, 65% and 51% respectively. The authors concluded that while the course was aimed at the mature-age student (70% were over 25), "a structured approach to supporting transition may be beneficial for all students" (Boelen & Kenny, 2009, p. 537).

In a more extensive analysis of the effect of a bridging course, Rutishauser and Stephenson (1985) undertook a study to determine the effectiveness of an introductory 3-day course in basic chemistry and physics to assist arts students transition to the science content of an undergraduate nursing course in the UK over a 5-year period. Despite some problems associated with the study (i.e. changes made to the exam format over the six-year period of the study and the increase in academic background of the arts students), the non-science students who had the benefit of attending the introductory course performed notably better. Before the introduction of the course, these students scored significantly less in the mid-semester test (39.1%

vs 53.6%) and final exam (47.3% vs 56.4%). After the course was introduced, there was no significant difference between the arts and science students in marks and failure rate.

2.6.2 Programs in Science

Two other bridging course investigations are worth considering, even though they do not relate directly to a nursing cohort. The first is an Australian program for chemistry and the second a biology course in the US.

The University of Sydney conducts a 7-day chemistry bridging course for students undertaking a first-year chemistry unit. It consists of 13 lectures, each followed by a 2-hour tutorial session conducted in small groups, and covers basic chemistry topics that would be covered in the HSC course. While the program is strongly recommended for students without high school chemistry, it is not compulsory. Youl, Read, George, Masters, Schmid, & King (2005) reported that in the 2003 cohort for Fundamentals of Chemistry 1A, the failure rate for those attending the bridging course was significantly lower than those with little or no prior chemistry experience who did not attend the course (mean difference of 12.8, p=0.0036). In fact, there was no significant difference in the final exam mark between students completing the bridging course and those who studied HSC chemistry. In the analysis of the 2005 cohort (Schmid, et al., 2012; Youl, et al., 2006), researchers found results consistent with the 2003 cohort, supporting the conclusion that participation in the bridging course was associated with improved academic performance. In addition to academic performance, bridging course participants' sense of 'degree of preparedness' during Week 3 of the semester was substantially higher than students with little or no prior chemistry knowledge who had not taken the course (80% compared with 21.7%), largely because much of the material was a revision of the bridging course. The researchers concluded that the bridging course allowed for the development of relevant fundamental chemical concepts that served as a foundation for the construction of new concepts. Furthermore, academic self-efficacy in the context of chemistry was explored qualitatively. Researchers reported increased confidence as a result of participation in the bridging course, suggesting that higher academic performance could be influenced by enhanced academic self-efficacy as proposed by Bandura (1997). Overall, they concluded that the bridging course had been successful in bridging the gap for students with limited prior experience in chemistry by providing fundamental knowledge and increasing confidence. Indeed, it was recommended that the relative impact of increased self-efficacy on academic performance in relation to other factors warrants further investigation (Youl, et al., 2005).

Wischusen and Wischusen (2007) investigated the effectiveness of a five-day 'Biology Intensive Orientation for the Student' program (BIOS) at Louisiana State University using a mixed method approach. It covered similar content to the first few weeks of lectures in BIOL1201 and incorporated study skills. Seventy-two percent of participants (N=60) reported much greater self-confidence for the upcoming semester having completed the course. Participants performed significantly better than the control group (N=56) in the first and second exam and final course average in BIOL1201. In fact, the program was considered so successful, the authors reported that the concept of a bridging program was taken up by other faculties at the university.

2.6.3 On-line Programs

While the benefits of face-to-face courses are well-documented, they are not always accessible. Educators have considered on-line programs as an alternative. Several on-line and CD-based courses have been designed to meet the needs of a specific course, to reduce cost and provide flexible support (Botch, et al., 2007; Gresty & Cotton, 2003; McCabe, 2009a), allowing students to continue in full-time employment until the commencement of the degree program. However, general on-line tutorial-type courses can be inefficient or irrelevant (McCabe, 2009a) as students, already anxious about studying science, try to make sense of what may seem like a foreign language.

2.7 Summary and Conclusion

This study draws foundationally on Cognitive Load and Social Cognitive theories to identify salient predictors of academic performance. A review of the literature substantiates the significant role self-efficacy plays in student academic performance. However, the link between academic performance and anxiety seems to be more tentative and the effect of demographic factors appear inconclusive.

Within the literature, a significant amount of research can be found on self-efficacy, including chemistry self-efficacy. However, a limited number of researchers have investigated chemistry anxiety with even less considering its role in academic performance. Most of this research has occurred in general chemistry so the findings have limited transferability to a chemistry course designed specifically for nursing students in Australia, the majority of whom would not be expecting to be studying a significant amount of chemistry in their degree. A paucity of research is especially evident in relation to a nursing student cohort, particularly as regards chemistry anxiety.

The review of literature relating to short bridging courses indicates the usefulness of such programs in helping to ameliorate the chemistry knowledge gap and increase self-efficacy. However, none of these studies have measured self-efficacy and anxiety with validated instruments, especially in the chemistry domain. Furthermore, some of these reports resemble general accounts rather than research-based investigations. No literature describing the effect of a short bridging course dedicated to chemistry for pre-registration nursing students has been located. To date, no studies have been found that consider the relationship between self-efficacy, anxiety and prior chemistry experience in a chemistry course for nursing students using both psychometrically sound instruments and extensive interviews.

Specifically, this study responds to concerns about the anecdotally-reported elevated levels of chemistry anxiety experienced by nursing students with insufficient prior chemistry experience and will contribute to our understanding of problems confronted not only by these students, but by any tertiary student faced with the prospect of tackling a science subject in which they have little experience. The investigation of the interplay between self-efficacy, anxiety, prior chemistry knowledge, demographic variables, perceptions of chemistry and academic performance will result in a more comprehensive picture of the chemistry experience of nursing students than has been previously portrayed.

The following chapter describes the research approach employed in this study and reports on the development of the quantitative instrument used for the main study.

3 METHODOLOGY AND DATA COLLECTION

Chapter Overview

Appropriate methodology is dependent on a conceptual framework of research. This chapter begins with the paradigm, methods and research approach used in the implementation of this project. After a description of the participants, ethical considerations are discussed. A review of the instruments used to measure self-efficacy and anxiety is undertaken through the lens of social cognitive theory and the construction and analysis of the pilot study instruments are described. Processes used to develop the main study questionnaire instrument from the pilot study are outlined and the procedures used to administer the questionnaires and conduct interviews are detailed.

3.1 Paradigm and Approach

When considering self-efficacy and anxiety in tertiary students, researchers have favoured the use of quantitative strategies. This study goes beyond the "mono-method" (Onwuegbuzie & Leech, 2005, p. 384) approach in order to delve deeper into the experiences of first-year nursing students in chemistry. The research problem requires a mixed method approach to address questions that could not be answered by quantitative analysis alone and to strengthen inferences, to explain and probe nuances in quantitative data and to provide a voice for diversity of experiences (Creswell & Clark, 2011; Teddlie & Tashakkori, 2003).

The "philosophical intent" (Mackenzie & Knipe, 2006, p. 7) that guides the researcher is influenced by the research problem and in turn, influences the methodology chosen. The pragmatic paradigm was chosen to guide this study because it places the research question at the centre of the enquiry rather than any one system of philosophy or reality (Mackenzie & Knipe, 2006), both of which become secondary to the problem itself (Teddlie & Tashakkori, 2003). Links have been made with the full range of the paradigm spectrum in order to "open up inquiry to all possibilities while tying that search to practical ends" (Maxcy, 2003, p. 86), hence providing a richness and depth to the data. Qualitative findings were pragmatically used to illuminate and explain the quantitative results, hence building a more complete picture of the research problem.

While mixed method research can be conducted within any paradigm (Mackenzie & Knipe, 2006), the pragmatic paradigm is the most common (Lodico, Spaulding, & Voegtle, 2006; Tashakkori & Teddlie, 2003) and is often used by scholars working in the field of education evaluation, health science and nursing, representing a very practical and flexible way of approaching research (Teddlie & Tashakkori, 2003). Investigation techniques were chosen to provide the best possible insights into the chemistry experience of first-year nursing students.

3.2 Research Design and Methods

In order to gain a more complete picture of the chemistry experiences of first-year nursing students, an explanatory sequential design (Creswell & Clark, 2011; Creswell, Clark, Gutmann, & Hanson, 2003) was deemed the most appropriate, incorporating an element of the convergent design (Creswell & Clark, 2011). In response to the pragmatic paradigm, a range of methods was employed in order to understand the research problem (Creswell, 2008). A summary of the research process used in this inquiry can be found in Table 1.

Table 1. Development of the research process

Paradigm	• Pragmatic
Theoretical Framework	• Social Cognitive Theory • Cognitive Load Theory
Research Approaches	• Mixed method • Explanatory sequential design with an element of convergence • Grounded theory tools
Data Collection	• Questionnaires • Survey • Focus group interviews • Follow-up individual interviews • Academic records
Data Analysis	• Factor analysis • Inferential statistics • Hierarchical multiple regression leading to a predictive path model • Constant comparative thematic analysis leading to a qualitative model

The explanatory sequential design generally occurs in two related phases. In Phase 1, the quantitative data, which tends to be given a higher priority, provides a general picture (Creswell, 2008). Following a pilot study to refine the self-efficacy and anxiety instruments, the first phase in this study involved two stages incorporating the collection of both quantitative and qualitative data. The administration of questionnaires using the pre-test post-test method indicated the levels of chemistry self-efficacy and anxiety perceived by the first-year nursing students throughout the semester. Following a brief descriptive analysis of the quantitative data in order to "furnish a sampling frame" (Barbour, 2008, p. 156), focus group interviews based on prior chemistry experience were used to illuminate the quantitative data (Barbour, 2008). Focus group data were largely collected independent of the quantitative data and the two data sets were analysed independently. The subsequent merging of these data sets represents the convergent part of the design (Creswell & Clark, 2011). Phase 2 involved the collection of further qualitative data in order to explore explanations arising from the analysis of the previously collected qualitative (constant comparative thematic analysis) and quantitative (correlational and causal-comparative approach) analysis. Interview protocols were developed and individual interviews provided insights into the sources and explanations of the constructs under investigation. A summary diagram to illustrate this emergent design can be found in Figure 4.

Embedded in the design of this inquiry is the concept of teacher as researcher, a methodology framework that has been evolving for over 30 years. In the broad sense, it encompasses "all forms of practitioner inquiry that involve systematic, intentional and self-critical inquiry about one's work in K-12, higher education, or continuing education classrooms … and other formal educational settings" (Cochran-Smith & Lytle, 1999, p. 22). It views teachers as being more than just active participants, but as " expert knowers" who act as "powerful agents" capable of bringing about "educational reform" (Cochran-Smith & Lytle, 1999, p. 16). Cochran-Smith and Lytle (1999) propose a number of possible conceptual frameworks, one of which is the teacher researcher as a way of knowing within a community. In this inquiry, the lecturer is also the researcher and contemplates the learning of chemistry in and as part of a community of first-year nursing students. This type of research blurs the boundaries between teachers and researchers and raises questions about the exposure of the teacher-researcher's biases and purposes.

The issue of bias is addressed in the discussion of trustworthiness in the following chapter. Ultimately, it is the purpose of a teacher-researcher to implement change in order to improve the experiences and life opportunities of the students (Cochran-Smith & Lytle, 1999).

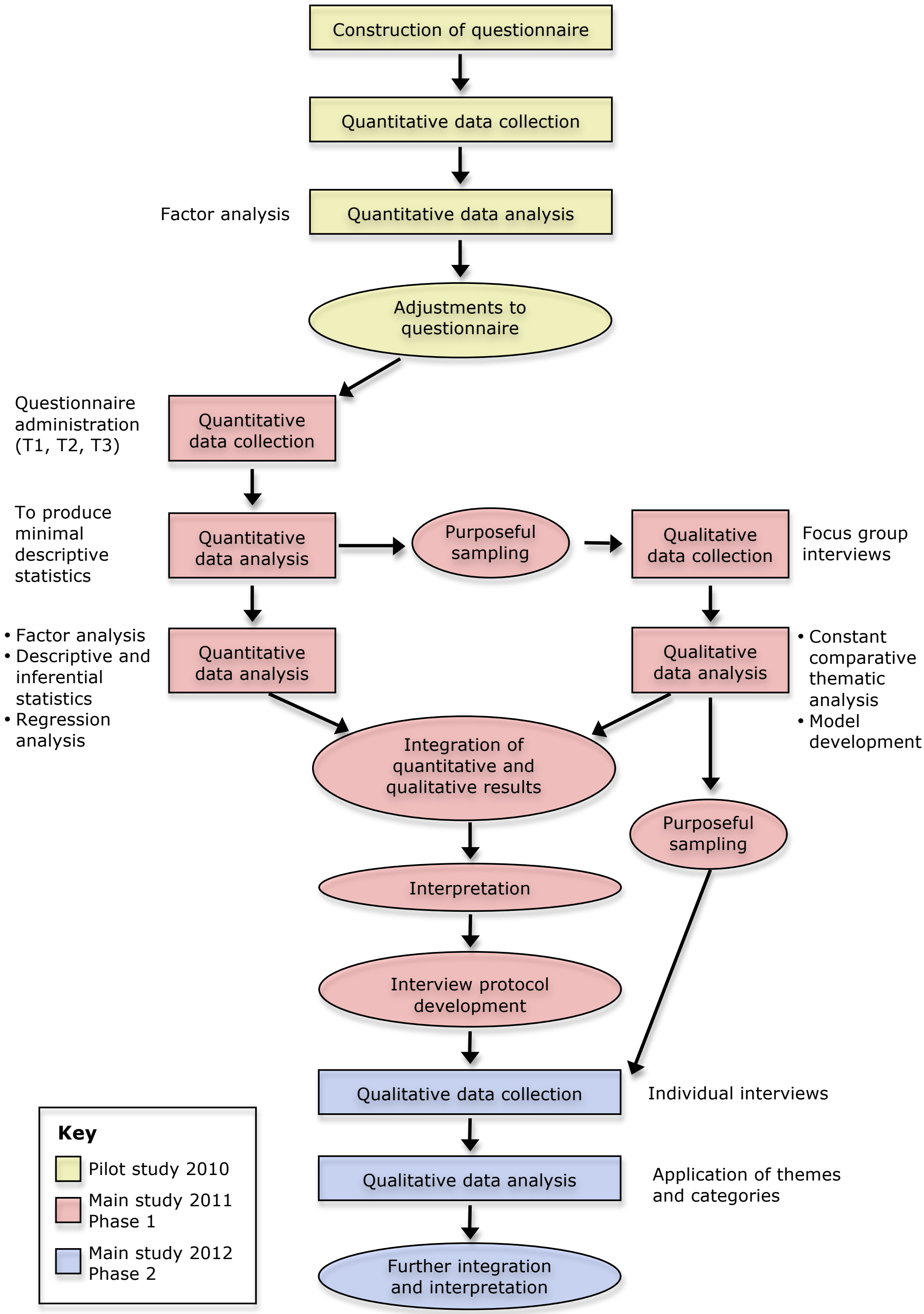

Figure 4. Illustration of the design of this study

The cohort fell naturally into three categories based on prior chemistry experience. In this study, participants were not assigned to treatment or control groups but rather self-selected as voluntary participants in the chemistry bridging course or senior chemistry. Accordingly, it can also be considered a quasi-experimental design (Creswell, 2008; Mertens, 2010).

Within the pragmatic paradigm, quantitative and qualitative findings are presented concurrently. This necessitated the employment of the "personal voice of the naturalistic researcher" (P. L. Johnstone, 2004, p. 268) when discussing qualitative components and the more traditional 'third person' language for the quantitative data.

3.3 Participants

All nursing students enrolled in the Health Science I unit at a tertiary institution in NSW, Australia, were invited to participate in the study, constituting a convenience sample. The college of higher education is a relatively small, private tertiary institution with religious affiliation. The School of Nursing offers the Bachelor of Nursing degree on two campuses: a city and a rural campus. Enrolments in this unit are typically between 100 and 140. The college was selected because I was a sessional lecturer at the institution and delivered the chemistry component of the Health Science I unit on both campuses.

Because of the nature of the pre-test post-test design, students who withdrew from the course or failed to complete the series of questionnaires were removed from the study.

The participants naturally fell into three groups based on prior chemistry experience:

1. Senior Chemistry (SC): students who completed chemistry in Years 11 or 12
2. Bridging Chemistry (BC): students who did not complete Year 11 or 12 chemistry but completed the 3-day chemistry bridging course
3. Poor Chemistry (PC): students who did not complete Year 11 or 12 chemistry nor the chemistry bridging course.

Similar to a study conducted by Pajares and Kranzler (1995) these prior experience categories are based on exposure to chemistry and do not indicate level of achievement.

3.3.1 The Students

Pilot study Of the 127 students enrolled in HESC14700 at some stage during Semester 1 of 2010, all but seven gave consent, representing an overall response rate of 94%. Ten students withdrew from the course, but four were retained in the study because questionnaire data sets were complete. Twenty students were not present in class during the administration of the survey either at T2 or T3 and were subsequently removed from the study. Data from 94 students were used for factor analysis, representing 82% of the eligible cohort (N=114). Demographic information is summarised in Table 2.

Main study Of the 129 students who were enrolled in HESC14700 at some stage during the first semester of 2011, all but six gave consent, completing at least one of the questionnaires, representing an overall response rate of 95%. Eight students were repeating the unit and were not included due to the difficulty in classification of prior knowledge. Three had completed the bridging course in 2010 but enrolled in the unit in 2011, again making if difficult to classify according to prior knowledge. Eight students withdrew at various times during the semester, but one was retained in the study because survey data was complete. Another, who was given advanced standing for the unit after enrolling, subsequently withdrew from the course. An additional three students enrolled late and were not present in class during the administration of the questionnaire in the first lecture of the unit, and were subsequently removed from the study because of incomplete data sets. Data from 101 students were used for analysis, representing 93.5% of the eligible cohort (N=104) and 84.2% of the students who completed the semester of study.

In order to check for homogeneity between the two campuses and provide additional relevant variables for correlation, demographic information was collected and is summarised in Table 2.

In order to justify the treatment of both campus groups as a single cohort, independent samples t-tests (two-tailed) were performed to see if any differences existed between the groups for demographic characteristics, self-efficacy and anxiety measures and academic performance. The only statistically significant difference between the two campuses was the average age, with the city campus (M=24.48, SD=8.70) having a higher mean age than the rural campus (M=20.17, SD=5.13), $t(99)$=2.691, p=.008.

Table 2. Demographic statistics for the pilot and main studies

Demographic	**Category**	**Number or %**	
		Pilot	**Main**
Total		94	101
Campus	Rural	41	35
	City	53	66
Course	Bachelor of Nursing degree		74.3%
	Diploma of General Studies program		25.7%
Gender	Female	76 (80.9%)	92 (91.1%)
	Male	18 (19.1%)	9 (8.9%)
Age	Average	22.72 *SD*=8.30	22.99 *SD*=7.90
	17 - 18 years of age	37.2%	34.7%
	19 – 20 years of age	28.7%	23.8%
	21 – 24 years of age	13.8%	18.8%
	25 – 34 years of age	10.6%	12.9%
	35+ years of age	9.7%	9.8%
Work Hours	0 hours	NA	35.6%
	1 – 9 hours per week	NA	47.5%
	10+ hours per week	NA	16.9%
English	First language or totally confident with English	NA	89.1%
	Second language	NA	10.9%
Mode	Studying full-time	90.6%	92.1%
	Studying part-time	9.4%	7.9%
Health Care Experience	No previous experience	NA	56.0%
	No healthcare qualifications	NA	68.3%
	Assistant in Nursing (AIN), Enrolled Nurse (EN), endorsed EN.	NA	30.7%
	Unrecognised medical practitioner degree	NA	1.0%

3.3.2 Lecturer

According to Pintrich (1994), motivational beliefs such as self-efficacy and anxiety are partially an interpretation of the classroom context. Since Health Science I is delivered on two campuses, it was important to control as many contextual factors as possible. Having the same lecturer, tutor and laboratory coordinator for both sets of students was a crucial factor that contributed to the reduction in external variables that could influence students' beliefs, perceptions and academic performance. Unavoidably, this was not the case for the Chemistry Bridging Course as it was conducted simultaneously on both the city and rural campuses. I conducted the bridging course on the city campus and a recent BSc/BTch graduate with a chemistry major taught the course on the rural campus.

3.3.3 Ethical Considerations

This project (along with an amendment) was approved by the institution's Human Research Ethics Committee (HREC). A letter was given to all participants, explaining the nature of the project and seeking permission to access academic records and record interviews. All data were held in strict confidence, securely stored and, in accordance with the institution's policy, will be destroyed after five years. Student identification numbers were used to correlate data from the questionnaires, academic records and interviews and identities were then coded. Only the researcher had access to the codes. Interview participants were assigned pseudonyms to protect identity. Students were given the option to participate in both the questionnaire study and interviews and coercion was not employed. In addition, students were informed of their right to withdraw from the research at any time. Because I taught the participants and data was collected during the delivery of the course, particular care was taken to prevent bias interfering with student grades. Apart from the use of the T3 questionnaire to select appropriate participants for the focus groups, questionnaires were not closely examined until after grades had been determined. Finally, impact on students' time was minimised by administering the surveys during lecture time and conducting focus group interviews over the lunch break.

Relevant documents relating to ethics clearance for the participants are included in Appendix 4.

3.4 Quantitative Study: Instruments and Data Collection Procedure

The first year of research (2010) constituted the pilot study with the main focus being on trialling and consequently adjusting, if necessary, the questionnaire items selected for measuring self-efficacy and anxiety in preparation for the main study in 2011. For the main study, data were collected in two phases. Questionnaires were administered and focus group interviews were conducted in the first semester. Data analysis was then conducted and findings integrated. In phase two, individual interviews were used to gain feedback on findings and increase trustworthiness. A time-line for data collection is given in Appendix 5. The procedure for quantitative data collection will now be outlined, including the development of the questionnaires.

To minimise any lecturer influence on initial self-efficacy and anxiety judgments related to chemistry, the questionnaire instrument was delivered to participants at the beginning of the first lecture for both the Chemistry Bridging Course (T1) and Health Science I (T2). An explanation of the voluntary nature of the study and the questionnaire was given which was followed by the administration of the questionnaire under exam-like conditions, taking approximately15 minutes. Students were asked to complete the instrument again in the last lecture (Week 7/8) of the chemistry component of the course (T3). At this time, written permission to access academic records and record focus group interviews was gained from participants.

Additional quantitative data were collected on two other occasions: at the conclusion of the chemistry bridging course, where students were invited to complete a feedback survey form (see Appendix 6), and at the beginning of each focus group interview, where participants were asked to rank their experienced level of difficulty and effort for chemistry and for sociology and psychology (see Appendix 10).

A discussion of the development of the self-efficacy and anxiety scales for the questionnaires follows.

3.4.1 Instrument Considerations

Various tools have been developed to measure self-efficacy and anxiety in students from primary school through to tertiary education. With typical Health Science I enrolments of just 120 students each year, it was necessary to maximise the response rate in this research project. Therefore, it was planned to administer the questionnaire during lecture time. Consequently, it was important to limit the length of the instrument to minimise the impact on lecture time. Ideally, self-efficacy and anxiety items would be interspersed throughout the questionnaire. However, the nature of responses required for the self-efficacy items differed from responses required for the anxiety items so self-efficacy and anxiety items were organised into separate sections.

A number of researchers have acknowledged problems associated with self-reporting instruments (Bandura, 1994; Duncan & McKeachie, 2005; Harvey & McMurray, 1994; Lawson, et al., 2007; Mallow, 1994; Schunk, 1990; Udo, et al., 2004; J. E. Williams, 1994). In any self-reporting instrument, it is inevitable that some participants will exaggerate and others under-estimate their levels of confidence and anxiety. Mallow (1994) and Udo et al. (2004) acknowledge this problem in their gender bifurcated studies on science anxiety. They point out that based on cultural and stereotypical expectations, males may under-report and females over-report anxiety. In the case of the Science Anxiety Questionnaire used in their studies (Mallow, 1994; Udo, et al., 2004), reference was made to the research by Alvaro and Hermes (1978, and 1985, as cited in Udo, et al., 2004) on electromyography (EMG), a physical measure of tension, to show that the physical measure gave results consistent with the questionnaire. The authors posit that this provides an "important measure of confidence in the validity of the self-reports of science anxiety" (Udo, et al., 2004, p. 442).

In the current study, self-reporting instruments were used in a pre- and post-test situation. Rather than an absolute indicator, changes in both chemistry self-efficacy and anxiety were considered, making self-reporting instruments appropriate. In response to the recommendation by Pintrich and De Groot (1990) that results should be replicated using other measures, some focus group questions were asked that helped validate the self-report instrument.

3.4.2 Chemistry Self-efficacy Scale

The assessment of self-efficacy as a more task-specific construct began in the late 1970s. The properties of self-efficacy can be measured using questionnaire instruments and many self-efficacy scales over a wide range of areas have been developed, validated and implemented. While earlier research on self-efficacy in educational settings focused largely on elementary school (Multon, et al., 1991) and mathematics (Zimmerman & Martinez-Pons, 1990) , there has been a growing body of research in science self-efficacy at the tertiary level. A review of the literature reveals many instruments developed to assess self-efficacy at varying levels. Generally, these consist of a number of items and participants are asked to rate how confident they are about a particular task on a Likert-type scale. A self-efficacy score is generally calculated based on the sum or average score of the items. Several issues arise from the analysis of these instruments, with implications for the interpretation of research into self-efficacy. The important considerations which arise are now considered.

A sound instrument is more likely to result if a good conceptual analysis is followed (Bandura, 2006). Several researchers have been careful to outline the theoretical basis of their instrument (Baldwin, Ebert-May, & Burns, 1999; Dalgety, et al., 2003; Uzuntiryaki & Aydin, 2009). For example, Baldwin, Ebert-May and Burns (1999) based their instrument on the definition of scientific literacy. Uzuntiryaki and Aydin (2009) searched the literature and included items based on the various theories of goals of science. Dalgety, Coll and Jones (2003) employed an inclusive definition of chemistry culture to develop their instrument, emphasising the importance of a sound theoretical framework. Without attention to this fundamental principle, instrument development can lack focus and validity can be questioned.

Bandura (2006) emphasises that there can be no all-purpose measure of self-efficacy beliefs since the construct, by definition, is context, domain and task-specific. In an educational context, many researchers have measured general academic self-efficacy (Al-Harthy, et al., 2010; Bresó, et al., 2010; Kurbanoglu & Akin, 2010; Lent, et al., 1986; Pintrich & De Groot, 1990; Usher & Pajares, 2006; Zusho, et al., 2003). An example of an item included could be, "I'm sure I can do an excellent job on the problems and tasks assigned for this class" (Pintrich & De Groot, 1990). Unfortunately, since a clear task or activity has not been presented, it may be difficult to make a judgment about capability. Students may feel they can do an excellent job on some tasks but not others, or they may view different subjects as being difficult. Such global or broad measures can simply transform self-efficacy into a general personality trait (Pajares, 1996).

In an attempt to combat the omnibus measures of general academic self-efficacy, some researchers have developed new instruments or modified existing ones in order to be more domain specific. As Thomas, Anderson and Nashon (2008) have noted, most existing instruments "do not account for the classroom context or help students locate their self-report in relation to the learning of specific subjects such as science" (p. 1703). For example, Glynn and Koballa (2006) developed a science self-efficacy scale which was then modified to reflect the specific disciplines within science, that is, physics, chemistry, and biology (Glynn, et al., 2009). In many cases, this involved simply rewording the same items with the domain word replaced. For example, “I am confident I will do well on the science tests” became “I am confident I will do well on the chemistry tests” (Glynn, et al., 2007). While being more domain specific, these measures do not necessarily reflect specific skills required for the different science disciplines. Others have developed specific science discipline self-efficacy instruments in the areas of biology (Baldwin, et al., 1999) and chemistry (Dalgety, et al., 2003; Uzuntiryaki & Aydin, 2009). Furthermore, an instrument suitable for use with science majors may not be appropriate for a nursing cohort (Andrew, 1998; Dalgety, et al., 2003), particularly if the course content is significantly different. Smith and Fouad (1999) also emphasise the need to explicitly focus on specific subject-matter in a given context.

Superior to both broad and domain specific questionnaires are instruments that contain task-specific items. According to Bandura (1997), the predictive capabilities of an instrument are maximised when students are asked to judge their capabilities on items with a clear task in mind. This principle has been incorporated into instruments by a number of researchers (Lawson, et al., 2007; Pajares & Miller, 1994; J. E. Williams, 1994). For example, in assessing maths self-efficacy in college students, Pajares and Miller (1994) asked students to rate their confidence in solving eighteen mid-range-difficulty mathematics problems. The self-efficacy measurement corresponded directly to the criterial performance task, that is, solving the same maths problems. A similar strategy was employed by Williams (1994). Other researchers have also attempted to make their items more task-specific e.g. ”How confident are you that you could explain how a cow’s skull is suited for eating plants?” (Lawson, et al., 2007). Indeed, the meta-analysis conducted by Multon et al. (1991) showed that the strongest effect size for the relationship between self-efficacy and academic performance was found when more specific efficacy items were used. Generally, the predictiveness of self-efficacy measures increases with specificity and correspondence to the skill being assessed (Bandura, 2006; Pajares, 1996; Zimmerman, 2000).

While broad measures of self-efficacy can be problematic, it is also important that items not be too specific. For example, Uzuntiryaki and Aydin (2009) consider a number of items used by Andrew (1998) and Dalgety, Coll and Jones (Dalgety, et al., 2003) to be too specific, obscuring assessment of self-efficacy and limiting the use of the instrument in another setting. It is important to reach a balance between specificity and applicability based on the purpose of the instrument (Pajares, 1996).

Aside from specificity, inappropriately defined self-efficacy measures are also a problem in some existing instruments, with confusion centering around distinguishing self-efficacy from self-concept and self-esteem. As noted in Chapter 2, self-efficacy is a judgment of capability whereas self-esteem and self-concept are a judgment of worth based on social and self-comparisons (Bandura, 2006; Pajares, 1996). An item testing self-concept could read, "I am good at science", whereas self-efficacy would read, "How confident are you about explaining the structure of an atom?" The self-comparison aspect of self-concept can be seen in the following item in the self-efficacy strand of the Motivated Strategies for Learning Questionnaire (MSLQ) (Pintrich & De Groot, 1990): "Compared with other students in this class I think I know a great deal about the subject". This requires a comparison of self with fellow students, a characteristic related more to self-concept, and does not require the student to make a judgment about capability with respect to a specific task. Of the nine items on the self-efficacy strand found in the MSLQ, four require participants to compare their abilities with other students. When Glynn and Koballa (2006) adapted the MSLQ to produce the Science Motivation Questionnaire (SMQ), students were still required to make a comparison on one of the five items on the self-efficacy scale ("I expect to do as well as or better than other students in the science course."). Similar items of self-comparison reflecting the self-concept construct can be found in other questionnaires (e.g. Witt-Rose, 2003). In addition, the link between self-concept and academic performance is not as strong as for self-efficacy. Self-efficacy assesses performance capabilities rather than personal qualities or how participants feel about themselves (Zimmerman, 2000) and does not include judgments made by comparing oneself with others.

Outcome expectancy and performance expectancy are other constructs often confused with self-efficacy. Items assessing these constructs appear in a number of self-efficacy instruments. For example, several contain items based on grades, such as "I believe I can earn a grade of "A" in the science course" (Glynn & Koballa, 2006) or "How confident are you that you will be successful in this biology course?" (Baldwin, et al., 1999). Such items are not based on perceived capability with respect to a specific task, hence not strictly adhering to the self-efficacy construct.

By definition, self-efficacy is a judgment of what the subject "can do", not "will do", the latter being a statement of intention (Bandura, 2006). While many questionnaires have been careful to address this issue (for example, Dalgety, et al., 2003; Midgley, et al., 2000; Uzuntiryaki & Aydin, 2009), some contain items using both expressions (such as Baldwin, et al., 1999; Benson, 1989; Glynn & Koballa, 2006; Witt-Rose, 2003). Other questionnaires consistently misuse the term "will". For example, "I will be able to learn in class" (Bresó, et al., 2010).

The use of multiple items to assess the same facet has also been criticised. For example, the Patterns of Adaptive Learning Survey (PALS) contains five items on the self-efficacy scale, four of which ask how confident students are about doing the hardest work in the course ("I can do even the hardest work in this class if I try" and "Even if the work is hard, I can learn it"). When items are essentially paraphrases of each other, what appears to be factors are only specific variance (Kline, 1994). Pajares (1996, p. 550) points out that while high internal consistency is achieved, "such assessments primarily provide a redundant measure of the general domain."

While some researchers consider self-efficacy as a uni-dimensional construct and present it as a single measure, others recognise that self-efficacy is multi-faceted, even within a specific domain. In chemistry, researchers have identified various aspects of chemistry self-efficacy. For example, factor analysis of the instrument developed by Uzuntiryaki and Aydin (2009) revealed three dimensions: cognitive skills, psychomotor skills and everyday applications. Baldwin et al. (1999) showed that factor analysis of their instrument supported the multi-dimensional nature of self-efficacy in biology, the dimensions being methods, analyzing data and application. Generally, in order to increase the predictive power of an instrument when considering academic performance, the scale must reflect the behaviour being assessed. This is more likely to be successful if dimensions are identified using factor analysis and separate scores are derived.

In summary, self-efficacy assessment is most predictive when derived from a sound theoretical basis and when appropriate levels of specificity are maintained. When developing a self-efficacy instrument in an educational setting, the items should at least be in the domain of the assessment. Ill-conceived assessment scales based on a misunderstanding of the construct can limit the explanatory and predictive value of an instrument (Bandura, 2006). It is clear that an optimum level of specificity guided by context, domain and task, must be determined to suit the purposes of the study.

In order to monitor the levels of and changes in chemistry self-efficacy in this inquiry, a suitable instrument that fits with the theoretical construct was required. Based on Bandura's criteria outlined above, no such questionnaire in the current literature fitted the scope of this study. Consequently, an instrument was constructed to measure chemistry self-efficacy for nursing students, aiming for an ideal level of specificity for Health Science I and recognising various dimensions of the construct.

Most self-efficacy scales have been developed based on existing instruments. For example, Glynn and Koballa (2006) based their Science Motivation Questionnaire (SMQ), including the self-efficacy factor, on the MSLQ (Pintrich & De Groot, 1990). Dalgety et al. (2003) developed their chemistry self-efficacy instrument using Baldwin et al.'s (1999) College Biology Self-efficacy Questionnaire (CBSEQ), with modified items from additional instruments (Rowe, 1988, and Schibeci, 1982, as cited in Dalgety, et al., 2003). A similar strategy was employed for instrument development in this study.

Pilot Study: Chemistry for Nurses Self-efficacy Scale

After examining a variety of self-efficacy instruments found in the literature, a total of 16 items[1] were chosen for the Chemistry for Nurses Self-efficacy Scale (CNSS). Seven items were adapted from the College Chemistry Self-efficacy Scale (CCSS) (Uzuntiryaki & Aydin, 2009), three from the Chemistry Attitudes and Experiences Questionnaire (CAEQ) (Dalgety, et al., 2003) and four from the Self-efficacy for Science Scale (SESS) (Andrew, 1998). See Appendix 7 for a summary. Two additional items were written by myself in consultation with another chemistry educator to incorporate other aspects of chemistry self-efficacy for nursing students. Items were selected based on suitability to the chemistry experiences of a first-year nursing cohort at the college and centred around three key areas: cognitive skills, laboratory skills and everyday applications. In Health Science I, the laboratory component of the course requires students to record results and answer questions. However, students are not expected to write a full laboratory report. Hence, items such as "How well can you write a laboratory report summarising main findings?" (Uzuntiryaki & Aydin, 2009) or "Writing up the experimental procedures in a

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[1] Note that Item 17 on the pilot study questionnaire was not part of the self-efficacy scale but was added to provide data for a colleague working on an unrelated research project.

laboratory report" (Dalgety, et al., 2003) are tasks not required of the nursing students in chemistry in Health Science I. Furthermore, even though the SESS was designed for nursing students in an Australian university, many of the items covered principles of science not relevant to the chemistry course conducted at this institution.[2] Items for the pilot CNSS can be found in Appendix 7.

A 5-point Likert-type response scale was chosen ('1'= not confident and '5'= totally confident) because it is most commonly used in the available instruments. With only five options to consider, less time is required for students to make their judgements, a critical consideration in the procedure for this study. Since anxiety is almost exclusively measured on a 5-point scale in the literature and the self-efficacy items and anxiety items were to be subjected to factor analysis simultaneously as an indicator of discriminant validity, it was more meaningful to have a 5-point self-efficacy scale.

Before factor analysis was conducted on the self-efficacy scale, four items (12, 13, 15, 16) describing everyday applications of chemistry were eliminated because, on reflection, the items were not "tailored to the domain of functioning and/or task under investigation" (Pajares, 1996, p. 550) since the chemistry covered in Health Science I is targeted at nursing applications, rather than everyday applications. As such, they were deemed to have little theoretical basis for inclusion. It also meant that the instrument was more consistent with the academic performance criteria outlined by Bandura (2006).

Factor Analysis of the Chemistry for Nurses Self-efficacy Scale – Pilot Study

An explanation of the procedures used for factor analysis is outlined in the following chapter where details for factor analysis conducted for the main study are given. The results of factor analysis of the pilot study are included here to give the reader an understanding of the evolution of the CNSS used for the main study.

To investigate the underlying structure of the remaining 12-item questionnaire assessing self-efficacy, data collected from 94 participants were subjected to principal axis factoring using varimax rotation with Kaiser

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[2] Where possible, permission was sought from the authors of the various questionnaires accessed in this study. Email replies giving permission were received from Uzuntiryaki and Mallow. Unfortunately, email addresses listed on the journal articles for many authors were not current.

normalization using PASW Version 17. The suitability of applying factorial methods to the data was checked. The KMO measure of .879 and the BTS value of 556.698, *p*<.001 along with many item correlations above .3 suggested that the data was suitable for factor analysis.

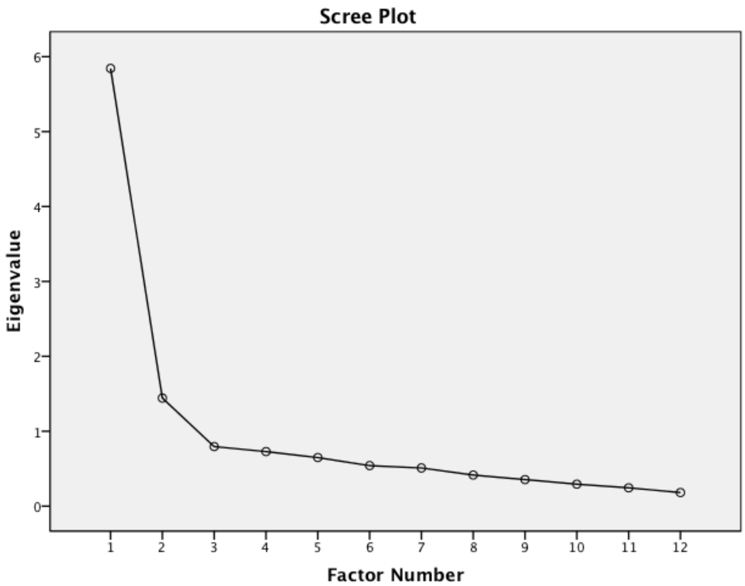

Figure 5. Scree plot for the factor analysis of the pilot CNSS at T3

Consideration of eigenvalues >1 and the scree plot (see Figure 5) indicated a two-factor structure for the chemistry self-efficacy items accounting for 53.2% of the variance. When factor loadings were examined, two items appeared to cross-load.[3] Item 10 was removed and the structure was re-examined using the remaining items. Item 5 was found to load on both components and was also removed. Loadings and variances for the final 10-item, 2-factor solution are given in Table 3. Consideration of the two factors led to the following names: "cognitive chemistry self-efficacy" (CS) which explained 43.3% of the variance, and "chemistry laboratory self-efficacy" (LS) which explained 9.9% of the variance. Interpretation of these factors was consistent with previous research where the terms cognitive and psychomotor skills have been used (Uzuntiryaki & Aydin, 2009). In total, these two factors accounted for 53.2% of the variance in the CNSS data.

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[3] Cross-loading was considered significant where the difference between the factor loadings was <.1

Table 3. Varimax rotated factor structure of the chemistry self-efficacy pilot questionnaire (T3, *N*=94)

Item		*Factor 1 CS* Cognitive Chemistry Self-efficacy	*Factor 2 LS* Chemistry Laboratory Self-efficacy
1	explaining the structure of an atom	**.816**	
8	achieving a passing grade in chemistry	**.776**	
7	reading the formulas of elements and compounds	**.717**	
14	giving examples of common acids and bases	**.654**	
2	explaining the properties of elements using a periodic table	**.637**	.312
11	explaining something learnt in this course to another person	**.613**	.306
9	explaining the relevance of studying chemistry for nurses	**.520**	
3	working with chemicals safely		**.842**
4	interpreting graphs related to chemistry	.329	**.634**
6	carrying out experimental procedures in the laboratory		**.626**
	Total number of items	7	3
	Eigenvalue	4.784	1.401
	% Variance:	43.29%	9.88%
	Cronbach's alpha	.878	.767
	Mean corrected item-total correlation	.663	.602

NB: Loadings less than .3 have been omitted.

Main Study: Chemistry for Nurses Self-efficacy Scale (CNSS)

Following factor analysis of the pilot questionnaire, several changes were made to the self-efficacy instrument. It was noted that Item 4 – 'Interpreting graphs related to chemistry' – could conceptually be placed in the CS factor. To strengthen the laboratory skill factor which contained only three items, two additional related items were modified and added from the CCSS (Uzuntiryaki & Aydin, 2009) and CBSEQ (Baldwin, et al., 1999). Another cognitive skills item from the SMQ was included along with a further item written by the researcher relating to pH. These changes resulted in a new CNSS of 15 items, six of which were new for the main study. These were designed to reflect two dimensions of chemistry in nursing –

cognitive skills and laboratory skills. The CNSS component of the questionnaire for the main study can be found in Appendix 9.

3.4.3 Chemistry Anxiety Scales

As with self-efficacy, there is a diversity of measures for the various types of anxiety ranging from general trait anxiety to chemistry laboratory anxiety (Bowen, 1999). Studies focusing on motivation theory include the measurement of test anxiety along with other constructs in their instruments (e.g. Glynn, et al., 2007; Pintrich & De Groot, 1990). Anxiety in the context of a specific discipline has also been explored, particularly in mathematics. Science anxiety and more recently, chemistry anxiety, have also been investigated. Two significant instruments for determining anxiety in the science domain have emerged.

The Science Anxiety Questionnaire, developed by Alvaro (1978, as cited in Mallow, 1994) to investigate the effectiveness of a Science Anxiety Clinic at Loyola University Chicago, has been used in a number of studies to explore science anxiety in tertiary students studying science (Brownlow, et al., 2000; Mallow, 1994, 2006; Mallow, et al., 2010; Udo, et al., 2004; Udo, et al., 2001). It is used to screen for students who may benefit from the Science Anxiety Clinic (Mallow, 1994). The original 44-item self-reporting instrument was constructed with analogous science and non-science items, such as asking a question in a science class as compared to asking a question in a history class, allowing for anxiety comparison between the two. The 5-point Likert-type scale allowed for responses of “not at all”, “a little”, “a fair amount”, “much” or “very much”.

Various methods have been used to analyse the data from this questionnaire. Reliability coefficients for the science and non-science scales have been reported as 0.904 and 0.850 respectively (Mallow, 1994), allowing for the summation of the 22 science and 22 non-science items. In addition, the percentage of students suffering acute anxiety in general, in science or in non-science items have been determined. The instrument has been used to investigate science anxiety in physics students (Udo, et al., 2001), in non-science majors (Udo, et al., 2004) and other tertiary cohorts (Brownlow, et al., 2000). To date, no details relating to factor analysis have been found for this instrument.

The Derived Chemistry Anxiety Rating Scale (DCARS) was developed by Eddy (2000) based on the 24-item Revised Mathematics Anxiety Rating Scale

(RMARS) (Plake and Parker, 1982, as cited in Eddy, 2000) on the assumption that the definitions for 'mathophobia' and 'chemophobia' are analogous. Eddy included "Learning Chemistry Anxiety", "Chemistry Evaluation Anxiety" and "Handling Chemicals Anxiety" to produce a three-factor instrument consisting of 36 items measured on a 5-point Likert scale where 1 represents "not at all" and 5 means "extremely". It has a reported overall reliability of .95 (Cronbach's alpha) and reliabilities for each of the three factors, Learning, Evaluation and Handling Chemicals of .93, .91 and .89 respectively. While Eddy reports having conducted factor analysis to confirm the existence of three factors in her study of 475 students enrolled in introductory chemistry at Indiana University of Pennsylvania, no data from that analysis was included in the report.

More recently, the DCARS was chosen by McCarthy and Widanski (2009) to ascertain the prevalence of chemistry anxiety amongst college students (*N*=264). While no mention was made of factor analysis or reliability, the reported means for each of the three factors were very close to those quoted by Eddy (2000). A modified version was administered by Oliver-Hoyo and Allen (2005) in a pre- and post-test procedure. Approximately 200 students enrolled in a general chemistry course were asked to complete 25 of the 36 original items from DCARS online during the first and last two weeks of classes to examine what effect an active learning environment in the delivery of a general chemistry course had on chemistry anxiety. Again, no factor analysis and reliability data was reported, but reported means were comparable with the studies by Eddy (2000) and McCarthy and Widanski (2009).

Pilot Study: Anxiety Scale

For the pilot study, the Science Anxiety Questionnaire (Mallow, 1994) was chosen because it takes into account the distinction between science anxiety and non-science anxiety and has been used in pre-test post-test situations. Since chemistry anxiety is the focus of the current study, many of the general science items and those relating specifically to biology and physics were not relevant. In selecting items, the basic premise of the Science Anxiety Questionnaire was followed, and six chemistry items (1, 3, 5, 15, 26, 36) along with the analogous six non-science items (7, 22, 27, 35, 40, 44) were selected from the original instrument. Some slight modifications were made to 7 of the items to reflect the chemistry in nursing aspect of the study and the items were placed in random order. Students were asked to rate how frightened they were about the 12 items, using the same classifications as the original instrument for the 5-point Likert-type scale. Anxiety items can be found in Appendix 8.

To investigate the underlying structure of the questionnaire assessing anxiety, data collected from 94 participants were subjected to principal axis factoring using varimax rotation with Kaiser normalization using PASW Version 17. Suitability of applying factorial methods to the data was checked. The KMO measure of .787 and the BTS value of 468.822, $p<.001$, along with many item correlations above .3, suggested that the data was suitable for factor analysis. However, only one component emerged, which was supported by the scree plot (see Figure 6). Forty-one point four percent of the variance in the data was accounted for, with communalities ranging from .373 to .694. Cronbach's alpha was .871.

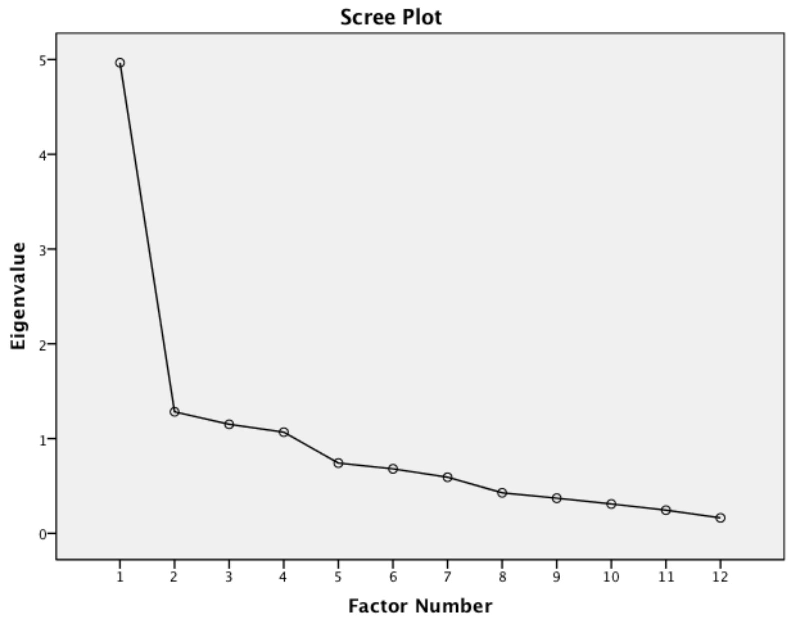

Figure 6. Scree plot for the factor analysis of the pilot anxiety instrument at T3

Factor analysis failed to produce the two components - science anxiety and non-science anxiety - suggested by the literature (Mallow, 1994; Udo, et al., 2001), even when directed to give two factors. This would indicate that students did not conceptualise these two types of anxiety in the instrument and did not distinguish between the same type of anxiety (e.g. test, asking a question, being watched) in a different domain. Consequently, apart from using it as a general measure of academic anxiety, the instrument was of little value, and a new approach was adopted for the main study.

Main Study: Chemistry for Nurses Anxiety Scale (CNAS)

An alternative approach was employed for the main study for two reasons. As shown in the previous section, the shortened version of the Science Anxiety Questionnaire failed to produce the factor structure for which the instrument was designed. Secondly, it was deemed more appropriate to explore further aspects of chemistry anxiety. The non-science items were eliminated and the focus moved to specific aspects of chemistry anxiety.

A modified DCARS was deemed a suitable instrument to employ in the main study to assess chemistry anxiety amongst first-year nursing students. The use of all 36 items was not viable because of time constraints during delivery of the questionnaire. Thirteen items from DCARS were chosen across all three factors: learning chemistry, chemistry evaluation, and handling chemicals. An additional item from the pilot study was modified and included in the ‘Learning chemistry’ dimension. In response to the research conducted in chemistry laboratory anxiety (Bowen, 1999; Kurbanoglu & Akin, 2010), the third factor was broadened to incorporate the use of equipment and procedures associated with laboratory experience. Three items from the DCARS were modified slightly to reflect academic and cultural context. A total of 16 items were included and presented in a 5-point Likert scale in keeping with the original DCARS instrument. The Chemistry for Nurses Anxiety Scale (CNAS) was designed to represent three aspects of chemistry anxiety: learning (7 items), evaluation (5 items) and laboratory experiences (4 items). A further item, “getting the required academic support and assistance for chemistry”, was included as an evaluation tool for the institution but was not included in the factor analysis.

The questionnaires incorporating the CNSS and CNAS for the main study can be found in Appendix 9.

3.4.4 Additional Items for the Questionnaire: Perceptions of Chemistry

Additional items were included in the questionnaire to provide further information about first-year nursing students’ perceptions of chemistry. Items included ‘level of enjoyment when chemistry was last studied’, various items on the 'importance of chemistry to nursing', how well they expected to do in chemistry this semester, and for the T3 questionnaire, feedback on the course in relation to prior chemistry knowledge.

3.4.5 Effort and Difficulty Survey

In order to compare the cognitive load experienced by students in chemistry with a non-science subject such as psychology and sociology, Paas's one-item self-reporting measure (Paas, 1992) which is most frequently employed in "educational science" (de Jong, 2010, p. 114), was used. Focus group participants were asked at the beginning of the interview to estimate on a scale of 1 to 9 (from 'none' to 'extremely high') the level of mental effort required for chemistry and for sociology and psychology (a unit studied by the first-year nursing students in their first semester). They were also asked to rate the 'difficulty of the content' and of 'learning the content' in chemistry. Despite the identification of several problems with this method of measuring cognitive load (de Jong, 2010), the fact that it was used as a measure of comparison rather than an absolute measure, should abate some fears. The four-item survey is included in Appendix 10.

3.4.6 Academic Capacity Indicator

The Standard Progressive Matrix test (SPM *Plus*), known as the Ravens Progressive Matrix (RPM), was devised to measure the eductive component of Spearman's *g*.

> Educative ability is the ability to forge new insights, the ability to discern meaning in confusion, the ability to perceive, and the ability to identify relationships. … the essential feature of eductive ability is the ability to generate new, largely non-verbal, concepts which make it possible to think clearly. (Raven, Raven, & Court, 1998, p. 1)

RPM consists of 60 problems arranged in five sets of "diagrammatic puzzles that exhibit serial change in two dimensions simultaneously" (Raven, et al., 1998, p. 1) which become progressively more difficult. As such, it measures the capacity to make sense of complexities and to process information while minimising language bias, making it an appropriate instrument for chemistry capacity. The authors claim it provides an index of intellectual capacity and does not purport to measure 'ability', 'intelligence' or 'problem solving ability'. It has been deemed appropriate for use with adults in a wide variety of settings, providing an internally consistent tool demonstrating construct validity (Raven, et al., 1998). There is some evidence to suggest that males obtain slightly higher means on this test while females show significantly greater variability (Irwing & Lynn, 2005).

It should be noted that any test of this kind has limitations and provides information on only part of the cognitive spectrum. RPM was used in this study to act as a control for the effect of capacity on academic performance as it is less influenced by educational background than other measures (Pajares & Kranzler, 1995). While it may have been more advantageous to use the advanced version, it was not available for use in this educational institution.

Eighty-five students (84%) volunteered to complete the RPM outside scheduled class time. It was administered according to the guidelines in the manual. Results were made available to the students on request.

3.4.7 Academic Performance Indicators

The literature reveals numerous ways of expressing academic performance. The final grade for Health Science I was determined using two semester tests (25%), eight laboratory reports (25%) and the final exam (50%). In this unit, laboratory reports were completed before students left the laboratory, which meant they had access to significant support from laboratory assistants if required. Consequently, the average marks for this component of the course were quite high and did not necessarily reflect a student's true ability. Further, it has been shown that laboratory marks only weakly correlate with academic performance in tertiary chemistry (Seery, 2009). For this inquiry, academic performance was determined using the chemistry component of raw test and exam marks only, reflecting the relative weightings given to each in the final grade: 28.6% Test 1 + 14.3% Test 2 + 57.1% Final Exam.

To enhance the analysis of the selected variables and academic performance, students were placed into three academic performance groups: low achievers (<45%), average achievers (45-69%), and high achievers (70+%).

3.5 Qualitative Data Collection

As earlier noted, surprisingly few studies have taken a qualitative approach to studying chemistry self-efficacy and anxiety in a tertiary setting. When qualitative data has been included, it has been in the form of interview data (Andrew & Vialle, 1999; Mallow, 2010; Schmid, et al., 2012). Two types of interviews were used for this study: focus groups (Phase 1) and individual follow-up interviews (Phase 2).

3.5.1 Phase 1: Focus Groups

While focus groups have long been considered the staple of market researchers (Patton, 2002), they are becoming more established within the social sciences (Barbour and Kitzinger, 1998, as cited in A. Williams & Katz, 2001) and have been utilised in several studies considering science education in nursing (El-Farargy, 2009; Friedel & Treagust, 2005; Gresty & Cotton, 2003). Focus groups are unique in that they allow for the collection of "high quality data in a social context where people consider their own views in the context of the views of others" (Patton, 2002, p. 386). They capitalise on shared experiences and encourage an atmosphere where group members influence and are influenced by the other participants (A. Williams & Katz, 2001). Members of a focus group have an opportunity to hear responses and make additional comments (Patton, 2002), providing an exploration and clarity of views not easily gained from individual interviews (Barbour, 2008; Kitzinger, 1995). In addition, the group can help clarify or articulate what others may be thinking (Kitzinger, 1994), providing mutual support when expressing views. While those with a minority opinion may be hesitant to express their views in a group setting, focus groups help identify group norms and extreme views (Barbour, 2008; Kitzinger, 1994; Patton, 2002). It is a way of enhancing survey results (Kitzinger, 1995; A. Williams & Katz, 2001), providing a means of investigating not just *what* people think, but exploring *how* and *why* (Kitzinger, 1994).

Six focus group interviews were conducted over the lunch break to minimise time demands on the students, each interview lasting for between 25 and 45 minutes. A relaxed and informal environment was created (Puchta & Potter, 2004), made easier since a relationship had already been established between the researcher and the participants. An interview protocol was created to guide the discussion (see Appendix 11). In keeping with the intention of focus groups, participants were given freedom to explore any dimension that related to the main issues of self-efficacy, anxiety and past chemistry/science experiences. Interviews were recorded using video and digital audio. Transcripts were made of the interviews, ready for analysis.

Focus Group Participants

On the T3 questionnaire, students were asked to indicate their willingness to participate in a group to discuss aspects of their chemistry experience. Purposeful sampling strategies were then employed to create groups based on a shared experience displaying the various dimensions of the principle characteristic of this study (Barbour, 2008; Creswell, 2008) – prior chemistry experience. Creswell (2008) notes that focus groups work well when interviewees are similar to and are cooperative with each other. Members of six focus groups, three from each campus consisting of 3-5 students, were selected based on the three categories SC, BC, and PC (previously defined). Morgan (1988, as cited in Barbour, 2008) points out that while groups should be homogenous for background (in this case, prior chemistry experience), this should not be the case for other characteristics such as attitudes. On this basis and using information supplied by the questionnaires, further selection criteria reflecting the range in age, gender, perceptions of chemistry and academic performance were employed to ensure diversity.

Participants were assigned pseudonyms consistent with their prior chemistry experience group in order to simplify the identification of comments reported in the findings and discussion: SC student pseudonyms begin with 'S' (e.g. Sarina), BC begin with 'B' (e.g. Bella), and PC with 'P' (e.g. Paul). The final composition of the 27 focus group members, along with demographic and quantitative data, is reported in Appendix 12.

3.5.2 Phase 2: Individual Interviews

While focus groups provide opportunities to gauge shared experiences and highlight contrasting views, one-on-one interviews were conducted to delve deeper into the "rich variation" (Patton, 2002, p. 341) of personal experiences. Since individual interviews were conducted after initial data analysis, explanatory questions were developed in light of the data analysis (see Appendix 13). Individual models were subsequently constructed.

Of the three interview approaches outlined by Patton (2002), the general interview guide approach was selected for this phase of the study because guiding questions were derived from the focus group transcripts and the quantitative analysis in order to produce a more comprehensive picture of the chemistry experience of each particular individual. Interviews were recorded digitally and then transcribed.

Originally, these interviews were to be conducted in the second semester of the course. However, unexpected complications associated with my health prevented this from occurring. While not ideal, individual interviews were conducted towards the end of the third semester of the students' course.

Interview Participants

One member from each focus group was selected to verify the focus group transcript and participate in the interviews. Selected students were those who could verbally articulate, appeared comfortable sharing ideas (Creswell, 2008) and represented a variety of demographic, academic performance and attitude perspectives. Students who were individually re-interviewed are identified in Appendix 5 and boldfaced and marked with '*' in Appendix 12.

3.6 Summary

A mixed method approach operating within a pragmatic paradigm was chosen to allow for a more coherent description of the experiences of first-year nursing students in chemistry. A review of the literature established the need to reconstruct existing instruments to measure chemistry self-efficacy and anxiety for the nursing students. Factor analysis of the pilot study questionnaires resulted in further modifications and adaptations. Two phases of an explanatory sequential design were implemented. In the first phase, quantitative and qualitative data were collected in parallel. Focus group interviews were conducted to illuminate the questionnaire findings. Phase 2 individual interviews provided not only reflections on the integrated findings, but increased the trustworthiness of the inquiry, an issue to be addressed in the following chapter. The next chapter also outlines the procedures used for data analysis and gives details of the factor analysis of the instruments and the analysis that led to the qualitative model.

4 DATA ANALYSIS

Chapter Overview

The previous chapter gave details of the procedures used for data collection, including the development of the CNSS and CNAS. This chapter explains the processes used to analyse the data. A description of the factor analysis of the questionnaires is given, along with a brief outline of inferential statistical procedures used in this inquiry. This is followed by the constant comparative thematic analysis of the interview data, resulting in the emergence of themes and a qualitative model. Issues of reliability, validity and trustworthiness are also addressed.

4.1 Quantitative Data Analysis

Data were entered into PASW (Predictive Analytics Software) Version 18.0.3 (formally and subsequently known as SPSS). Likert-scale data were entered based on a 0 (not at all) to 4 (totally confident / extremely anxious) rating.

The first process in analysing the quantitative data was to conduct a factor analysis on the two instruments developed after the pilot study: Chemistry for Nurses Self-efficacy Scale (CNSS) and Chemistry for Nurses Anxiety Scale (CNAS). An explanation of the procedures used and the results of the factor analysis follow. Mean scores for the self-efficacy and anxiety factors were then determined and were subjected to a number of standard statistical procedures.

4.1.1 Analysis of the Chemistry Self-efficacy and Anxiety Instruments

In order to identify the "nature of latent constructs underlying the variables of interest" (Bandalos & Finney, 2010, p. 93), exploratory factor analysis was chosen. Several criteria were employed to confirm the appropriateness of factor analysis.

There has been much discussion concerning appropriate sample size for reliable factor analysis. Some suggest the 'ratio of subjects to items' guide which can range anywhere from 5:1 (Allen & Bennett, 2008) to 10:1 (Nunnally, 1978, as cited in Pallant, 2007). Osborne and Costello (2009) cite a number of researchers that support the use of the absolute sample size criterion, with numbers ranging from N=50 to N=400 as suggested possible minimums. Bandalos and Finney (2010) note that recent studies indicate characteristics of the data being an important factor when considering sample size and state that N=100 may be sufficient if only three factors are measured and variables have communalities >.7 (i.e. how much of the variance in each item is explained by the factor (Allen & Bennett, 2008)). Indeed, factor recovery with *N*<50 has been found to be satisfactory if structure is simple, factors are well defined and limited in number, and loadings are relatively high (de Winter, Dodou, & Wieringa, 2009). With a sound theoretical foundation, *N*=101 was deemed to be a sufficiently large sample size to produce reliable and meaningful factors in this inquiry.

To investigate the underlying structure of both the CNSS and CNAS, data were subjected to separate principal axis factoring employing varimax rotation with Kaiser normalization. This method was chosen due to the relatively small sample size (Briggs & McCallum, 2003, as cited in Bandalos & Finney, 2010), where normality is more likely to be violated (Fabrigar, Wegener, MacCallum, and Strahan 1999, as cited in J. W. Osborne & Costello, 2009). Moreover, the use of this method is in keeping with a large proportion of studies on self-efficacy and anxiety reported in the literature (e.g. Dalgety, et al., 2003; Hargroder, 2007; Usher & Pajares, 2006; Uzuntiryaki & Aydin, 2009; Velayutham, Aldridge, & Fraser, 2011).

The appropriateness of using exploratory factor analysis was confirmed by considering four main criteria: the KMO (Kaiser-Meyer-Olkin) measure of sampling adequacy (>.6) (Pallant, 2007); BTS (Bartlett's test of sphericity) (significance<.05); an examination of inter-item correlation matrix values to ensure that substantial associations exist (all items must have at least one correlation of .3) but not too high (which would indicate replication of similar items) (Kinnear & Gray, 2010) ; and amenability of data for factoring (i.e. normality), keeping in mind that factor analysis is relatively robust against normality violations (Allen & Bennett, 2008). Values for the KMO and BTS for both scales are reported in Table 4. Examination for normality showed a moderate amount of skewness or kurtosis in a number of variables but all were <|2| (see Appendix 14 for values). Inspection of the histograms and normal Q-Q plots indicated most items to be sufficiently normal.

Table 4. Values for the suitability of CNSS and CNAS for factor analysis

	CNSS	CNAS
Kaiser-Meyer-Olkin Measure (KMO)	.918	.916
Bartlett's test of sphericity (BTS)	945, *p*<.001	1348.512, *p*<.001
Inter-item correlations	many coefficients > .3	

While analysis was performed on data collected at both T2 and T3, it was deemed more appropriate to adopt the structure generated from T3 since the measurement of self-efficacy is more reliable when students are familiar with the task on which they are being asked to rate confidence (Zimmerman, 2000). Further, Multon et al. (1991) found larger effect sizes from post-treatment measures of self-efficacy than from pre-treatment. Factor analysis was not considered for T1 data due to the relatively small number of cases (*N*=31). Factor analysis conducted on T2 data produced an almost identical factor structure to that for T3 data.

Understanding that "factor analysis is as much an art form as it is a science" (Acton & Miller, 2009, p. 255), many considerations were taken into account in order to arrive at a parsimonious factor solution. While eigenvalues > 1 have been cited in much research as the criteria for determining the number of factors, this has been widely criticised as a less than adequate indicator, often resulting in an inappropriate number of factors (Acton & Miller, 2009; Bandalos & Finney, 2010; J. W. Osborne & Costello, 2009). In this study, three additional criteria were considered. Examination of the scree plot indicates that the factors above the "elbow" should be retained. Secondly, eigenvalues were generated from a randomly generated data set of the same size using a statistical on-line package developed by Marly Watkins (2000, as cited in Pallant, 2007, p. 191). In parallel analysis, these values are compared with those obtained from the factor analysis and the number of factors that exceed the corresponding eigenvalue from the random sampling are retained. According to Pallant (2007), this has been shown to be the most accurate of the three criteria. Another consideration was the strength of the factor generated, recognising that factors with less than three variables are weak and may be difficult to replicate (Bandalos & Finney, 2010).

Problematic items with significant cross-loading[4] were checked for reliability contribution before removing and the subsequent re-running of the factor analysis. Because of the relatively small sample size, variables with low loadings (<.5) were scrutinized. Communalities were also examined and items with values <.3 were considered a poor fit with others in the factor (Pallant, 2007). Ultimately, the adopted solution was as simple a structure as possible (Bandalos & Finney, 2010;

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[4] Cross-loading was considered significant where the difference between the factor loadings was < .1.

Pallant, 2007) and one that made the most sense in light of the current conceptual understandings of the constructs from the literature and the theoretical framework of social cognitive theory.

Findings from the factor analysis for the main study follow.

4.1.2 Results for the Factor Analysis of CNSS – Main Study

Despite the existence of three components emerging from the CNSS with eigenvalues >1 accounting for 63.6% of the variance, two factors were considered salient based on the scree plot, the Parallel Analysis and the conceptual understanding of self-efficacy (see Figure 30 and Table 42 in Appendix 15). In addition, one of the self-efficacy factors on the three-component structure consisted of only two items. When directed to extract two factors, examination of factor loadings revealed cross-loading for Item 14 on both self-efficacy dimensions. The deletion of this item had minimal impact on Cronbach's alpha (from .924 to .918). The final solution for 14 items demonstrated a relatively simple structure and was consistent with theory. Loadings and variance are given in Table 43 in Appendix 15 and final communalities, which were all >.47, are listed in Appendix 14. Consideration of the two factors led to the following names: "cognitive chemistry self-efficacy" (CS) which explained 34.6% of the variance, and "laboratory chemistry self-efficacy" (LS) which explained 24.0% of the variance. Interpretation of these factors was consistent with the types of factors found in previous research (Uzuntiryaki & Aydin, 2009) and resonate with theory. In total, these two factors accounted for 58.6% of the variance in the CNSS data. The final composition of the factors is displayed in Table 5.

4.1.3 Results for the Factor Analysis of CNAS – Main Study

Exploratory factor analysis was also conducted on the CNAS. Consideration of eigenvalues >1, Parallel Analysis and the scree plot (see Table 44 and Figure 31 in Appendix 16) all indicated a two-factor structure for the chemistry anxiety items accounting for 66.5% of the variance. On examination of factor loadings, it was noted that Item 30 loaded relatively evenly on both anxiety dimensions. Item 30 was removed and the structure re-examined using the remaining items. Two more anxiety items – 28, 20 – were subsequently removed due to cross-loading. Loadings and variances for the final 13-item, 2-factor solution are given in Table 45 in

Appendix 16 and final communalities, which were all >.48, are listed in Appendix 14. Consideration of the two factors led to the following names: "chemistry test anxiety" (TA) which explained 40.1% of the variance, and "chemistry laboratory anxiety" (LA) which explained 26.2% of the variance. Interpretation of these factors

Table 5. Composition of the four factors derived from the CNSS and CNAS, with factor loadings

CNSS Factor 1. Cognitive chemistry self-efficacy (CS)		
1.	explaining the structure of an atom	.546
2.	explaining the properties of elements by using a periodic table	.493
4.	interpreting graphs related to chemistry	.570
6.	identifying an element or compound from its chemical formula	.654
7.	achieving a passing grade in chemistry	.766
8.	explaining the relevance of studying chemistry in a nursing context	.702
9.	explaining something learnt in this chemistry unit to another person	.745
10.	interpreting results from a chemistry laboratory session	.598
11.	choosing an appropriate mathematical formula to solve a chemistry problem	.819
13.	mastering the knowledge required in this chemistry course	.805
CNSS Factor 2. Laboratory chemistry self-efficacy (LS)		
3.	working with chemicals safely	.774
5.	carrying out experimental procedures in the laboratory	.818
12.	reading the procedure then successfully conducting a chemistry experiment	.712
15.	correctly using the equipment in the chemistry laboratory	.809
CNAS Factor 1. Chemistry Test Anxiety (TA)		
18.	studying for a chemistry test or exam	.852
19.	memorising chemistry definitions and formulas	.834
21.	thinking about an upcoming chemistry test one day before	.775
23.	identifying a substance from its chemical formula	.656
24.	sitting a chemistry test or exam	.912
25.	reading the word 'chemistry'	.665
26.	solving a difficult problem on a chemistry test	.781
27.	waiting to get a chemistry test returned	.803
CNAS Factor 2. Chemistry Laboratory Anxiety (LA)		
16.	performing a chemistry experiment in the laboratory	.801
17.	interpreting graphs or charts that show the results of a chemistry experiment	.626
22.	using the equipment in a chemistry experiment	.847
29.	mixing chemicals in the laboratory	.913
31.	spilling a chemical	.598

was consistent with previous research (Eddy, 2000). In total, these two factors accounted for 66.3% of the variance in the CNAS data. The final composition of the factors is displayed in Table 5.

It was expected that the CNAS would comprise three factors. While the emergence of both chemistry laboratory and test anxiety was consistent with previous research (Bowen, 1999; Eddy, 2000; McCarthy & Widanski, 2009), a separate 'learning chemistry anxiety' factor failed to appear. Each of the removed items were intended for this factor, with the remaining items loading onto the 'test anxiety' factor. It would appear that either students did not conceptualise learning chemistry and evaluation of chemistry as separate constructs, or more 'learning chemistry' items were required.

4.1.4 Evaluation of the Factor Analysis

Reliability

For quantitative data, reliability refers to consistency, dependability or repeatability. Two aspects were considered for assessment in this study. The most commonly used measure of reliability for multi-item scales in instruments, particularly for those that use a Likert scale (LoBiondo-Wood & Haber, 1994), is the Cronbach alpha. In this study, all ratings were >.8, indicating that the factors are highly reliable (Cohen, Manion, & Morrison, 2007). Secondly, mean corrected item-total correlations were above .3 (Pallant, 2007) showing that each item made a strong contribution to the consistency of the scores. Reliability statistics are recorded in Table 6.

Table 6. Reliability statistics for CNSS and CNAS factors

Factor	Cronbach's alpha	Mean corrected item-total correlation
CS	.918	.528
LS	.875	.554
TA	.938	.653
LA	.869	.598

Validity

To validate an instrument, it is necessary to consider several sources of evidence (Mertens, 2010). The traditional range of validity measures - content, criterion-related (predictive, concurrent) and construct (convergent, discriminant) -

were applied to the instrument to establish that it was measuring what it purported to measure (Creswell, 2008), that is, various dimensions of chemistry self-efficacy and anxiety.

In order to assess validity of the content of the instruments for the main study (content validity) (Creswell, 2008), two other lecturers from the institution, one based in the education faculty with both educational measurement and science expertise and the other a chemistry lecturer with previous experience teaching chemistry to nurses, examined the items. An additional item incorporating a nursing context was suggested, and “interpreting the results of a pH reading for a patient” was added to the CNSS. An English-as-a-second-language expert reviewed the questionnaire and acknowledged that the scientific terminology in numerous items may be difficult for some students but the level of language was appropriate for a tertiary institution[5].

Criterion-related validity determines whether “the scores from an instrument are a good predictor of some outcome they are expected to predict” (Creswell, 2008, p. 172). Based on social cognitive theory, one would expect a higher level of self-efficacy and a lower level of anxiety at the beginning of the course amongst students who had higher levels of prior chemistry knowledge. In this instance, *concurrent* validity was investigated using independent t-tests. Results (recorded in Table 46 in Appendix 17) indicated that students who studied senior chemistry at school had higher levels of both cognitive and laboratory self-efficacy at the beginning of the course. However, discrimination of groups based on measures of anxiety at the beginning of the semester failed to reach significance, an issue considered in Chapter 6. Based on the theoretical underpinnings from the literature, *predictive* validity was assessed using achievement measures (Creswell, 2008). Pearson product-moment coefficients were calculated for correlations between final academic performance and the T3 values for each factor (see Table 47 in Appendix 17). As expected, strong and statistically significant correlations were found for the cognitive factors (CS and TA), and weak correlations with the laboratory factors (LS and LA).

Construct validity seeks the clarification of “the ‘operationalized’ form of the construct” (Cohen, et al., 2007, p. 138) and was assessed using two measures. Table

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[5] The English language proficiency level required for nurse registration in Australia is at least 7.0 on the IELTS, and a minimum level of 6.0 for an international student is required for enrolment by this institution.

48 in Appendix 17 demonstrates that the two self-efficacy factors exhibit *convergent* validity because they highly correlate with each other (Creswell, 2008). While not as strong, the two anxiety scales are also significantly correlated. Furthermore, the reliability of the scales compares favourably with those from which they were derived (see Table 49 in Appendix 17). The relatively low correlations between the self-efficacy and the anxiety dimensions indicate that the scales are sufficiently dissimilar, thus demonstrating *discriminant* validity (Creswell, 2008). Similarly, the correlations between TA and LA and between CS and LA are less than .80 (Brown, 2006, as cited in Velayutham, et al., 2011, p. 12), further demonstrating discriminant validity. To show that students did discriminate between self-efficacy and anxiety, exploratory factor analysis was conducted using items from the CNSS and CNAS simultaneously. A stable, three-factor structure emerged – one for self-efficacy and two for anxiety – with little cross-loading, indicating students conceptualised these constructs as separate entities.

4.1.5 Statistical Procedures for Quantitative Analysis

In order to establish inter-relationships among pertinent variables in this inquiry, a series of statistical analyses were applied using PASW Version 18. Tests for normality were conducted, where descriptive statistics of skewness and kurtosis (absolute values <2), graphics (both histograms and normality probability plots), and statistical measures (Shapiro-Wilks) were all considered (Allen & Bennett, 2008; Sheng, 2008). Homogeneity of variance is an assumption for t-tests and ANOVA and was tested using Levene's test for equality of variances.

Bivariate relationships between age, self-efficacy, anxiety, previous chemistry experience and academic performance were explored using two-tailed Pearson product-moment correlation coefficients, independent t-tests (two-tailed), paired samples t-tests, and one-way between groups analysis of variance (ANOVA) followed by post-hoc tests employing Scheffe using an α of 0.05. Despite having less statistical power than some other post-hoc alternatives, Scheffe was chosen since some groups were not similar sizes (Allen & Bennett, 2008) and because, being the most cautious of post hoc tests, it would reduce Type 1 error (Pallant, 2007). In order to "make judgments about the practical significance of the results with prior literature" (Thompson, 2008, p. 258), effect sizes were calculated[6]. Since the sample size was relatively small, Cohen's *d* has been reported for t-tests (Thompson, 2008) and eta-squared η^2 for ANOVA (Pallant, 2007)[7]. Variables of significance ($p <$ 0.05) were then subjected to hierarchical multiple regression analysis where academic performance, self-efficacy and anxiety were successively treated as dependent variables, in order to determine the amount of variance accounted for by the various significant independent variables.

4.2 Qualitative Data Analysis

4.2.1 Analysis of the Interview Data

Cresswell (2008) points out that there is no single set approach to the analysis of interview data, particularly since the analyst brings his or her own experience to the process. For this inquiry, tools from grounded theory were used to facilitate a heuristic analysis (Charmaz, 2006). In order to maximise engagement with the data (Mertens, 2010), interviews were personally transcribed by the researcher. Transcripts, including group dynamics for the focus group interviews, were read several times "to immerse oneself in the data and gain a sense of the possibilities" (Lodico, et al., 2006, p. 304) for classification. The inductive line-by-line process of coding (Charmaz, 2006) was initially conducted on the city BC focus group (a sample page can be found in Appendix 18 which led to the identification of

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[6] As a guide, Cohen (1988, as cited in Pallant, 2007) has proposed effect size magnitudes for group comparisons as follows:

d: 0.2 is regarded as small, 0.5 as medium, and 0.8 as large.

η^2: .01 is regarded as small, .06 as medium, and .14 as large.

[7] Cohen's $d = \dfrac{M_1 - M_2}{\sqrt{\dfrac{\sigma_1^2 \times (N_1 - 1) + \sigma_2^2 \times (N_2 - 1)}{N_1 + N_2 - 2}}}$ for independent t-tests

Cohen's $d = \dfrac{M_1 - M_2}{\sqrt{\dfrac{\sigma_1^2 + \sigma_2^2}{2}}}$ for paired samples t-tests

eta squared: $\eta^2 = \dfrac{SS_{between}}{SS_{Total}}$ for ANOVA (Allen & Bennett, 2008) provisional categories to act as a springboard for more detailed analysis (Strauss, 1987). A set of a priori codes was not employed and, as much as possible, the process was not constrained by the theoretical perspectives of cognitive theory. As suggested by Williams and Katz (2001), core insights, common phrases and words, mood and non-verbal clues were all considered.

After initial coding and memoing on paper (see Appendix 19 for some examples), the transcripts were entered into NVivo. This was to facilitate the processes of locating and comparing codes and categories (Patton, 2002). It also provided further opportunity to re-examine and refine the emerging code framework and determine its resilience (Mertens, 2010). Additional memos were written during this constant comparative phase. Once initial analysis of all focus groups was done, participant comments were systematically scrutinised (Barbour, 2008), yielding additional insights which resulted in further amendment and coalescence of codes and categories. Convergent and divergent characteristics were also identified, providing significant perspicacity for discussion in Chapters 5 to 8. Some sections of text incorporated more than one code and the overlap of codes was useful in later analysis of links between themes and categories.

While the data analysis process is often divided into two phases (initial and focused) (Charmaz, 2006), the approach used in this study was more cyclic with initial codes progressively placed into categories as patterns surfaced. Some samples of early coding frames are reported in Appendix 19. Early in the project, clustering of codes and categories (Creswell, 2008) and discussions with supervisors facilitated the formation of three major themes: connectivity, reductivity and self-reflectivity (later renamed reflexivity). As the iterative process of data examination progressed, connections were made within and between the themes, aided by the use of flow diagrams and mind maps. A number of samples have been included in Appendix 20.

Finally, as outlined in Figure 7, after carefully considering the major themes, the key constructs and the theoretical framework for this study, a model was developed representing the interactions of the three main themes – connectivity, reductivity, and reflexivity. The process of model-making clarified the relationships even further and additional adjustments were made to the coding frame as a number of categories were collapsed and refined. Finally, individual interviewees were asked to reflect on the various categories in the model and to articulate possible links between them, particularly with confidence, anxiety and learning. Table 7 summarises the themes and categories and the model can be seen in Figure 8. Individual models constructed for each participant can be found in Appendix 21. An exploration of the model follows.

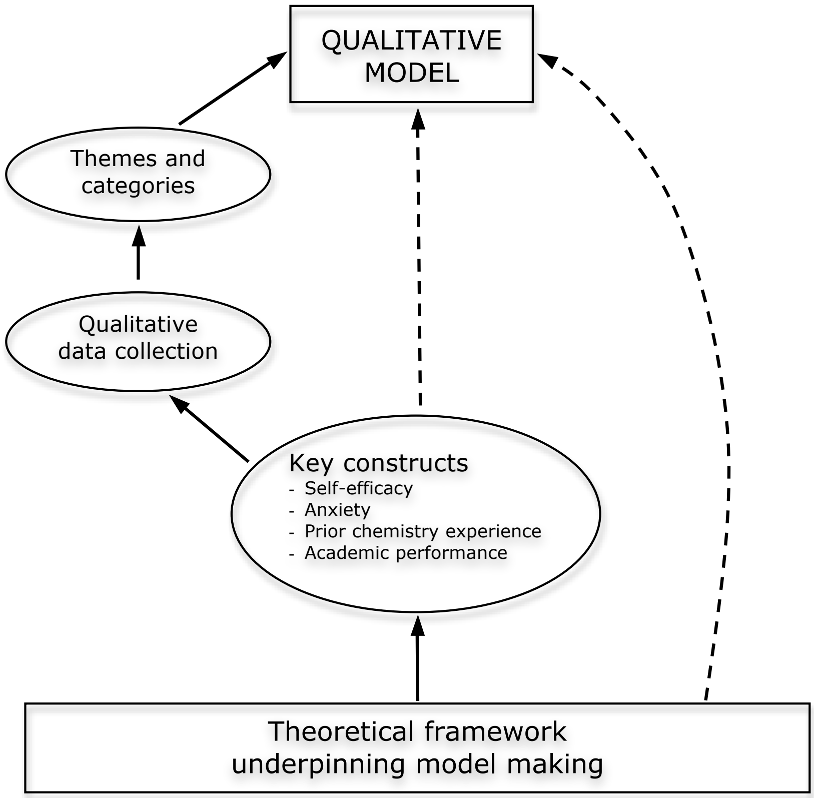

Figure 7. Model making process for the qualitative data

Table 7. A descriptive summary of the themes and categories emerging from the qualitative data

Theme 1. Connectivity			
Description: The affinity nursing students have with the curriculum, the profession of nursing, and with people.			
Category/Code		*Description*	*Evidence*
Curriculum	Chemistry	The degree of engagement with the chemistry curriculum. Incorporates enjoyment and interest as a result of studying Health Science I.	"I think all this just spurs me on to go to uni to do more chemistry." *Beth* "when I started studying it, it's OK with me like, because I like it." *Sandy* "To be honest, I don't like chemistry." *Polly*
	Other subjects	Comparisons made between chemistry and other subjects currently being studied.	"Too much to remember. Everything, it's just overwhelming in HS II" *Prue* "sociology is more talking and giving out your opinions and views." *Pam*
Application	Profession	Explores the link between chemistry and the nursing profession.	"I'm happy that we're studying chemistry because I think it's relevant to nursing." *Paul* "I think … there's a lot that we wouldn't really use." *Sonia*
	Everyday life	Chemistry applied to everyday lives.	"There are a lot of things that never made sense now make sense and to my everyday life I find it quite useful." *Pierce*
Social Interactions	Lecturer	References made concerning the influence of lecturers.	"If they love the subject, then they'll be an amazing teacher." *Bree* "It's probably the fact that you're a good teacher. Like, you're always happy to see us and you engage the class." *Prue*
	Tutors	Exchanges with tutors from the institution or privately engaged.	"That old fella … he's amazing." *Paige* "I'm getting there slowly, but I have a tutor now as well." *Bronte*
	Peers	Occurrence of class friendship networks, working in groups, working individually.	"You actually made friends over the three days." *Bella* "I work better when I bounce off people." *Pippa*
	Other	Incorporates references to other significant relationships, such as family and the work environment.	"my husband is so upset, he goes 'don't mention chemistry …'" *Beryl* "I've been working in aged care as well … and the nurses look … and they're like, what is that? That's … very in depth." *Paige*
	Support	Specific instances of how any of the above groups provided support, either academically or emotionally.	"So you can have an attempt on your own, … and then, yeh, if you needed help, it's available." *Simon* "and if we needed someone it was only one person and then we'd have to wait and we never got our work done on time." *Bree*

Theme 2. Reductivity			
Description: Factors that reduce the complexities of chemistry for understanding and the subsequent learning process.			
Category/Code		*Description*	*Evidence*
Nature of chemistry		Chemistry has many unique features, including language, that challenges students in their learning. Chemistry is logical and has mathematical components.	"'Cause I've seen structures and stuff on my boy's book, and I looked at it and I go this is absolute Greek." *Beth* "I think for me the hardest things is to get my head around like atoms and proteins … and you can't really see type thing." *Phebe*
Control of Learning	Foundation knowledge	Because of the nature of chemistry, a degree of basic knowledge is required for learning.	"I could see I was out of my depth and that I wasn't familiar with it, and didn't have any previous knowledge." *Paula* "You have to start off with the foundation, and I already know kind of, where that was goin' to come from." *Samuel*
Control of Learning	Learning strategies	Strategies – either unique or generic – required or employed to learn chemistry concepts.	"I crammed." *Prue* "Go through this every night … and do it slowly." *Beth* "You have to understand it … it's not something you can just memorise." *Phebe*
Control of Learning	Course structure	Organisational features of Health Science I such as class size, timetabling, pace, lecture notes, etc that may influence learning.	"I really like the format of the book." *Becky* "So, it's really good, just take it slow. I like slow." *Sofia*
Control of Learning	Study load	The amount of work present in any aspect of the nursing course.	"It took away a lot of hours of study." *Simon* "But it just seems so volumous in such a short amount of time." *Paula*
Control of Learning	Effort to learn	The degree of application required or employed to learn.	"When other things were going on, I wasn't really likely to put in much effort." *Sarina*
Control of Learning	Work	Paid employment.	"I had to work as well, so that cut my time down for study." *Bronte*
Exposition		Clear, logical and meaningful descriptions and explanations are important for understanding chemistry.	"… and it was really good how you explained it." *Brett* "If the other person understands it, then you feel like you, your job is done." *Sandy*

Theme 3. Reflexivity		
Description: Students engage in bidirectional self-referent thought, reflecting on, assessing and reacting to both capabilities and achievement.		
Category/Code	*Description*	*Evidence*
Confidence	Consideration of perceived abilities along with circumstances that have facilitated confidence change.	"It was more like you knew you would understand it." *Sarina* "Oh, I still don't think I can do it." *Paris* "I can do this … then you'd start to get to the really hard stuff and then it started to go down again." *Brittney*
Anxiety	Expressions of worry or nervousness in general or in relation to chemistry.	"I wasn't anxious until, like, tests came." *Pippa* "I was very relieved, there was like not much we had to remember compared with high school." *Soraya* "Back to the stress thing. It took a load off my shoulders. I wasn't having panic attacks." *Becky*
Goal orientation	This incorporates the spectrum of goal setting from extrinsic to intrinsic, and any other comments relating to motivation.	"So I studied … just because I wanted to get a good mark." *Sofia* "I was really excited to do chemistry – to learn something I've never learnt before." *Beth*
The Lens: Preconceived Ideas	School experiences, including prior achievement and the level of chemistry background, and pre-existing prejudice about chemistry have a major influence on self-referent thought processes. These act as a lens through which reflections are made.	"I did it [science] in year 7 to 10 and I was never any good at it." *Bella* "I thought it was going to be ridiculously difficult." *Becky* "At school .. I found it really hard … and a lot of it … seemed really irrelevant to learn." *Soraya*

4.2.2 The Qualitative Model

The learning process is multiplex and the model that has emerged from this inquiry is just one representation of some of the complexities involved in the teaching and learning of chemistry for first-year nursing students. As stated by Lincoln and Guba (2007, p. 17), "the best an inquirer can do … is to establish plausible inferences about the patterns and webs." While not intended to represent a grounded theory, Figure 8 shows a representation of the main themes – connectivity, reductivity, reflexivity – and the interrelationships between them, along with the 4th facet of the model – 'Learning and Academic Performance'. A discussion of each of the themes follows to show the role each plays in the chemistry experiences of students. Categories, along with their interactions within the themes are explored.

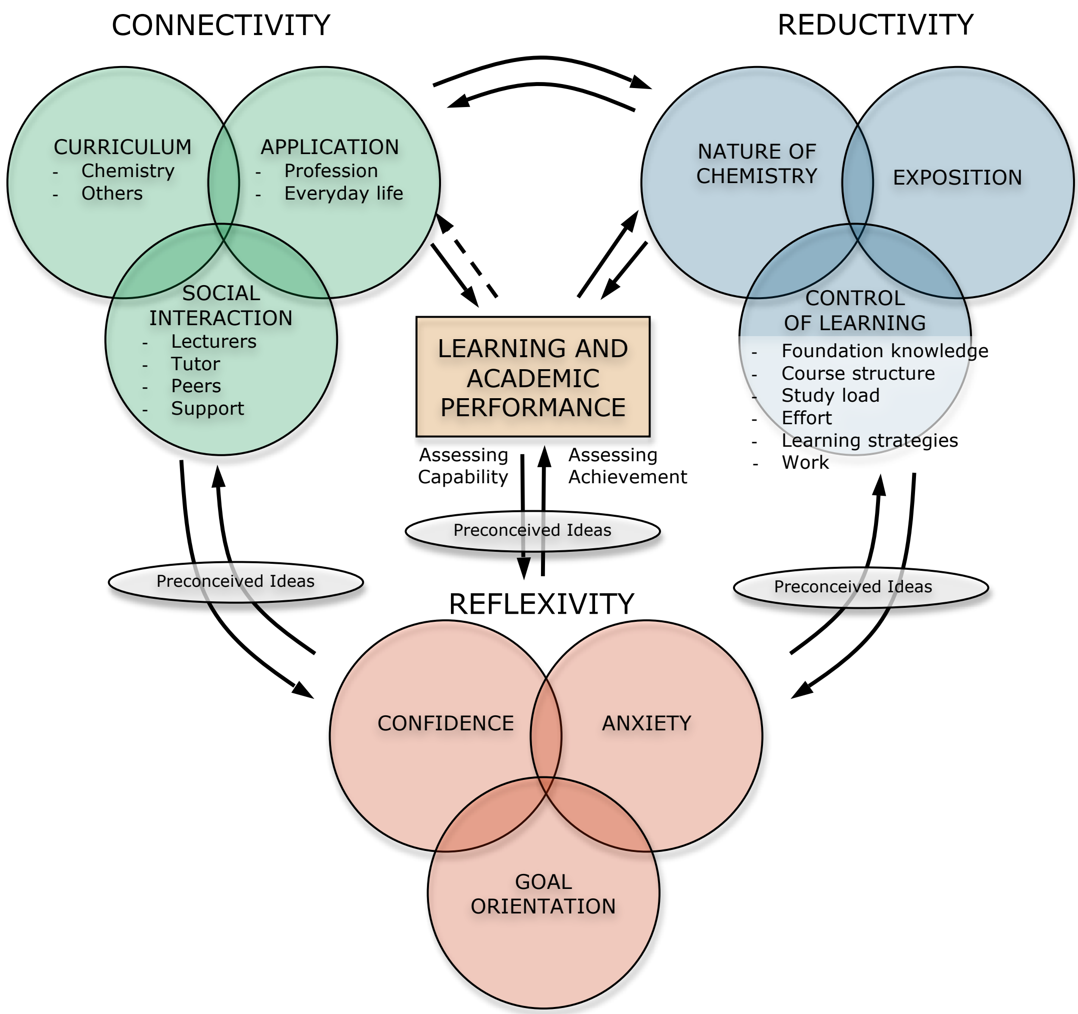

Figure 8. The qualitative model depicting themes and categories, showing the relationships between each other and with 'learning and academic performance'

Finally, interactions between themes are elucidated. However, the richness of the interplay of these themes and categories, particularly in relationship to the key constructs of self-efficacy, anxiety, prior chemistry experience and academic performance, is described in chapters 5 to 8.

Theme 1: Connectivity

Connectivity represents the affinity that nursing students have with three aspects of their experience: the *curriculum*, the *applications of chemistry* and their *social interactions*. ‘Curriculum’ includes both chemistry and other units of study in the nursing degree. Students discussed the extent to which they could relate to chemistry and embedded in these comments was the notion of enjoyment. For many students, the degree to which they struggled with chemistry seemed to affect the connection they could make with the subject. Inevitably, chemistry was compared with other subjects studied by students, particularly with respect to enjoyment and required effort.

Secondly, for chemistry learning to be relevant, students must be able to see a degree of ‘application’ to the profession of nursing, and to everyday life. A number of participants alluded to the correlation between their degree of connection with chemistry and the degree of relevance they perceived chemistry has to nursing. Students identified numerous specific examples from both lectures and the health-care workplace of how chemistry could be applied to the profession of nursing. Interestingly, this was the case even for those who did not make a strong connection between nursing and chemistry. While applications of chemistry to everyday life were not the focus of Health Science I, many students were still able to see the relevance of chemistry in their daily lives. Again, this influenced their level of connection with the curriculum.

The third category, ‘social interactions’, incorporates relationships with people in their circle of influence such as the lecturer, tutorial and laboratory staff, class peers and others such as family and workplace colleagues. Both the academic and emotional support received by students from each of these relationships was discussed. The interplay between the social category with curriculum and application was also evident. For example, there was a strong link between the perception of lecturer skills and characteristics and students’ connection with chemistry, particularly amongst those who entered the degree with a poor chemistry background. There was also evidence from students working in the nursing sector of the influence that work colleagues had on their level of connection with chemistry and in turn, the link students made with chemistry in nursing.

In summary, this theme embraces both the connection and disconnection students have with the curriculum (particularly chemistry) in their degree, the nursing profession and various social associations with reciprocal relationships between the three categories clearly evident.

Theme 2: Reductivity

Exemplified in the learning of chemistry is the idea of reductivity. Chemistry is perceived as being difficult and its concepts and processes can be challenging for the novice, easily leading to cognitive overload. Moreover, many nursing students will never be required to operate at a high, abstract level in this discipline. It is therefore important to reduce the complexities involved in the learning of chemistry to a level manageable by all potential nurses. The reductivity theme consists of three main categories: *nature of chemistry*, *control of learning* and *exposition*. Aspects of Johnstone's model of the nature of chemistry (A. H. Johnstone, 2006) were revealed by students with poor chemistry background. The unique language, often referred to by PC students as alien or foreign, the cumulative nature of concept development, the logical and mathematical facets of the subject, along with the multidimensional conceptual levels encountered in chemistry, require a reductivist approach not only to learning but also when teaching this sometimes challenging subject.

In addition to problems associated with the 'nature of chemistry', students indicated the need to have some sense of 'control over their learning' in order to reduce the complexities of learning chemistry and identified a number of aspects that play a role in this. Fundamental to this inquiry was the notion of foundation knowledge. Many PC students expressed the difficulty they experienced in the early lectures because they lacked a level of fundamental foundation knowledge. For the BC students, the material covered in the bridging course proved to be valuable in their early experiences with Health Science I. Students also discussed several learning strategies they applied to chemistry concepts, not all of which were effective. Organisational features of the course such as tutorials, laboratories, class size and the provision of worksheet-type lecture notes affected the degree of control students felt they had over their learning environment. High study loads in other subjects and engaging in significant levels of paid work reduced the sense of control for many. This was influenced by the extent of foundation knowledge which, in turn, affected the amount of effort that students could put into the learning process.

Finally, because of the conceptual nature of chemistry, the exposure to clear, logical and meaningful explanations - 'exposition' - emerged as an essential component in reducing the complexities of chemistry and the promotion of increased levels of understanding.

Theme 3: Reflexivity

Originally named self-reflectivity, reflexivity is firmly founded in social cognitive theory. Reflexivity implies action as a response to incoming data, rather than just reflecting upon it, and considers ways in which students engage in bidirectional, self-referent thought. It incorporates three key categories: *confidence*, *anxiety* and *goal orientation*. 'Preconceived ideas' was originally listed as a fourth category, but as various arrangements for a model were explored, it became apparent that these ideas formed part of a collection of experiences students brought to the course. Rather than treating these as a separate category, I recognised the role prior experiences play in the way students perceive and process incoming information. Students possess preconceived ideas about chemistry, derived from prior academic experiences largely drawn from school memories, and these coloured the interpretation of experiences in Health Science I, particularly early in the semester. Consequently, rather than acting as a category of reflexivity, these preconceived ideas were envisaged as a lens through which assessments were made and hence appear in the connecting links between reflexivity and the other themes in the model.

It was not surprising to find the constructs of confidence and anxiety emerge as categories since students were asked specifically about them in interviews. Rather than trying to restrict the description of confidence to the narrower definition of self-efficacy which is domain and task specific, this category includes any reflection of perceived ability, along with circumstances that may have facilitated changes in confidence. Anxiety incorporates expressions of worry, stress or nervousness and unlike the quantitative measure, is not restricted to just chemistry anxiety. Students also talked about other components of motivation such as 'goal orientation' and indicated the influence of both extrinsic and intrinsic goals. Of all the themes, the categories in reflexivity are the most closely affiliated with each other because their roots can be found in various motivation theories. Social cognitive theory purports that anxiety acts as an antecedent for self-efficacy, and students explained how worry affected their perceived levels of ability. Conversely, students who lacked confidence experienced anxiety. Research has demonstrated the predictive role of confidence in goal setting (Pajares, 1996), with expectations being partly determined by beliefs (Bandura, 1986).

The 4th facet of the model: Learning and academic performance

Since much of what students spoke of in focus group interviews was in the context of their perceptions of learning, this did not emerge as a separate code as such. Rather, ‘learning and academic performance’ was added to the model when theoretical underpinnings and key constructs of my inquiry were considered (see Figure 7). In this study, academic performance implies achievement in tests and the final exam and as such, is a quantitative measure. However, students did not always refer to this more prescriptive description of knowledge acquisition, but often made reference to cognitive concepts such as understanding or confusion. In addition, social cognitive theory maintains that learning is not always shown in performance (Bandura, 1997). Consequently, the term ‘learning’ has been included with ‘academic performance’. This facet of the model provides a platform to illuminate reciprocal relationships of ‘learning and academic performance’, since students’ ability to connect, reduce and reflex ultimately affects their learning and academic performance. This more complete model provides important additional insights into Research Question 3.

Some theme interactions

Not only are categories linked within the three themes, but interactions occur between themes, as demonstrated by the bidirectional arrows in the model in Figure 8. Note that the arrow linking ‘Learning and Academic Performance’ to ‘Connectivity’ is dashed, because the evidence for this link is not as strong when individual models were considered. Students’ ability to reduce the complexities of chemistry can influence the connection students make with the subject. For example, Pam and Paula were unable to overcome the deficit in their foundation knowledge, which affected their confidence, anxiety and academic goals in chemistry, and diminished their sense of connection with the subject, minimising their ability to see the relevance of chemistry to nursing. When a lecturer is able to clearly articulate chemical concepts, the reduction in complexity leads to a stronger connection not only with the subject, but also with the lecturer, facilitating an increase in confidence and decrease in anxiety. When students work in peer groups, confidence may increase because they have opportunities to explain concepts to each other and increase their levels of understanding. In addition, several students noted that working with peers provided much needed motivation to learn. Indeed, bidirectional interrelationships were found between most of the themes and categories. For participants of individual interviews, these interactions have been identified in representative models found in Appendix 21.

The relationships between pertinent categories from these themes and the key constructs of this inquiry – self-efficacy, anxiety, prior chemistry experience and academic performance – will be explored in the following chapters. The voices of the first-year nursing students will be heard as links are made between the quantitative and qualitative findings.

4.2.3 Qualitative Data Evaluation: Trustworthiness

There is some debate about the use of the more traditional criteria of reliability and validity for qualitative data (Cohen, et al., 2007; Lincoln & Guba, 2007). Instead, a plethora of terms have been used to describe possible criteria for evaluating these in naturalistic investigations, including authenticity, detail, honesty, depth of responses, meaningfulness to respondents, neutrality, confirmability, and comprehensiveness (Cohen, et al., 2007). Patton (2002) supports the use of the term "trustworthiness" to describe the goal of producing "high quality qualitative data" (p. 51), a term equated with "rigor" by Lincoln and Guba (2007).

Since analysis of qualitative data is largely interpretative, different criteria must be employed to determine whether research has been well done (Johnson & Turner, 2003). Various classifications and techniques for assessing the quality of qualitative research have been put forward. In this study, three elements were considered when evaluating trustworthiness: credibility, transferability and dependability.

To demonstrate the representative nature of the focus group sample, independent samples t-tests were conducted to compare the characteristics with those who did not participate in interviews. There were no statistically significant differences between measures of self-efficacy, cognitive ability, academic performance and perspectives on chemistry. However, final test anxiety (TA3) was significantly lower in the focus group (M=1.44, SD=0.93) compared with the non-participants (M=1.96, SD=1.02), $t(97)$=2.03, p=.024, d=0.52. In addition, within the BC group, the focus group interviewees indicated on the T3 questionnaire that the bridging course had been most effective in both reducing anxiety, $t(29)$=2.17, p=.038, and preparing them for Health Science I, $t(29)$=2.07. p=.047.

Credibility

It is important that the researcher be cognizant of possible problems associated with both data collection and analysis. Several strategies have been suggested to address this aspect of trustworthiness. These include engagement of the researcher with the research site, presentation of a balanced view of the data, declaring possible researcher partisanship, and triangulation (Lodico, et al., 2006).

In order to present a deep picture of the experiences of first-year nursing students in chemistry, a good relationship must exist between the researcher and participants (Lodico, et al., 2006). In this study, I was not only the researcher but also the lecturer, tutor and laboratory supervisor for the students. As a result of this prolonged engagement (Lincoln & Guba, 2007), a significant amount of trust and rapport developed before qualitative data collection commenced. Some students commented that it was much easier to discuss their experiences because they were already comfortable with me.

Secondly, good qualitative research relies on the presentation of "a balanced view that represents all constructions and the values that undergird them" (Lincoln & Guba, 2007, p. 20). In this study, "fairness" (Lincoln & Guba, 2007) was enhanced by purposeful sampling for participant selection in the focus groups (outlined previously) based on responses gleaned from the questionnaire. This ensured a range of personal chemistry perspectives with varying levels of academic performance (as indicated by Test 1 scores) in order to explore both harmonious and conflicting experiences.

The perspectives and biases of the researcher pose a threat to credibility at both the data collection and analysis stages. Patton (2002) points out that personal and professional information should be reported to advance honesty. Researcher details about personal connections, how access to the study site was gained, previous experience in teaching chemistry and some anecdotal experiences relating to chemistry and nursing have already been declared in the introduction and in Chapter 3. The influence of researcher bias was minimised by the use of member checking in the second round of interviews (Lodico, et al., 2006). Not only were interviewees asked to verify the accuracy of the transcript of the focus group to which they belonged, but they were solicited for reactions to the emergent qualitative model and quantitative findings (Lincoln & Guba, 2007). The individual interviews played an important role in enhancing credibility.

It is highly possible that student responses were inhibited by the influence of the researcher - that they were being asked to comment on aspects of the subject that I was responsible for delivering. To address bias at the collection stage, it was made clear that they were selected as focus group members because they represented a diversity of views and experiences in chemistry and that I was eager to glean a range of perspectives. They were encouraged to both agree and disagree with each other. Also, focus group participants were asked at the conclusion of the interview to reflect on the extent to which their answers may have been influenced by the fact that I was their lecturer. There was a strong sense that this had not impacted the feedback given, and a few student responses follow:

> Pam: No. (*others nodding in agreement)* I told you what I heard was 'blah, blah'.
>
> Bronte: Not at all. This is for education. This will be used to benefit -
> Brett: - others.
> Bronte: - others as much as us.
> Interviewer: So, you didn't sort of hold back?
> All: Not at all. No.
>
> Sofia: I [was] honest anyway.

In addition, individual interviewees were asked to comment on the degree to which their participation in the focus group may have been influenced by other members of the group. All enjoyed the experience and felt the group environment was "more stimulating" (*Pippa*) because it provided opportunity to "bounce off each other's experiences" (*Paula*). Only Pippa suggested that some of her comments may have been a little inhibited because at that stage of the course she did not know Pierce really well.

Tashakkori and Teddlie (2003) broadly define triangulation as "the combinations and comparisons of multiple data sources, data collection and analysis procedures, research methods, and/or inferences that occur at the end of a study" (p. 674). This collection and integration of data and methods enhances accuracy and credibility, builds confidence and produces deeper insights into possible relationships (Creswell, 2008; Patton, 2002). In this study, two types of triangulation were used. The use of *methodological triangulation* flows from the pragmatic paradigm that assumes compatibility between different methods (Patton, 2002), and in this inquiry, questionnaires and two levels of interviews were used to examine self-efficacy, anxiety and some perceptions of chemistry. Several aspects of *data triangulation* were addressed as various types of comparisons of information were made. Firstly, since data were collected from two focus groups in each chemistry background category (one from each campus), triangulation of data sources within the naturalistic component of the research incorporated comparison of the perspectives within chemistry background groups and between focus group interviews and individual interviews. Secondly, the overall findings from interviews were compared with the quantitative findings and individual responses of interviewees were compared with their self-reported instrument data. Any convergence from triangulation increases the confidence of the findings. While such comparative analysis produced some conflict, this does not necessarily indicate invalid findings, but rather "divergence opens windows to better understanding the multi-faceted, complex nature of the phenomenon" (Patton, 2002, p. 559). Corroboration of data provided not only confidence in the conclusions drawn (Patton, 2002) but resulted in a more comprehensive picture of the chemistry experiences of first-year nursing students.

Transferability

In naturalistic inquiries, judgment concerning the transferability of research findings to other settings is made by the reader (Lodico, et al., 2006). Since this is dependent on the contextual similarities and differences of site, situation and participants, a rich description of the participants' experiences along with the context of the research setting have been provided. Furthermore, extensive quotes from the transcripts have been included in the following chapters to allow the reader to determine whether application to a different context is possible (Lincoln & Guba, 2007).

Dependability

An extensive explanation has been given in this and the previous chapter outlining the procedures and processes involved in collecting and analyzing data. To further facilitate dependability, a research journal was used to record reflections from interviews, document decisions made about coding and emergent themes during data analysis, thereby leaving an audit trail (Lincoln & Guba, 2007). In addition, the reliability of the code set was enhanced by inviting a chemistry educator with experience in teaching the Health Science I unit (Mays & Pope, 1995) to apply the coding frame to focus group transcripts selected randomly - city BC and rural PC. A few codes required clarification (preconceived ideas and the nature of chemistry) and an additional code was suggested – "effort to learn" - which was subsequently adopted. The level of agreement was over 85%.

Interviews were recorded using video and digital audio files, providing opportunity for "subsequent analysis by independent observers" (Mays & Pope, 1995, p. 110).

4.3 Summary

Factor analysis of the two scales – CNSS and CNAS – revealed four dimensions: cognitive chemistry self-efficacy (CS), chemistry laboratory self-efficacy (LS), chemistry test anxiety (TA) and chemistry laboratory anxiety (LA). Matters of reliability and validity were addressed, revealing the instrument to be psychometrically sound. Three themes emerged from constant comparative thematic analysis of the naturalistic data gathered from the focus group interviews in Phase 1 and individual interviews in Phase 2: connectivity, reductivity, and reflexivity. These themes are used in the following chapters as an organisational framework for interrelating the quantitative and the qualitative data. A range of measures of trustworthiness was outlined for the qualitative data and the inquiry as a whole.

In order to "communicate the unique insights" (O'Cathain, 2009, p. 156) afforded by the mixed method approach utilised in this study, and in keeping with the philosophical stance of pragmatism (Bazeley, 2009), an integrated model (O'Cathain, 2009) is adopted where both qualitative and quantitative findings, along with the discussion of these findings, have been incorporated into chapters based on the key constructs: chemistry self-efficacy, chemistry anxiety, academic performance and the bridging course (prior chemistry experience). Each chapter will close with a summary of the findings and conclusions pertaining to relevant research questions. The following chapter explores facets of chemistry self-efficacy and its relationship to other key constructs and themes.

5 CHEMISTRY SELF-EFFICACY: FINDINGS AND DISCUSSION

Chapter Overview

This chapter begins with an analysis of the two dimensions of the CNSS (Chemistry for Nurses Self-efficacy Scale) that emerged from the factor analysis outlined in Chapter 4: cognitive self-efficacy (CS) and laboratory self-efficacy (LS). Quantitative findings relating to these two dimensions and interview data from the reflexivity, connectivity and reductivity themes are then integrated and discussed with respect to demographic factors, prior chemistry experience, and academic performance. Changes in the self-efficacy constructs over a semester are also explored. The chapter concludes with a consideration of the key findings in the context of the four research questions.

5.1 Differences in Chemistry Self-efficacy Dimensions for the Total Cohort

The means and standard deviations for both the cognitive and laboratory self-efficacy scales were calculated and are recorded in Table 8 and illustrated in Figure 9. Note that the term "initial" refers to measures made before students have experienced any chemistry at the institution and is derived from the T1 score for BC participants and T2 scores for PC and SC participants. The term "final" refers to the measures derived from the T3 score for all participants.

Table 8. Chemistry self-efficacy (SE): initial and final means (and standard deviations) for cognitive and laboratory self-efficacy

Chemistry self-efficacy dimension	*N*	Initial SE[a]	Final SE[b]
Cognitive (CS)	101	1.64 (0.79)	2.64 (0.75)
Laboratory (LS)	101	2.37 (0.96)	3.06 (0.71)

a. Initial SE incorporates SE at T1 for BC students and SE at T2 for PC and SC students
b. SE measured at T3 for all students

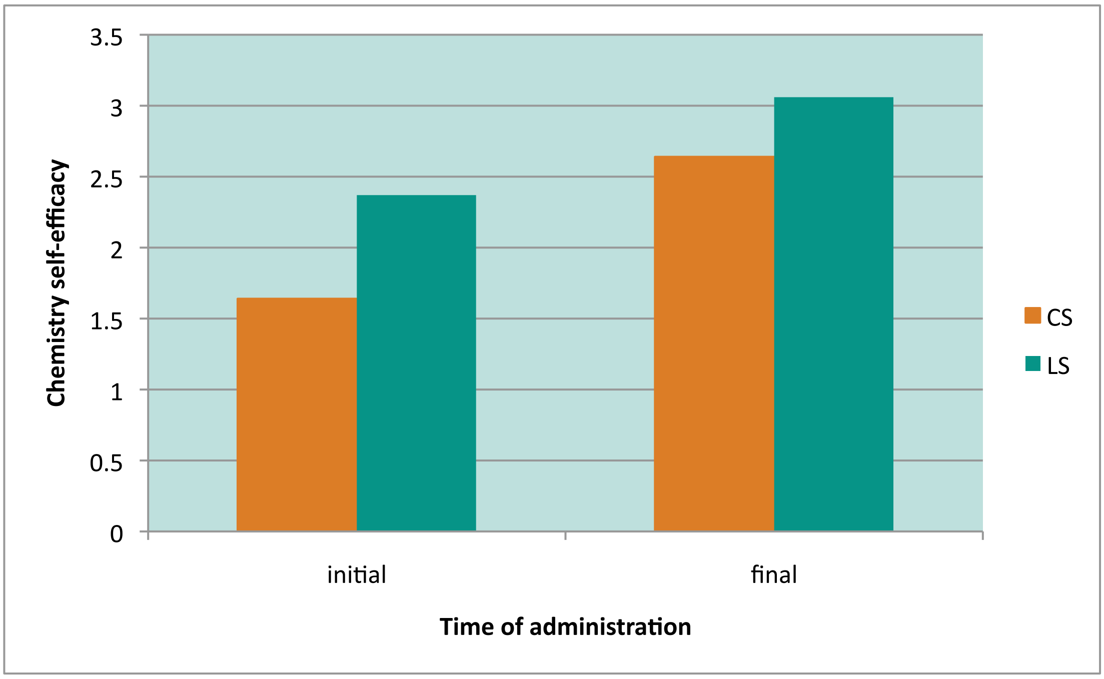

Figure 9. Changes in CS and LS over the semester

Paired samples t-tests revealed that laboratory self-efficacy (LS) was statistically significantly higher than cognitive self-efficacy (CS) for initial and final measures (see Table 9), with large effect sizes. These findings concur with that of Smist (1993) for a general chemistry cohort, although the effect size in that study (*d*=0.32) was not as large.

Table 9. Comparing initial and final measures of cognitive and laboratory self-efficacy using paired sample t-tests

Time	Mean difference: [LS-CS] (*SD*)	df	*t*	Significance (*p*)	Effect Size (Cohen's *d*)
Initial	0.73 (0.73)	100	10.044	<.001	0.83
Final	0.42 (0.68)	100	6.246	<.001	0.58

5.1.1 Changes in and Antecedents of Self-efficacy

In this section, quantitative changes in self-efficacy for the total cohort will be examined and supported by a discussion of pertinent categories from the qualitative model, such as 'social interactions' and 'exposition'. Section 5.3 will examine 'reductivity' categories pertinent to prior chemistry experience. The influence of the 'curriculum' and 'application to nursing' will be considered in the context of perceptions of chemistry (Section 5.4), and 'effort to learn' and previous academic performance will be considered in Section 5.5.

Paired samples t-tests confirmed that both cognitive and laboratory self-efficacy showed large and statistically significant increases for the total cohort from the initial to the final measures (see Table 10). This was supported by numerous comments made in focus groups interviews:

Pippa[8]: I got more confident as the seven weeks went on.

Bella: I'm more confident in myself that I can actually do it.

Table 10. Changes in self-efficacy over the semester (final – initial)

Chemistry SE	Mean difference: (*SD*)	df	*t*	Significance (*p*)	Effect Size (Cohen's *d*)
LS	0.69 (0.83)	100	8.275	<.001	0.82
CS	1.00 (0.73)	100	13.686	<.001	1.30

Comparing initial and final scores, 92% of students increased in cognitive self-efficacy to some degree over the semester. In contrast, only 71.3% of students reported experiencing an increase in laboratory self-efficacy, possibly because 17.8% reported no change over the semester. In addition, the effect sizes for increases in mean LS were not as large as CS, arguably because LS was significantly higher than CS to start with.

The number of studies that consider changes in self-efficacy over a particular time period are relatively scarce. However, the finding in this study that chemistry self-efficacy increased (with a strong effect size) for the total cohort is in contrast to changes reported in much of the literature. This study is quite unique in that initial measures of self-efficacy were administered at the beginning of the first lecture for the semester (as did Garcia (2010)), which means the measure minimises any influence the course itself may have. In other reported studies, initial data for self-efficacy were taken in either Week 2 (Dalgety & Coll, 2006; Lawson, et al., 2007; Smist, 1993) or Week 5 (Obrentz, 2011; Zusho, et al., 2003) of the semester giving an opportunity for students to formulate beliefs based on their experiences over the

[8] Pseudonyms were assigned based on the first letter of each prior chemistry experience group name: SC students begin with 'S', BC begin with 'B' and PC begin with 'P'. All comments are from the focus group interviews unless otherwise indicated. The composition of each focus group can be found in Appendix 12.

first two to five weeks. Some studies simply state data were collected at the beginning of the semester making it difficult to determine how much exposure to the subject students had already experienced.

While the time of initial data collection may play a role, there is little consistency in both the strength and direction of the reported changes in self-efficacy, even when the type of instrument is taken into account. For example, Lawson et al. (2007) reported a strong increase (*d*=1.55) in task-specific biology self-efficacy over the semester, comparable with the strength of the increase found in this study for chemistry (*d*=1.30 for CS). When considered over the three-year degree program, Friedel and Treagust (2005) also found an increase in bioscience self-efficacy (*d*=0.66) in a nursing cohort.

In contrast, decreases in both chemistry self-efficacy (*d*=0.27) and academic self-efficacy (*d*=0.85) have been reported in some introductory chemistry classes (Obrentz, 2011; Zusho, et al., 2003), while no change in these measures have been found over a semester in other studies (Cavallo, et al., 2004; Lent, et al., 1986; Smist, 1993). One possible explanation for the disparity may lie in the degree of difficulty of the material covered in the respective courses. It is important to note that the chemistry covered in Health Science I is relatively basic, and does not include many of the difficult topics that would be incorporated in a typical introductory/general chemistry course. Even so, the chemistry studied in Health Science I is challenging for students who have not studied senior chemistry. In interview, one such student had this to say:

> Brittney: For about, I think it was ¾ of it, like, through chemistry, like, the whole time it was getting like, I was like "Oh, I can do this. I can do this," and the further along it would go, I'd be like, "That's fine. Yeh" and then you'd start to get to the really hard stuff, and then it [confidence] started to go down again.

Brittney perceived that her chemistry self-efficacy improved until she encountered a challenging topic in the course. Bronte found the topic of blood buffers to be the most challenging and while her self-efficacy was perceived to fall when confronted with this topic, it eventually "plateaued out" after this point. If more formidable topics were included and the pace of lectures in this course mirrored that of the general chemistry courses, self-efficacy may well have dropped. A plausible explanation for the increase in self-efficacy reported in introductory chemistry students by Garcia (2010) could lie in the fact that 94% of the cohort had taken between one and four semesters of chemistry at high school.

Some of the categories from the 'connectivity' and 'reductivity' themes in relation to changes in confidence will now be discussed.

Social interactions

Focus group members suggested that the support provided by working with peers in tutorials, laboratories and private study groups contributed to changes in confidence over the semester. For example, a number of PC students explained how working with peers in groups such as laboratories, really helped them feel more confident, because it allowed them to "bounce off people" (*Pippa*), a term also used by Sofia in her individual interview when referring to study group participation. For Brett, explaining concepts to others enhanced his confidence in chemistry.

> Brett: I started helping people around me in the calculations and stuff, so that definitely boosted my confidence … so I understood enough to be **able** to teach them. (*Individual Interview)*

Peers can act as a potent force in the development of self-efficacy. Comparative information from performance on academic tasks and exposure to the modelling of academic and domain-specific skills contribute to the "social construction of intellectual self-efficacy" (Bandura, 1997, p. 234). Self-efficacy operates within socio-cultural influences, where individuals are viewed as both producers and products of the social system (Pajares, 1996).

Some comments highlighted the role of tutorials in building and maintaining confidence. Not only was this associated with mastery learning, where students have an opportunity to answer questions to assess their level of understanding of concepts covered in lectures, but also with support from the lecturer.

> Pierce: … but then even if you can't fully understand, then you've got the tutes, and the tutes reinforce what you've learnt and you put into practice, … you just kind of like, well I'm gonna get it by Monday afternoon.

> Simon: It's a bit of confidence building. So you can have an attempt at your own, do things on your own and then, yeh, if you need help, it's available.

> Prue: The tutorials helped a fair bit too. Just going through the questions and like when you hit something you couldn't do, you could just pop

your hand up and you'd explain it so easily and then you'd be able to do it.

Pippa: It made my confidence a lot higher because I understood it and I knew I could go to you if I didn't understand it. (*Individual Interview*)

The lecturer was also identified by Beth as a source of confidence:

Beth: Well, you gave all the class, I would say, a lot of confidence 'cause you're a very positive lecturer. (*Individual Interview*)

While many students had positive tutorial experiences, this was not the case for Paige who attended a larger tutorial session. A lack of consistent support in addressing problems with questions caused her to exclaim, "can't do it!" (*Paige*). Furthermore, both Pam and Paula revealed they had employed a private tutor. Pam noted that her confidence had -

Pam: … increased to what it was. Yeah. I've got a bit more confidence, and um, an idea of what you are actually saying, sort of instead of blah, blah, I'm actually hearing words and letters.

Pam's comment further demonstrates the relationship between level of understanding and self-efficacy.

Exposition

While the link between confidence and clear explanations was not explicitly made in the focus group interviews, the connection was drawn by all individual interviewees except Samuel, when shown the categories of the qualitative model.

Sofia: … when they were clearer I was like kinda getting it in my head following along so that built my confidence a lot. (*Individual Interview*)

Pippa: [Clear explanations] definitely brought my confidence up and made it a lot easier. (*Individual Interview*)

Brett, too, was convinced of the unequivocal relationship between understanding and confidence.

Brett: For sure. Definitely. Cause, well, I don't know, like how you put it, the way you explained chemistry was different to how I'd been explained it all through school. Like, I don't know how you did it. Your - how you - maybe your examples, and, I don't know your, I don't know, I think it's your examples, however you did it, but it, you showed me that it wasn't that hard. You can, you can get it. (*Individual Interview)*

The reciprocal nature of this relationship was also true for Sofia, who found that once confidence was gained, she was then able to explain concepts to her peers.

> Sofia: … my confidence built and I felt more confident to teach her things as well and to be able to talk about what we were studying.

5.1.2 Individual Self-efficacy Items

Paired samples t-tests were conducted for individual items on the chemistry self-efficacy scale from initial to final means for the total cohort (see Appendix 23). A statistically significant increase was found for all 15 items. The three self-efficacy items with the highest increase were 1 (explaining the structure of the atom), 2 (explaining element properties using the periodic table), and 6 (identifying an element or compound from its chemical formula). It is interesting that the content of these items was introduced to students early in the course and was foundational to an understanding of later topics. Interview transcripts confirmed the importance students place on foundational knowledge:

> Bernice: I know this – I'm all good – we've done this.

The three items with the smallest increase in self-efficacy were Items 7 (achieving a passing grade in chemistry), 9 (explaining a chemistry concept to another person), and 13 (mastering the knowledge required in this chemistry course). These three items have in common some element of assessment whether it be in written or oral form, and it is in this area where students obviously experienced a lack of certainty about their capacity to perform. The factor analysis described in Chapter 4 located Test Anxiety as an important factor in students' thinking and this will be discussed in the next chapter.

5.2 Differences in Chemistry Self-efficacy based on Demographic Variables

A review of the literature in Chapter 2 showed that research linking demographic factors to self-efficacy for tertiary students is inconclusive.

5.2.1 Gender

Means and standard deviations for all measures of chemistry self-efficacy for both males and females are recorded in Table 52 in Appendix 24 and represented in Figure 10. In order to explore any possible link between gender and cognitive and laboratory chemistry self-efficacy, independent t-tests were conducted for each of the

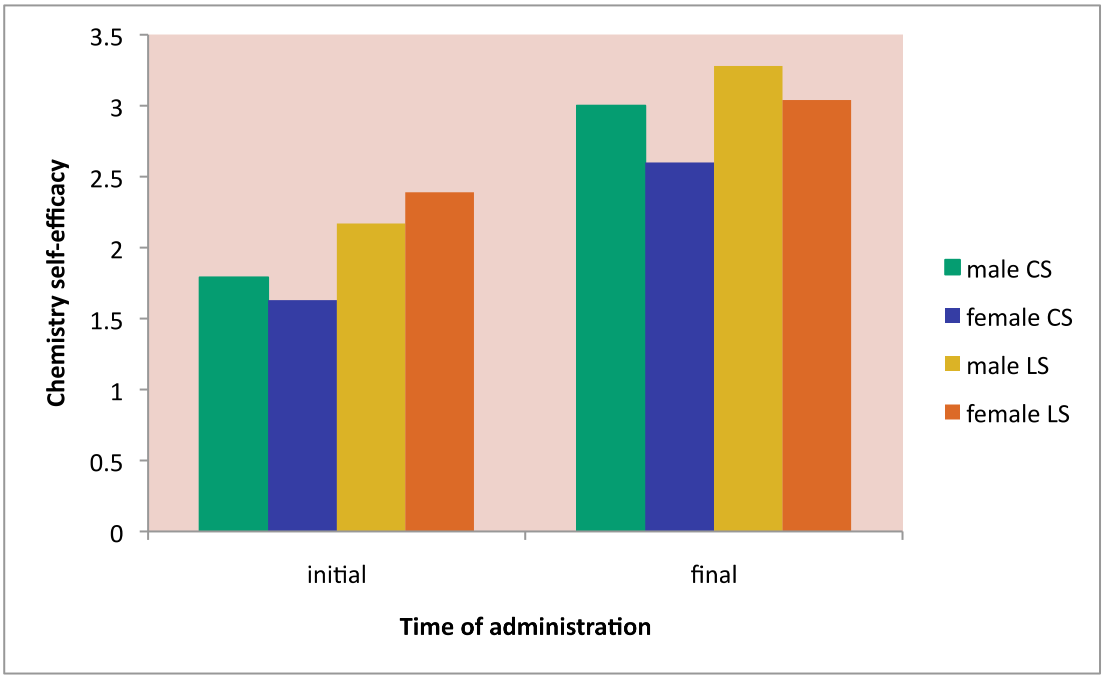

Figure 10. Mean CS and LS scores based on gender

initial and final measures. Despite males having higher cognitive self-efficacy (CS) means, the differences failed to reach statistical significance. Differences in LS means were statistically insignificant. While the interpretation of results for this small cohort of males (8.9%) demands caution, this finding is supported by previous research at the tertiary level. No gender bifurcation was found in self-efficacy investigations in nursing studies (Andrew, 1998; Harvey & McMurray, 1994), in chemistry self-efficacy in general chemistry classes (Aydin, et al., 2011; Taasoobshirazi & Glynn, 2009), science self-efficacy (Smist, 1993; Witt-Rose, 2003), or academic self-efficacy (Lent, et al., 1986). However, other studies with tertiary science courses have demonstrated that males possess significantly higher chemistry self-efficacy (Obrentz, 2011), laboratory self-efficacy (Smist, 1993), science self-efficacy (Glynn, et al., 2009) and physics self-efficacy (Cavallo, et al., 2004) with effect sizes of d=.53, d=0.52, g=.34 and d=.55 respectively. Such effect sizes cannot be ignored. It may be that in the Cavallo et al. study (2004), which consisted of biology majors studying an introductory physics course, stereotypical attitudes to physics contributed to this result. This may also help to explain the finding in Andrew's (1998) study where the self-efficacy for physics factor was the only one to show gender bifurcation. Glynn et al. (2009) note that social-cultural factors may play a role when considering self-efficacy in the science domain.

The failure of the quantitative data to show any significant gender bifurcation is supported in part by the qualitative findings where no comments were found relating gender to confidence.

5.2.2 Age, Hours of Work, Health Care Experience

Examination of the Pearson product-moment correlation coefficients in Table 11 reveal small, negative correlations between age and cognitive self-efficacy (CS), with more mature students experiencing lower levels of CS. Only the final measure was statistically significant (r=-.229, p<.05).[9] While the interview data does not suggest any reasons for this, it may be that mature students have a more realistic appraisal of their abilities (Ofori & Charlton, 2002). However, ANOVA tests failed to show statistically significant differences (p =.132 for initial and .208 for final) for CS measures between the three age groups (17/18, 19-21, 22+). While the trend and effect size of this study (r^2=.052 at T3) are comparable to that of Zeegers's (2004) consideration of academic self-efficacy for first-year Australian science students (r=-.26, r^2=.068), it is not as strong as that found for academic self-efficacy by Ofori and Charlton (2002) in a nursing cohort (r=-.41, r^2=.168). One possible explanation for the size of the correlation in the latter study may be the higher mean age (M=26, SD=8) when compared with both the Zeeger study (M=20.9, SD=6.2) and this one (M=22.99, SD=7.9).

Table 11. Pearson product-moment correlations between cognitive self-efficacy (CS) and various demographic variables

	Initial CS	Final CS
Age	-.152	-.229*
Hours of Work	-.125	-.241*
Health Care Experience	-.128	-.162

* p<.05, ** p<.01

Correlations between CS and hours of work and health care experience are also negative and relatively small. It is interesting to note that the correlation between health care experience and hours worked is large (r=.504, p<.001). Medium correlations were also noted between age and health care experience (r=.425,

[9] Complete correlation matrices for initial and final measures between all key constructs in this inquiry can be found in Appendix 22.

p<.001) and between age and hours of work (r=.347, p<.001). Students with high levels of health care experience tended to be older. As expected, these students engaged in more hours of paid work per week in order to meet financial commitments. As such, the negative correlations between self-efficacy and hours of work and health care experience may simply be an indirect effect of age. This could explain the lack of literature that considers correlations between work hours and self-efficacy.

No statistically significant correlations were found between LS and age, hours of work, or health care experience.

5.3 Differences in Chemistry Self-efficacy Based on Prior Chemistry Experience

Pearson product-moment correlations showed a statistically positive and significant relationship between chemistry self-efficacy and prior chemistry experience (see Table 12), with students possessing more prior experience in chemistry having higher measures of CS. In fact, the degree of prior chemistry experience accounted for 13.9% and 5.9% of the variance in CS2 and CS3 respectively. The relatively small correlations with LS indicate that laboratory self-efficacy may be shaped less by past chemistry experiences.

Table 12. Pearson product-moment correlations between chemistry self-efficacy (SE) and prior chemistry experience (CS and LS) at T2 and T3

	SE 2	SE 3	
Prior chemistry experience	.430***	.340**	**CS**
	.217*	.113	**LS**

* p<.05, ** p<.01, *** p<.001

As earlier noted, surprisingly few studies have considered the relationship between prior experience in a subject and self-efficacy. While the strength of the relationship found by Gretsy and Cotton (2003) was not as strong as the present study, they also found that students with a previous biology qualification had more confidence to pass tests in the first year of their nursing course (r=.214). Glynn et al. (2009) found a strong correlation between high school preparation for science and science self-efficacy (r=.52) in a non-science major introductory biology cohort.

Table 13. Cognitive self-efficacy (CS): means (and standard deviations) measured initially, at T2 and T3 for the total cohort and groups based on prior chemistry experience

Cohort		*N*	CS initial[a]	CS2	CS3
Total cohort		*101*	*1.64 (0.79)*	*1.81 (0.82)*	*2.64 (0.75)*
Prior chemistry experience	PC	44	1.41 (0.75)	1.41 (0.75)	2.45 (0.59)
	BC	31	1.46 (0.66)	2.02 (0.75)	2.50 (0.89)
	SC	26	2.24 (0.73)	2.24 (0.73)	3.12 (0.61)

a. Initial CS incorporates CS at T1 or BC students and CS at T2 for PC and SC students

A one-way between groups analysis of variance (ANOVA) was used to further investigate the impact of prior chemistry experience of nursing students on chemistry self-efficacy (see Table 13 for CS means and *SD* and

Table 54 in Appendix 25 for LS values) which showed that prior chemistry experience makes a statistically significant difference to the level of chemistry self-efficacy students have at various stages of the Health Science I course. A discussion of the results follows.

5.3.1 Initial Differences in Chemistry Self-efficacy

ANOVA showed significant differences between prior chemistry experience groups for initial measures of CS, $F(2,98)=12.482$, $p<.001$, $\eta^2=.203$. Post hoc tests with Scheffe (using an α of .05) revealed that the mean score for the SC group ($M=2.24$) was significantly and substantially higher than both the PC ($M=1.41$, $p<.001$, $d=1.86$) and the BC ($M=1.46$, $p<.001$, $d=1.13$) groups, with no significant difference between the PC and BC students at this time.

Since self-efficacy is shaped by mastery experiences (Bandura, 1997), it was not unexpected that students who had studied chemistry either in Years 11 or 12 at high school would have significantly higher initial levels of chemistry self-efficacy than either BC or PC students. As expressed by Sarina, "…I knew that I'd be able to do it." Correspondingly, since the BC and PC students would have had similarly poor levels of initial exposure to chemistry, a similar level of self-efficacy for these groups was also anticipated.

For initial LS (see

Table 54 in Appendix 25), ANOVA also showed significant differences between prior chemistry experience groups, $F(2,98)=4.338$, $p=.016$, $\eta^2=.081$. Post hoc tests showed that a statistically significant difference existed only between SC (*M*=2.81, *SD*=0.84) and BC (*M*=2.09, *SD*=0.88) students, *p*=.018, *d*=0.86.

5.3.2 Differences at T2 – the Effect of the Bridging Course

Following the bridging course, ANOVA indicated significant differences between groups at the beginning of Health Science I for CS2, $F(2,98)=11.942$, $p<.001$, $\eta^2=.196$. Post hoc tests with Scheffe showed that bridging course attendance had resulted in an improvement in self-efficacy so that no statistically significant difference was found between the CS2 scores of SC (*M*=2.24, *SD*=0.73) and BC students (*M*=2.02, *SD*=0.75), *p*=.521. In addition, the BC students had a significantly higher CS mean score than the PC students (*M*=1.41, *SD*=0.75), *p*=.003, *d*=0.81. These differences are illustrated in Figure 11.

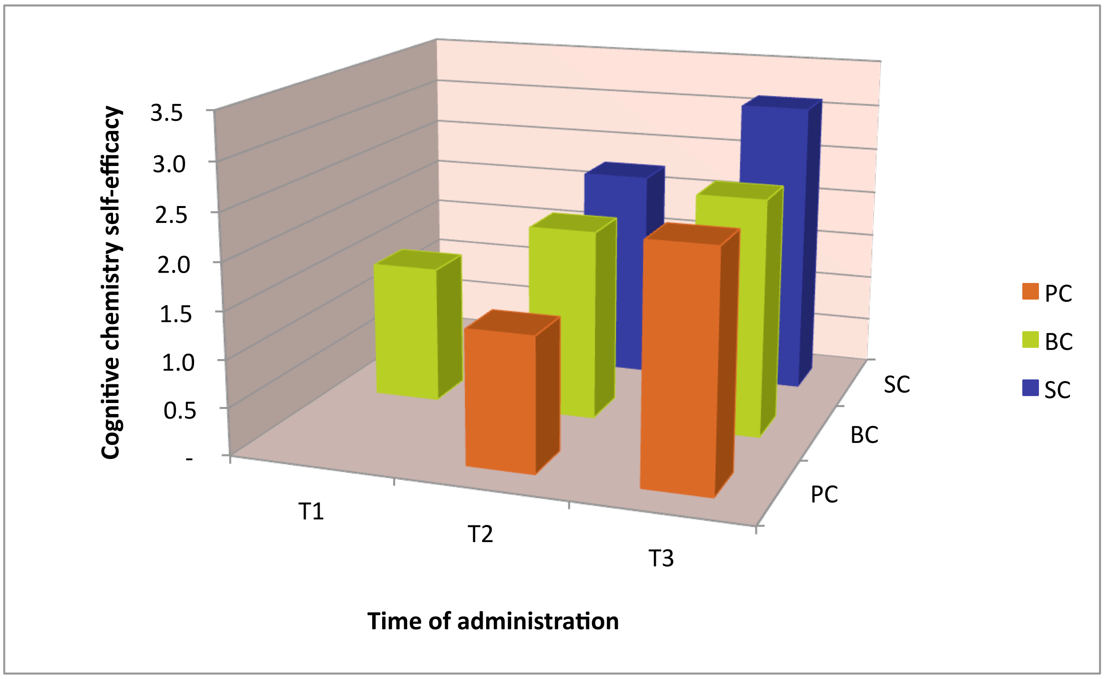

Figure 11. Changes in CS based on prior chemistry experience

Based on social cognitive theory, it was anticipated that participation in the bridging course would improve chemistry self-efficacy, since students were provided with an opportunity to increase chemistry competence through knowledge and skill acquisition. However, the fact that it increased to a level similar to that of the SC group at the beginning of the semester was both surprising and encouraging and indicated the effectiveness of such a program in building self-belief in students.

Focus group interviews also demonstrated that the bridging course increased the confidence of many attendees.

> Brittney: But then we did the bridging course, and I was like, "Aw. I'll be right."

> Brett: … for confidence, I think, definitely … like it showed me just how much I did understand about chemistry. (*Individual Interview)*

> Bella: Walking into [the first chemistry] class [of the semester] it was like, "Suck eggs. I know everything." My confidence was there [having done the 3-day course].

This last comment illustrates one of the two factors that collaboratively improved confidence. By the end of the bridging course, students felt they had gained sufficient foundation knowledge to enter the course. This is explored further in Section 5.3.4. Secondly, they found they were capable of achieving which was a potent informant of personal efficacy (Bandura, 1997).

> Brittney: … like after the first day, I was heaps surprised at how much I actually picked up and could remember, and like after the 3 days I was like, wow, I actually learned that stuff.

> Beryl: The more we got into the bridging course, what we achieved in the morning, in the afternoon, and the end of the day, … yea, it was achievable with learning.

According to social cognitive theory, mastery experience is the most influential source of self-efficacy. Opportunity to practice concepts covered in lectures and in small tutorial groups helped inform this improvement in self-efficacy, because they provided "authentic evidence" of success in chemistry as a result of sustained effort (Bandura, 1997, p. 80). The administration of an identical pre- and post-test (10 multiple choice questions) also served to build confidence:

> Bella: By the end, I'm looking at it and going "yea – I know that, and that." 9/10. Oh yes!

> Bernice: Proof. You're sitting there going "oh my god. Look at what I just learnt!" It didn't seem like it was such a big deal when we actually did it over the 3 days. "Wow, this is great." Looking at it going "that's massive."

Schmid et al. (2012), Youl et al. (2005) and Youl et al. (2006) reported similar qualitative findings, noting that attendance at a 7-day bridging course with the intent of studying an introductory chemistry course had enhanced academic self-efficacy.

Surveys conducted after bridging courses in biology (Wischusen & Wischusen, 2007) and for enrolled nurses converting to a degree program (Boelen & Kenny, 2009) reported increases in student confidence of 72% and 63% respectively. Analysis of the questionnaire data from this study showed that 74% of bridging course attendees experienced an increase in self-efficacy.

Of course, not all students experienced a large increase in self-efficacy as a result of attending the bridging course. Bridget's comment suggests one possible explanation for this:

> Bridget: Like, I didn't really feel like going into it [the bridging course] because I didn't know what chemistry was like or how hard it would be so was OK at the start, but then …

Her preconceived ideas concerning the nature and level of difficulty of chemistry meant she was unprepared for the challenge and by the end of the three days, she was still doubting her ability to master the material.

While ANOVA testing with post-hoc Scheffe showed SC students had a significantly higher initial LS mean than BC students, similar testing for LS2 showed this was no longer the case, with no significant difference between the mean scores of any of the prior chemistry experience groups, $F(2,98)=2.422$, $p=.094$. Bridging course attendance provided some familiarity with laboratory activities and it would seem that this was sufficient to increase the laboratory confidence to a point comparable with both SC and PC students.

> Beryl: It was good because I'd never been in one. I was really nervous with all the test tubes.

5.3.3 Differences in Chemistry Self-efficacy at T3

When chemistry self-efficacy was measured at the beginning of the last lecture of the chemistry component of the unit (T3), ANOVA results showed that differences between groups based on prior chemistry experience persisted, $F(2,98)=8.335$, $p<.001$, $\eta^2=.145$. Post hoc tests with Scheffe revealed SC students ($M=3.12$, $SD=0.61$) had significantly higher mean self-efficacy scores than both PC ($M=2.45$, $SD=0.59$, $p=.005$, $d=1.12$) and BC ($M=2.50$, $SD=0.89$, $p=.001$, $d=0.77$) students, with no significant difference between the self-efficacy scores of the PC and BC students ($p=.951$), as seen in Figure 11.

What is interesting is that the strength of the correlation between prior chemistry experience and CS decreased slightly over the semester ($r_{T2}=.430$,

r_{T3}=.340) highlighting the importance of the time of data collection when reporting findings. This may help explain the unexpected finding by Andrew (1998) using a t-test that showed science self-efficacy was not influenced by the study of science at high school in a first-year nursing cohort. In her report, there is no mention of the time of measurement of self-efficacy. If it was measured at the end of the year, the influence of high school science experience may have been ameliorated by the effect of mastery experience in two science subjects over the year.

In a result that concurs with LS2, ANOVA testing for LS3 showed no significant difference between the mean scores of any of the prior chemistry experience groups, $F(2,98)=1.550$, $p=.217$.

So, while it may appear that the bridging course had no overall impact on chemistry self-efficacy over the 7 weeks in which the chemistry component of Health Science I was taught, it is important to note that the BC students had a significantly higher CS score than the PC students at T2, the point of entry to Health Science I. The impact of attendance at lectures, tutorials and completion of Test 1 in Week 5 seem to have had the effect of levelling out the differences between these two prior chemistry groups. However, the difference at T2 cannot be ignored and can clearly impact such factors as retention. The implications of these findings for a bridging course will be discussed in Chapter 8.

5.3.4 Changes in Chemistry Self-efficacy Over the Semester for Prior Chemistry Experience Groups

It has already been noted in Section 5.1 that there was a significant increase in cognitive and laboratory self-efficacy for the total cohort over the 7 weeks of teaching the chemistry component of Health Science I. The question is whether this also applied to each of the prior chemistry experience groups. Paired samples t-tests, the results of which are recorded in Table 14 and Table 15, confirm that both cognitive and laboratory chemistry self-efficacy showed large and statistically significant increases for each group based on prior chemistry experience.

Table 14. Changes in cognitive self-efficacy (CS) from initial to final measures for the total cohort and by groups for prior chemistry experience

Prior Chemistry Experience Group	Mean change in CS (*SD*)	df	*t*	Significance (*p*)	Effect Size (Cohen's *d*)
Total Cohort	1.00 (0.73)	100	13.686	<.001	1.30
PC	1.04 (0.75)	43	9.149	<.001	1.54
BC	1.04 (0.86)	30	6.781	<.001	1.33
BC (T2–T1)	*0.56 (0.70)*	*30*	*4.433*	*<.001*	*0.79*
BC (T3-T2)	*0.48 (0.66)*	*30*	*4.061*	*<.001*	*0.58*
SC	0.88 (0.52)	25	8.532	<.001	1.31

Table 15. Changes in laboratory self-efficacy (LS) from initial to final measures for the total cohort and by groups for prior chemistry experience

Prior Chemistry Experience Group	Mean change in LS (*SD*)	df	*t*	Significance (*p*)	Effect Size (Cohen's *d*)
Total Cohort	0.69 (0.83)	100	8.275	<.001	0.82
PC	0.71 (0.85)	43	5.538	<.001	0.80
BC	1.04 (0.86)	30	5.156	<.001	1.03
BC (T2–T1)	*0.48 (0.73)*	*30*	*3.690*	*.001*	*0.55*
BC (T3-T2)	*0.39 (0.81)*	*30*	*2.666*	*.012*	*0.53*
SC	0.45 (0.66)	25	3.493	.002	0.62

The significant increases in CS and LS observed for each group were also subjected to an ANOVA analysis. Despite the SC group having the smallest mean increase for both CS and LS, the failure of this change to be significantly different from the changes for the PC and BC cohorts (*p*=.628 & .198) indicates that each group increased in CS to a similar degree.

It was noted in Section 5.1 that self-efficacy items 1, 2 and 6 had the largest increase in CS and items 7, 9 and 13 had the smallest increase. While the top three and bottom three items all demonstrated significant increases in self-efficacy for the total cohort, it remained to determine whether this was also the case for each of the prior chemistry experience groups. When mean changes were examined based on prior chemistry experience, the increase in Item 13 (mastering the knowledge required in this chemistry course) failed to reach statistical significance for both the PC group (*p*=.078) and BC group (*p*=.509). In addition, no statistically significant increases were found for Items 7 (Achieving a passing grade in chemistry, *p*=.448) and 9 (Explaining something you will learn in this chemistry unit to another person, *p*=.217) for the BC group. The initial mean for both of these items was higher for the BC group compared with PC students, with the final means being very close. Items 7, 9 and 13 were the three items with the smallest but significant increase for the total cohort. For the SC group, all increases were statistically significant. It would appear, then, that the small but significant increases in self-efficacy for items 7, 9 and 13 were due to the contribution of the SC group. The BC and PC groups continued to lack confidence in those self-efficacy items that involved some form of assessment. The question as to whether this phenomenon also translated into increased anxiety is taken up in the next chapter.

Interestingly, although the quantitative results in Table 14 and Table 15 indicate an overall significant increase in CS over the semester for the SC group, perceptions expressed by some of the SC city focus group provided a deeper insight. Sandy, whose high initial self-efficacy score changed very little over the semester (ΔM=0.20), also perceived in interview that her confidence level had not significantly changed. However, according to the questionnaire data, both Samuel and Sarina's mean CS scores had increased significantly (by 0.90 and 1.2 points respectively), even greater than the mean for the SC cohort, yet they perceived no change when interviewed in the focus group. A possible explanation for the contrary qualitative reports by Samuel and Sarina may lie in the overall demeanour of the SC students. It was clear from observing the interviews, that these students were substantially more confident than the other groups. This, coupled with a higher initial CS mean, may have caused some of the SC students to be less aware of the increase. On the other hand, Sofia did confirm the overall increasing trend in CS for SC students, and included one reason for this:

> Sophia: My confidence went up after doing it here, versus high school, yeh. I found it heaps easier.

This mismatch of interview and questionnaire data was also observed in the PC group. For example, Phebe reported that her confidence dropped over the seven weeks of chemistry, yet her CS scores indicated an increase of 1.30. Indeed, inspecting the difference in z-scores between Phebe's CS3 and academic performance (1.34) shows she significantly overestimated her ability in chemistry. It would seem in this case, that the level of confidence expressed in the interview was more closely aligned with her performance.

While the questionnaires indicated overall increases for most students, examination of the interview data revealed that this was not necessarily a steady increase from the beginning to the end of the chemistry component of Health Science I, but rather was subject to fluctuations according to prior chemistry experience. Examination of the interview transcripts uncovered a number of sources of self-efficacy that contributed to the overall increase and to periodic variation based on prior chemistry experience. From the 'reductivity' theme, 'foundation knowledge' emerged as one of the most significant categories, with some influence from 'nature of chemistry.'

Foundation knowledge

The most frequently discussed source of efficacy, particularly in relation to early experiences in the semester, was foundation knowledge. For both the SC and BC students, the realisation that material covered in the first few weeks was familiar was a significant source of confidence, a major theme also noted by Schmid et al. (2012) and Youl et al. (2006) in interviews of bridging course attendees following three weeks of introductory chemistry lectures. Examples from the current study illustrate this.

> Becky: I was feeling calm and secure and confident.
>
> Bernice: I know this - I'm all good - we've done this.
>
> Beryl: … you really managed to pick the fundamentals to get us the confidence.
>
> Bella: It's sort of like when you did the bridging course, you already got the basis for when you got into class. You sort of actually knew some things, it's sort of like, we did that in the bridging course …
> *(everyone nodding and wanting to add comments)*
>
> Beth: … we sort of knew everything really.
>
> Simon: … cause it gave me a little bit more confidence, cause I thought, "oh I actually know these things."

This is further supported by data collected from the questionnaire at T3. Eighty-seven percent of BC students reported that the bridging course had helped either a fair amount, much or very much in preparing them for Health Science I. Using the same criteria, 88% of SC students claimed senior chemistry had been helpful to them in the course.

The comments made by BC and SC students contrasted with those expressed by PC students. The realisation that they lacked previous experience in chemistry when many of their fellow students did not suffer this lack resulted in a decrease in confidence early in the semester.

> Pierce: Yea, probably when we just first started, it's like, "woh, this is like completely new." I didn't know anything, and so I was just like taking on something that I had no background …it was just all like, just seeing on the board like the periodic table, and I'm like, "woh, how am I ever meant to remember this?"

> Paris: … I remember the first lecture where you said "put your hand up if you did the bridging course" and a lot of people looked around. It just gave me this instant "Oh no, I didn't do it" … it just gave you that instant sort of no hope feeling.

Both Paula and Pam, members of Paris's focus group, empathised with this comment.

A lack of foundation knowledge resulted in a similar decrease in confidence when the BC students encountered new material later in the semester.

> Becky: … I questioned myself a bit the first time we hit something we hadn't looked at in the bridging course, and I went, "wait a second. I don't know anything about this."

In addition to foundation knowledge, both BC and SC students found confidence in the sense of assurance they felt for future understanding. Even if they did not grasp a concept immediately, they were sure they would comprehend it eventually.

> Sarina: It was more like you knew you would understand it. Whereas some people who haven't done it [i.e. senior chemistry], they don't know if they're ever gonna understand it.

> Becky: We also knew that if it didn't come straight away, that sometimes it did take a little while for something to click.

When difficulties are interpreted through the filter of robust self-efficacy, individuals are more likely to exercise greater persistence (Pajares, 1996).

Nature of Chemistry

Because of the unique language, levels of representation and complex and cumulative concept development, chemistry is widely regarded as difficult. As expected, self-efficacy changed in relation to the difficulty level of the material being presented. Generally, SC students were not phased by new or challenging material:

> Samuel: There was definitely a lot of stuff which we didn't cover in Year 11 or 12 but it was just kinda building on top of that.

This could be due to their already high levels of self-efficacy. For BC students in the rural group, there was consensus that confidence "started going downhill" (*Brett*) when the difficult topic of blood buffers was encountered.

5.4 Chemistry Self-efficacy and Perceptions of Chemistry

In the questionnaire, students were asked two key questions relating to their 'perceptions of chemistry' in Health Science I: 'enjoyment of chemistry since last studied' and 'importance of chemistry to nursing.' Research has shown that self-efficacy can be predictive of attitudes to science (Kurbanoglu & Akin, 2010). In this section, bivariate correlations between these perceptions and self-efficacy are reported. Insights into these relationships will be explored using the 'connection with the curriculum' and 'application to the profession' categories from the qualitative model. Few comments were made in focus group interviews specifically about confidence in the context of enjoyment of chemistry or the importance of nursing. However, a number of links were drawn in individual interviews during the discussion of the qualitative model, providing some supportive evidence for the quantitative findings.

5.4.1 Bivariate Correlations

Pearson product-moment correlations were calculated to explore relationships between various perceptions of chemistry and chemistry self-efficacy. Correlations with CS are reported in Table 16. All correlations with LS were less than .31 with few reaching statistical significance. These can be found in

Table 55 in Appendix 25.

The correlations with CS are significant and large and show an increase from the initial administration of the questionnaire to the final administration (T3). This suggests that the course has been successful in enhancing the relationship between CS and each of the perception items.

Table 16. Initial and final Pearson product-moment correlations between cognitive self-efficacy (CS) and various 'perceptions of chemistry' variables

Perception Item	Initial	Final
Level of enjoyment since last studying chemistry	.414***	.678***
Importance of chemistry to nursing	.224*	.465***
Contribution of chemistry to competence as a nurse		.539***

* *p*<.05, *** *p*<.001

5.4.2 Enjoyment of Chemistry

The strong correlation found in this study between 'enjoyment of chemistry' and CS3, *r*=.678, a link predicted by social cognitive theory (Bandura, 1997), adds support to the finding of Zusho et al. (2003) where 'interest in chemistry' and self-efficacy measured at Week 10 showed a moderate correlation, *r*=.47, *p*<.001. Individual interview comments support the reciprocal relationship: an increase in confidence can increase enjoyment, and enjoyment can influence confidence.

> Beth: I enjoyed it. It was fun, therefore it gave me confidence. (*Individual Interview*)
>
> Pippa: I became more confident towards the end because I really enjoyed it. (*Individual Interview*)
>
> Brett: Well, obviously if you enjoy doing something (*pause)* it you're better *(pause)* if you're adequate at doing something, then, you're obviously going to enjoy doing it more than if you just absolutely suck at something, so. (*Individual Interview)*
>
> Sofia: With the confidence came the enjoyment. (*Individual Interview*)

5.4.3 Importance of Chemistry to Nursing

While the relationship reported in Table 16 between the 'importance of chemistry to nursing' and self-efficacy is not as strong as that of 'enjoyment', it is comparable to other studies that have considered assorted perceptions of importance, such as personal relevance (Obrentz, 2011, r=.52) and task value (Zusho, et al., 2003, r=.49). These correlations are similar to that between CS3 and 'contribution of chemistry to your competence as a nurse'. Three of the five individual interviewees confirmed that self-efficacy influences task value, as argued by Bandura (1997).

> Pippa: I was confident because I did see, like with osmosis, oedema, like, that applied to nursing and I was really confident. (*Individual Interview*)

> Beth: Well, if you didn't see the application of chem. to nursing, you're in real trouble … When you do get the connection, it gives you confidence because you understand why things are happening within the body. (*Individual Interview*)

Fenton (2010) has shown that nurses who are confident in their ability to engage with scientific information are more likely to find science relevant to nursing.

Both Paula and Phebe suggested that while they did see some relevance in studying chemistry, the difficulties associated with the perceived unnecessary depth did affect confidence, causing it to go "a bit downhill" (*Phebe*). In contrast, Bree made the following interesting point on the notion of depth of knowledge in relation to relevance to nursing.

> Bree: I feel more confident now, I don't know if anyone else does, but I feel confident knowing that we are one of just a few colleges or universities that actually does chemistry, because a lot of others don't do it.

That the study of chemistry at a level beyond that provided by other institutions increased confidence also emerged strongly from the city BC interview. Perhaps this was an indirect consequence of attending the bridging course, since this concept was not mentioned by other focus groups.

5.4.4 Relationship with Prior Chemistry Experience Groups

Correlations between perceptions and CS3 across the PC, BC and SC groups are shown in Table 17. All groups show large and highly significant correlations for most of the items. It is interesting that the correlations between CS3 and the two items concerned with relevance of chemistry to nursing are lowest for the SC group. This finding is supported by the fact that neither Samuel nor Sofia linked 'application to the profession' to confidence in their qualitative models. Relevance, it would seem, plays a more important role in perceived self-efficacy for the PC and BC groups who struggle with chemistry concepts, given their lack of experience in the subject.

Table 17. Pearson product-moment correlations between cognitive self-efficacy and 'perceptions of chemistry' variables at T3 for the three prior chemistry groups

Perception item at T3	PC	BC	SC
Level of enjoyment since last studying chemistry	.677***	.676***	.681***
Importance of chemistry to nursing	.514***	.530**	.270
Contribution of chemistry to competence as a nurse	.549***	.591***	.416*

* *p*<.05, ** *p*<.01, *** *p*<.001

5.5 Chemistry Self-efficacy and Academic Performance

Social cognitive theory purports that self-referent processing of accomplishments, along with social influences, plays a role in determining behaviour. In this section, bivariate correlations between cognitive variables and self-efficacy are calculated and discussed. The interplay of effort, self-efficacy and academic performance is then explored. This is followed by an investigation into the differences and changes in self-efficacy based on three academic performance groups. Finally, discrepancies between self-reported self-efficacy measures and academic performance are analysed.

5.5.1 Bivariate Correlations

The strong correlation found in this study between CS3 and academic performance, r=.654, p<.001, accounting for approximately 42.8% of the variance in academic performance, adds further support to the well-established link reported in the literature and hypothesised by Bandura (1997). Indeed, when Brett was asked in an individual interview to identify categories from the qualitative model that were influential in his academic performance, he indicated that confidence was amongst the most influential.

Statistically significant Pearson product-moment correlations between self-efficacy and academic performance for tertiary students reported in the literature range from r=.12 for academic self-efficacy (Hargroder, 2007) to r=.70 for maths problem solving self-efficacy (Pajares & Miller, 1994). For chemistry self-efficacy, strong correlations (i.e. >.5) have been found by a number of researchers (Obrentz, 2011; Turner & Lindsay, 2003; Zusho, et al., 2003), while others have reported at least a medium (.3<*r*<.5) correlation (Smist, 1993; Tutor, 2006; Uzuntiryaki & Aydin, 2009). When general measures of academic self-efficacy have been used, the correlation tends to be of medium effect (Al-Harthy, et al., 2010; Klomegah, 2007; Lent, et al., 1986; J. W. Thomas, et al., 1987), including those measured using nursing cohorts (Andrew & Vialle, 1998; Silvestri, 2010; Tutor, 2006). Multon et al.'s (1991) meta-analysis on research involving self-efficacy and academic performance found effect sizes for this phenomena ranging from 0.13 to 0.58, with an average variance of 14% in academic performance attributed to self-efficacy.

The low and statistically insignificant correlations between LS3 and academic performance, e.g. *r*=.185 (see

Table 56 in Appendix 25) suggests laboratory chemistry self-efficacy is a poor predictor of academic performance. In comparison, Uzuntiryki and Aydin (2009) used an almost identical set of items on their psychomotor skills dimension and found a small yet statistically significant correlation (*r*=.18, *p*<.05) with the final grade in a general chemistry course. While the researchers do not indicate how the grade was formulated, it would be safe to assume that laboratory reports were a component, perhaps partially explaining the reported significant correlation. However, such a small correlation does cast some doubt on the meaningfulness of the result, despite statistical significance. Due to the low influence of LS on academic performance, LS data is not used in the following investigations into self-efficacy and academic performance.

Echoing the findings of studies that have taken multiple measures of self-efficacy over the semester, the size of the correlation between cognitive chemistry self-efficacy and final achievement ($r_{initial}$=.333, *p*<.01; r_{final}=.654, *p*<.001) increased with the proximity with which the measurements were taken with respect to each other (Garcia, 2010; Lawson, et al., 2007; Obrentz, 2011; Zusho, et al., 2003). This trend is also supported by Multon et al.'s (1991) meta-analysis on self-efficacy studies.

There are a number of possible explanations for the relatively high effect sizes found in this study. Ongoing assessment during the semester (i.e. Test 1) provided students with feedback by which to make a more realistic evaluation of their capabilities. Secondly, the domain-specific nature of the self-efficacy instrument could play a role. Pajares (1996) asserted that more specific measures of self-efficacy result in higher correlations with academic performance. It has also been demonstrated that effect sizes based on classroom-related measures of self-efficacy are significantly greater than for standardized achievement measures (Multon, et al., 1991). Thirdly, relatively high effect sizes could be related to the fact that the correlation was made with chemistry performance in a nursing cohort. For example, Silvestri (2010) found a higher correlation between general self-efficacy and chemistry achievement than with any other subject in a nursing degree program.

5.5.2 Self-efficacy, Effort and Academic Performance

Embedded in social cognitive theory is the assertion that beliefs of personal competence affect behaviour, such as effort and perseverance demonstrated in the face of obstacles (Pajares, 1996). This is a principle recognised by students:

> Interviewer: Did it [confidence] influence a) the amount of effort you put in, and b) the amount of time you put into it because you knew you would get it eventually?
>
> Beth: Yes, yes. Definitely.

According to social cognitive theory, students with high levels of self-efficacy will put in more effort and persist at a given cognitive task, and this was manifested by a number of students.

> Beryl: You can get it. So, if you've got that, and you meet a dilemma that you don't know, you know that you can work to get through it.
> Beth: Yea.

Both Beth and Beryl reported high levels of CS. Beryl went on to demonstrate how her confidence allowed her to persist in her study even when faced with challenges.

> Beryl: … and just reading through books to find out, you know, to work out why you don't understand it, that takes an enormous period of time.

The converse is true for individuals with low self-efficacy.

> Bronte: … and the first thing that comes in your mind is self-doubt. "Can we do it? Is it even a waste of time trying to do it?"
>
> Beth: I'm going to listen and keep up. Whereas, if I knew nothing, I'd go "Oh my god. Umm. I don't know what you are talking about."
> Bella: You put barriers up.
> Beth: You do. You go "I'm just going to .. I'm just not going to listen because it's just so past me, I can't even start."

These student reflections illustrate how difficult it can be to even approach study when self-efficacy is low. Furthermore, elevated self-efficacy can affect overall approaches to study, with research showing that highly efficacious students are more likely to employ a mastery approach to learning using metacognitive self-regulated strategies (Al-Harthy, et al., 2010; Bandura, 1997; Tutor, 2006; Zimmerman & Martinez-Pons, 1990) and "working forward" problem solving strategies in chemistry (Taasoobshirazi & Glynn, 2009):

> Sofia: … I'm just kinda, I'm a lot better just being able to study for it, being able to set things out, and I definitely feel more confident.

During her individual interview, Sofia pointed out that in turn, the mere process of putting in effort built her confidence.

In contrast, some students were so confident that they employed little effort when it came to test preparation.

> Brittney: Honestly, I think um, because I was like, "I'd be fine, I'd be fine", I didn't do as much study as I probably should have,
> Bree: That's what I did as well.
> Brittney: because I thought, "I'll be right, you know, I know it, I know it." So, I think that I didn't study enough because of that.

> Sarina: Ah, I didn't study very much.
> Samuel: *laughs*
> Interviewer: Because you were that confident?
> Sarina: No. (*smiling*) No, I just had so many other things going on, and I realized afterwards I should have studied more. Maybe I was a bit too confident.

What is interesting to note here is that Sarina's poor performance in the test failed to affect her perceived CS, which remained high. Social cognitive theory suggests that academic failures become "non-diagnostic of personal capabilities" if little effort has been employed (Bandura, 1997, p. 84). Observations such as these add weight to studies that have found students with high self-efficacy may show lower persistence on tasks believed to be too easy (Salomon, 1984).

Despite low self-efficacy, some students, like Paris, nevertheless put in a lot of effort when studying.

> Paris: Oh, I still don't think I can - do it. I don't know. I just find that each time I look at it, it's not there, like it just doesn't stick, and I just have to keep going back and back and back until I find it somewhere.

Paris's voice portrayed a sense of helplessness. When the struggle becomes difficult to this degree, self-efficacy appraisal is influenced by an implied lower ability. Even if academic performance is achieved under these circumstances, self-efficacy is unlikely to increase (Bandura, 1997).

While high self-efficacy can be a powerful motivating factor resulting in increased effort that may lead to higher academic performance, comments from students indicate that motivation for study is a complex construct with other variables contributing to the amount of effort and level of persistence.

5.5.3 Self-efficacy and Achievement Level

A number of studies reported in the literature compare self-efficacy changes for low and high achievers. In order to determine whether changes in self-efficacy were similar across academic performance groups and to allow literature comparisons to be made with this study, the cohort was divided into three groups based on academic performance: low achievers (<45%), average achievers (45-69%), and high achievers (70+%). Initial and T3 values for CS means for each group are recorded in Table 18 and illustrated in Figure 12. ANOVA revealed that significant differences in CS3 existed between these groups, $F(2,97)=36.212$, $p<.001$, $\eta^2=.427$, and post hoc tests using Scheffe demonstrated significant differences in CS3 between all academic performance groups: high > average ($p=.001$, $d=0.93$); average > low ($p<.001$, $d=1.02$); and high > low ($p<.001$, $d=2.38$).

Table 18. Cognitive self-efficacy (CS) based on academic performance groups: means (and SD) for initial and final measures and changes in CS over the semester (final - initial)

Academic Performance Category*	Initial CS (*SD*)	Final CS (*SD*)	Mean change in CS (*SD*)	df	*t*	*p*	Effect Size Cohen's *d*
Total Cohort	*1.65 (0.79)*	*2.64 (0.74)*	*0.99 (0.73)*	*100*	*8.275*	*<.001*	*1.30*
Low	1.38 (0.60)	2.06 (0.50)	0.68 (0.65)	35	6.184	<.001	1.23
Average	1.55 (0.78)	2.68 (0.71)	1.13 (0.85)	31	7.574	<.001	1.52
High	2.03 (0.87)	3.25 (0.50)	1.22 (0.58)	31	11.830	<.001	1.72

* Low = <45%, Average = 45-69%, High = 70+%

While Section 5.1 showed a strong and significant increase in chemistry self-efficacy for the total cohort, paired samples t-tests were performed to see if this was the case for each group based on achievement. Table 18 shows that chemistry self-efficacy showed large and statistically significant increases for each academic performance group over the semester. In addition, ANOVA revealed that the mean change in self-efficacy across the academic performance groups varied significantly, $F(2,97)=5.979$, $p=.004$, $\eta^2=0.116$. Post hoc test comparisons using Scheffe showed that high performers ($M=1.22$) experienced a significantly bigger increase in mean CS when compared with the low performance group ($M=0.68$), $p=.008$, $d=0.37$. The difference in mean change in CS for the average and low groups was also significant, $p=.029$, $d=1.01$. The difference between the high and average groups failed to reach significance. Note the relative changes for each group in Figure 12.

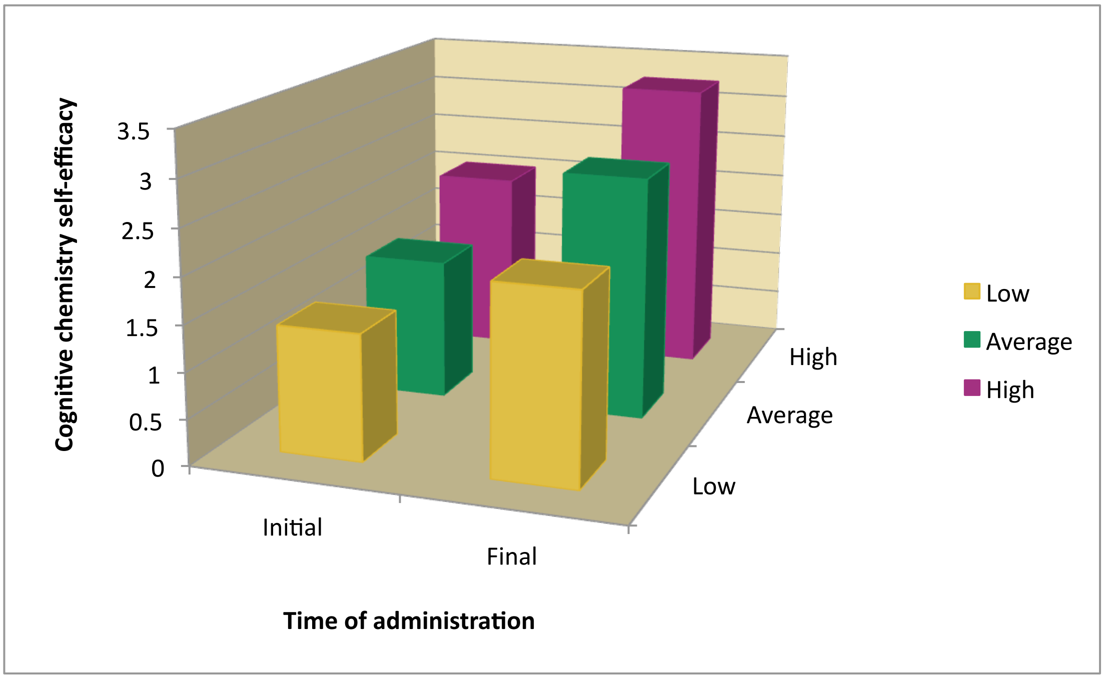

Figure 12. Changes in CS based on academic performance group

These findings are in stark contrast to those reported by both Obrentz (2011) and Zusho et al. (2003) who found a decrease in chemistry and academic self-efficacy respectively for low achievers after dividing their general chemistry cohorts into three achievement groups.[10] It is worth noting that of all the groups in my study, the low achievers' CS increased the least. However, consistent with this study, Zusho et al. (2003) did note an increase for high achievers, whereas Obrentz (2011) found no change for high achievers. Garcia (2010), who divided the introductory chemistry cohort into pass and fail categories, found an increase (around d=1.0) in chemistry self-efficacy for pass students and no change in the fail group over the semester.

According to social cognitive theory, past experiences shape self-efficacy, with success enhancing beliefs and failures diminishing them, particularly if failures occur early in the acquisition of skills (Bandura, 1997). Yet, surprisingly few comments were made in focus groups on this important antecedent. Students did report that solid performances in Test 1 provided a "nice confidence booster" (*Paige*) and allowed some to "definitely feel more confident" (*Sofia*). However, all individual interviewees except Paula agreed that academic performance played a role in developing their perceived self-efficacy.

> Sofia: Like, up until the first test I was like, a bit like sketchy, like just wondering if I could like actually bring my marks up.
>
> Soraya: Like, just comparing the marks from, like when you did chemistry in school to when we did like the chemistry tests here, like I didn't do that well in school with chemistry, whereas here my marks were a lot better, so, yeh.
>
> Beth: If you do badly in your first exam, your confidence will plummet … you'll lose your motivation because you think, "I tried hard for that" and then you didn't get anywhere. (*Individual Interview*)
>
> Pippa: I become more confident if my performance is better. (*Individual Interview*)

Similar comments by introductory chemistry students were reported by Garcia (2010). A poor result in Test 2 for Simon and Sofia had little effect on their confidence.

> Sofia: I knew I could to it. I just, yeh, needed to put more effort into it.

---

[10] Oberentz's academic performance groups based on final course grade: low (N=119, <2.3), average (N=114, 2.7-3.0), high (N=176, 3.3-4.0)

Zusho et al.'s academic performance groups based on average course achievement: low (N=144, <70%), average (N=144, 70-80%), high (N=132, >80%)

As purported by Bandura (1994), students with high self-efficacy like Simon and Sofia are more likely to attribute their failure to a lack of effort rather than a lack of ability, preventing a significant drop in confidence.

Reflecting Bandura's concept of reciprocal determinism (Bandura, 1997; Pajares, 1996), student comments indicated that performance in tests not only shaped self-efficacy, but this, in turn, informed subsequent performance.

> Sofia: Because I was more confident, I wanted to do more and I wanted to get better. (*Individual Interview*)
>
> Pippa: My confidence brought me up more. (*Individual Interview*)
>
> Beth: Confidence does impact [academic performance], 'cause if you're telling yourself you can't do it, you're not going to be able to do it. (*Individual Interview*)

In contrast to these observations, Samuel failed to see a causal relationship between confidence and performance.

> Samuel: There are some people who are confident, like me, confident in a way, but I don't do particularly well in class, like I'm not getting HDs or anything. (*Individual Interview*)

Given that the lowest mark for Test 1[11] in the high performance group was 69%, and only four out of 32 students in the average performance group failed Test 1, it was anticipated that these positive academic performances would result in an increase in self-efficacy for many students. However, the significant increase in self-efficacy amongst the low achievers, albeit to a lesser degree, was not expected since only three students received a pass for Test 1. There are a number of possible explanations. Since many of the items in the CNSS were task-specific, there is no doubt that even the poor students would have felt an increase in self-efficacy for items such as 1 and 2 ("explaining the structure of an atom" and "explaining the properties of elements by using a periodic table") after lecture attendance. In addition, many of the focus group participants mentioned how important the tutorials were in helping them understand concepts and in building confidence as a result of the support available to them during this time. The amount of external aid received by students has been identified as a contributing factor to perceived efficacy

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[11] Test 1 was administered at the beginning of Week 6 of the semester. T3 was given at the end of Week 7 (city campus) and beginning of Week 8 (rural campus).

(Bandura, 1997) and the institution where this study was conducted prides itself on the support it offers students, receiving a five-star rating for student-staff ratios and teaching quality in 2011 (*The good universities guide 2012: Universities and private higher education providers*, 2012). Another possible explanation for the increase in CS in the low performance group was found in Paula's individual interview. Paula was in the low achievement group, yet her chemistry self-efficacy changed very little over the semester. A recurring theme from her individual interview was that she remained confident in her ability to master the material, explaining that her academic performance was linked to the pace of the course. Consequently, it would appear that factors other than achievement in Test 1 have played a significant role in the formation of self-efficacy in the low performance group. Indeed, social cognitive theory suggests self-efficacy is more strongly predictive of performance rather than the performance predictive of self-efficacy (Pajares & Miller, 1994).

In summary, self-efficacy has been shown to be strongly correlated with academic performance, both directly and indirectly, with academic performance also informing self-efficacy. However, perceived self-efficacy encompasses so much more than just a reflection of past performance, taking into account perceived difficulty levels, effort, support, and circumstances, with the individual subsequently organising and interpreting them in a unique way (Bandura, 1997).

5.5.4 Discrepancies between Self-efficacy and Academic Performance

Statistical analysis has shown that self-efficacy and better academic performance are positively correlated. But are there cases where perceived self-efficacy does not match the level of academic achievement? For example, do some students over-rate or under-rate their capacity to achieve? In the literature, the majority of self-efficacy–academic performance discrepancy analyses have occurred in mathematics, using question-specific self-efficacy measures, where academic performance is determined by administering identical questions. For this study, using a procedure similar to Williams (1994), the difference between z scores for CS and academic performance was calculated in order to determine an over/underestimation discrepancy value (i.e. discrepancy = zCS3 - zAP). A difference in z-scores less than -0.75 was designated as under-confidence and greater than 0.75 as over-confidence. (Note that similar results were obtained when a value of ±1.0 was used as the cut-off point.) In addition, the cohort was also divided using just two groups – over or underestimation. Results for the total cohort and academic performance groups are recorded in Table 19.

Bandura (1997) explains that discrepancies between self-efficacy and performance can arise from performance ambiguities, external constraints or faulty self-appraisal as a result of personal factors. Consequently, he warns against undue dependence on performance to assess the accuracy of self-efficacy appraisal since performance is influenced by many other determinants.

Table 19. Distribution of the difference in z-scores for CS3 and academic performance for the total cohort and for academic performance groups

Academic performance category*	Based on three groups			Based on two groups	
	diff z<-0.75	|diff z|≤0.75	diff z>0.75	diff z < 0	diff z ≥ 0
Total cohort	*17*	*65*	*18*	*45*	*55*
Low	4	22	10	10	26
Average	5	21	6	14	18
High	8	22	2	21	11

* Low = <45%, Average = 45-69%, High = 70+%

Overall, more students overestimated rather than underestimated self-efficacy, which has also been demonstrated in a number of other studies (Lawson, et al., 2007; Pajares & Kranzler, 1995; Pajares & Miller, 1994) and is consistent with the prediction by social cognitive theory (Bandura, 1997; Pajares, 1996). Rather than seen as a flaw, social cognitive theory purports that some degree of overestimation is useful, even necessary, for psychological well-being and human accomplishment (Bandura, 1997) because it sustains motivation in the face of life's inevitable obstacles. However, large misjudgements can have deleterious consequences because when activities beyond capabilities are attempted, inevitable failure will result in disappointment (Multon, et al., 1991). Similarly, underestimation is not desirable, particularly in difficult situations, because it "leads to routine thoughtless avoidance of activities well within personal capabilities" (Bandura, 1997, p. 70) resulting in limited aspirations, skill development and potential because less effort and persistence is demonstrated.

When academic performance categories are considered, the low achievement group had more students who overestimated CS3 while the high achievement group had more students who underestimated it. This phenomenon, known as the Dunning-

Kruger effect, where overestimation is greatest amongst those of low cognitive ability (Kruger & Dunning, 1999), has been demonstrated in a general chemistry cohort (Bell & Volckmann, 2011) and a college biology cohort (Lawson, et al., 2007). Furthermore, these studies also found that high achievers were more likely to underestimate their performance.

5.6 Summary of Self-efficacy Findings in the Context of the Research Questions

The chapter lends support to social cognitive theory which purports that self-efficacy is formed by the dynamic integration of many variables (Bandura, 1997). Overall, students were more efficacious with laboratory skills than cognitive tasks. Statistical analyses demonstrated that the LS dimension of the CNSS is less useful for prediction than the CS dimension, with very few statistically significant correlations between the LS component of self-efficacy and key constructs in this study. The findings from this chapter will be summarised in relation to the self-efficacy component of the four research questions.

Research Question One stated, "What role do demographic variables play in self-efficacy …?" While the small number of males in the cohort warrants some caution in interpretation of independent t-tests, no gender bifurcation in self-efficacy was found in this study which is consistent with much of the literature. Correlation analysis indicated a small, negative relationship between age and cognitive chemistry self-efficacy. Further, because of the strong correlation between age and hours of work and health care experience, the small, negative correlations of these variables with CS may have been indirectly due to age. There were few differences when laboratory chemistry self-efficacy was considered.

Research Question Two considered, "How does self-efficacy … and student perceptions of chemistry change over the course of the semester?" Paired samples t-tests showed strong and statistically significant increases in both CS and LS for the total cohort, for each gender, for each prior chemistry experience group and for groups based on academic performance. Apart from the low achieving group, these changes were of a similar magnitude. Interview data revealed that the rate of increase in self-efficacy was not uniform throughout the semester, with students identifying periods of plateaued and even decreased self-efficacy. While tutorials and test results served to inform self-efficacy, several categories from the qualitative model were identified as sources of change in self-efficacy over the semester. Categories from the 'reductivity' theme included existence of 'foundation knowledge', 'exposition', and 'the nature of chemistry', particularly the difficulty of the material. From the 'connectivity' theme, support gained from 'social interactions' with peers and the lecturer, and to a lesser extent, the 'application of chemistry to nursing' and 'connection with the curriculum' were found to contribute to the formation of personal efficacy in chemistry. Furthermore, the strength of the correlations between CS and various perceptions of chemistry increased over the semester so that by T3, there were strong relationships with enjoyment and relevance.

Research Question Three stated, "What relationships can be established between self-efficacy, … prior chemistry experience and academic performance?" In relation to prior chemistry experience, SC students exhibited higher CS means than both BC and PC students initially and at T3. It is interesting to note that the highest correlation between CS and prior chemistry experience occurred at the beginning of the semester (T2).

While insignificant correlations were found with LS, the strength of the correlation between CS3 and academic performance (r^2=.43) was even higher than that reported in much of the literature. In agreement with social cognitive theory, interview data revealed that self-efficacy influenced effort and persistence when studying for tests. The high achieving group had statistically higher CS3 than the average group, which in turn had a higher mean CS3 than the low achieving group. These differences were also detected in the overall demeanour of the focus groups. Despite large increases for all performance groups, the increase in CS for the average and high achievers was significantly greater than for the low achieving group. The increase in CS for the low achieving group was unexpected and represents a unique finding to this study. It may be that the amount of support given to students played a significant role in increasing self-efficacy for this group. When data was examined for discrepancies between self-efficacy and academic performance, the high achievers were more likely to underestimate their ability while the low achievers were more likely to be overconfident.

Research Question Four asked, "To what extent has a 3-day bridging course been beneficial to nursing students studying Health Science I?" Before beginning any chemistry at the institution, there was no significant difference in the initial CS measures for PC and BC students. Both quantitative and interview data showed that as a result of bridging course attendance, BC students started Health Science I with significantly higher levels of cognitive self-efficacy than the PC students, with the level being comparable to SC students. This finding is supported by research reported on other bridging course programs. The acquisition of foundation knowledge gained through lectures and mastery experiences in tutorial settings, along with the results gained in the post-test, contributed to the belief of 74% of BC students (as reported on the questionnaire) that they were now more capable of achieving in chemistry than when they began the bridging course. By the end of the chemistry component of Health Science I, the CS advantage that the BC students had over the PC students at the beginning of the course had dissipated, and there was no longer any significant difference in CS.

The results and discussion that emerged from the analysis of both the CNAS and interview data for anxiety will be considered in Chapter 6, along with a discussion of the relationship between self-efficacy and anxiety.

6 CHEMISTRY ANXIETY: FINDINGS AND DISCUSSION

Chapter Overview

Following the format of the previous chapter on chemistry self-efficacy, this chapter explores the two dimensions of the CNAS (Chemistry for Nurses Anxiety Scale) derived from the factor analysis outlined in Chapter 4: test anxiety (TA) and laboratory anxiety (LA). Both quantitative and qualitative findings relating specifically to chemistry anxiety and the interaction with demographic, prior chemistry experience and academic variables are presented. The relationship between dimensions of self-efficacy and anxiety is also discussed. Findings are progressively discussed in relation to the literature. The chapter concludes with a consideration of the key findings in the context of the research questions.

6.1 Differences in Chemistry Anxiety Dimensions for the Total Cohort

The means and standard deviations for both the test and laboratory anxiety scales for each measure were calculated and are recorded in Table 20 and illustrated in Figure 13.

Table 20. Chemistry anxiety: initial and final means (and standard deviations) for test and laboratory anxiety

Chemistry anxiety dimension		Number of cases	Initial[a] Anxiety	Final[b] Anxiety
Test	(TA)	101	2.03 (0.90)	1.82 (1.02)
Laboratory	(LA)	101	1.43 (0.73)	0.97 (0.85)

a. Initial anxiety incorporates anxiety at T1 for BC students and anxiety at T2 for PC and SC students.

b. Final refers to measures made at T3 for all students.

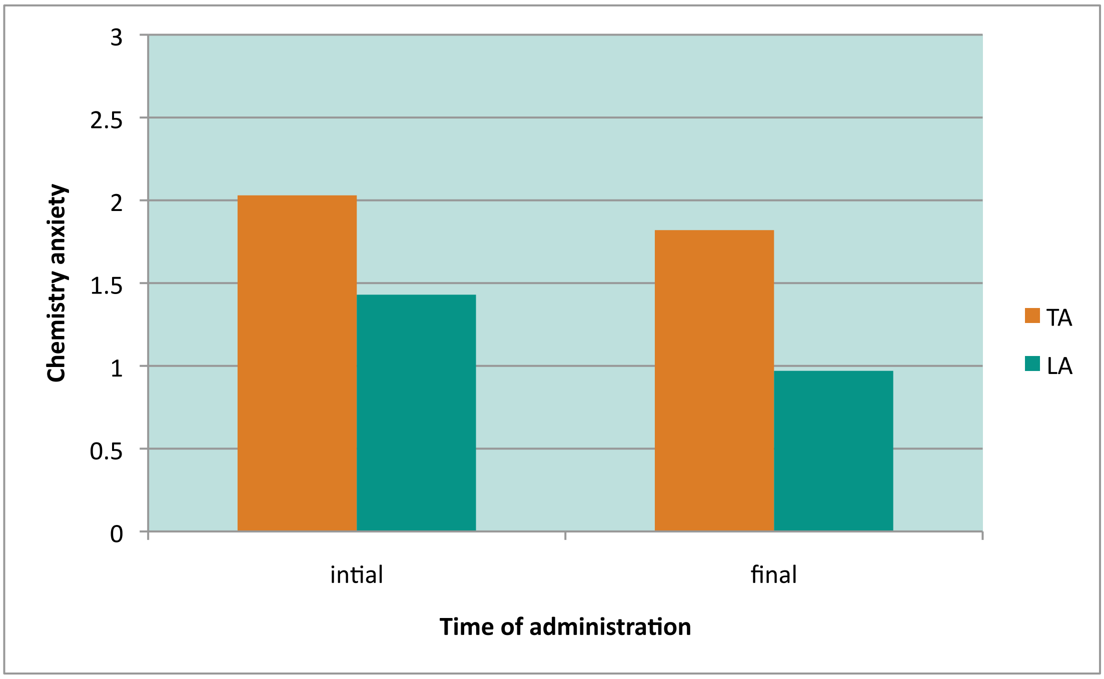

Figure 13. Changes in TA and LA over the semester

Paired samples t-tests revealed that test anxiety (TA) was statistically significantly higher than laboratory anxiety (LA) for both initial and final measures (see Table 21), with large effect sizes. This finding is supported by Eddy (2000) who found a statistically large and significant difference between chemistry evaluation anxiety and handling chemicals anxiety (p<.001, d=3.28). During focus group interviews, very few references were made to anxiety in relation to laboratory work, suggesting it was not a significant source of anxiety. While a few indicated some fear,

Beryl: I was really nervous with all the test tubes.

Becky: I love watching other people do it but I just don't like the responsibility of playing with chemicals.

the majority of comments indicated a fairly relaxed attitude to laboratories.

Pippa: I wasn't anxious during the lab or anything.

When individual interviewees in Phase 2 were asked to compare the anxiety they experienced in tests with laboratories, all stated that tests were more stressful, a perspective confirmed by comparing T3 anxiety values for these students. Despite Sofia scoring a mean of '1' on both dimensions, she felt that for her, anxiety

Sofia: … probably was higher for the tests … than labs, because for the labs, you had a chance to look over the work you needed to do and prepare

> yourself, whereas with tests you look over stuff but you're not 100% sure what's going to come up. (*Individual Interview*)

Table 21. Comparing initial and final measures of test and laboratory anxiety using paired samples t-tests

Time	Mean difference: [TA–LA] (*SD*)	df	*t*	Significance (*p*)	Effect Size (Cohen's *d*)
Initial	0.60 (0.82)	100	7.356	<.001	0.73
Final	0.92 (1.07)	99	8.618	<.001	0.91

6.1.1 Changes in Anxiety

Despite the fluctuations in anxiety over the semester, the means recorded in Table 20 indicate an overall decrease in anxiety by T3. Paired samples t-tests demonstrated that when initial mean scores were compared with measures taken at T3 (see Table 22), both LA and TA decreased significantly over the semester, but with a much smaller effect size for TA.

Table 22. Changes in chemistry anxiety over the semester (final – initial)

Chemistry Anxiety	Mean change in anxiety (*SD*)	df	*t*	Significance (*p*)	Effect Size (Cohen's *d*)
TA	-0.23 (0.95)	99	-2.396	.018	0.27
LA	-0.46 (0.85)	99	-5.496	<.001	0.58

The decrease in laboratory anxiety supports research by Oliver-Hoyo and Allen (2005) who found a decrease in the 'handling chemicals' dimension of the DCAR (Derived Chemistry Anxiety Rating Scale) (t=-1.68, p=.03) in a general chemistry cohort. The four laboratory exercises in Health Science I provide a lot of scaffolding for students, with minimal exposure to dangerous chemicals and significant supervisor support. Given this atmosphere, it was expected that laboratory anxiety might decrease. On the other hand, Eddy (2000) found that when interviewed, general chemistry students identified unstructured laboratory exercises, explosions and acid burns as sources of laboratory anxiety.

For chemistry test or assessment anxiety, the findings from previous research in general chemistry classes are mixed. The only study to report a decrease in anxiety over a semester (d=0.87) was that of Bauer (2008), but his sample was quite small (N=21). In addition, all students had done at least one chemistry class at high school, and he measured feelings of general anxiety towards chemistry, rather than chemistry test anxiety. Some researchers have found no change in test anxiety over a semester for general chemistry students (Oliver-Hoyo & Allen, 2005; Zusho, et al., 2003) and one has reported a small increase (Obrentz, 2011) (*d*=.10).

As a result of the qualitative data analysis, a number of factors emerged which were found to be agents for change in chemistry anxiety over the semester. Categories under the connectivity and reductivity themes, such as 'social interactions', 'exposition' and 'course structure – notes' were found to apply across the range of student experiences and a discussion of these follows. Categories relevant to prior chemistry experience and perceptions of chemistry will be covered in Sections 6.3 and 6.4. The 'effort' category under the reductivity theme will be considered in Section 6.5.

Social interactions

There is some evidence from the focus group interviews to indicate that the presence of a female chemistry lecturer may have contributed to a reduction in anxiety. It has been reported that female students can reap additional reductions in science anxiety if the science course is taught by a female (Udo, et al., 2001), and given the high female numbers in this nursing cohort, this could go some way to explaining the diversity of findings reported in the literature for changes in some type of anxiety.

> Interviewer: Did it make any difference me being a female?
> All: Yes, I like it, yes.
> Beth: Because we could relate to you better, and you were
> Bernice: She was so flamboyant, and
> Beth: Yeh, you really got into it, whereas if a man behaved like that you'd go,
> Bernice: We're doing nursing. How many more of us are females anyway? I mean, it's unfair to the males but with so many more females, but it was so enlightening, wow, that's a female doing chemistry.
> All: Yeh.
> Beth: That's the first thing, when we first went into the bridging course. I went, "Oh, she's a girl!"

Personal characteristics of the lecturer that appear to have played a role in anxiety reduction also emerged.

> Bree: I think it's just because a lot of people feel more comfortable with you as well.

> Pippa: Mine was the first day, and I was "Oh, my god." Like, "this is going to be so hard" but once we got into it, it was alright and I actually like

it, mainly because of you though, ‘cause I don’t think I would have liked it at all.

Interviewer: If you were tracking your anxiety levels over the three days of the bridging course, as you reflect back, what specific things helped to reduce that for you?
Bernice: Just how calm and relaxed you were. Like, whereas, a lot of lecturers and teachers and so forth, when you get in, they stand behind the desk, and go “let’s just do it now.” Whereas you were like, “Hi guys.”
Beth: You were more approachable.
Becky: Yeh.
Bernice: “Welcome to chemistry. You might be a bit worried but it’s not going to be like that.” You were very approachable, whereas most teachers are *(moves hand across face - indicating they are faceless and non-emotional)*

Approachability was a characteristic mentioned many times. Negative experiences with teachers and ineffective teaching style can lead to anxiety and confusion (Akinsanya, 1984; Gogolin & Swartz, 1992). The role of the lecturer as a source of anxiety should not be underestimated:

Beryl: It was achievable, you were on time, it was time specific, you delivered it really well, and with that, reduced people’s anxiety.

While positive lecturer characteristics were important moderators of anxiety for many students, it is worth noting that the SC students made little reference to lecturer characteristics, apart from the ability to explain clearly.

In addition to the connection made with the lecturer, interactions with peers served to reduce the anxiety of students as they found support by working in groups during tutorials, laboratory exercises and private study.

Sofia: Usually like I’m really anxious and study in groups because they all kinda know what they’re doing. (*Individual Interview*)

Paula: Without that teamwork to kinda help put the puzzle together of what you’ve gotta do [in labs], it’s a lot. That’s a high anxiety. (*Individual Interview)*

According to Bandura (1997), operating in small social systems allows the individual to exercise greater control over personal agency, thereby decreasing anxiety. Science education research has shown that working in groups can help alleviate anxiety, especially for females (Mallow, 2006; Olupide & Awokoy, 2010).

Support offered by private tuition was also important for struggling students.

Interviewer: So, how are you feeling now, Pam?

Pam: Still a bit stressed, but not as bad. Yeh, not as bad, because if I didn't have my tutor, I'd be more stressed and grey hair.

Private tutors can reduce anxiety because of the vital role they play in helping students grasp difficult concepts, a discussion of which follows.

The qualitative data from this study concur with previous research that emphasises the predictive importance of support from lecturers, tutors, personal tutors and peers for decreasing anxiety levels in nursing and non-science students (Gibbons, et al., 2011; Gogolin & Swartz, 1992).

Exposition

The high standard of exposition during lectures in Health Science I has already been demonstrated by interview comments in the previous chapter. Despite this, when material is difficult, or students cannot understand a concept, anxiety levels rise.

Paige: … And then I went to the first tutorial and it was really frustrating and lots of crying and screaming on the phone, "This is ridiculous. Why are we doing all this chemistry?" like, at my mum, and "it's ridiculous."

Paula: Just feeling a bit discouraged because I wasn't getting it as well. (*Individual Interview*)

This sentiment was also expressed by Bree, Becky and Brittney. As expected then, when students did understand, anxiety dropped.

Pippa: It brought my anxiety down, getting clear explanations. (*Individual Interview*)

Bronte: I'm getting there slowly, but I have a tutor now as well, but it's not as daunting – it's just understanding the concepts, just the basics.
Brittney, Brett: mm
Bronte: I'm getting over that anxiety and the fear factor. Once you get a hold of that
Bree: Once you understand the concepts, hey?
Bronte: Yeh, it gets a lot better.

Beth: The way you teach - it's very clear, … thereby reducing your anxiety in learning the subject. (*Individual Interview*)

The literature shows that the ability of the teacher to connect and explain is crucial in moderating anxiety levels, particularly where students expect to have difficulty (Gogolin & Swartz, 1992).

Scheduled tutorial classes provided support by giving further opportunity for students to have concepts explained.

> Paula: Just having someone to sit there and explain it to you again. … But what helped was the one-on-one, and maybe next time even an extra person in the room would be good ...

> Sofia: Yeh. Probably the buffers and there was a couple of, just the bonds and stuff got me a bit, so that was really confusing. I just didn't know like how you set it out or how you like identified them or anything, but by tutorial, like I got it explained to me, and it was better.

Similarly, when Pierce was asked about anxiety reduction, he talked about the tutorials. Indeed, just knowing that tutorials are available can reduce anxiety (Nicoll & Butler, 1996).

Course structure - Notes

Another factor that helped to reduce anxiety over the semester was the way in which the course notes were structured. Students purchased a set of lecture notes with spaces to complete key words, diagrams and examples during lecture time. See Appendix 28 for a sample page.

> Soraya: I think I was more relaxed for the chemistry lectures. Like, I'd seen the book and everything so, it was all set out and um, I just sort of know what to expect with the exams with that, so I wasn't really anxious about, whereas with like psychology, there are just so many lectures and so many slides, like you just don't know what to study for with that, so I think it was a lot more set out and that made me relax.

> Bernice: Very straight forward, very in front of you. Seriously, it took off a lot of the pressure.

Given the complex nature of concepts in chemistry, the reduction of extraneous cognitive load is particularly important, even for those with prior chemistry experience, demonstrating the important role educationalists can play in minimising this source of cognitive load (de Jong, 2010; Paas, et al., 2010). This study supports findings that show that when course organisational features are ineffective, distress can result (Gibbons, et al., 2011).

6.1.2 Individual Anxiety Items

Paired samples t-tests conducted on individual items on the Chemistry for Nurses Anxiety Scale (CNAS) showed a decrease for all items from initial to final, but this failed to reach significance for Items 18, 19, 21 and 24, all related to chemistry tests (see Appendix 26 for means and SD for initial and T3 anxiety items, along with paired-samples t-test results). Statistically significant decreases for the remaining 13 items ranged from the largest decrease of 0.64 for Item 23 (Identifying a substance from its chemical formula), $t(98)=5.521$, $p<.001$, $d=0.61$, to the smallest significant decrease of 0.25 for Item 25 (Reading the word 'chemistry'), $t(99)=2.127$, $p=.036$, $d=0.22$.

Oliver-Hoyo and Allen (2005) used a modified version of the DCARS in a pre-post test design for a general chemistry class consisting of non-chemistry science majors ($N=113$). Ten items were similar to the CNAS: 17, 20, 21, 23, 24, 25, 26, 27, 29 and 31. A comparison of the items showed that in both studies, Items 21 (Thinking about a chemistry test) and 24 (Sitting a chemistry test/exam) showed no significant change. Further, levels of anxiety for these items were very similar (2.29 vs 2.31 and 2.42 vs 2.32). In both studies, the two items relating to chemicals (29 and 31) showed significant decreases. The remaining six item comparisons showed mixed results. While items related to learning chemistry – 20, 23, 25 – all showed a significant decrease in my findings, increases were reported by Oliver-Hoyo and Allen (2005).

6.2 Differences in Chemistry Anxiety Based on Demographic Variables

Many factors contributing to anxiety in science have been identified in the literature. While the findings related to demographics are inconclusive, some studies have found a small correlation of some of these factors with anxiety.

6.2.1 Gender

Means and standard deviations for all measures of chemistry anxiety based on gender are recorded in Table 57 in Appendix 27. Despite males having lower anxiety scores for all measures, independent-samples t-tests showed this only reached statistical significance for TA3[12] ($M=1.04$ vs 1.90), $t(12.276)=3.562$, $p=.004$, $d=0.86$. This concurs somewhat with McCarthy and Widanski (2009) who only found gender bifurcation on the evaluation scale of the DCARS ($d=0.68$). Obrentz (2011) also

[12] Levene's test was significant for TA3 so equal variances were not assumed for this case.

found males possessed significantly lower assessment anxiety in chemistry (*d*=0.50). However, using the same instrument as McCarthy and Widanski, Eddy (2000) found gender bifurcation on all three scales – learning chemistry, chemistry evaluation and handing chemicals, with males indicating lower anxiety levels. Insufficient data in Eddy's study prevents calculation of effect sizes. As I noted in my reflective journal, an interesting observation from the focus group interviews was that the females in each focus group were more likely to make comments relating to anxiety than were the males. Apart from the fact that females outnumbered the males in each focus group, it is possible that the males were less inclined to express anxiety due to social mores. Conversely, it is also possible that the lack of comments reflects an overall lower level of anxiety, with higher levels of science anxiety in females reported in numerous studies (Akabş & Kan, 2007; Chiarelott & Czerniak, 1987; Mallow, 1994; Udo, et al., 2004; Udo, et al., 2001). Alternatively, it may be that females have a tendency to over-report anxiety while males under-report (Udo, et al., 2004). However, Mallow et al. (2010) note that the anxiety gender gap previously reported using the Science Anxiety Questionnaire does appear to be narrowing. Caution needs to be exercised when interpreting gender findings from this study because of the small number of males in the cohort.

6.2.2 Age and Work Hours

There were no statistically significant Pearson product-moment correlations between any measures of anxiety and age. While significant age differences in reactions to academic stress have been noted in college students (Misra & McKean, 2000), Brownlow, Jacobi and Rogers (2000) found no relationship between age and science anxiety.

A small, statistically significant correlation was found between the number of hours worked each week and TA3 (r=.212, p=.034), with higher number of working hours associated with higher test anxiety. When considering stress in general, Beck and Srivastava (1991) found working second-year nursing students reported more stress than those who did not work.

6.3 Differences in Chemistry Anxiety Based on Prior Chemistry Experience

Pearson product-moment correlation coefficients were calculated for measures of test and laboratory anxiety against prior chemistry experience.[13] The only statistically significant correlation with prior chemistry experience was found for TA3, r=-.306, p=.002, with less test anxiety perceived by students with more chemistry experience. That no correlation was found at the beginning of the semester is somewhat surprising, because one would anticipate higher levels of anxiety amongst students who had less chemistry experience.

All LA measures failed to reach significance, suggesting that laboratory anxiety is not related to prior chemistry experience, a finding echoed by McCarthy and Widanski (2009) in a general chemistry cohort. Therefore, LA will not be considered for the remainder of this section.

Table 23. Test anxiety: means (and standard deviations) measured initially, at T2, and T3 for the total cohort and groups based on prior chemistry experience

Cohort		*N*	TA Initial	TA2	TA3
Total cohort		*101*	*2.03 (0.90)*	*2.09 (0.95)*	*1.82 (1.02)*
Prior chemistry experience	PC	44	2.26 (0.92)	2.26 (0.92)	2.16 (0.96)
	BC	31	1.74 (0.74)	1.93 (0.95)	1.68 (1.01)
	SC	26	2.03 (0.90)	2.03 (0.90)	1.42 (1.02)

ANOVA was used to further investigate the impact of prior chemistry experience of nursing students on mean measures of TA reported in Table 23. Differences between groups based on prior chemistry experience reached statistical significance for initial and final measures of chemistry test anxiety (see Table 58 in Appendix 27). Consequently, post hoc tests with Scheffe were conducted for initial and final TA. A discussion of the differences measured throughout the semester follows.

6.3.1 Initial TA Differences Based on Prior Chemistry Experience

One-way ANOVA showed small but significant differences between prior chemistry experience groups for initial measures of TA, $F(2,98)$=3.210, p=.045, η^2=.061. Before classes commenced, post hoc tests with Scheffe revealed that PC

[13] Correlation matrices for initial and final measures between all key constructs in this inquiry can be found in Appendix 22.

students (*M*=2.26) had significantly higher test anxiety than BC students (*M*=1.74, *p*=.045, *d*=0.61). Surprisingly, there was no significant difference between SC (*M*=2.03) and both BC and PC students, a finding somewhat supported by Brownlow et al. (2000) who found science anxiety to be unrelated to high school science preparation. The initial chemistry test anxiety differences based on prior chemistry experience were unexpected, with the literature revealing less initial anxiety for "learning chemistry" (Eddy, 2000; McCarthy & Widanski, 2009) and "chemistry evaluation" (McCarthy & Widanski, 2009) in students with previous chemistry experience. In addition, higher chemistry anxiety was found in non-science majors when compared with science majors at the beginning of the semester (Bauer, 2008). These contrary findings could be related to the definition of 'prior chemistry experience'. In Eddy's (2000) study, students were divided into two groups where low chemistry experience was defined as having two or fewer chemistry courses taken in high school and college. In McCarthy and Widanski's (2009) study, students were assigned to the low group if they had never taken a chemistry course. They do not state whether this was a college or high school chemistry course.

It is interesting to ponder why PC students scored significantly higher on initial TA than the BC students. What may have contributed to high TA for PC students was the fact that many of the PC group agreed that it was a mistake not to elect to do the bridging course. This became even more obvious to students once classes started. Furthermore, it is possible that BC students may have experienced an anticipated "placebo effect" simply as a result of enrolling in the bridging course, although there is no evidence to support this from interview data.

There can be no doubt that many students came to the first chemistry class with considerable amounts of anxiety towards chemistry.

> Interviewer: So, when you found out that you were going to be studying a reasonable amount of chemistry in the course, how did you feel about that?
> Bronte: I was overwhelmed.
> Bree: Yeh.
> Bronte: I was pretty daunted.
> Brittney: I was pretty scared at the beginning.
>
> Becky: Oh – my – gosh!
>
> Pippa: I was anxious when we first started.

Much of this initial anxiety was due to preconceived ideas about chemistry, particularly the widely held perception that chemistry is difficult (Dori, 1994; Mallow, 2006; R. Smith, Karousos, Cowham, Davis, & Billington, 2008).

> Beryl: I didn't know anything about chemistry, and I know my daughter did chemistry in HSC and it was so hard that she had to drop it, and I went, oh ..
>
> Beth: No, well my son did it, and did well, but he's a smart boy. He had to work really hard at it, and I went, oh my god, if he finds it hard, I'm gonna ..
>
> Interviewer: What were some things that contributed to your anxiety about having to study chemistry when you came here?
> Bree: Just the word. It just seems hard. Just the thought of chemistry- no, I'm not doing that.
>
> Pam: Even the word chemistry, I had no idea, and it scared me …
>
> Sofia: My anxiety levels were higher, definitely higher for chemistry than psych and sociology, … chemistry has always been like a hard subject in my mind.

For most students, this would have been their first semester of study at a tertiary institution. This sense of fear for the unknown may have resulted in elevated levels of test anxiety in SC students, who may have been unsure about the extent to which their previous chemistry experience would contribute to success in this course. Sofia was asked to comment on the relatively elevated initial TA mean for SC students during her individual interview.

> Sofia: Maybe because, like, we all were just really nervous. Like you hear 'chemistry' and everyone is just kinda like, "oh, by goodness," and so while the other people, like the people who weren't in the senior chemistry, they heard of it and they're like, "it's chemistry, like, I'm anxious about it," whereas we were anxious in a different way because we'd done it before and we were scared of how hard it was. (*Individual Interview*)

As previously stated, prior chemistry experience in this study does not take into account the quality of that experience. Comments made by some SC students also suggest that poor school experiences contributed to their initial, relatively high levels of anxiety:

> Interviewer: So you were all feeling pretty good when you saw the book or just as we started?
> Sofia: I was stunned.
> Sonia: Scared.

Sofia: I was like, I was very scared when I saw chemistry because I like, didn't do very well in it … It was just like a big muddle for me in my head, like all through senior high school.

Sonia and Sofia were two of five SC students in the total cohort with z scores > 1 for initial TA. Two of the other five students were international students on temporary student visas and the fifth gained entry into the degree program despite a low VCER score (HSC rank in Victoria). The school experiences of Sonia (who only completed Year 11 chemistry) and Sofia clearly created initial anxiety levels above what would normally be expected for the SC group. However, there were students who showed little anxiety, even at the beginning - mostly students with prior chemistry experience.

Interviewer: When you think back to the first day of classes, did you feel any anxiety at all when you looked at the chemistry?
Samuel: *nodding no*.
Sarina: That was actually one of the classes that I enjoyed going to, 'cause I knew that I'd be able to do it.
Samuel: I was excited for chemistry.

Brett explained that his initial level of anxiety was low (confirmed by his initial TA score of 0.8) because of his exposure to chemistry throughout school.

Brett: I don't really think I felt that much anxiety towards chemistry.
Interviewer: I noticed that.
Brett: Like, I remember since Year 6 doing chemicals, well not chemicals, but basic chemistry, and like, acids has always been in my memory. I can't even remember when I learnt it, so for me, anxiety isn't really a big thing. (*Individual Interview)*

6.3.2 Differences at T2 – the Effect of the Bridging Course

One-way ANOVA revealed that by the end of the bridging course, there were no significant differences in test anxiety between any groups based on prior chemistry experience, $F(2,98)=1.274$, $p=.284$. Even though a paired samples t-test showed no significant increase in TA for the BC group from T1 to T2 ($p=.261$), the bridging course did result in an increase in TA levels of the participants so that a difference no longer existed between BC and PC students, a startling and unexpected finding. Fifty eight percent of participants reported some degree of increase in TA based on questionnaire responses. This figure is in stark contrast to bridging course survey results taken at the end of the bridging course, where only 14.3% stated anxiety levels towards chemistry had increased as a result of attending the bridging course (see Table 72 in Appendix 36). The interview analysis revealed an increase in anxiety for a small number of attendees. For these, the anxiety substantially grew as a result of first day attendance at the bridging course.

> Bronte: I cried in the bridging course –
> Brittney: Aw.
> Bronte: - the first day of the bridging course.
> Brittney: Really? After the first day I was like,
> Bronte: Yeh, I did. I was overwhelmed.

Bronte was one of three students who showed a large increase in test anxiety (> 1.3) as a result of attending the bridging course. All three students subsequently failed the course, perhaps justifying their increased fear of chemistry. Interestingly, Bronte indicated in the focus group that after an initial increase in anxiety following the first day of the bridging course, she experienced an overall decrease in anxiety from "10 out of 10 at the beginning [to] probably … about 4 by the end" (*Bronte*). Yet her test anxiety scores showed the biggest increase from T1 to T2 (1.75) out of all the bridging course attendees. Laboratory anxiety also increased for Bronte. Perhaps the thoughts expressed in the interview were projected from the whole semester experience, where her questionnaire data suggested a slight decrease in TA over the semester. Alternatively, the decrease in anxiety described in the interview may have been general anxiety rather than chemistry anxiety, since she did mention several times how meeting people at the bridging course really helped to reduce her anxiety, a comment that resonated with the rest of her rural BC focus group. The city BC focus group also acknowledged the importance of peer connection in reducing general anxiety.

> Becky: … and so for me, it got the fear of meeting a whole new class of people out of the way …
> Bella: I knew when I walked into class, at least I could sit next to someone.
> Bernice: … we kind of bonded together.
> Beth: We did. Of course we did.

6.3.3 Differences in Chemistry Test Anxiety at T3

When measured at the end of the chemistry component of the course, ANOVA showed that differences in TA between prior chemistry experience groups existed, $F(2,98)=5.146$, $p=.008$, $\eta^2=.096$. Post hoc tests with Scheffe revealed that by T3, the SC cohort ($M=1.42$, $SD=1.02$) had lower test anxiety than the PC group ($M=2.16$, $SD=0.96$), $p=.011$, $d=0.77$. Interestingly, there were no significant differences between SC and BC students (p=.600), nor between PC and BC students (p=.126). These comparisons are illustrated in Figure 14. A discussion of additional factors that contributed to these differences follows.

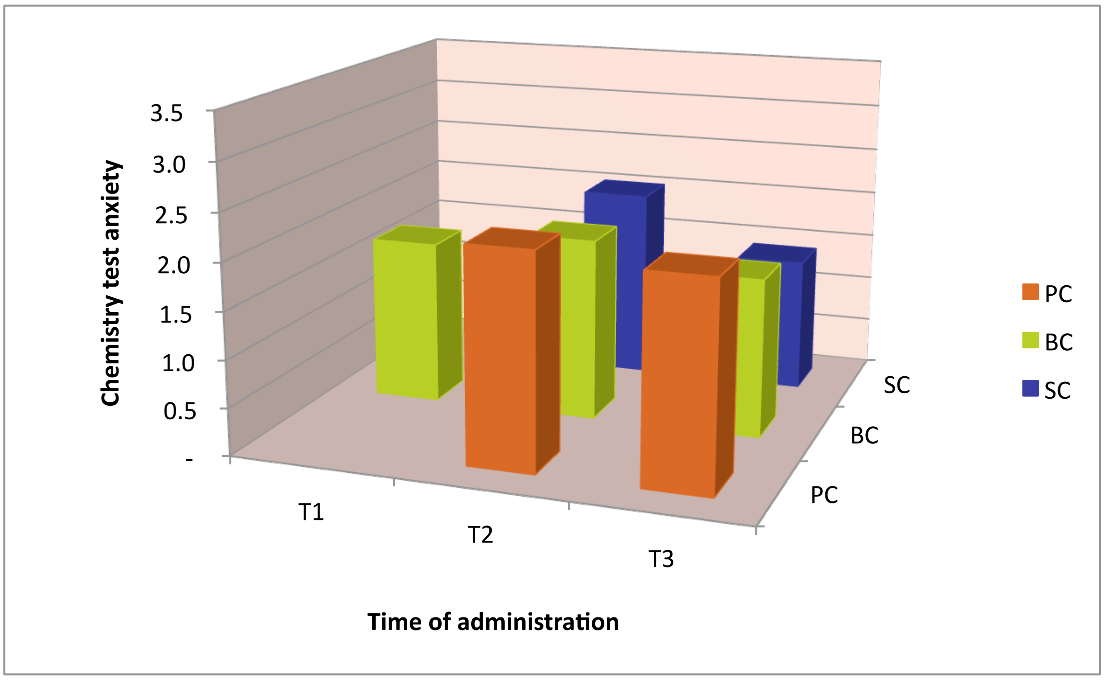

Figure 14. Changes in TA based on prior chemistry experience

6.3.4 Changes in Chemistry Anxiety Over the Semester for Prior Chemistry Experience Groups

Significant decreases in both LA and TA for the total cohort over the semester have already been demonstrated in Section 6.1.1. Paired samples t-tests were performed to compare the extent of the changes in chemistry anxiety based on prior chemistry experience. Results are reported in Table 24 and Table 25. All groups experienced a statistically significant decrease in LA over the semester with comparable effect sizes. Despite a decrease in TA shown in Table 24 for all groups from initial to final measures, this was only statistically significant for SC students, consequently accounting for the majority of the reported decrease in the cohort overall. For example, Sonia and Sofia's z-scores for TA went from 1.36 to -0.19 and 1.63 to -0.80 respectively.

Table 24. Changes in test anxiety (TA) from initial to final measures for the total cohort and by groups for prior chemistry experience

Chemistry Anxiety	Mean change in TA (*SD*)	df	*t*	Significance (*p*)	Effect Size (Cohen's *d*)
Total cohort	-0.23 (0.95)	99	-2.396	.018	0.27
PC	-0.10 (0.92)	43	-0.688	.495	-
BC	-0.11 (0.98)	29	-0.619	.541	-
BC T2-T1	*0.15 (0.74)*	*30*	*1.145*	*.261*	-
BC T3-T2	*-0.31 (0.73)*	*29*	*-2.307*	*.028*	*0.32*
SC	-0.58 (0.86)	25	-3.434	.002	0.62

Table 25. Changes in laboratory anxiety (LA) from initial to final measures for the total cohort and by groups for prior chemistry experience

Chemistry Anxiety	Mean change in LA (*SD*)	df	*t*	Significance (*p*)	Effect Size (Cohen's *d*)
Total cohort	-0.46 (0.85)	99	-5.496	<.001	0.58
PC	-0.44 (0.84)	43	-3.485	.001	0.54
BC	-0.47 (0.99)	29	-2.585	.015	0.69
SC	-0.51 (0.69)	25	-3.692	.001	0.56

These findings are consistent with the SC interview data that suggested SC students were more relaxed after experiencing chemistry at the level encountered in Health Science I. Comments indicated that students recognised the value of their prior knowledge and were consequently less test anxious, particularly those who were unsure at the beginning due to poor school experiences.

Simon: I thought it was going to be a lot harder than what it was,
Soraya: *nodding*
Simon: like the chemistry in this class. So, I wasn't really worried when I saw it, what it was.
Soraya: Ours was a lot harder as well [at school], so I was very relieved …

In addition, the results of Test 1 would have informed TA3, and all SC focus group participants performed well in this test (*M*=75.6%). It was also very apparent from the focus group interviews that SC group members were particularly relaxed, an observation recorded in my research journal.

Research journal entry:

City group: It was amazing the difference with respect to confidence and anxiety!!!! They were actually more anxious in sociology! The difference was very obvious. (24/5/2011)

Rural group: Again, the students with SC did not find the chemistry daunting. In fact, Soraya thought it would be harder than it was. (26/5/2011)

Interestingly, the BC group did experience a moderate and statistically significant decrease in test anxiety from T2 to T3. Changes in anxiety based on prior chemistry experience have not been previously reported in the literature.

Several factors associated with change in anxiety have already been considered in Section 6.1, including social interactions, exposition and lecture material. As was the case with self-efficacy, interview data revealed that even though there was an overall decrease in anxiety, the anxiety measure was subject to fluctuations during the semester. Prior chemistry experience and preconceived ideas played an important role in variations across the student cohort. In addition, related categories from the 'reductivity' theme, such as 'foundation knowledge', 'nature of chemistry' and 'course structure' emerged as significant modifiers of anxiety experienced in chemistry and are presented here.

Foundation knowledge

As with self-efficacy, the interplay of foundation knowledge and anxiety was a major theme that emerged from the focus group interviews. For Paula, foundation knowledge proved to influence anxiety more than confidence.

> Interviewer: Did your lack of foundation knowledge affect your confidence or anxiety?
> Paula: More anxiety. (*Individual Interview*)

As noted by Simon and Soraya earlier, the completion of at least some chemistry at the senior level meant that SC students were more relaxed at the conclusion of the chemistry component of Health Science I. The bridging course attendees were also less anxious, particularly early in the semester.

> Soraya: So I was very relieved. So, there was not much we had to remember compared to high school.
>
> Bree: Doing the bridging course made it easier because you've already got, like, that basis and then you're like, "oh, I can take a breath because I already know this stuff."
>
> Beryl: If I hadn't have done it [the bridging course], I would have felt that I'd already, like I'd come in late.
> Becky: mm
>
> Brittney: For the first few weeks, we could just sit back and relax.

In contrast, the level of anxiety of the PC students, particularly in the first few weeks, rose because of their lack of foundation knowledge.

Paula: I could see it was out of my depth and that I wasn't familiar with it, and that I didn't have really, any previous knowledge. I think that, I think I might have heard that it was a good thing if people had done Yr 11 and 12 chemistry because they would pick it up a bit easier and that sort of put me back because I thought, "woh, I haven't, so I'm gonna struggle here." You know, that sort of - yeah. A bit scary.

Pippa: … anxiety [was] through the roof because I was so nervous. (*Individual Interview*)

Interviewer: Were you anxious Pierce?
Pierce: Yeh, probably when we just first started, it's like, "woh, this is like completely new." I didn't know anything, and so I was just like taking on something that I had no background, well, not that I know of, I've got no background in chemistry at all, and so um, it was just all like, just seeing on the board like the periodic table, and I'm like, "woh, how am I ever meant to remember this?"

However, as explained previously, this was not just restricted to PC students. Some SC students, like Sofia, doubted that they had gained much benefit from their poor high school experiences, resulting in high initial anxiety levels.

Sofia: Initially, my foundation knowledge coming into it made me a bit more anxious, just because I didn't do very well … in high school … I was anxious because of my misconceptions of chemistry before. (*Individual Interview*)

When foundation knowledge and basic chemistry skills were not acquired early in the course by PC students, anxiety levels continued to rise as the semester progressed.

Interviewer: In the content, can you recall any particular time where you thought, "woh?"
Paula: In the middle of it I felt, well towards the exam I thought, "OK, good, this is nearly over," but in the middle I just felt so overwhelmed, like, you know, I wish I could go back and start again. And I couldn't, so in the middle of it for me.
Pam: In the middle, … I still don't know what they're talking about. My god. You know. I want to go back.
Paula: Yeh.
Pam: I want to start again.

Pam's comments were reflected in her questionnaire scores, where TA rose from 2.50 to 3.88, indicating extreme test anxiety by the end of the chemistry component.

As with self-efficacy, anxiety levels changed for BC students when unfamiliar material was introduced:

Becky: My anxiety spiked and I questioned myself a bit the first time we hit something we hadn't looked at

Beryl: Yeh, yeh.

Becky: in the bridging course, and I went, "Wait a second. I don't know anything about this."

In contrast, SC students were less phased by previously unencountered topics:

Interviewer: Were there any topics that caused just a touch of anxiety compared to others?

Simon: I wouldn't say it caused me anxiety, but more so than anything else, um, was just DNA, 'cause it was unfamiliar, but that's the only reason, yeh.

These comments emphasize the important role played by a student's perception of their foundation knowledge in a subject like chemistry in reducing anxiety and enhancing the learning process.

Nature of chemistry

As previously shown in Section 6.3.1, students perceive chemistry as difficult, particularly noting its complex nature,

Beryl: … In the sense that when you do chemistry, there are so many factors to take in.

and this was associated with elevated anxiety. The "alien" language and multiple levels of representation were the main sources identified in interviews.

Paula: Yeah, once the equations were starting to roll on and things like that, um, just getting an overall view of the content, um, I just thought, oh, I really need to get some extra assistance with this subject.

Pam: I had no hope of passing, … I was in shock. When you were talking, all I was hearing was blah, blah, blah…. and I'm sitting there and you're talking and you're going like this, and I'm thinking, "What the hell are you saying?" And then sometimes you'd repeat, and I'd think, OK, she's repeatin' and I'm trying to listen and I'm thinking "What is she talking about? I have no idea what you are talking about." And I was so scared. Seriously, I wanted to cry, absolutely, I wanted to cry. I had no idea what you were talking about, and the first time you said the periodic table, "has she got her periods? What's she talking about?"

In addition, Paula noted that her test anxiety was much higher in chemistry when compared with other subjects simply because of the nature of the subject.

Interviewer: Was your test anxiety higher in chemistry, compared with other subjects?

Paula: Most definitely. Higher for chem. because I know it's not naturally my strength. Like, it's not a subject that I kind of lean to easily or pick up easily, so that's why. (*Individual Interview*)

Very few comments were made by either BC or SC students linking anxiety to the nature of chemistry. It would appear that even minimal exposure to the unique characteristics of and skills required for chemistry is sufficient to ameliorate this as a source of anxiety. Even though Sofia's anxiety was high initially, it decreased as she became comfortable with the various representations of chemistry.

Sofia: I was anxious at the start 'cause I knew the nature of chemistry in my head as to what it was and I was like, aw, it's a lot harder … but as I went along … it didn't scare me as much because then I started knowing what it was and I started knowing the language and knowing the symbols and all that kinda stuff. (*Individual Interview*)

However, not all PC students experienced anxiety over the representational nature of chemistry.

Paula: As far as the language and symbols went, that didn't give me anxiety. (*Individual Interview*)

As noted by other researchers, the nature of chemistry acts as a formidable source of anxiety for many because of its perceived difficulty and the mathematical component of the subject (Dori, 1994; Eddy, 2000).

Study load

Possessing a solid foundation in chemistry contributed to the reduction of cognitive overload and in turn reduced anxiety. While PC students were particularly vulnerable to cognitive overload in chemistry,

Paula: So much in the time frame - and sometimes that pressure is felt by the student. It's like, here's a truckload, here's another truckload.

BC students expressed relief at the reduction in their study load as a result of bridging course attendance, with SC students feeling little extra study pressure from Health Science I.

Beth: Also, if we had not done it [the bridging course], we also had to deal with anatomy and you wouldn't have had the time each night to go over it because there simply wasn't the time. That's what I found. I kept thinking, "thank God I've done that bridging course. I've only got this much time to go over the chem. that we were doing because I've got to do anatomy, or this and that," so it was ..(*shaking head*) ..

Sofia: My study load wasn't as bad as I thought it was going to be. … I kinda spread it out … It didn't really affect too much on my anxiety. (*Individual Interview*)

For some students, Health Science II (Anatomy and Physiology) contributed to cognitive overload, elevating general anxiety.

Pippa: Health Science I and II were ridiculous. They were so hard to study for. It was a huge study load. Also being first semester of first year, it's so overwhelming. (*Individual Interview*)

Paige: I was like, mostly in anatomy, I'm like, floating in space when I'm in classes because there is just so much stuff like thrown on you.

Prue: Too much to remember. Everything, it's just overwhelming in Health Science II.

Brett: Um, I was pretty overwhelmed in like A & P, 'cause I was just like … "here's 120 terms and sit down and memorise them and know exactly where they are and be able to tell me," it's wow … I felt anxiety about that. (*Individual Interview)*

Being presented with a multitude of facts is a well-documented source of anxiety in science education in nursing (Beck & Srivastava, 1991; Caon & Treagust, 1993; Davies, et al., 2000; Dori, 1994; Logan-Sinclair & Coombe, 2006; Nicoll & Butler, 1996; Walhout & Heinschel, 1992). Processing and absorbing the facts results in a disproportionate amount of study in these subjects.

Course structure - Pace

For PC students, a lack of solid grounding in chemistry meant that the pace of classes also contributed to their anxiety.

Pam: If it was longer for what we had throughout the year, I reckon we could have got it more. So, instead of doing two or three units at a time in one lecture, spread it out more, to make it longer, so people can actually understand it more and have more time to ask questions and you could repeat yourself three or four times … But if it was longer, I reckon people would understand it more and won't be so stressed and .. too much, too short time.

Interviewer: So the structure of the course was a big thing for you?
Paula: Yeh, the time frame. 'Cause, I didn't have that background ... so that was a bit anxious for me … I felt like I was just sinking, because I needed more time. (*Individual Interview*)

The pace at which material is covered in lectures was noted as a source of anxiety by Eddy (2000) in her chemistry anxiety interviews and has also been reported in bioscience classes for nurses (Jordan, et al., 1999). Interestingly, there were no comments made by SC students relating to cognitive overload or pace of classes.

Because SC students had a foundation in chemistry, they were less likely to suffer from anxiety by the end of the course and this resulted in a significant difference in TA when compared with PC students. If one assumes that non-science majors have less high school science than science majors, the finding in this study has some support in the literature, where science majors have reported significantly lower 'anxiety towards science' than non-science majors (Gogolin & Swartz, 1992; Udo, et al., 2004). The background gained in the bridging course was sufficient to reduce the difference in anxiety between BC and SC students to insignificant levels, for all tests of anxiety.

6.4 Chemistry Anxiety and Perceptions of Chemistry

Negative attitudes have been linked to higher levels of science anxiety (Mallow, 1994). Pearson product-moment correlations between chemistry anxiety and perception variables for this study were calculated and recorded in Table 26. Although not quite as strong as those found with CS, significant negative correlations for chemistry test anxiety against chemistry perceptions were observed, with highly anxious students less likely to enjoy chemistry and place less importance on chemistry for nursing.

Table 26. Initial and final Pearson product-moment correlations between test anxiety (TA) and various 'perception of chemistry' variables

Perception item	Initial	Final
Level of enjoyment since last studying chemistry	-.183	$-.582^{***}$
Importance of chemistry to nursing	-.193	$-.430^{***}$
Contribution of chemistry to competence as a nurse		$-.407^{***}$

*** $p<.001$

There were no meaningful correlations between chemistry laboratory anxiety and measures of chemistry perceptions, which is in contrast to the finding by Kurbanoglu and Akin (2010) who employed the Chemistry Attitudes Scale (15 items including boredom in lessons, reading books about chemistry, enjoyment, importance to daily life, etc) for four general chemistry classes across Turkey. They found that chemistry laboratory anxiety had a negative relationship with chemistry attitudes, r=-.42. Structural equation modelling indicated that positive attitudes to chemistry predicted lower laboratory anxiety.

As was the case with self-efficacy, the largest negative correlations between chemistry anxiety and perceptions were found at T3. However, the 'importance' trend is not supported by Obrentz (2011) who found a decrease in the magnitude of the negative correlation between test anxiety and personal relevance over the semester for a general chemistry cohort, with no significant correlation by the end of the semester. Similarly, Zusho et al. also (2003) found no correlation between test anxiety and task value at the end of the semester for general chemistry. In order to determine whether the lack of relationship found in the Obrentz study may have been related to the fact that the majority of students had a strong senior chemistry background, correlations were conducted at T3 based on prior chemistry experience. These are recorded in Table 27. The most startling finding here is that there are no meaningful correlations between chemistry test anxiety and chemistry perceptions for the SC group. This may explain the results found by Obrentz. Note also that the strengths of the negative correlations are the greatest for the BC group.

Table 27. Pearson product-moment correlations between test anxiety and 'perceptions of chemistry' variables at T3 based on prior chemistry experience

T3 Perception item	PC	BC	SC
Level of enjoyment since last studying chemistry	-.579***	-.798***	-.197
Importance of chemistry to nursing	-.321*	-.761***	-.221
Contribution of chemistry to competence as a nurse	-.296	-.791***	-.033

* p<.05, ** p<.01, *** p<.001

Focus group interview data failed to reveal any comments linking enjoyment or relevance to anxiety directly. However, a number of individual interview comments add some supportive evidence to the reported correlation findings.

Beth: By understanding [why things happen in the body], it reduces your anxiety, obviously. (*Individual Interview*)

Dori (1994) found that nursing students' inability to relate chemistry to real-life situations was a source of anxiety. Paula alluded to a relationship between stress and enjoyment.

> Paula: It's probably the most stressful subject I've had so far and, yeh, I always knew I had my adrenaline pumping every time I thought of chemistry. (*Individual Interview*)

There is little wonder why Paula failed to enjoy chemistry (reporting a score of '1' on a scale of 0 'hated it' to 4 'loved it'), given her strong, negative emotional reaction to the subject. However, Mallow et al. (2010) failed to identify any obvious connection between science anxiety and science attitudes in a series of focus group interviews with university students.

6.5 Chemistry Anxiety and Academic Performance

This section considers the interplay between chemistry anxiety and academic performance. Following correlations and examination of student comments in relation to test anxiety, differences in anxiety based on academic performance groups are reported so comparisons with literature can be made.

6.5.1 Bivariate Correlations

Negative, statistically significant Pearson product-moment correlations were found with academic performance for both initial (r=-.220, p<.05) and final TA (r=-.597, p<.001), with students experiencing high test anxiety less likely to do well academically. The strength of the negative correlation between chemistry test anxiety and academic performance increased as the semester progressed. By T3, there was a strong negative correlation, indicating that up to 35.6% of the variance in academic performance could be attributed to chemistry test anxiety when measured at this time. This is a reflection of the finding by Obrentz (2011) who also noted an increase in strength between assessment anxiety and academic performance in a general chemistry cohort as the semester progressed, reporting a significant correlation between assessment anxiety and academic performance at the end of the semester, r=-.46, p<.01. Similar strengths were found in studies between maths anxiety and academic achievement (r=-.46 and -.51) (Pajares & Kranzler, 1995; Pajares & Miller, 1994). While Zusho et al. (2003) also noted the strongest correlation between test anxiety and academic performance in a general chemistry class at the end of the semester, it only accounted for 4.8% of the variance, r=-.22, p<.001. In general, stronger correlations seem to occur where the anxiety instrument and academic performance measures are more specific, that is, when the instrument measures domain specific anxiety and the academic performance is based on that measure for a given class rather than an overall GPA. Using the Test Anxiety Inventory (20 items, two subscales of worry and emotionality, based on symptoms experienced before, during and after any test) with 4000 undergraduate students, Chapell et al. (2005) found a statistically significant negative correlation with GPA of r=-.15, p<.001, representing a very small effect size, equating to differences in performance equivalent to one third of a letter grade. The practical significance of this finding is questionable, given that quite small correlations can become statistically significant with large samples (Pallant, 2007). This may be why Zeegers (2004) found no direct effect of test anxiety on the academic achievement of 118 tertiary science students.

A statistically significant negative correlation between LA and academic performance was found at T3 only (r=-.203, p<.05), representing a weak effect. Few studies have considered this relationship, but Bowen (1999) found that when the various laboratory anxiety scales from the CLAI (Chemistry Laboratory Anxiety Instrument) were administered mid-semester, negative correlations between laboratory scales and both expected exam grade and laboratory grades were found to be insignificant.

According to Table 23, by T3, test anxiety for the SC group was less than for the BC group, which in turn was less than for the PC group, that is, $TA3_{SC} < TA3_{BC} < TA3_{PC}$. Correlations between TA and academic performance were conducted based on prior chemistry experience and are recorded in Table 28. This indicates that the BC group is making the largest contribution to the negative correlation between academic performance and test anxiety at T3. The implications of prior chemistry experience for academic performance will be explored further in Chapter 7.

Table 28. Pearson product-moment correlations between academic performance and test anxiety based on prior chemistry experience

	PC	BC	SC
Initial TA	-.099	-.346	-.313
Final TA	-.442**	-.833***	-.398*

* p<.05, ** p<.01, *** p<.001

6.5.2 Qualitative Findings: Anxiety and Achievement

Given the findings reported in Section 6.1.2, test and exam times are arguably the most stressful periods of the semester. Students from all three prior experience groups agreed with this in interview.

> Interviewer: Were there times in this semester when you felt particularly more anxious than others with respect to chemistry?
> Paige: Before exams.
> Paul: Yeh.
>
> Soraya: Tests.
> Sofia: *nodding in agreement*
>
> Bella: I found that right before the first test we did, that was another time my stress and anxiety started to waver again. Like, oh, you know, what happens if what I've learnt is wrong in my own head?
>
> Pippa: I wasn't anxious until, like, tests came.

Analysis of interview data revealed varying degrees of test anxiety in nursing students. For example, Samuel and Beth both suggested that they experienced very little anxiety at all. For others, test anxiety was not confined to chemistry.

> Pippa: … when it comes down to a test or like theory, I just panic or lose it all, I just, that's just how I work … I don't know, I just struggle with tests, like for everything, not just chemistry, it's just. I don't know.

Numerous studies have noted that non-science anxiety accounts for a significant proportion of variance in science anxiety (Mallow, 1994; Udo, et al., 2004; Udo, et al., 2001). Interestingly, Pippa rated both her initial and final TA quite low (both 0.75) on the questionnaire. When asked to clarify this discrepancy during her individual interview, Pippa was unsure whether she had misread the scale for this part of the questionnaire but said she "wouldn't just tick anything just for the sake of it" (*Individual Interview*).

A number of students did testify to the unique test anxiety experienced in chemistry.

> Pippa: In chem. … you either get it right or you don't. It's sort of not like a fluffy kind of subject that you can work your way around it. You either know it or you don't, so it's a lot of pressure to know stuff. So, yeh, I was more anxious in chemistry. (*Individual Interview*)
>
> Paula: Most definitely higher for chem. because I know it's not naturally my strength. (*Individual Interview*)

What is evident from these comments is that the ‘nature of chemistry’ played a role in elevated chemistry test anxiety. In contrast, many of the SC students were more comfortable with chemistry tests because of the type and nature of questions used.

> Interviewer: Were you anxious about sociology at all?
> Sandy: Yep. To some extent. I am
> Samuel: The tests a little bit.
> Sandy: Yeh, the tests, yeh, ‘cause if you talk about the test thing because, [sociology] is more of the other thing than MCQ is, so I get confused with that ... [Chemistry is more] logical. …
> Sarina: You always know how well you’ve done in chemistry whereas, with sociology you have to wait.
> Samuel: Mm. Mm
> Sarina: You never know whether you’ve stuffed it up or not.
> Sandy: Yeh.
> Interviewer: So you feel more anxious about the sociology test than the chemistry test?
> All: Yeh.

Eddy (2000) found that all types of tests contributed to evaluation anxiety for a general chemistry cohort. While her interviews also revealed an increase in anxiety when students were unaware of the test format, this did not emerge as an issue for the nursing students in my study because they had access to some past tests via the institution’s learning management system.

A number of students demonstrated that elevated test anxiety can lead to an increase in effort expended when studying for tests.

> Prue: I crammed. I crammed a heap. … definitely leading up to it, I was panicking.
>
> Sofia: I started a couple of days before whereas usually I would start the night before because I was scared about the first test.
>
> Sofia: I put a lot of effort in at the start because I was really anxious … so that upped my academic performance. (*Individual Interview*)
>
> Soraya: I put a lot of effort into studying like for the first test, but for the last one we did, I didn’t really worry too much about it (*little laugh*). I just, kinda, went over my notes a little bit.

As noted by Soraya, students with low test anxiety may relax and put in less effort, or relax and leave insufficient time for thorough preparation. It would appear then, that the effect of anxiety on academic performance may be mediated by effort.

While some anxiety may help to motivate students to study, thereby contributing to eustress[14], the following comments demonstrate how excessive stress can impede student's ability to understand and learn (Akabş & Kan, 2007; Glynn & Koballa, 2006; Gogolin & Swartz, 1992; Mallow, 2006).

Becky: I got to the point … where I was nearly crying, and I was like, I need to go home, I need to have a break and do it later, because I was so distressed that I couldn't do it.

Becky: Again, back to the stress thing. It [the bridging course] took a load off my shoulders. So, I wasn't having panic attacks which meant that it would have taken away my ability to do the other things.
Bernice: Exactly.
Becky: I was feeling calm and secure and confident.

Becky: And because we were less stressed, we were then able to take in other stuff.
Beth: Oh yeh.
All: Mm, yes.

Excessive stress affects not only the ability to learn leading up to a test, but can also have a devastating impact on academic performance, and for some students, "it just goes blank … [and] the anxiety takes over" (*Bronte*) during tests.

Bree: But I thought like, it was fine, but then as soon as you get that test, you're like, "o oh, I don't remember it" or you'd do the test then -
Bronte: the anxiety
Bree: - you'd finish it and go, "oh, god, I knew what that was."

Bernice: "I know it really well" and when I actually came to it in the exam I'm like, "oh my god. I've read through that a thousand times, I know it," but I can't get my head [around it], because I was too anxious. I know that when I was studying.

Pierce: I studied and I felt, I felt like all right about it. Um, I guess I don't stress too much … I did the practice test and I felt like I had that down pat … I wasn't too worried about it. But then, when I got in there, I don't know if I got worried, but I was getting confused between the terms, and I'm like, I know this, like, but I didn't, and so I forgot what things were.

Pam: … I'm still scared about the test, you know, I still worry that, like sometimes I get so frustrated that as soon as I get into the exam room I forget everything, it just goes out and as soon as I walk out I think, "ohhh, that's what that was," you know, without even looking at my

---

[14] Eustress is moderate stress interpreted as beneficial to the person experiencing the stress, resulting in a positive response.

> notes. It just comes straight away, it just goes blank, because of the stress, and you worry what's going to be in the exam, I just go blank, and I think, "ohh, there goes that mark, it's gone."

Pam's TA3 score of 3.88 was the highest of the total cohort. As indicated, such high levels of anxiety can be debilitating in a test where such "disruptive thought continuously intrudes on, and impairs, academic performance" (Bandura, 1997, p. 236).

6.5.3 Anxiety and Academic Performance Groups

In order to further investigate the relationship between test anxiety and achievement and to compare findings with the literature, the cohort was divided into three groups based on academic performance: low (<45%), average (46-69%), and high (70+%). Differences between academic performance groups and TA means are reported in Table 29 and illustrated in Figure 15. LA values can be found in Table 59 in Appendix 27.

Table 29. Test anxiety (TA) based on academic performance groups: means (and SD) for initial and final measures and changes in chemistry test anxiety over the semester (final - initial)

Academic Performance Category	Initial TA (*SD*)	Final TA (*SD*)	Mean change in TA (*SD*)	df	*t*	*p*	Effect Size Cohen's *d*
Total Cohort	*2.03 (0.90)*	*1.82 (1.02)*	*-0.23 (0.95)*	*99*	*-2.396*	*.018*	*0.27*
Low	2.26 (0.82)	2.58 (0.82)	0.32 (0.91)	35	2.083	.045	0.39
Average	1.88 (0.82)	1.63 (0.80)	-0.25 (0.76)	31	-1.847	.074	0.31
High	1.95 (0.98)	1.14 (0.57)	-0.81 (0.84)	30	-5.442	<.001	0.87

Low = <45%, Average = 45-69%, High = 70+%

ANOVAs were conducted between performance groups for the initial and final measures of both TA and LA. Significant differences were found only for TA3, $F(2,96)=18.182$, $p<.001$, $\eta^2=.356$. Post hoc tests using Scheffe revealed that low performers were significantly more test anxious than both average ($p<.001$, $d=1.17$) and high ($p<.001$, $d=1.71$) performers, concurring with the finding of Obrentz (2011) for a general chemistry cohort. However, the effect sizes reported in the Obrentz

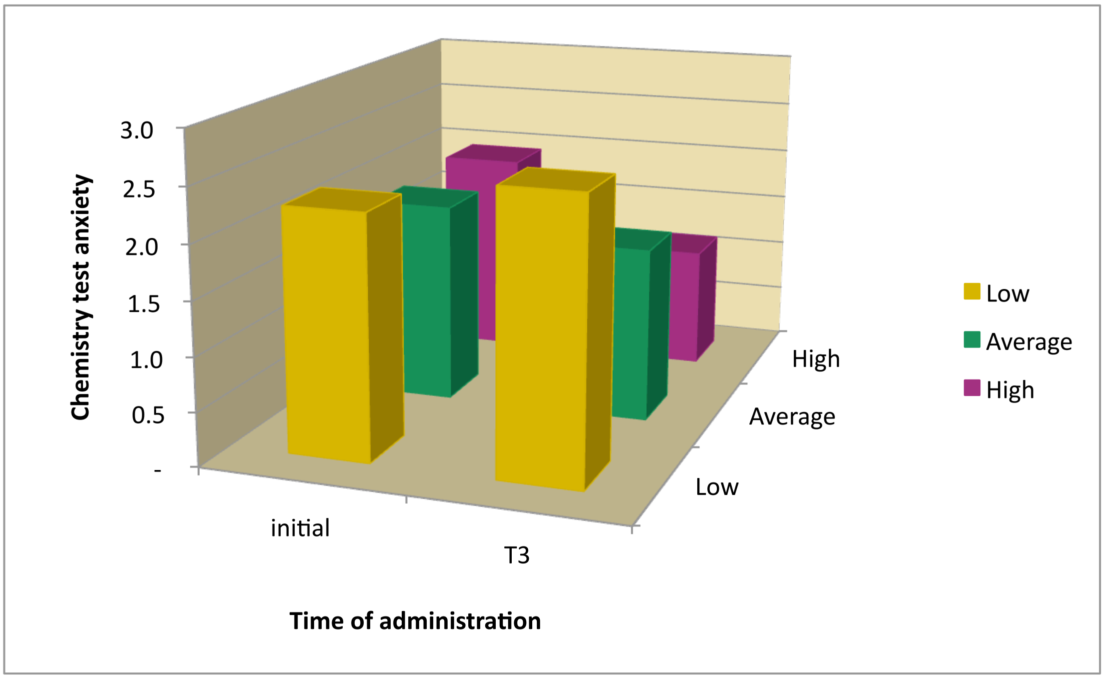

Figure 15. Changes in TA based on academic performance groups

study were not as high: *d*=0.62 when comparing low and average, and *d*=1.14 when comparing low and high performance groups. While the difference between the average and high achievers failed to reach statistical significance in my study (*p*=.065), it is worth considering the overall meaningfulness of this result, given the effect size, *d*=0.70 for this difference, is considered quite strong and compares favourably with those reported by both Obrentz (2011) and Zusho et al. (2003) (*d*=0.50 and *d*=0.41 respectively). Heeding the warning of Pallant (2007), all information needs to be considered in order to determine meaning, not just statistical significance and these two studies add some weight to the possible relevance of the statistically "insignificant" differences reported here.

Paired samples t-tests were performed to the see if there were significant changes in chemistry anxiety for each academic performance group over the semester. Results have been reported in Table 29 for TA and in Table 59 in Appendix 27 for LA. All performance groups experienced significant decreases in laboratory anxiety. Interestingly, test anxiety increased for the low achievement group, decreased for the high group and the small decrease for the average group failed to reach statistical significance. Note the strong effect size for the change in the high achievement group. Given that 94.4% of the low achievement group received less than 50% for Test 1 which was given prior to the administration of the final questionnaire, the increase in their test anxiety is understandable. Approximately 41% of students in the average group reported increases in test anxiety, whereas only 16% in the high group felt their test anxiety had either not changed or had increased.

Only two other studies have been found that consider changes in assessment anxiety for academic performance groups over a semester (Obrentz, 2011; Zusho, et al., 2003). While both reported an increase in test anxiety for the low performance group, this was only significant for the Obrentz (2011) cohort, d=0.37. Note the similar effect size. In contrast to the current findings, Obrentz (2011) found no change in anxiety for the high performing group and the decrease reported by Zusho et al. (2003) failed to reach significance. This represents a unique finding for this study.

6.6 Anxiety and Self-efficacy

> Pam: I thought, "I can't do this," and I got so scared, it just freaked me right out. Absolutely freaked me right out.

A number of comments made by students during the interviews indicated the apparent negative, reciprocal relationship between self-efficacy and anxiety. Pam's lack of confidence in her ability to handle the chemistry early in the semester led to severe anxiety, a response reflected in a number of mature-age students who had not completed the bridging course. In contrast, for Sarina and Samuel, high levels of chemistry self-efficacy stemming from the study of senior chemistry meant that anxiety levels were very low.

Table 30. Pearson product-moment correlations for initial and final self-efficacy and anxiety measures

	CSi	CS3	LSi	LS3
TAi	**-.172**	-.233*	**.057**	.012
TA3	-.160	**-.584*** **	.038	**-.159**
LAi	**-.147**	-.138	**-.126**	-.049
LA3	-.143	**-.293** **	-.198*	**-.312** **

i = initial

* p<.05, ** p<.01, *** p<.001

Table 30 shows the correlations between the initial and final self-efficacy and anxiety dimensions. When measured prior to experiences in chemistry at the institution, that is, the initial measures, there were no meaningful correlations between self-efficacy and anxiety. However, at the end of the lectures in Health Science I, moderate to strong negative correlations existed between CS3 and both laboratory and test anxiety. As predicted by social cognitive theory, students with high self-efficacy tended to be less anxious, with the strongest negative correlation found between cognitive self-efficacy and test anxiety at T3, r=-.584, followed by laboratory dimensions at T3, r=-.312. Previous research has reported similar findings. In a general chemistry context, correlations of chemistry self-efficacy and assessment anxiety at the end of the semester have indicated values of r=-.36 (Aydin, et al., 2011), r=-.37 (Zusho, et al., 2003), and r=-.43 (Obrentz, 2011). Negative correlations as high as r=-.56 have been found for tertiary students studying mathematics (Pajares & Miller, 1994) and a strong direct effect of self-efficacy on anxiety has been demonstrated using path analysis (Pajares & Kranzler, 1995).

It is interesting to note that both cognitive and laboratory self-efficacy have similar negative correlations with laboratory anxiety (see Table 30). Academic self-efficacy and chemistry laboratory anxiety have been shown to have a negative relationship in a general chemistry class, r=-.23 (Kurbanoglu & Akin, 2010). While this is comparable with the value reported here, r=-.29, it is worth noting that Kurbanoglu and Akin (2010) did not mention at what time during the semester the questionnaires were administered, making it difficult to know whether it should be compared with the initial or T3 value from this study.

Self-efficacy is central to anxiety regulation (Bandura, 1997), affecting the way stress is interpreted. As such, anxiety can be seen largely as a by-product of self-efficacy (Pajares & Kranzler, 1995). When confidence is low, students are more susceptible to achievement anxiety, becoming more likely “to magnify the formidableness of the tasks and their personal inadequacies” (Bandura, 1997, p. 236).

> Beth: If you do badly in your first exam, your confidence will plummet. You’ll get very anxious. (*Individual Interview*)

The following comments illustrate how building confidence reduces anxiety:

> Beryl: The more we got into the bridging course, what we achieved in the morning, in the afternoon, and the end of the day, those sort of segments, the anxiety did drop because, yea, it was achievable with learning.
>
> All: Yea.

Sofia: As I went along and my confidence built, it didn't scare me as much. (*Individual Interview)*

Brett: … it also took away my anxiety because my confidence increased … so if I can explain it to another person, then I can probably do it in an exam, so I wasn't really that worried about that. (*Individual Interview)*

Previous research has demonstrated that being efficacious means stressors are less likely to be perceived as distressing (Gibbons, et al., 2011).

Students also identified the reciprocal arrangement, indicating that anxiety can undermine belief in one's ability (Usher & Pajares, 2006).

Bernice: The more you learn the more you stress and become less confident.

Brittney: Well, when you're actually confident about doing chemistry, in my head I'm telling myself, "I can do it, I can do it. I know it all, I know it all." When I'm anxious about it, it's "I can't do it." It's the total opposite. Total opposite feeling.

When students were feeling anxious, their confidence in chemistry diminished, indicating the important informative role played by anxiety as one of many factors integrated in self-efficacy appraisal (Bandura, 1997; Pajares, 2002). The interpretation of strong, negative, emotional reactions experienced in relation to a particular task is affected by the existing level of self-efficacy, the difficulty of the task and prior experiences (Bandura, 1994; Britner & Pajares, 2006). If cognitive processing leads to a lower self-efficacy, this can, in turn, trigger further anxiety (Pajares, 2002).

There are several other instances in this study that demonstrate the self-efficacy – anxiety association. For example, this relationship was detected when changes in individual items from the questionnaires were compared. Overall, Chapter 5 reported increases in all self-efficacy items over the semester. Self-efficacy items showing the smallest increase were those relating to assessment. The anxiety items that failed to show any significant decrease were in fact those relating to chemistry tests. Similar patterns were also observed when the relationships with perceptions of chemistry were examined. Where CS3 strongly correlated with enjoyment and expected result, TA3 showed strong, negative correlations. The strength of the correlations between both CS3 and TA3 with the importance of chemistry to nursing was similar, again suggesting the close reciprocal nature of anxiety and self-efficacy.

While research is inconsistent in the reported degree of contribution of anxiety as a source of self-efficacy (Britner & Pajares, 2006), student comments and correlation findings in this study have demonstrated a close link between these constructs. Irrespective of the direction of the relationship, it is clear that both self-efficacy and anxiety have a significant impact on motivation (Obrentz, 2011). The interplay of self-efficacy, anxiety and academic performance will be explored using regression analysis in the following chapter.

6.7 Summary of Anxiety Findings in the Context of the Research Questions

Overall, students experienced higher levels of chemistry test anxiety than laboratory anxiety. The findings will be summarised in relation to the anxiety component of each of the four research questions.

Research Question One asked, "What role do demographic variables play in … anxiety …?" The finding that females were more likely to experience test anxiety is congruent with the literature, but caution needs to be exercised due to the small number of males in the cohort. No significant relationship was found between both dimensions of chemistry anxiety and age and only a small, negative correlation was found with paid work hours.

Research Question Two considered, "How does … anxiety and student perceptions of chemistry change over the course of the semester?" Qualitative data suggests that initial high levels of anxiety were due to preconceived ideas students had about chemistry, particularly the difficulty of this discipline. Statistically significant decreases were observed for both laboratory and test anxiety for the total cohort, but to a greater extent for LA. The decrease in TA is contrary to much of the literature and represents a unique finding for this study. The interview data presented a number of possible reasons for the observed unusual decrease in TA, with many stemming from the connectivity theme, such as lecturer characteristics (female, approachable, enthusiastic, able to give clear explanations) and support (lecture notes, tutorials, peers, private tutors). When changes in TA were examined for the various groups, only SC students and the high achieving group experienced a significant decrease over the semester. While the BC group had no change overall (i.e. from T1 to T3), there was a small but statistically significant decrease from T2 to T3. These findings relating to prior chemistry experience have not been reported previously in the literature. Furthermore, test anxiety negatively correlated with the various perceptions of chemistry, the strength of which increased as the semester progressed. Students with low TA3 tended to enjoy the semester more and saw more relevance in the study of chemistry to nursing.

Research Question Three stated, "What relationships can be established between self-efficacy, anxiety, prior chemistry experience and academic performance?"

Anxiety and prior chemistry experience As was the case with laboratory self-efficacy, there were no significant correlations between laboratory anxiety and prior chemistry experience. A surprising finding for test anxiety was that the initial TA mean for the PC group was higher than for the BC group. Such a finding has not been reported in the literature. Interview data revealed that the surprising lack of significant difference between the initial TA means for the SC and PC groups may have been due to the perceived poor quality of the school experience of some of the SC students. Furthermore, when compared at T2, there were no significant differences between the groups. By the time measures were taken at T3, students had experienced Test 1 which would have helped inform their assessment of test anxiety. SC students now had significantly lower TA than PC students. Note there was no significant difference between SC and BC and between BC and PC. Interviews revealed that reductivity categories such as the possession of foundation knowledge played an important role in anxiety because it affected students' ability to navigate the multidimensional nature of chemistry and its unique language. In addition, students with more prior experience in chemistry found the study load less of a burden and had less difficulty coping with the pace of the course. Foundation knowledge contributed to reduced cognitive load for both BC and SC students, reducing the stress involved in learning.

Anxiety and academic performance While no correlation was found between LA and academic performance, the strength of the negative correlation between test anxiety and academic performance increased over the semester, accounting for up to 35.6% of the variance in academic performance by T3. Interview data revealed that high levels of TA impeded not only the ability to recall in a test, but learning in the lead up to a test. Furthermore, the effect of TA on learning and academic performance appears to be mediated by effort. For some students, high test anxiety was interpreted as eustress resulting in the employment of increased effort when studying for tests while for others, distress resulted from a similar level of anxiety which inhibited learning. Based on academic performance groups, low achievers experienced higher levels of TA at T3 than both average and high achievers. It is interesting to note that this relationship inversely reflects the pattern found for cognitive self-efficacy. While TA decreased for the total cohort and the high performance group, this was not the case for all students. The average group indicated no significant change over the semester and the low achievers experienced an increase in test anxiety.

Anxiety and self-efficacy The close relationship between cognitive dimensions of self-efficacy and anxiety was demonstrated, with highly efficacious students tending to experience lower anxiety. Students related experiences for both directions of this inverse relationship, with anxiety acting as an informant of self-efficacy and in other instances, anxiety levels changing in response to changing self-assessment.

Research Question Four asked, "To what extent has a 3-day bridging course been beneficial to nursing students studying Health Science I?" It would seem that the bridging course did little to allay the chemistry test anxiety experienced by attendees. However, focus group discussions showed that general anxiety was to some degree alleviated by bridging course attendance, seemingly as a result of connections made with peers during this time. Nevertheless, as outlined in Research Question Four above, interview data from BC students did suggest that general anxiety was lower in the early stages of Health Science I due to the reduction in cognitive load. During the focus group interviews, BC students noted the difference in their persona compared with many PC students in the early weeks of the course. Despite the absence of change in TA from bridging course attendance, the BC students did experience a significant decrease (p=.028) in TA over the semester (d=0.32), whereas the small decrease for PC students failed to reach significance.

In the next chapter, other factors relating to academic performance will be considered and the relative contributions of all relevant variables to academic performance will be investigated using multiple regression.

7 ACADEMIC PERFORMANCE IN HEALTH SCIENCE I

7.1 Introduction

Chapters 5 and 6 demonstrated a strong positive correlation between self-efficacy and academic performance and a strong negative correlation between test anxiety and academic performance. When the nursing cohort was divided into three academic performance groups[15], significant differences in self-efficacy existed between all three groups, with high achievers having the highest CS. When measured at T3, low achievers had higher TA than the other two groups. High achievers experienced a strong increase in CS and decrease in TA over the semester for the chemistry component of Health Science I. Average achievers also experienced an increase in CS, but TA remained relatively constant over the semester. While an increase in CS was also noted for the low achievers, the magnitude of the increase was not as great as for the high achieving group. Further, the low achievers experienced a significant increase in TA over the semester. Interview data that supported these statistical findings were discussed. In addition, interview data that went against the statistical trends was also highlighted.

In this chapter, other factors that may play a role in the academic performance in chemistry for a first-year nursing cohort will be explored: age, work hours, prior chemistry experience and perceptions of chemistry. Pertinent categories from the three themes that emerged from the qualitative data (and reported in Chapter 4) are considered in the light of academic performance. Finally, a predictive model for academic performance derived from multiple regression analysis is explored to investigate the relative contribution of the relevant variables from this study to academic performance. The chapter concludes by considering the findings in the context of the research questions.

7.2 Academic Performance Statistics

Descriptive statistics for all measures of academic performance for the chemistry component of Health Science I are recorded in Table 31. The relatively low mean for Test 2 can be explained by the fact that this test was given three weeks after the completion of chemistry classes. In interview, a few students noted how

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[15] High achievers (70+%), Average achievers (45-69%), Low achievers (<45%)

difficult it was to go back and study chemistry when their recent focus had been on the microbiology component of the course.

> Paris: … since we've had our last chemistry lecture, and then learning like micro and been like concentrating on that, and then last week we thought, we'll start doing revision for the test, and we looked at the, like the last two tutorials on buffers and stuff and couldn't even remember doing it, like, it's just completely gone. So, it's like learning it all again for the test.

Table 31. Academic performance statistics, based on percentage scores

Academic performance measure	Number of cases	Mean	Standard Deviation	Maximum & minimum
Test 1 (Week 6)	101	58.91	22.80	3.3 – 97.8
Test 2 (Week 10)	100	48.09	22.30	4.5 – 93.2
Final Exam	100	55.71	19.81	11.3 – 91.3
Academic Performance[a]	**100**	**55.63**	**19.86**	**9.5 – 92.7**

a. Academic Performance = 28.6% Test 1 + 14.3% Test 2 + 57.1% Final Exam

Pearson product-moment correlations were calculated for measures of academic performance and are recorded in Table 32.[16] It is interesting to note the extremely strong correlation between Test 1 and final academic performance, r=.928, p<.001. Although a high correlation was expected since Test 1 constitutes 28.6% of the academic performance mark, it does indicate that of all the measures included in this study prior to the final exam, Test 1 is the strongest predictor of academic performance, accounting for up to 86% of the variance. Researchers in general

Table 32. Pearson product-moment correlations for measures of academic achievement

	Mean	Test 1	Test 2	Final exam	AP
Test 1	58.91%				
Test 2	48.09%	.738***			
Final exam	55.71%	.872***	.801***		
Academic performance	55.63%	.928***	.845***	.988***	
Ravens Progressive Matrix	*48.06*	*.429****	*.302***	*.421****	*.429****

** p<.01, *** p<.001

[16] Correlation matrices for initial and final measures between all key constructs in this inquiry can be found in Appendix 22

chemistry courses have also concluded that the performance in the first test is a robust predictor of performance in the course, although correlations were not quite as high, ranging from r=.6 to .8 (P. Mills, et al., 2009; Seery, 2009).

Results for the Ravens Progressive Matrix (RPM) test were not used as a measure of academic performance but are added to Table 32 for comparison purposes. RPM test scores may be thought of as a measure of cognitive capacity or readiness and while the correlations with measures of academic performance are lower than the other correlations listed, they are still moderate and significant. The results of an ANOVA test, $F(2,81)=8.632$, $p<.001$, $\eta^2=.176$, indicated that significant differences in RPM averages did exist between the three academic performance groups. Post hoc analysis using Scheffe showed that the average RPM score for high performing students (M=50.61, SD=4.12) was significantly higher than for the low performing group, (M=45.38, SD=4.37), $p<.001$, d=1.22. There was no statistical difference between the average performance group (M=47.70, SD=5.66) with either the low or high performers. This suggests that RPM test scores might be a useful component to include in a multiple regression model for predictors of academic performance (see Section 7.7).

7.3 Academic Performance and Major Themes: The Influence of Connectivity, Reductivity and Reflexivity

While there are many factors that affect learning, students' ability and opportunity to engage or *connect*, their ability to *reduce* the complexity of a discipline into forms or patterns for learning, and the nature of their personal interpretations and reactions or *reflex* to the curriculum influence their opportunities to learn which may impinge on their academic performance. These themes have been previously considered in the self-efficacy and anxiety chapters, and will be discussed here in relation to the learning experience and academic performance of first-year nursing students. A number of categories relate more specifically to prior chemistry experience and perceptions of chemistry, and will be explored in those sections. A discussion of the categories not explored in Sections 7.5 and 7.6 now follows.

7.3.1 Connectivity

We have already seen a number of categories from the connectivity theme emerge from the self-efficacy and anxiety data, particularly lecturer characteristics and peer relationships. The influence of 'social interactions' on learning and academic performance will be examined here, focusing on the lecturer, peers and support. The 'curriculum - chemistry' and 'the application of chemistry to the profession of nursing' categories will be considered in Section 7.6 where perceptions of chemistry will be discussed.

Lecturer

Comments made about the lecturer indicated the important role a teacher plays in facilitating learning.

> Bree: I think [the teacher] made a difference in the way [the subject] got taught. Like, in our courses it is the teacher.

For example, approachability not only reduced anxiety (see Section 5.2), but also contributed to learning.

> Bree: … if they're [lecturers] not easy to approach then you're not going to learn much, 'cause you're going to feel you can't put your hand up.
> Brett, Brittney: *nodding in agreement.*

Passion for the subject and encouragement were other recurring characteristics.

> Bree: If they love the subject, then they'll be an amazing teacher, but if not, well -
> Bronte: And you're passionate about chemistry, and that
> Brett: Yeh
> Bronte: bounces back onto us.
> Bree: You can see that. …
> Bronte: Your vibes as positive feedback is gonna come into us.

> Prue: In chemistry, it was more like, aw, I'm gonna learn something today. And it's probably the fact that you're a good teacher. Like, you're always happy to see us and you engage the class.

> Pippa: If you have a good teacher and they keep you interacted, you learn it, and you were good, like, you always kept us amused and tried to make it as fun as you can, and explained things really well, and take the time, like if we didn't understand it, we could go see you. (*Individual Interview*)

As noted in Chapters 5 and 6, SC students in focus group interviews had very little to say about connection with the lecturer. When asked to comment on this phenomenon during individual interviews, both Samuel and Sofia explained they relied less on the lecturer because they "already know things … and know what's going on" (*Sofia*).

Connection with the lecturer was difficult when students had to experience video-conferencing. Because the institution has two campuses, many of the lectures in other subjects were presented using this method. Students were overwhelming in their aversion to this mode of delivery and expressed appreciation for not having to experience chemistry this way. Video conferencing distracted students from learning and diminished their connection with the lecturer:

> Paige: No, like, you coming down to [the city] and not video conferencing [made a difference] because in classes like this … unless you're really concentrating, you're floating off to space, you don't have chatter which people do when video conferencing. … You do the little experiments in class, which is good.
> Pam, Paris: *nodding*
> Pam: You actually ask questions.
> Paige: Yeh.
> Pam: You're there and we actually see you there talking to us.
> Paula: Yeh, people are more reluctant to ask questions [in video-conferencing].

These findings, relating to the importance of connection with the lecturer, concur with previous qualitative research (Gogolin & Swartz, 1992; Kyriacos, et al., 2005; Schibeci & Riley II, 1986). As suggested by Pippa, the ability to give clear explanations was also an important attribute which will be discussed in the 'reductivity' section.

Peers and support

While connection with the lecturer contributed to academic engagement, so did connection with peers. Several aspects of social interactions with peers emerged from the interview data, indicating a link with the explanation of ideas, a category described as exposition, which has also been described in other studies (El-Farargy, 2010). Students found they could support and be supported in tutorials, laboratories and in private study groups. Generally, they found that opportunities to explain concepts in these environments would help them in their own learning.

> Bree: No, it was good because you could help other people who didn't attend or
> Brittney: and that helped you learn too,
> Bree: Yes.

Brittney: so helping them just made it so much more clearer in my head.

Brett: … learning off each other and trying to, 'cause I also learn from teaching, so when they had trouble and I was teaching them how to do it, that just reinforces it in my brain and I understood then. That was a big point [in my academic performance]. (*Individual Interview*)

Pierce: Even like, when someone … in the tutes … explains it to you, and then someone else doesn't know it and then you explain it to them, so then by you explaining it to them, you kind of, you're reinforcing it to yourself.

Simon: Um, Mandy needed a bit of help sometimes and explaining [some concepts] to her … made me remember them I guess, sort of teaching her I guess.

Prue: Yeh, because, it's again, the bouncing [of ideas] off each other … you … explain to someone, and they're like, 'oh I get that' and that explains something that somebody else didn't get. We'd usually explain it to each other … We'd always help each other.

Sonia: … my roommate is also doing chemistry so she would quiz me and that helps me to learn.

But not all students found this kind of student interaction a positive experience. Sarina expressed frustration, particularly early in the semester, at others' inability to understand what seemed to her to be simple chemistry concepts.

Working in groups, either in tutorials or laboratories, can help to reduce individual working memory limitations in complex tasks with high intrinsic cognitive load (F. Kirschner, Pass, & Kirschner, 2009). It also allowed students to feel supported:

Bernice: It was like we were all one team working together.

Paige: I like that I felt like we went through it together and if someone had a question, cause we were doing it as a group, everyone would hear the answer to the question.

Bronte: You boost up me and I'll boost up you … Keep the encouragement and reinforcement.
Bree: And that's what I like about it. Like, it's such a nice environment here and everyone's so friendly.
Brittney: 'Cause our class is so small and
Bree: and they encourage each other.
Brett: Yeh.

Note that connection with peers was facilitated by small class size. In addition, relationships with peers actually contributed to learning.

Brett: It makes it easier to learn when you, you know, yeh
Brittney: When you know people.
Brett: Yeh.

Bree: Once you make friends, then it's easier to ask questions
Bronte: yeh
Bree: 'cause you feel a bit more comfortable.
Brett: Yeh, definitely.

When the models derived from individual interviews were considered (see Appendix 21), it became apparent that the positive comments made about the support received from the lecturer and peers did not follow a pattern based on prior chemistry experience, age or achievement. The lecturer was important in the learning process for both Beth and Pippa, peers played a role for Sofia and Brett and no direct link was identified by Samuel and Paula.

7.3.2 Reductivity

The reductivity theme is central to the learning process because of the complexities inherent in chemistry. 'Foundation knowledge' was a significant category to emerge from the interviews in relation to self-efficacy and anxiety. This also has ramifications for academic performance, and along with 'the nature of learning chemistry' and 'effort to learn', will be explored in Section 7.5 in relation to prior chemistry experience. Reductivity categories to be considered here include 'exposition', 'course structure' and 'learning strategies.'

Exposition

Explanations are important for understanding chemistry and the ability to offer clear explanations emerged as a major factor in not only learning, but as outlined above, in connections made with peers. A strong link between exposition and the lecturer was also apparent.

Beryl: Well, the thing is, everything you said was for a reason.
Becky: mm
Beth: Oh, you really explained it well ..
Bernice: You say, "this happens", and I'm sitting there, "why does that happen?" and then she tells you.
Becky: You are brilliant at explaining.
Beth: You are.

Prue: You could just pop your hand up and you'd explain it so easily and then you'd be able to do it.

Paige: … I understood it when you were going through it because you explain it really well.

On the rural campus, the bridging course was presented by a less experienced teacher and these students noted how the lecturer can make a difference to the level of understanding. A few comments follow, but this will be explored further in Chapter 8.

Bronte: I would have been able to take in and grasp a lot more.
Brett: yeh .. [bridging course presenter] explained things totally different as well. Like, which often confused us …

Pippa indicated the link between the teacher and exposition skill when referring to her decision to not attempt chemistry in senior high school.

Pippa: Probably, because of my teachers at the school. I would, if I had you to explain it.
Prue: *nodding, smiling, agreeing*
Pippa: I would have loved it.

The ability to give meaningful explanations influenced both the connection students made with the lecturer and their ability to learn. Pertinent explanations given at the appropriate level for students contributes to the reduction of cognitive load, providing novice learners with the "schemas to integrate new information with their prior knowledge" (P. A. Kirschner, et al., 2006, p. 80). The ability of the teacher to explain and apply science to practice has been shown to be an important aspect of learning in the discipline (El-Farargy, 2010; Gogolin & Swartz, 1992; Kyriacos, et al., 2005; Schibeci & Riley II, 1986; Walhout & Heinschel, 1992).

Another facet of 'exposition' was the use of "layman's terms" when explaining chemistry concepts.

Beth: Also, what you were teaching actually made sense.
All: Yes, mmm
Becky: the way you said it. You said it in layman's terms.
Beth: You did! Because I thought it was really going to be … like another language,
Becky: Yeh.
Beth: and you just started talking about stuff that I - we could understand - and I thought, this is actually quite practical.
Bernice: You also brought it back to examples - like - day to day activities - like elements - whatever. And you said, "well, you could also relate it

to this" - like - day to day things we do everyday. And I sit there and go, "oh well, now that I think about it, yea, that makes sense."

Brett: … Like, you used like, totally different scenarios, that aren't related to chemistry.
Bree: You used everyday scenarios, whereas [bridging course presenter] just used chemistry ones, and we're like
Brett: and we don't, we didn't understand the chemistry ones.
Bronte, Bree: *agreeing*
Bree: Yeh, like you just used examples that we were all familiar with, not chemistry, cause we had no idea what they were talking about. And it just made it hard when they started putting it in a chemistry context …

The use of analogous every-day scenarios to enhance understanding of chemical phenomena is a commonly used strategy in chemistry teaching, assisting students to visualize the concept (Treagust, et al., 2003). Because problems with working memory overload can be generated by the language of science (A. H. Johnstone & Selepeng, 2001), the use of everyday scenarios to illustrate scientific principles means more working memory space is available for processing the concepts.

Exposition was associated with perceived academic performance for all models derived from individual interviews except Paula's. Even for Sofia, it "linked the stuff I'd learnt in high school and that made me do better."

Course structure: Notes and lectures

The structure of the course in terms of the format of lectures and notes had an impact on perceived academic performance. Students commented on how they really liked "the layout of the book" (*Paul*) and the way in which it contributed not just to anxiety reduction, but to concentration in class and gave direction for study. See Appendix 28 for a sample page from the lecture notes.

Becky: I really liked the format of the book, where there were gaps in it and then you had examples, and then tutorials were at the back.

Simon: … Like, just how it was set out. … you were never left in the dark to catch up later. It was very systematic I guess…

Sonia: I also really like the way that um, the book is set out and you have to fill stuff in as you're speaking and that helped me stay focused cause in other lectures, they're not asking you to really interact or like stay focused, then I just zone out.

Sonia: I like that you had your notes. … I think that just having your laptop there also is a massive distraction.

All: *lots of laugh*
Sofia: I really like that you had a hard copy of the notes and then you didn't have to be looking on the internet for notes and like trying to gather them altogether and stuff. … and like Sonia said, just being able to fill it in during the lectures, cause it keeps you like, focused on it. I really like that part of it, yeh.

Interviewer: So apart from the notes, was there anything else that made it easier here [as compared with senior chemistry at school]?
Sofia: Just the teaching methods as well. Like, the teaching method here was more structured. Like, in my brain its structure, and I like structure and I like it set out so it links. (*Individual interview)*

While this approach may appear somewhat antiquated, Gogolin and Swartz (1992, p. 500) note that "post-secondary nonscience students may be more successful in a science course that is highly structured, at least initially." In addition, several studies in the high school science environment (Chu, 2008; Danili & Reid, 2004; Hussein & Reid, 2009) and in a chemistry course for nurses (El-Farargy, 2009) have demonstrated that designing teaching materials to specifically minimize cognitive overload and field dependency have resulted in improved academic performance indicating the importance of considering human cognitive architecture when developing pedagogy in science (P. A. Kirschner, et al., 2006). Sofia's comments illustrated that thoughtful and systematic presentation of materials supported the cognitive processing necessary for learning (P. A. Kirschner, et al., 2006) possibly because sufficient working memory capacity was "available to allow a genuine internal mental interaction with new ideas" (Hussein & Reid, 2009, p. 171). What is interesting here is that even those with a science background found the scaffolding provided by the notes and lecture format helpful, enhancing engagement and confirming other research that indicates students like a highly structured learning environment (Thornton, 1997). A structured learning experience, particularly in chemistry, augments learning and facilitates links to existing knowledge (A. H. Johnstone, 1997).

Learning strategies

Although not asked specifically about learning strategies employed for chemistry, interviewees did mention a number of approaches taken that would impact on academic performance in this subject. The student comments occupied approximately 8% of the overall interview coverage. Some aspects have already been mentioned, such as working with peers in tutorials and laboratories and listening in class. While some strategies would apply in any academic situation, there are others related specifically to the nature of learning in chemistry.

Understanding Related to the idea that explaining concepts to peers during tutorial time helped students to clarify and learn chemistry ideas, is the notion that chemistry can be very difficult to learn without understanding it.

> Phebe: … chemistry, like, you have to understand … it as well to be able to do the tests. Like, you can't just memorise it and repeat it. I think it's more like you have to understand it, like understand how it works. Like, it's not something you can just memorise.

Success in chemistry is not really possible by simply memorising without a degree of understanding, a strategy also described by the majority of nursing students in the El-Farargy (2010) study. Rote learning leaves material unattached in the long-term memory, making it difficult to recall (A. H. Johnstone, 2006). Polly found herself in the low achieving group (< 45%), possibly as a result of employing this approach:

> Polly: The structures, the formulas, you have to memorise and understand. When I studied chemistry, I would just go for memorizing, not reasoning things out.

> Bernice: I'd go through and say, "oh yea, I know that … yep, I remember that" … and when I actually came to it in the exam, I'm like, 'oh my god, I've read through that a thousand times, but I can't get my head …"

Bernice and Polly demonstrated a superficial learning style (Thornton, 1997) and subsequently struggled to perform well. Indeed, in a study of first-year Australian students studying science, researchers found 87% adopted a surface approach to learning, particularly those who possessed minimal foundation knowledge, resulting in fragmented conceptions (Minasian-Batmanian, et al., 2005).

Logically set out Because of the logical nature of science, some students found it essential to approach the study of chemistry in a similar way.

> Brett: Like so you're writing it down, your using the formulas, yeh, putting it out directly, it's more formula based, … like fact, it's more sequential, it's like specific order. Like, you start with atoms, it just progresses through. … it's like a book – you can read it sort of thing, if that makes any sense at all. Whereas with like other subjects, it's not like, it's more you could just pick that point out of it right in the middle. (*Individual Interview)*

Bernice: … There were just so many little minute details, I'm sitting there going, "oh my god." It's just laying it out logically. I think that's what we learnt in the bridging course.
Becky: mm
Bernice: It seems so confusing sitting there in front of you and you go "wow," and then you just lay it out, one by one, step by step by step, and it might take you a while but once you get it there, and you just lay it out correctly, like what Beryl does, she goes back, she needs to have everything down in front of her …

In addition to the benefit gained from the structure of the lecture notes, several students mentioned the need to write things down and set it out in order to gain understanding.

Sofia: I'm a lot better just being able to study for it, being able to set things out.

Repetition Without some rote learning, an inadequate knowledge base in chemistry can result (BouJaoude & Giuliano, 1994), and repetition is required for this to occur. Furthermore, failure to understand concepts restricts a student's capacity to transfer information into long-term memory because meaningful learning is restricted (A. H. Johnstone, 1997). Even with understanding, however, students recognised that repetition was still required for this transfer to occur, a finding that concurs with El-Farargy (2010).

Bella: … then rehashing it a 3rd time when I actually was studying, which is like, "wow - I do remember that better."

Becky: It's repetition.
Beth: I do – I need that.
Bernice: Repetition to get it in your head.
Beth: Oh yeh.

Bernice: Like as much as I know it, I need to go through it again and again. … I didn't really sit down and engrain it into my head.

For many, the tutorials not only provided an opportunity to explain concepts to others, but also acted as a source of questions for repetition.

Beth: And there were a lot of examples to go through. The tutes were a decent size rather than just having 3 or 4, you had many, and I need, personally, I need many …

Pierce: … and the tutes reinforce what you've learnt and you put into practice, and when you put into practice you remember …

Sandy: … It helped a lot and you can revise everything in the tutorial …, so it really helped.
Sarina: mm

Bronte I enjoyed them. I enjoyed the tutorials, and I still use them today, so
Brittney: I think that they're good cause … you can just go back over what we've been learning.
Bronte: It's good revision.

Some students also noted that repetition could aid in understanding:

Paul: I feel like approaching it like studying for maths. I just go over the problems, or like, the molar mass or whatever, or those ones, and by just doing it again and again, the examples help me get it.

Brittney: And you're actually doing it, so it just clicks.
Bronte: Yeh, you can just keep back through your revision and you go, "I know exactly what Kerrie was saying now." So, I've got the tutorials there to keep going over and going over and I thought, "now I know what she was talking about and it actually makes sense now."

For bridging course students, hearing concepts being explained the second time really helped their understanding, particularly for challenging concepts:

Bella: Equilibrium - when we did it the 2nd time I thought, "I actually get that now."
All: Yes!
Beryl: Yes, exactly! And the buffers -
Bernice: Like when we did it in the bridging course, I'm sitting there going, "OK. I sort of have an understanding and idea of it" and then we did it in class, and it just kind of like, I put two and two together, whereas if we didn't do the bridging course, I would have been - well I sort of understand it.

Bella: and we rehashed it.
Beth: Mm. When you're learning anything the 2nd time it - just cements everything.

Inevitably, some students require substantially more repetition than others for long-term memory transfer.

Paris: … I just find that each time I look at it, it's not there, like it just doesn't stick, and I just have to keep going back and back and back until I find it somewhere.

Paige: Um, I understood it when you were going through it because you explain it really well, but then afterwards, when I did the tutorial, and then by the time we were doing the next thing I'd already forgotten the first.

Breaks Taking a break during study is always important, but particularly so when dealing with challenging concepts with potential for cognitive overload. A number of students noted that study became easier after a break.

> Bernice: That can happen in chemistry. It's not processing in my head, it's just not working. I went home and I had a one or two hour break and I sat back down and I just sat there for about two hours and I just did it.
>
> Bella: By also having the break, too, I think, you've been looking at it all day, you have your couple of hours break and you go back to it, and you can sort of, you know, relook at things, and sort of work out things.
> Bernice: It doesn't seem as complicated as it did ...
> Beth: Because you overload and you need to have a break.
> All: Yeh.
> Bernice: That's what I found with chemistry, like, sometimes you can hit it hard and get it really well, and then there are those times where, wow, I just need a break.

Practice tests To aid in their preparation for the two tests during the semester, students were given past test papers a week or so before each test. Students found these helpful in not only reducing test anxiety but as another avenue for test preparation, hence contributing to perceived improvement in academic performance.

> Pierce: … I did the practice test and I felt like I had that down pat.
>
> Paige: Like, pretty much, I think it [Test 1] was like the sample exam you put up.
> Paula, Paul: *Nodding*
> Paige: I just learnt how to do the things in that exam, and it's like, I hope 50% of my exam is stuff that's doing this 'cause I'm just learning how to do the stuff in the exam …

For novices, the 'worked example effect' has been shown to be an effective way of learning and developing problem solving skills because it reduces the burden on limited working memory space (P. A. Kirschner, et al., 2006).

Other study commitments Student comments confirmed that the level of performance attained will inevitably be affected by the study load experienced from other classes.

> Soraya: I had all this other stuff in my head and other tests were happening as well, like psychology and all that.
>
> Sandy: Yes because lots of other tests, like every week …

Tutorials It is interesting to note that tutorials and laboratories provided not only support,

Paula: Just having someone to sit there and explain it to you again.

but also facilitated the employment of several learning strategies, a tactic shown to be more prevalent amongst high achievers (Andrew & Vialle, 1998). Tutorials also provided further opportunities for enhancing understanding, whether that be further explanation from the lecturer, tutor or fellow student.

Bella: Obviously, what you were giving us, we could then go and apply it ourselves, and go "oh, you know, I actually understand what she was doing in each of those steps."

They acted as a source of exercises for repetition, and for some, like Soraya, they helped to compensate for a lack of self-discipline by 'forcing' students to actually sit and do some work on a weekly basis.

Soraya: I think they were pretty helpful like, it made us do work, like answer questions and stuff.

Tutorial attendance in Health Science I was compulsory, with an average attendance for both campuses of approximately 88%[17] so its effect on academic performance beyond the comments made is difficult to determine. There is a paucity of research that has considered attendance at tutorials as a factor in achievement, although they have been shown to be an important factor for many students learning bioscience (Davies, et al., 2000). For nursing cohorts in biological science courses, the studies have shown mixed results. One study found tutorial attendance had a significant effect on end-of-year exam performance (McKee, 2002) but another found no statistical difference between those who attended tutorials and those who attended only a few sessions (Potolsky, et al., 2003). It should be noted that in the latter study, low attendees had higher pre-requisite science grades, and it is possible that these students with more substantial prior knowledge felt less need to attend tutorials. The tutorials may have served to increase the performance of those with lower pre-requisite grades to a comparable level.

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[17] Accurate records were kept for the rural campus because I took the roll each week, with an average of 97% attendance at each tutorial. For the city campus, students did not always remember to sign the roll before leaving, so the average of 86% is a conservative attendance value and could be higher.

7.3.3 Reflexivity

Research has demonstrated self-efficacy to be the paramount motivation construct in relation to academic performance (Obrentz, 2011; Zusho, et al., 2003). Interview comments that pertain to relationships between academic performance and both confidence and anxiety have already been considered in previous chapters. Other key aspects of motivation related to goal orientation emerged from the interview data. For simplicity, goal orientation, although considered as a continuum, can be divided into two types: extrinsic and intrinsic (Pintrich, 1994). In reality, individuals may possess a mixture of goal types that influence the level of engagement in a given task. Extrinsic motivation will be discussed here, and two aspects of intrinsic motivation - task value beliefs and interest - will be analysed in Section 7.6 when perceptions of chemistry are considered.

For many students, extrinsic factors such as passing or getting a good grade, provided motivation for study. Student comments indicated that studying was a means to an end.

Brittney: To tell you the truth, I just don't want to fail.

Sonia: … everyone knows that you need chemistry, you need to pass to do what you want to do in life, or something like that, and, ah, yeh, so I think that was a big factor.

Bella: … so going into chemistry thinking 'I needed to pass this, I need to pass this so my dreams don't end.'

Brett: To become a nurse, to graduate. That was the sole reason. I wouldn't have gone into, chosen to go into chemistry because of chemistry. I wanted to become a nurse, so to become a nurse, to get that piece of paper, I had to do the subject of chemistry. … I was actually aiming for a credit I think. I was like, mm pass is probably too easy, so I thought I'd go for a little bit more. (*Individual Interview*)

Pam: 'Cause if you can't pass chemistry, you can't go to the next level.

Becky: So I was willing to study because I wanted to do well at it.
Beth: I did too.

Sofia: … I studied a lot more thoroughly than I would for tests, just because I wanted to get a good mark.

In individual interview, Samuel noted that for him, setting goals to study would be the biggest 'reflexivity' factor influencing his academic performance.

Focus group and individual interviews have revealed that social connections (lecturer, peers, support), reduction of some complexities of chemistry through exposition, learning strategies, and structuring notes and lectures, along with the possession of extrinsic goals, can all play a part in enhancing academic performance. The next section considers the role of demographic variables in academic performance.

7.4 Demographics and Academic Performance

7.4.1 Gender

While the average academic performance of males was higher than females (see Table 60 in Appendix 29), an independent t-test showed that the difference was not significant (p=.665), adding further evidence to the lack of gender bifurcation in academic performance in nursing (Van Lanen, et al., 2000) and general chemistry courses (Andrews & Andrews, 1979; BouJaoude & Giuliano, 1994; Glynn, et al., 2009; Hailikari & Nevgi, 2009; Seery, 2009). However, the small male sample size requires some caution in interpretation and generalisation of these results.

7.4.2 Age

No significant Pearson product-moment correlation was found between age and academic performance, r=.031, p=.757. Mean performance values for each age group are recorded in Table 61 in Appendix 29. Of all the demographic variables, the effect of age on academic performance reported in the literature seems to be the one that has the most conflicting results. A number of studies in the nursing context have found mature students to outperform younger ones (Houltram, 1996; Humphreys, 2008; Kevern, et al., 1999; Ofori & Charlton, 2002; Salamonson & Andrew, 2006; Van Lanen, et al., 2000; van Rooyen, et al., 2006), but only one of these (Van Lanen, et al., 2000) considered academic performance in chemistry. However, a number of other nursing student studies have found age to be a non-predictor of overall academic performance (McCarey, et al., 2007) and of academic performance in bioscience (Whyte, et al., 2011). There are a number of possible explanations for the contrary findings. As noted in Section 2.4.1, studies vary in the cut-off points for age categories. In addition, there is variation in whether correlation, chi^2 analysis or regression methods are used to examine the relationship between age and achievement. A lack of correlation in my study could be related to the fact that 35% of the cohort were 17 or 18 years of age, with 71% less than 23 years of age, making the age distribution quite different to many other nursing cohorts which tend to have higher numbers of mature-age students. For example, only 51% of the cohort in Van Lanen et al.'s (2000) study were less than 23 years old. Very few studies involving the prediction of academic performance in general chemistry have considered age, but have focused more on prior knowledge and measures of aptitude such as SAT or ACT. It may be that in a chemistry class, the benefits gained from maturity such as application and motivation, are outweighed by the disadvantage created by the length of time since studying science at school.

Despite the inclusion of four participants over 34 years of age in the focus groups, there were surprisingly few comments made about age in relation to ability or performance. Only one mature-age student suggested that age may affect ability:

> Beryl: You've just got to go through so much, that you've got, because it's all new … that there is no underlying knowledge to draw from and when you get to **this** age …

However, Beth (age >35) implied that maturity allowed the older students to be more aware of the requirements for learning, an idea she also raised in individual interview:

> Beth: Well, you know the benefits of being older are fantastic. It's great being old because you just know what you need to do. You know yourself. You just know what you need to do to get something done. … I had a really good attitude because in my old age, I had a better attitude towards education. I want to be there. I want to learn. (*Individual Interview*)

It may be that age, rather than having a direct effect on academic performance, mediates other factors, with mature students more likely to engage in support seeking (Ofori & Charlton, 2002) and conscientious approaches to study (McCarey, et al., 2007; Ofori, 2000), to possess more learning skills (Whyte, et al., 2011) and to use deep-learning approaches (Zeegers, 2004).

7.4.3 Work Hours

A small negative correlation was found between academic performance and number of hours worked each week, $r=-.261$, $p=.009$, indicating that academic performance is hindered by increasing number of work hours. This was certainly the case for Bronte, who was studying full-time and working 40 hours per week:

> Bronte: I didn't study anywhere as hard but I had to work as well, so that cut my time down for study. That was my downfall, my biggest downfall. There's no excuses …

Sarina, who averaged 27 hours of work per week on top of her full time study, also indicated that the amount of effort she put into the course depended on how much she was working. While the achievement of the 17 students who worked 10+ hours per week (*M*=47.21, *SD*=21.36) was lower than those who engaged in no paid work (*N*=36, *M*=57.65, *SD*=18.82) or who worked between 1 and 9 hours per week (*N*=47, *M*=57.14, *SD*=19.71), the differences failed to reach statistical significance using ANOVA (*p*=.157). It is possible that this difference may have reached statistical significance if the cohort had been bigger. While this finding concurs with some reports based on nursing student cohorts (Harris, et al., 2004; McKee, 2002), another has shown that the academic performance in pathophysiology of second-year nursing students who worked more than 16 hours per week was significantly lower than those who had no paid employment (*d*=0.59) (Salamonson & Andrew, 2006). In another Australian study that considered first-year science students (McKenzie & Schweitzer, 2001), full-time students who worked part-time had the lowest GPA at the end of first semester. Generally, longer work hours are associated with lower academic achievement in first-year Australian university students, particularly amongst those who work more than 16 hours per week (James, et al., 2010).

7.5 Academic Performance and Prior Chemistry Experience

There is commonly a wide variety of backgrounds and ability of students entering a tertiary chemistry course (Hahn & Polik, 2004; James, et al., 2010; Krause, et al., 2005; Shapiro, 2004). Studies that consider the relationship between some sort of prior knowledge and academic performance fall into two categories: those that take into account the quality of prior knowledge and those that do not. While it is helpful to have a reliable measure of prior knowledge that includes quality and quantity (Dochy, et al., 1999), it was not feasible in this study (see Section 3.3). In the analysis reported here, prior chemistry experience is simply based upon whether chemistry was attempted in the senior years of high school, whether it was gained in a 3-day bridging course, or whether no prior experience was gained beyond

Year 10. Quantitative relationships between prior chemistry experience and academic performance will be explored first. In order to illuminate the quantitative analyses, a discussion of categories from the 'Reductivity' theme delineated by prior chemistry experience will follow - foundation knowledge, nature of chemistry, course structure-pace, and effort to learn.

7.5.1 Quantitative Findings

A significant Pearson product-moment correlation was found between prior chemistry experience and academic performance, r=.337, p=.001. Similar correlations have been found in studies involving general chemistry cohorts using the California Chemistry Diagnostic Test (CCDT), r=.42 (Karpp, 1995), high school chemistry grades, r=.569 (Seery, 2009), and a chemistry pretest, r=.42 (Ozsogomonyan & Loftus, 1979). The literature also reports significant correlations between academic performance in biological science for nursing students and both high school science grades (McKee, 2002; Potolsky, et al., 2003) and the completion of high school biology (McKee, 2002; Whyte, et al., 2011). Indeed, in a narrative review, 91.5% of prior knowledge studies showed the positive effects on academic performance, with prior knowledge generally explaining between 30 and 60% of the variance in academic performance (Dochy, et al., 1999).

Table 33. Academic performance statistics based on prior chemistry experience

Cohort		Number of cases	Academic Performance		Maximum & minimum
			Mean	SD	
Total cohort		100	55.63	19.86	9.5 – 92.7
Group	PC	44	46.60	19.49	9.5 – 88.0
	BC	30	54.20	20.58	17.4 – 83.0
	SC	26	66.93	15.00	41.4 – 92.7

Academic performance data based on prior chemistry experience are reported in Table 33 and illustrated in Figure 16 and again show that academic performance increased with increasing prior experience. This trend was also observed on the two occasions analysis was applied to the first-year chemistry student cohort data at the University of Sydney for students enrolled in Fundamentals of Chemistry 1A (Schmid, et al., 2012; Youl, et al., 2005; Youl, et al., 2006). In order to investigate this relationship further, ANOVA was employed. Results demonstrated that prior chemistry experience did make a difference to academic performance in Health Science I, $F(2,97)=6.814$, $p=.002$, $\eta^2=0.132$. Post hoc analyses using Scheffe showed that significant differences existed between SC and both PC ($p=.002$, $d=1.13$) and BC ($p=.045$, $d=0.70$) groups. This supports other research in general chemistry that has shown that students with high school chemistry experience significantly outperformed those without (Seery, 2009). Despite the BC students having a higher mean, the difference in academic performance between BC and PC groups failed to reach significance ($p=.633$). Analysis of results from the chemistry bridging course at the University of Sydney concurred with the finding in my study that students with senior chemistry outperformed those with no prior knowledge. However, their study showed that the academic performance of bridging course students were statistically comparable to both senior chemistry and no prior experience groups (Schmid, et al., 2012). Further, Wischusen and Wischusen (2007) found that attendance at a biology bridging course resulted in superior exam results compared with those who did not attend.

One possible explanation for the apparent superior performance of bridging course attendance in these studies is that the bridging courses were seven and five days respectively, providing more opportunity to cover a greater amount of

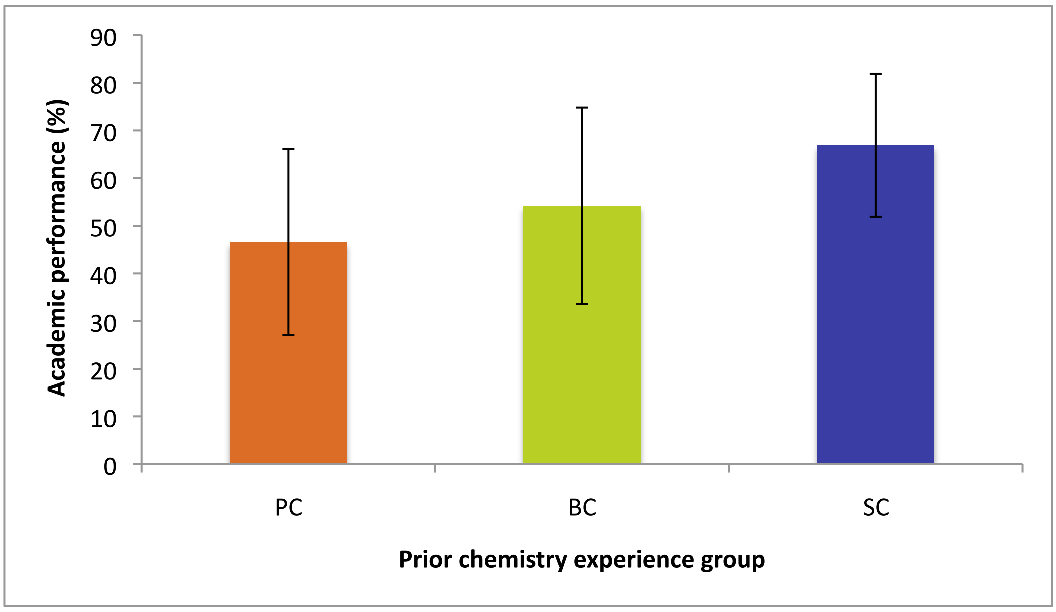

Figure 16. Academic performance for prior chemistry experience groups (with standard deviation bars)

foundation material. In addition, neither included laboratory work leaving more time for concept development and practice.

Table 34. Cross-tabulation of academic performance and prior chemistry experience groups

	PC	BC	SC	Total
Low	23 (52.3%)	10 (33.3%)	3 (11.5%)	36
Adjusted residual	3.0	-0.4	-3.0	
Average	12 (27.3%)	9 (30.0%)	11 (42.3%)	32
Adjusted residual	-0.9	-0.3	1.3	
High	9 (20.5%)	11 (36.7%)	12 (46.2%)	32
Adjusted residual	-2.2	0.7	1.8	
Total	44	30	26	100

Low = <45%, Average = 45-69%, High = 70+%
Values in brackets indicate the percentage of students from the prior chemistry experience group.

Despite the lack of a statistically significant difference between the performance of PC and BC students, there is other evidence to suggest that the bridging course did indeed play a role in academic performance. Table 34 and Figure 17 show the distribution of students in each of the academic performance groups based on prior chemistry experience. Note that in the low performance category, the majority of students came from the PC group (63.9%), with the SC group accounting for only 8.3% of this performance band. It is also interesting to note that the BC students are fairly evenly distributed amongst the three performance groups. A Chi-square test for independence was used to evaluate whether the distribution patterns were significantly different from each other.[18] The results showed there was a significant difference, $\chi^2(4, N=100)=12.49$, $p=.014$, Cramer's $V=0.25$.[19] In addition, an inspection of the adjusted residuals in Table 34 indicates three notable cells (i.e. values > |2|) (Acton & Miller, 2009). PC students are more likely to be in the lowest academic performance group, with SC students less likely. Also, PC students are less likely to be found in the high academic performance group. These figures add some weight to the assertion that the bridging course did

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[18] The assumption of 'minimum expected cell frequency' was not violated, since 0 (.0%) cells had an expected count less than 5 (minimum expected count 8.32).

[19] When using 3 categories, Pallant (2007) suggests that a Cramer's V value of .21 represents a medium effect size. Alternatively, for the same statistic, Cohen's w = 1.12 which can be considered a large effect size (Allen & Bennett, 2008).

contribute to improved academic performance. The results are somewhat consistent with those reported in the University of Sydney bridging course study which compared grade distribution in the various prior chemistry experience groups and found that the proportion of higher grades in the senior and bridging course groups were similar to each other, both being higher than those with no prior experience (Schmid, et al., 2012). It should be noted that they did not confirm the difference in distributions statistically.

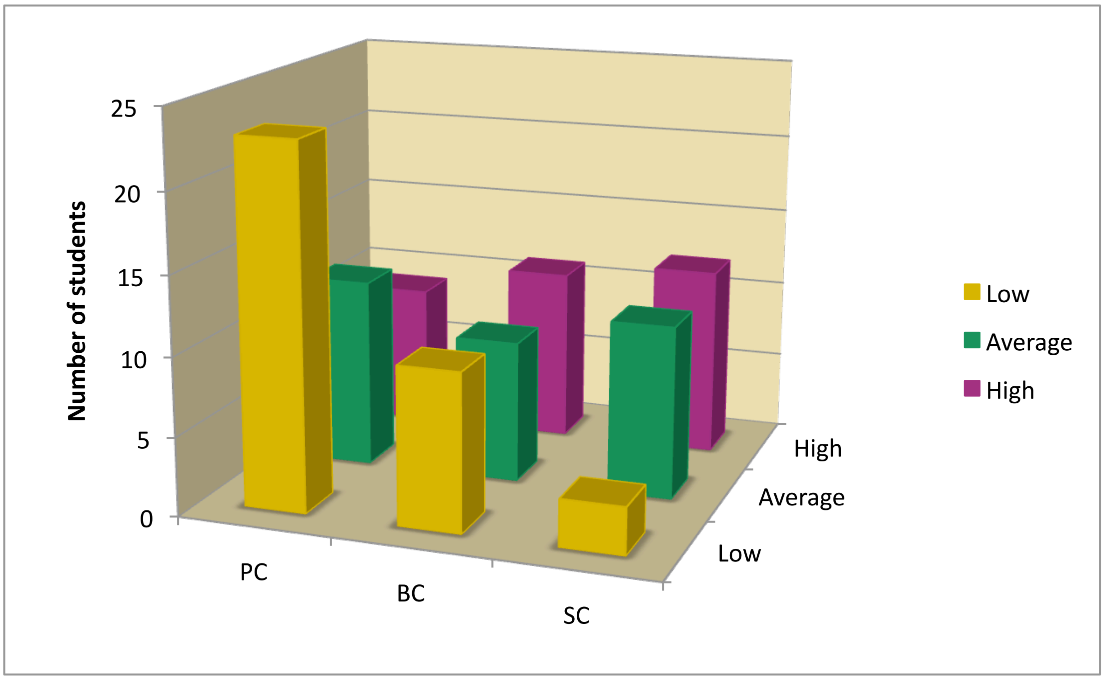

Figure 17. The distribution of students in each academic performance group based on prior chemistry experience

It could be possible to conclude that SC students outperformed the other groups because of superior reasoning ability or cognitive capacity. A small correlation was found between PRM and prior chemistry experience, r=.222, p=.041. However, when ANOVA was used to compare prior chemistry experience groups for RPM scores, it failed to reach significance, $F(2,82)$=2.644, p=.077, adding support to the idea that the difference in academic performance could be attributed to prior chemistry experience rather than the hypothesised higher ability of the SC students. A similar finding was reported by Schmid et al. (2012) where comparison of university entrance marks (UAI) revealed no statistical difference between the three prior chemistry experience groups.

When SC students were asked at the end of the chemistry component of Health Science I how they would rate their chemistry background coming into the course, 84% felt it was adequate or better. Indeed, the more helpful the students found their senior chemistry experience, the better the academic performance, $r=.599$, $p=.002$. It would appear, then, that the prior chemistry experience of the SC students contributed to higher academic performance, suggesting that the quality of prior knowledge does make a difference (Hailikari & Nevgi, 2009). When Samuel was presented with the findings displayed in Figure 16 and asked to comment on the difference between the SC and BC results, he offered the following explanation:

> Samuel: It'd say it is less the actual information and … knowledge, and more the way of incorporating the knowledge. Like, actually thinking about it analytically, symbolically and building those kind of ways of thinking … you know being scientifically literate and actually being able to think about things in that kind of abstract, analytical kind of way. So you build that over several years or even more. It's not just something you can learn in a couple of days. (*Individual Interview*)

Brett, too, felt that SC students would be building on existing knowledge and skills, whereas PC students were "starting fresh – it's hard" (*Brett, Individual Interview).* However, he was somewhat surprised that BC students did not have a significantly higher mean than the PC students because

> Brett: [the bridging course] gave you the knowledge that you needed for the first half of the semester, and it was just in 3 days, so it was like, as much as you could pick up, which was surprisingly a lot … it just continuously helped you throughout the semester. (*Individual Interview)*

While the BC students would have gained some declarative knowledge from the bridging course, the SC students are more likely to have gained higher levels of procedural knowledge. Of the four levels of chemistry knowledge identified by Hailikari and Nevgi (2009), the ability to apply knowledge (the highest level) was shown to be the only type of prior knowledge to relate positively to the final grade in a general chemistry class. The importance of the quality of prior knowledge was also demonstrated in another general chemistry cohort when it was found that receiving an "A" in high school chemistry was the only significant predictor of grade with respect to prior knowledge, and that students with no high school chemistry performed better than those who received a "C" at high school (Ozsogomonyan & Loftus, 1979). Adding further support to the importance of quality of prior knowledge when examining academic performance was the finding that the post-test multiple-choice results of the bridging course participants correlated with academic performance, *r*=.526, *p*=.035.

In order to investigate further the role cognitive capacity may play in the correlation between prior chemistry experience and academic performance, students were placed in three groups based on RPM scores. Pearson product-moment correlations were then conducted for each RPM group between prior chemistry experience and academic performance (see Table 35). What is interesting is that the only statistically significant correlation occurred in the low RPM group. For students with lower cognitive ability, higher academic performances were more likely found in students with more chemistry experience. Since there is no significant correlations between prior chemistry experience and performance in the middle and high cognitive capacity groups, it would appear that, as suggested by Cavallo, Rozman and Potter (2004), students with higher reasoning ability may be better able to overcome their lack of prior knowledge. Since chemistry requires "formal operational reasoning skills" (Van Lanen, et al., 2000, p. 769), prior chemistry experience appears to be a more critical factor for those students with less capacity.

Table 35. Pearson product-moment correlations between prior chemistry experience and academic performance based on Ravens Progressive Matrix groups

RPM group	*N*	Academic Performance mean (*SD*)	Correlations between PCE and AP	
			r	*p*
< 47	28	49.30 (18.45)	.413	.029
47 – 50	26	58.44 (18.80)	.135	.510
51 +	30	66.75 (16.35)	.280	.134

NB: Post hoc tests with Scheffe revealed a statistically significant difference in academic performance between the low and high RPM groups only.

Foundation knowledge

The possession of foundation knowledge was an important category that emerged from both the self-efficacy and anxiety interview analyses and also proved to be a significant feature when academic performance was examined. Brett made the link in his interview:

Brett: … well, for half the semester [I] was probably being re-taught it, then there was new stuff after that. So, that boosted my performance. (*Individual Interview*)

Since science is organised in a hierarchical way, reasonable background knowledge is required to progress to the next level of understanding (da Silva & Hunter, 2009).

Bella: I think if I had actually gone straight just to class that first day not knowing anything, I don't think I would have done half as well as what I would having knowing it.

BC students felt that the bridging course provided them with essential prior knowledge, allowing them to build on concepts more easily, a theme noted in other bridging course research (Boelen & Kenny, 2009; Youl, et al., 2005; Youl, et al., 2006).

Beryl: People who didn't do the bridging course, they never actually had, the information was coming at them, and they never had a base for that information to go on,
Beth, Becky: mm
Beryl: and if I hadn't have done it, I would have felt that I'd already, like I'd come in late
Becky: mm
Beryl: and not ever feeling that I was on the same page as everyone.
Beth: That's right.

Interestingly, these four bridging course attendees had post-test scores from the bridging course of at least 8/10 and were placed in the high achieving group at the end of the semester. In contrast, the PC students felt at a disadvantage for not possessing some basic concepts:

Paula: I could see it was out of my depth and that I wasn't familiar with it, and that I didn't have really, any previous knowledge.

Interviewer: What aspects of [the bridging course] do you think would have helped you?
Paula: Familiarity in advance. Just, so you're prepared. So you get the sort of basic, the basic framework of it all. So then, I'd sort of, got a head start and not be so overwhelmed. …
Paris: I think it would have helped me a lot. Just having that better understanding of what I was walking into.

Prior knowledge proved important even for those SC students with a poor performance in senior high school chemistry:

Soraya: Like, it's surprising how much I remembered from high school as well.

Sarina: You've just got that basic knowledge there that will always be built on.

When the qualitative models derived from the individual interviews were considered (see Appendix 21), foundation knowledge was identified as a key factor in academic performance by all participants except Pippa.

In terms of cognitive load theory, students with prior knowledge are less likely to experience cognitive overload for three reasons. They are able to chunk incoming information, the information anchored in the long-term memory (LTM) allows the filter to select relevant information more efficiently, and they can create more meaningful links to information in the LTM (El-Farargy, 2009; Reid, 2008). Consequently, the working memory has more space to process because it is has less information to hold. For the novice, the working memory is limited because it is busy holding information, much of which may be irrelevant. Further, it is difficult for the learner to find a "connection on which to attach the new knowledge" making it not only challenging to learn but "impossible to retrieve" (A. H. Johnstone, 1997, p. 265). Since "conceptual understanding is dependent on the way ideas are linked to each other in meaningful patterns" (Reid, 2008, p. 54), the ability of the novice to understand concepts presented in chemistry lectures is therefore compromised, ultimately affecting academic performance because when the working memory is overwhelmed, learning ceases (Reid, 2008).

The nature of chemistry

Several aspects of the nature of learning chemistry and its relationship with academic performance became apparent during interviews. The cumulative nature of concept building in the subject, the unique language, the various levels of operation outlined in Johnstone's model (2006) and the logical nature of science are features considered in the following discussion.

Cumulative concept development Having prior knowledge meant that students had the foundation on which to build more challenging concepts, a particularly important aspect of the nature of learning chemistry. There is no doubt that students recognised that knowledge in chemistry is "sequential" (*Brett*) and cumulative (El-Farargy, 2010; Hailikari & Nevgi, 2009) and concept development progressive (Strube, 1991):

Paul: Like, chemistry it seems to build progressively, and then anatomy, it's just like so much stuff that doesn't seem related, I mean obviously it's all related but, yeh, it seems worse, [chemistry is] kind of progressive.

Prue: But, yeh, chemistry, it's, you've just got to get the main concepts of it and how this flows on to that, that equals that.

Samuel: There was definitely a lot of stuff which we didn't cover in Year 11 or 12 but it was just kinda building on top of that, so
Sandy: Yup.

For Sofia, her struggle with chemistry at school related to a lack of basic knowledge:

Sofia: … and my teacher, she wasn't very helpful, like I just found it really confusing, everything, and then I forgot the basics, so it was just like a big muddle for me in my head, like all through senior high school.

Unique language A significant challenge for the science novice is the language, with much of it being described as foreign (Gresty & Cotton, 2003; Penman, 2005). For some, it essentially equates with learning another language (Logan & Angel, 2011). The lack of acquisition of chemical language can be a significant barrier to learning and solving problems in chemistry (Ver Beek & Louters, 1991). Students from both the PC and BC groups commented on the unique language of chemistry:

Beth: When I first went to the chemistry course, it was like stepping into another world.
Beryl: It is.

Beth: Because I thought it was really going to be like - like another language.

Beth: This is absolute Greek.

Brittney: Terminology, even just the terminology.

Beryl: But when you looked at it and you didn't know what it all meant, it was basically gobbledy-goo, it was quite phenomenal.

Pam: When you were talking, all I was hearing was blah, blah, blah.

The unique language of chemistry requires significant processing, and for the novice, consumes the working memory space leaving little capacity to attend to the concepts presented. Consequently, either little information is passed to the long term memory, or what is passed on is transient (A. H. Johnstone & Selepeng, 2001). Further evidence for just how alien chemistry can be was provided by the BC students when they commented on their reactions when they first saw the pre-test.

> Bernice: At first, I'm reading through it and it's like – did she give me the right piece of paper?
> All: *hilarious laughter*
>
> Beryl: But what was interesting was when you said when we were doing the test, 'if you don't know it just guess', you cannot guess in chemistry
> All: *hilarious laughter*
> Beryl: What's the point between guessing and not doing anything? – nothing!
> Bernice: Guessing now in chemistry, now that I kind of get it and it could be this one or that one, whereas I was literally going eany, meany, miney, mow.

Learning the language of chemistry is imperative for academic success because complex unfamiliar language consumes much of the working memory space (A. H. Johnstone & Selepeng, 2001; Ver Beek & Louters, 1991). In fact, it has been suggested that the difficulties experienced by beginning tertiary chemistry students "appear to be largely precipitated by a lack of chemical language skill rather than by a lack of native reasoning" (Ver Beek & Louters, 1991, p. 391).

Nature of chemistry model Aspects of the multi-levelled model of the nature of chemistry (A. H. Johnstone, 2006) presented in Section 2.1.1 posed problems for those lacking in prior experience. For example, PC students were the only ones to comment on problems with the "sub-micro" nature of chemistry.

> Phebe: Um, yeh. I don't know why I think for me biology was more, um, like how it was based it was more like animals, more plants kind of base. It wasn't, I think for me the hardest thing is to get my head around like atoms and proteins and all this stuff and you can't really see type thing, whereas in biology it was a lot more practical.
>
> Pam: Maybe with anatomy, you can see more.
> Paula: That too. Visual.
> Pam: You can actually visualize
> Paula: It makes more sense.
> Pam: [Health Science II lecturer] showing you the parts, and you know, the things we're cuttin' up into pieces and looking inside. With chemistry, you can't see it,
> Paula: That's true.
> Pam: and whatever is floating around. So you gotta imagine that in your head and it's hard tryin' to imagine it, without actually physically touching it.

The “representational” facet of the model presented problems, particularly for those with a poor chemistry background.

> Paula: Yeah, once the equations were starting to roll on and things like that, … I just thought, oh, ...
>
> Bronte: I enjoyed science at school, and I think it’s just the formulas that rattled me here.
> All: *agreeing*
>
> Polly: The structures, the formulas, you have to memorise and understand.
>
> Pam: … There’s no numbers and letters in your head you’ve got to remember [in sociology] and gotta figure out what goes with who and what is connected to what. They’re [sociology and chemistry] just totally different.

Research has shown that students’ understanding of symbols in a general chemistry class can be more problematic than their understanding of language (Marais & Jordaan, 2000). The importance of working with symbolic representations and modelling abilities for understanding chemistry concepts was demonstrated by Chittleborough and Treagust (2007). They showed that representations link simultaneously to both the macroscopic and sub-microscopic levels (described as the “unique duality” required in chemistry), and concluded that limited background meant students had limited capacity to both interpret and link, affecting the depth of understanding.

Because of the abstract nature of chemistry, the use of a range of representations is necessary to develop an understanding of the submicroscopic makeup of matter (Treagust, et al., 2003). While experts can move comfortably between the three levels of chemistry – macro, sub-micro and representational - this represents potential gross overload of the working memory capacity of the novice (A. H. Johnstone, 2006). Research with senior chemistry students has demonstrated that for effective learning based on deep understanding, simultaneous use of the three levels is required (Treagust, et al., 2003). Previous exposure to chemistry builds familiarity with the various aspects of chemistry, facilitating movement between the levels and promoting understanding.

Conceptual, logical and mathematical nature of science Previous comments from Pam and Polly illustrate that chemistry is a subject where concepts must be understood. As outlined in Section 7.3.2, without a degree of understanding, concepts are difficult to learn and academic performance is affected.

> Phebe: Like, sociology and psychology, they're kind of interesting but there's not like a whole lot of concepts that you have to remember … [but in] chemistry, like, you have to understand, like understand it as well to be able to do the tests.
>
> Beryl: … when you do chemistry, there are so many factors to take in.

The logical and sequential nature of chemistry and its relationship to maths was also discussed by a number of students, including SC students. For the SC students, these were considered positive aspects of the nature of chemistry making it easier to learn.

> Sandy: I think it is more close to your basic life things, so you always have a logical explanation why a thing is like this and why things are like they're meant to be.
>
> Bernice: The way it was for me, like in the bridging course, when you lay it out in front of you, logically, step by step, the process, it's so much easier. … No, it's like I need to think about it logically and -
>
> Beth: You are quite right, because it is so logical, it's like maths, you know.
> Others: Yeh.
>
> Paul: I feel like approaching it like studying for maths.
>
> Sarina: You're either right or you're wrong. It's not like in English where you can kind of talk your way, it's like fact.
> Samuel: *smiling*. Mm
> Sarina: It's like maths. You're either good at maths and science or you're not.

It is not uncommon for nursing students to enjoy the 'clear-cut' nature of learning chemistry, taking this dualistic and simplistic stance (El-Farargy, 2010). The importance of maths ability in the prediction of academic performance in general chemistry courses has been clearly demonstrated in numerous studies (Andrews & Andrews, 1979; Hahn & Polik, 2004; Karpp, 1995; Lewis & Lewis, 2007; Mamantov & Wyatt, 1978; Ozsogomonyan & Loftus, 1979; Tai, et al., 2006; Turner & Lindsay, 2003; Van Lanen, et al., 2000; Wagner, et al., 2002). Maths-based questions such as stoichiometry are often regarded as algorithmic, with descriptive questions as conceptual. Schmid et al. (2012) found that prior chemistry experience played a greater role in maths-based questions in a general chemistry exam, where senior chemistry students out-performed the rest of the cohort. However, these students did just as poorly as the bridging course and poor background students on conceptual questions. While the level of maths required in the chemistry component of Health Science I is relatively low, the interview comments would suggest that in the minds of a number of students, ability in maths still played a role in academic performance.

> Interviewer: How do you think your maths ability affected academic performance?
> Beth: Quite a bit. Yeh.
> Interviewer: You think so, even though there's not much maths in [Health Science I]?
> Beth: Yes, but it's the same thought processes, it's the same. (*Individual Interview*)

The nature of concept construction in science requires a unique learning approach. Rutishauser and Stephensen (1985, p. 561) suggest that this approach "may be incongruent" with that employed in humanity-type subjects where the style is more 'holistic.' Consequently, the study of chemistry for students with a lack of foundation knowledge is exacerbated when coupled with a "natural bent" (*Paula*) away from science.

As was the case with 'connection with the lecturer', SC students said very little about the link between the 'nature of learning chemistry' and academic performance. Their experience in the subject meant they were already familiar with the language and the levels on which chemistry processing needs to occur. Surprisingly few direct links were drawn between this category and academic performance in the individual interviews. There could be two possible reasons for this. Firstly, it was identified closely with foundation knowledge, a category already established as having a strong influence on performance. Secondly, since individual interviews were conducted 12 months after the course, students were more familiar with operating within 'the Johnstone triangle' and the nature of chemistry was more or less taken for granted, as explained by Beth.

> Beth: … the language and the symbols are not a problem, because you've got the basics. (*Individual Interview*)

Course structure - Pace

Adjustment of the pace of presentation to combat perceived difficulty has been reported in previous nursing literature (Jordan, et al., 1999). It was not surprising to see that those with little prior knowledge struggled to keep up in Health Science I, contributing to their anxiety (see Section 5.4.3).

> Paula: I think, if I'd had more time to study it I would have been alright, but it just seems so volumous[20] in such a short amount of time. If I'd had more time or if it had been more spread out - .
>
> Paula: It was just having time to learn it, like, to really grasp it… I was pretty confident I wasn't going to pass because of that timeframe not being there to be able to grasp it completely. (*Individual Interview*)
>
> Pam: ….. So, I reckon if it was in a longer time period …I reckon people would get better marks …

For Paula, this aspect of her experience was a recurring theme in the individual interview. Reid (2008, p. 56) notes that cognitive overload will occur when "too much has to be thought about *at the same time*". Since the amount of material that can be processed in an allocated time is limited (A. H. Johnstone, 1997), modifying the speed or amount of time given in class is one way to help reduce working memory demand for some students (El-Farargy, 2009). In contrast, as explained by Sofia, the SC students enjoyed the "slow" pace of the course:

> Sofia: Um, yeh, it's a lot, it's a lot simpler and a lot better, spread out and you explain it a lot better, like slowly, versus just like skimming over it, and some people haven't done chemistry. So, it's really good, just take it slow. I like slow. So that was good.

While the BC students noted the difference in pace between the bridging course and Health Science I lectures,

> Beryl: … the delivery, and how you did it, was the same.
> All: Same
> Bernice: It was just faster in Health Science.

they, too, seemed relatively happy with the rate at which material was covered, suggesting that the possession of some prior knowledge reduces the demand on working memory allowing students to process more information in the given time period.

Effort to learn

It has already been demonstrated (Sections 5.6 and 6.6) how levels of self-efficacy and anxiety can affect the amount of effort put into learning and

---

[20] voluminous

subsequently, the level of achievement. In order to compare the cognitive load experienced by students in chemistry with a non-science subject such as sociology, Paas's one-item self-reporting measure (Paas, 1992) was used with a scale of 1 (none/not at all) to 9 (extremely high) (see Appendix 30). Using this method, focus group participants were asked to reveal levels of mental effort and difficulty.

For the total focus group cohort, a paired-samples t-test was conducted to see how students perceived the mental effort required and difficulty of chemistry compared with 'Sociology and Psychology'. The mean for the mental effort required for chemistry (M=7.04, SD=1.43) was significantly higher than the mental effort required for sociology and psychology (M=5.00, SD=1.64), $t(26)$=4.990, p<.001, d=1.33 with a large effect size. This confirms other research that indicates nursing students put more effort into science than other parts of the course (Caon & Treagust, 1993; Friedel & Treagust, 2005).

ANOVA was then used to investigate the impact of prior chemistry experience on the perceived effort required and difficulty of learning chemistry for focus group participants. While there was a steady decrease in means from PC to BC to SC for questions relating to effort and difficulty of chemistry content (see Appendix 30), only Question 4 ("How difficult was it for you to learn the chemistry material?") reached significance at the 0.05 level, $F(2,24)$=4.637, p=0.020, η^2=.279. Post hoc tests with Scheffe revealed that SC students (M=4.87, SD=1.68) found chemistry less difficult to learn than PC students (M=7.20, SD=1.32), p=0.020, d=1.59. However, there were no significant differences between SC and BC students (M=6.30, SD=1.70) or between PC and BC students. While the mean difference between the SC and PC groups in Question 3 ("How difficult is the content of chemistry?") just failed to reach statistical significance (p=.063), the large effect size of d=1.34 is certainly worth noting.

That there was no significant difference between prior chemistry experience groups in the mental effort required for chemistry was an unexpected finding and indeed conflicts somewhat with interview data. A high correlation between prior chemistry experience and speed and accuracy of study behaviour has been reported in the literature (Dochy, et al., 1999), and one would expect greater foundation knowledge to result in a higher speed of learning and a subsequent reduction in mental effort. Of course, the size of the interview cohort was small (N=27) and significant differences may have emerged had the group been larger. Interview data indicated that having prior knowledge in chemistry meant that, as mentioned in Chapter 6, the study load was reduced when a test was imminent, and research has shown a negative correlation between academic performance and time available for study (Harris, et al., 2004). This was revealed by some SC and BC students.

> Brett: And then when I started learning something towards the end I was like like, nuh, now I need to knuckle down … because at the beginning of the semester I sort of knew it, like, I don't really need to study, let's just go in there. Maybe I'll look over the formulas but I know how to use the formulas, I know the concepts. I'll go over the things I need to memorise. And then towards the end of the semester, towards the exam, I was like, well now I've actually learned something so now I need review, I need to actually more so try, um, with that. (*Individual Interview*)
>
> Simon: It took away a lot of hours of study.
>
> Soraya: … it just cut down the study.

Only SC students referred to procrastination when it came to studying for a test. While there were no doubt procrastinators in all prior chemistry groups, it appeared as though the SC students were still able to perform well enough to pass because the transfer of information into the long-term memory, which requires a significant amount of effort (El-Farargy, 2009), is enhanced if a substantial network of interconnected links on which attachment can occur already exists (A. H. Johnstone, 2000).

In summary, the responses of the various prior chemistry experience groups varied when aspects of reductivity were discussed. SC students found that the prior chemistry knowledge gained at school gave them the foundation to more easily process new concepts and consequently found the material less difficult to learn than the PC or BC students. In addition, they experienced little difficulty with the mathematical element of the course and moved with apparent ease between the macroscopic, microscopic and symbolic aspects of "the nature of chemistry" model. As a result, they were able to operate at the procedural level of problem solving, allowing them to achieve at a higher level. BC students were very positive about the role of the bridging course in providing a basic chemistry foundation.

7.6 Academic Performance and Perceptions of Chemistry

Focus group and individual interviews indicated that the strength of the connection made with the 'curriculum – chemistry' and the 'application of chemistry to the profession of nursing' not only have a relationship with self-efficacy and anxiety, but also learning and academic performance. In this section, findings from 'connection with the curriculum' category will be used to reveal insights behind the 'enjoyment of chemistry' item in the questionnaire, and the 'application to the profession' findings will help to create a more complete picture of the implications of the 'importance of chemistry to nursing' item.

Table 36 gives the Pearson product-moment correlations between academic performance and initial and final measures of perceptions of chemistry variables. It is interesting to note that measures of perception recorded at the beginning of the course gave little indication of final academic performance in Health Science I. However, correlations for both perception variables strengthened as the semester proceeded and were significant at T3.

Table 36. Pearson product-moment correlations between academic performance and 'perceptions of chemistry' variables

	Level of enjoyment when last studying chemistry		Importance of chemistry to nursing	
	initial	final	initial	final
Academic performance	.180	$.577^{***}$	-.082	$.437^{***}$

* *p*<.05, ** *p*<.01, *** *p*<.001

As a consequence of these significant correlations at T3, one-way ANOVAs were conducted to compare perceptions of chemistry means for academic performance groups. Means and standard deviations for both initial and T3 measures of 'enjoyment of chemistry when last studied' and 'importance of chemistry to nursing' are recorded in Table 63 and Table 64 in Appendix 31. No statistical differences between the academic performance groups in initial levels of 'enjoyment' were detected. Post hoc tests with Scheffe, however, showed that the low performance group (*M*=3.00, *SD*=0.86) felt initially that chemistry was more important for nursing than the average performers (*M*=2.44, *SD*=0.84), *p*=.030, *d*=0.66. There were no significant differences between the other groups. However, significant differences emerged for both enjoyment and importance by the end of the chemistry component of the course (ANOVA results reported in Table 65 in Appendix 31) and a discussion of these, along with interview data for enjoyment and importance, follows.

7.6.1 Enjoyment of Chemistry

Interviews showed that initial levels of enjoyment in chemistry were largely reflective of school incidents in science. As expected, a wide range of experiences was represented. Some students connected positively with the subject at school and their survey ratings reflected this.

> Pam: Well, it was a long time for me. I enjoyed the science part …
>
> Sandy: For me, … I was inspired to become a medical person, … so I was a science student, so I really enjoyed it.
>
> Samuel: … I've always liked science.

Many nursing students have described a strong dislike of science at high school (Andrew & Vialle, 1998) and amongst my interviewees, the number of students who had neutral (26%) or negative memories (52%) of school science outweighed those with positive experiences (22%). Some, like Paula, felt they had a "natural bent" towards humanities subjects.

> Paula: Yeh, and I just think generally, I sway more to humanities kind of subjects rather than science. We're all different I guess … I was more interested in like history …
>
> Brett: 'cause I didn't really click with chemistry in high school. I didn't like it.

For others, like Sonia, enjoyment was linked to the perceived level of difficulty.

> Sonia: I think when you're not good at something, you generally don't like it, but that's probably the reason … so I think, as soon as things started to get complicated [at school], I didn't really like it.

When a subject becomes difficult, students tend to dislike it and disconnect from it. This was certainly the case for SC students who struggled with senior chemistry at school.

However, as a result of studying Health Science I, many focus group participants indicated significant changes in their connection with chemistry.

> Brittney: but I quite enjoyed it so I'm kind of upset I didn't pick it at school.
>
> Pierce: But yeh, now it quite interests me.

Pippa: Like, "this is going to be so hard" but once we got into it, it was alright and I actually liked it.

Beth: I'd love to know what all that other chemistry is.
Bernice: Sometimes you'd say, "oh we don't need to go into detail with that because we don't need to know it," and I'd go, "Oh, I'd like to know that."

Beryl: and it's really nice to hear that we really appreciate it. You've opened these doors up.
Beth: That's how I feel.
Beryl: Where, my husband is so upset, he goes "don't mention chemistry."
All: *Laugh*
Beth: My children go, "oh mum you're such a bore."
Beryl: That's right.
Beth: I feel like the world has opened up so much wider, it's just incredible.
Beryl: How could you drop chemistry, it's sort of like, "how could you get pregnant?"
All: *Laugh*

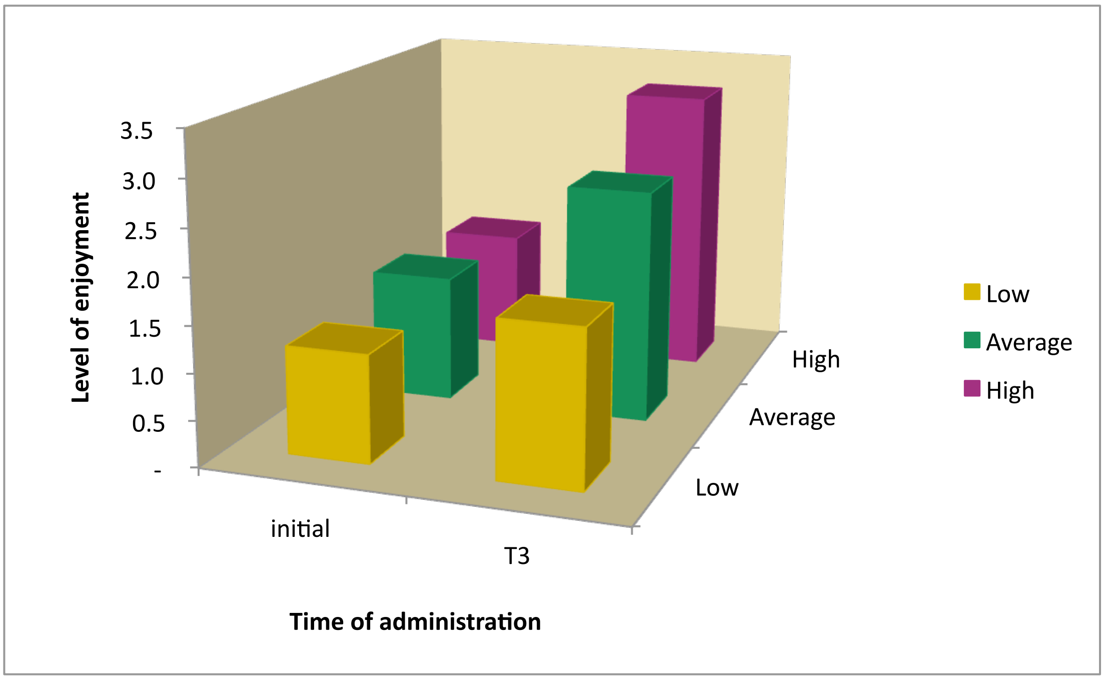

Figure 18. Changes in 'level of enjoyment when chemistry was last studied' based on academic performance groups

The strong connection with chemistry expressed by Beth and Beryl, and indicated by a rating of '4' on the enjoyment scale, translated into high academic performances. Indeed, post hoc tests with Scheffe showed high performers 'enjoyed chemistry in Health Science I' at a significantly higher level than both average

(p=.020, d=0.75) and low (p=.001, d=1.59) performers, and that average performers enjoyed the semester of chemistry more than low performers (p=.001, d=0.89) (see Figure 18).

Interview data showed that students did associate level of enjoyment with academic performance because it acted as a source of intrinsic motivation.

> Becky: I studied it because you made it fun,
> Bella: Yes, that's true.
>
> Beth: I was really excited to do chemistry - to learn something I've never learnt before, and as the course went I, I just got more excited.
>
> Becky: I was excited to challenge myself, and see how I could do …
>
> Bella: I actually enjoyed getting my chemistry book.
> Beth: So did I.
> Bella: It wasn't like anatomy, -
> Beth: It's the first book I pull out every night.
>
> Paul: I find the deep concepts of chemistry and stuff interesting. So that's more motivation to study and stuff.
>
> Pippa: I enjoyed it, so I wanted to learn it. (*Individual Interview*)

Research has shown that students who like chemistry tend to have a mental orientation of readiness for study (Cheung, 2009). On the other hand, students who do not enjoy chemistry find it difficult to spend time learning the subject. Although Paige's overall level of enjoyment ('4') correlated with her high academic performance, there were times of frustration for her, particularly in the early part of the semester, and this affected her motivation to learn at the time.

> Paige: So, I don't want to do chemistry because you just get frustrated and it's not fun.

Level of enjoyment is a factor which has been shown to be particularly influential on academic performance when little prior knowledge is present (Dochy, et al., 1999). This will be explored further in the following chapter.

When individual qualitative models were reviewed, 'connection with the curriculum – chemistry' was linked to academic performance for all participants. Despite a self-confessed general tendency towards procrastination, Samuel's enjoyment of the subject resulted in more effort, which increased his performance.

> Samuel: I'd say I studied chemistry a little bit more than other subjects, even though I probably didn't need to.

Interviewer: So that's coming back to … connecting with chemistry - because you enjoyed it.
Samuel: Yeh. (*Individual Interview*)

In contrast, Paula's lack of enjoyment (rated at '1') and connection with chemistry played a minor but negative role in her performance.

Paula: I think it [enjoyment] has some effect, most definitely … what you're passionate about you tend to do better in. (*Individual Interview*)

Sofia also identified the reciprocal link between performance and enjoyment:

Sofia: … so once I knew things, I was like, "oh, this is cool." Like, "I like this subject" and I pushed myself to learn more … you get good results and you start understanding things and it - it's just better. It's nicer to come to class. (*Individual Interview*)

Paired-samples t-tests were performed to determine how enjoyment changed as a result of studying chemistry in Health Science I. Results are recorded in Table 18 in Appendix 31 and illustrated in Figure 18. All academic performance groups experienced a statistically significant increase in 'enjoyment of chemistry' over the semester (low d=0.49, average d=1.12, high d=1.77). Further, ANOVA showed that the extent of the increase in enjoyment varied, $F(2,95)=5.900$, $p=.004$, $\eta^2=.110$. Post hoc tests using Scheffe showed that the increase in enjoyment for high achievers was significantly greater than that experienced by the low achievers, $p<.001$, d=1.03. Zusho et al. (2003) also conducted an ANOVA to determine if levels of interest changed in a general chemistry cohort based on performance groups, and found statistically significant differences. High achievers reported an increase, but in contrast to the findings outlined here, average achievers indicated no change, and low achievers reported a decrease. It should be noted, however, that the effect sizes of the changes (d=0.08, d=0, d=0.14) were very small casting some doubt on the meaningfulness of these changes. The small changes may partially be due to the fact that the first measure of interest was taken 10 weeks into the semester. It is unlikely that big changes in interest would occur between weeks 10 and 15.

While the Information Processing Model is largely cognitive and does not profess to deal with attitude and motivation, researchers in this area do recognise the role that conceptual overload can make to not only the development of attitudes to chemistry (A. H. Johnstone, 2006) but the way attitudes contribute to the perception filtering process and the manner in which information is handled (Jung & Reid, 2009). It has been shown that an inability to understand scientific concepts due to cognitive overload can generate dissatisfaction and disillusionment in the learner which may be reflected in a declining attitude towards the subject (Jung & Reid, 2009) accounting in part for the different levels of enjoyment in the various academic performance groups in this study.

7.6.2 Importance of Chemistry to Nursing

While some students rated the importance of chemistry as '4 - essential' at the beginning of the course,

> Paul: Nah, like I reckon it's pretty relevant to what we're doing … it's good that we're doing it. Yeh, I'm happy that we're studying chemistry because I think it's relevant to nursing.

many students had trouble making a professional connection with chemistry early in the semester.

> Interviewer: Did you ever think during the course that chemistry is really relevant to nursing?
> Bernice: Not when we started learning about it.
> Bella: Not at the start.
>
> Bronte: Well, I don't really think, well, at the beginning, I couldn't really grasp the concept of why we are doing chemistry for nursing.
> Brett, Bree: Yeh, mm.

However, as noted in the literature, when chemistry is presented in an integrated way to show its relevance to future nursing, student attitudes can change (El-Farargy, 2010; Fenton, 2010; Kyriacos, et al., 2005; Logan & Angel, 2011; Logan-Sinclair & Coombe, 2006). Focus group participants noted several specific nursing applications of chemistry mentioned throughout the semester: formulas and medications, concentrations, osmotic pressure/tonicity/IV fluids/oedema, urine analysis, pH levels, equilibrium and buffers, pathology, and blood gas levels. As students were presented with specific nursing examples, the relevance for many increased.

> Bronte: but now,
> Brett: Yeh
> Bronte: since we've been doing Anatomy & Physiology more
> Brittney: yeh
> Bronte: I understand more how important it is … to have chemistry with nursing.
> Brittney: You understand the chemical side to the body
> Bronte: The buffers. The pH levels. Yeh, so. Now it's all starting to fit into place.

Brett: Yeh, definitely when we started, I couldn't see any point of it. But, now I definitely do.

Despite these comments from Brett, Brittney and Bronte, none actually recorded an increase in relevance reported in the questionnaire from T1 to T3. Since the focus group interviews were held two weeks after the completion of the T3 questionnaire, students were possibly making a more reflective assessment of the importance of chemistry to nursing than what was possible in the heat of the moment of having just completed a relatively difficult chemistry topic at the time T3 was administered. This more reflective stance is further illustrated by the city bridging focus group:

Bernice: No, I was like why do we need chemistry in nursing? I now know why.
Beth: Oh, it's essential. You have to do chemistry.
Bella: I think I didn't understand it actually at first. I thought, oh, we need to know a bit of chemistry, but I didn't think it was that involved that we needed to know all that chemistry, but now that I do know it, I felt I can apply that bit there. It wasn't just, we were doing chemistry for no reason.
Beryl: I just don't see how you can do it [nursing] without it.
Beth: Nor can I. How can you understand …
Bernice: Maybe not as much as we learned, but I can see that we need it.
Beth: But you need to know that to understand buffers and equilibrium and
Bernice: Yea, true.
Beth: you just can't learn those things without the basics.

The nuances found in the preceding interchange show a difference in opinion on the degree of relevance of the level of chemistry studied in Health Science I. The strength of the comments is reflected in the questionnaire ratings given at T3 by each of the participants: Beth and Beryl '4' and Bella '2', with Bernice indicating a decrease from '3' to '1'. Other students also commented on the lack of relevance, particularly with respect to the depth of some of the chemistry.

Phebe: … I know it's like background knowledge and that's what you were kind of saying but I was like, aw, realistically, when are we ever going to use this on the ward like at work, like I'm never really actually going to use this … and then like I think that by the time, like once the three years is actually over, how much chemistry are we actually going to remember from the first seven weeks, if that makes sense?

Paula: I think the basic concept of what it does is important, but I don't know if our level, the level of chemistry that we've done is, that high is really necessary.
Paige: Agreed. Like, I've been working in aged care as well …and these people are fantastic nurses and know a lot of stuff, and I'm like, does

> any of this look familiar to you? And they're like, what is that? Like, general chemistry - I understand that definitely is required, but there's things in there that are really, really full on … and seem unnecessary.

Other research supports Paige's contention that some student nurses struggle with relevance when they speak to good nurses who say chemistry has no bearing on nursing practice (Singh, 1995).

By the end of the semester, ANOVA followed by Scheffe tests (see Table 65 in Appendix 31) showed that low achievers rated the 'importance of chemistry to nursing' at a significantly lower level than both average (p=.023, d=0.53) and high (p<.001, d=1.15) achievers, with no significant difference between the high and average groups (p=.120). This is represented in Figure 19. This is consistent with the findings of Caon and Treagust (1993) who found the low achieving first-year nursing students were less likely to perceive the relevance of science to nursing. In my study, 36.1% of the low achieving group saw chemistry as slightly useful at best, compared with only 12.5% of the average performers and 3.1% of the high achievers. Motivation to learn science can be influenced by belief in the relevance of the science studied to one's career (Glynn, et al., 2007). However, no significant correlation has been found between relevance of science to nursing and academic

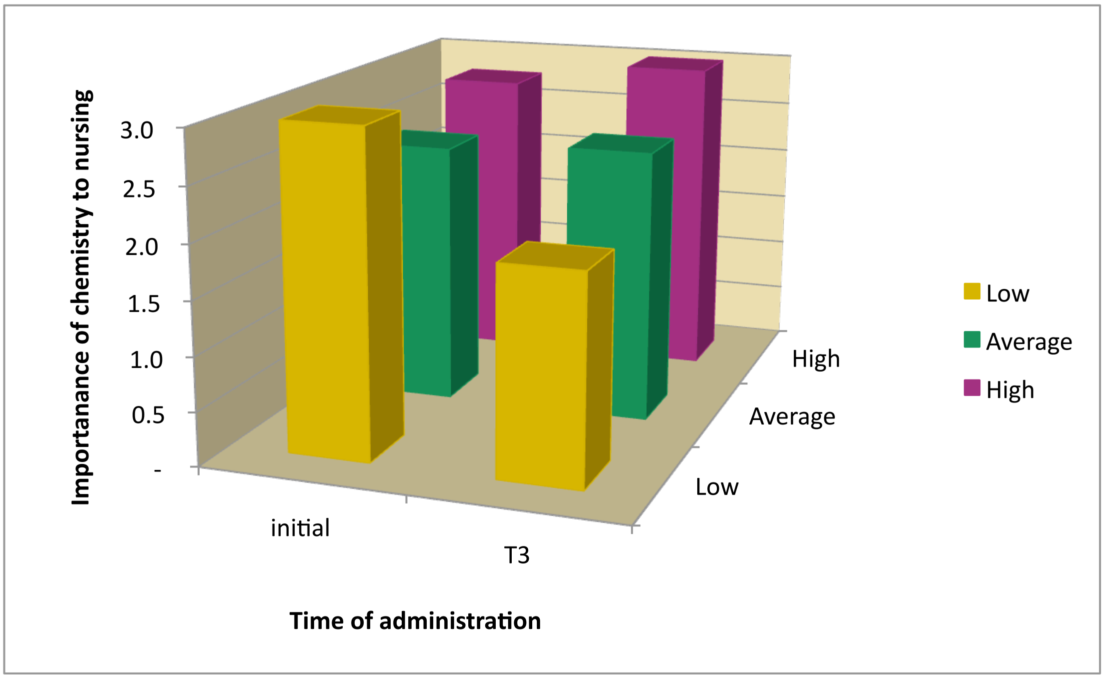

Figure 19. Changes in 'importance of chemistry to nursing' based on academic performance groups

performance by others (Jordan, et al., 1999).

The relevance of bioscience (of which chemistry is a component) to nursing has been widely reported in the literature. While some studies indicate students struggle to see its relevance (Thornton, 1997), it appears the majority of nursing students recognise at least some value in the inclusion of bioscience in the course (Andrew & Vialle, 1999; Davies, et al., 2000; Friedel & Treagust, 2005; Jordan, et al., 1999). In fact, a number of studies have found registered nurses recognise the importance of chemistry to clinical practice, providing knowledge and skills that allow them to increase their competency as patient advocates, particularly in rural settings (Fenton, 2010; Kyriacos, et al., 2005; Logan & Angel, 2011; Logan-Sinclair & Coombe, 2006). Furthermore, nursing students are less successful academically in subjects like bioscience when it is perceived to be less relevant to nursing (Andrew & Vialle, 1998; Caon & Treagust, 1993). The link between relevance, effort and academic performance was noted by Soraya.

> Soraya: At school … a lot of it [chemistry] just didn't make sense to me either, like it seemed really irrelevant to learn a lot of the stuff too, which annoyed me, so it means I didn't want to learn it.

The relative importance of chemistry to nursing can influence the amount of effort put into study.

> Interviewer: So, recognizing that [chemistry] is important …, does that influence you to put in more effort?
> Brittney, Brett, Bree: Yes, yes (*enthusiastically*)
>
> Brett: If I could see that it was directly related to nursing, I'd sort of keep it more in my brain. I'd be like, like it wouldn't be as superficial, I'd be like, I need to remember this point and I'd highlight that one and actually remember that point, yeh, remember that part. (*Individual Interview*)

In fact, Brett revealed in individual interview that 'confidence' and 'application to nursing' were the two most significant categories in relation to academic performance in his experience. It also became apparent that the motivation to study for some students came from the fear of incompetence resulting from lack of chemistry knowledge.

> Bree: I think a pass is good as well, except, I, I don't want to be in a hospital situation, and be like, "crap! I should have studied chemistry" and like you don't know -
> Bronte: what Kerrie was saying
> Bree: - and if you don't know things, you can kill someone.

Bronte: I think
Bree: That's what was driving me.
Bronte: the chemical imbalance on the haematology or something. You'd be like, I should have paid more attention in class.

Pierce: I thought it was kind of important. Cause, like, it is kind of like, even though the doctors give prescriptions, you got to get the amounts right and stuff. And if you give the wrong amount you can kill someone or not help someone …

Whilst it is true that perceived relevance of chemistry to nursing can impact 'effort to learn' and consequently academic performance, it may also be true that students will rate subjects which they find difficult and for which they demonstrate a low level of academic performance as low on the 'importance to nursing' scale. That is, the direction of the relationship could be reversed. For some students, poor past academic performance may diminish motivation to learn which results in less effort, leading to the belief that there is little relevance in what is being studied. For example, when Paige experienced difficulty and frustration in a tutorial, her response was to question the relevance of the material.

Paige: … And then I went to the first tutorial and it was really frustrating and lots of crying and screaming on the phone, "This is ridiculous. Why are we doing all this chemistry?" like, at my mum, and it's ridiculous.

When considering the 'importance of the study of chemistry to nursing', paired-samples t-tests indicated there was a significant decrease for the total cohort (d=0.31) and for the low achiever group (d=1.20) over the semester (see Table 64 in Appendix 31). In contrast, the increase reported by the average and high performers and illustrated in Figure 19 failed to reach statistical significance. This indicated that the large decrease in the low performance group was responsible for the decrease noted for the total cohort. A similar analysis has not been conducted in other studies using nursing cohorts, and results from general chemistry studies are somewhat conflicting. In one study, similar comparisons based on performance groups using task value for chemistry students showed a decrease for all students, with the low group experiencing the greatest decrease (d=0.76) (Zusho, et al., 2003). However, high performers showed an increase in 'relevance of learning chemistry to personal goals' in another study, possibly because enrolment in this class was connected to future career goals (Obrentz, 2011).

The result for the change in 'importance of chemistry to nursing' was confirmed by the response to the question 'To what extent has chemistry contributed to your competence as a nurse?' When divided into academic performance groups, ANOVA showed significant differences in responses between the groups (see Table 65 in Appendix 31). Post hoc tests with Scheffe indicated that both the average (*M*=2.41, *SD*=0.88) and high (*M*=2.72, *SD*=0.89) academic performance groups felt chemistry had contributed to their competence as a nurse to a greater extent than the low performers (*M*=1.64, *SD*=1.02) (*p*=0.004, *d*=0.80 and *p*<.001, *d*=1.12 respectively). There was no significant difference between the average and high achievers. To date, no studies have been found that have considered changes in 'importance of science to nursing' in different academic performance groups.

An interesting observation concerning the individual qualitative models is that those who placed a high level of importance on chemistry to nursing at T3 in the questionnaire (either '3' or '4') also linked 'application of chemistry to nursing' with academic performance (Pippa, Beth, Brett, Samuel). Neither Paula nor Sofia felt it played a direct role in their performance and recorded importance values of '1' and '2' respectively.

7.7 A Predictive Model for Academic Performance

Hierarchical regression analyses were used to investigate factors that could be used to predict academic performance in the chemistry component of Health Science I. This technique enables one to assess if the inclusion of a variable in a predictive model enhances the percentage variance explained in a dependent variable.

Several factors were taken into account when identifying the independent variables required to produce a parsimonious predictive model of academic performance for this study. Firstly, regression is best when independent variables have moderate to strong correlations with the dependent variable (Tabachnick & Fidell, 1996), so only those variables with *r* >.3 (Pallant, 2007) were considered. Secondly, in order to avoid multicollinearity, correlations between independent variables were checked to ensure *r* values were <.7 (Pallant, 2007). In addition, Tolerance and VIF[21] statistics were scrutinised to ensure values were within the accepted range: >.1 and <10 respectively (Pallant, 2007). Thirdly, the ratio of cases

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[21] Variance Inflation Factor, which is the inverse of Tolerance

to independent variables was also taken into consideration. Using the formula, N≥50+8*m* (*m* is the number of independent variables) as a guide (Tabachnick & Fidell, 1996), four to five variables could be considered a reasonable number for this sample. Finally, "theory is the best guide in selecting ... predictor variables", along with previous research evidence (Pedhazur, 1997, p. 197). Consequently, the following independent variables were selected for initial investigation: cognitive self-efficacy, test anxiety, Ravens Progressive Matrix[22], and prior chemistry experience. Note that Test 1 results were not included because it is a component of the overall academic performance, and correlates too highly with it, r=.928. The regression, then, considered predictors other than achievement in tests throughout the semester.

Preliminary analysis was undertaken to ensure no violation of underlying assumptions of normality, linearity and homoscedasticity. Both the normal probability plot of standardised residuals as well as the scatterplot of standardised residuals against standardised predicted values were inspected along with Mahalanobis and Cook's distances. The relevant graphs and values, along with decisions based on these, have been reported in Appendix 32.

Hierarchical regression analyses were conducted to assess what proportion of the variance in academic performance could be accounted for by motivational variables (CS and TA) beyond that already accounted for by cognitive readiness variables. Cognitive variables (Ravens Progressive Matrix scores and Prior Chemistry Experience) were entered in Step 1, and explained 23.9% of the variance in academic performance. Initial measures of CS and TA were entered at Step 2, but did not account for a statistically significant increase in variance. Finally, T3 measures of CS and TA were entered, explaining an extra 20.4% of the variance, resulting in a model that explained a total of 47.5% of the variance in academic performance. The relevant statistics associated with the multiple regression for academic performance are recorded in Table 37. Note that adjusted R^2 values are reported due to the relatively small sample size (N=84) (Pallant, 2007). In the final model, only CS3 (β=.407, t=2.976, p=.004) and TA3 (β=-.322, t=-2.483, p=.015) were significant predictors.

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[22] Only 86 students completed the RPM, so the inclusion of RPM in the regression meant only the data from these students were used.

Table 37. Standardized regression coefficients of variables predicting academic performance (*N*=84)

Variables predicting academic performance	Model 1	Model 2	Model 3
Step 1			
RPM	.390***	.369***	.072
Prior chemistry experience	.246*	.160	.085
Step 2			
CSi		.215*	.016
TAi		-.088	.058
Step 3			
CS3			.407**
TA3			-.322*
Total adjusted R^2	.239	.274	.475
R^2 change	.257	.052	.204
F change	13.843***	2.943	15.912***
p (for *F* change)	<.001	.059	<.001
df(1,2)	2,80	2,78	2,76

* *p*<.05, ** *p*<.01, *** *p*<.001

Path analysis is appropriate when "hypothesized relationships have strong theoretical and empirical support" (Pajares & Kranzler, 1995, p. 431). In this study, social cognitive theory has framed the selection of appropriate variables. Measures of CS and TA were each considered as dependent variables in order to build a path model. Standardized coefficients and other significant data for these hierarchical regressions are recorded in Appendix 33. When CS3 was assigned as the dependent variable, RPM (β=.406, *t*=5.042, *p*<.001) and CSi (β=.527, *t*=6.083, *p*<.001) were the only two significant variables, accounting for 50% of the variance in CS3. TA3 was then made the dependent variable and RPM was again predictive (β=-.409, *t*=-4.787, *p*<.001), along with TAi (β=.429, *t*=5.013, *p*<.001), accounting for 44.4% of the variance in TA3. Prior chemistry experience was the only variable to significantly predict CSi (β=.402, *t*=3.857, *p*<.001) and contributed to 14.9% of the variance. There were no significant predictors of TAi.

A path diagram depicting the progressive relationship between the variables is presented in Figure 20.

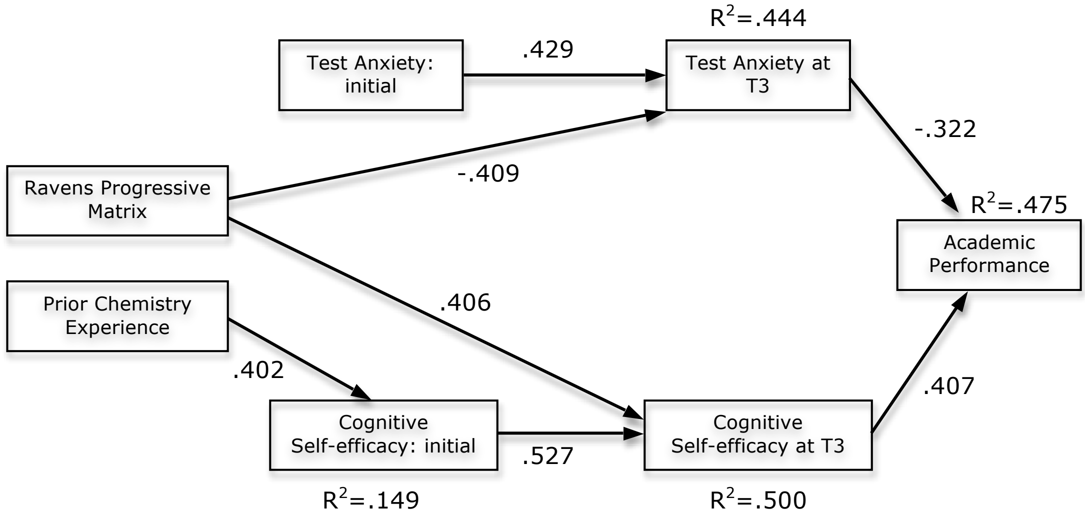

Figure 20. Path diagram derived from hierarchical regressions depicting significant relations among key variables

When comparing these multiple regression results with other studies, it is important to remember that "a regression solution is extremely sensitive to the combination of variables that is included in it" (Tabachnick & Fidell, 1996, p. 132). However, a number of studies have entered some type of cognitive ability, such as high school achievement or SAT-maths, at step 1 of a hierarchical regression in order to determine a predictive model for academic performance in tertiary science (McKenzie & Schweitzer, 2001; Obrentz, 2011; Seery, 2009; Zusho, et al., 2003) These studies found measures of cognitive aptitude accounted for between 17 and 40% of the variance in academic performance. Given the range of measures of ability used in these studies, the 24% (Model 1 in Table 37) found in my study compares favourably. When followed by measures of motivation, self-efficacy was also found to be a significant predictor beyond cognitive ability (McKenzie & Schweitzer, 2001; Obrentz, 2011; Zusho, et al., 2003), with standardised β coefficients of up to .40 reported, again, comparable with my study.

In contrast to self-efficacy, little research has incorporated anxiety in a multiple regression model for academic performance. In the Obrentz study (2011), assessment anxiety only became a significant predictor, in addition to SAT-maths, self-efficacy, effort regulation and prior chemistry experience, when measured at the end of the semester. Even then, its predictive strength was lower than chemistry self-efficacy (β=.13 vs β=.34). In other studies, it has proved to be nonsignificant (Britner & Pajares, 2006) or a very weak predictor, β=-.095 (Pajares & Kranzler, 1995). When Pajares and Miller (1994) performed a path analysis for academic performance in tertiary problem solving in maths, test anxiety was removed from the analysis due to multicollinearity with self-efficacy (*r*=-.87). Interestingly, Zeegers (2004) found neither test anxiety nor self-efficacy for academic skills predictors of academic performance for first-year science students using structural equation modelling. However, the fact that GPA for the whole year was used as the measure of academic performance and domain specificity was lacking in the instruments used could account for the lack of direct predictive power. Further, numerous variables that considered various approaches to learning were also included and it could be that these have greater direct predictive strength than anxiety and self-efficacy in that setting.

Measures of cognitive ability form the backbone of many predictive models for academic performance (Tai, et al., 2006). While numerous studies in science and maths education have revealed such variables to be the strongest predictor of academic performance (Dalziel & Peat, 1998; Lau & Roeser, 2002; McKenzie & Schweitzer, 2001; C. Mills, et al., 2009; Obrentz, 2011; Ozsogomonyan & Loftus, 1979; Tai, et al., 2006; Whyte, et al., 2011; Xu & Lewis, 2011), placing cognitive ability above self-efficacy (Lau & Roeser, 2002; Lawson, et al., 2007; Obrentz, 2011), others concur with the finding in my study that place the predictive strength of motivation constructs above cognitive ability measures (Brown, et al., 2008; Pajares & Kranzler, 1995; Zusho, et al., 2003). This apparent discrepancy may partially be addressed by the findings of Lau and Roeser (2002) who constructed academic performance path analysis models using hierarchical multiple regression. They found that the relative contributions of cognitive and motivational factors depended on the type of assessment used to measure science performance. When test scores were used rather than grades, the contribution of general ability was greater, while the contribution of self-efficacy remained fairly steady. It should be noted, however, that the cognitive ability variable was derived from four different measures, arguably making it a more robust representation of ability than that used in some other studies. In my study, the small level of discrimination produced by the standard RPM test as a measure of cognitive capacity may have contributed to the diminished predictive effect of cognitive ability for academic performance. When Pajares and Kranzler (1995) used the advanced RPM as a measure of cognitive ability in high school maths students, they found its predictive ability (β=.32) to be as strong as maths self-efficacy (β=.35) in mathematics performance.

While not directly predictive of academic performance, RPM was predictive of both CS3 and TA3, a finding confirmed by Pajares and Kranzler (1995). Others have also shown that self-efficacy mediated the effect of ability on academic performance (Brown, et al., 2008; Chacko & Huba, 1991; Lau & Roeser, 2002). It was somewhat surprising to find that RPM played no predictive role in initial measures of self-efficacy and anxiety. However, when the model was presented in individual interviews, participants unanimously suggested that students were unaware of their cognitive ability in chemistry early in the semester. As the semester progressed, they were able to evaluate their ability.

> Pippa: … everything is new at the beginning, so you don't know. Like for me, 'cause I'd never done chemistry before so I had no idea. Then once I realised that I could do it, I was getting things right and was able to do it and my ability was, well, then that related. (*Individual Interview)*

In this study, cognitive self-efficacy mediated the impact of prior chemistry experience on academic performance to the extent that experience was not a significant direct predictor of academic performance in this model (see Appendix 34 for direct and indirect path effects). Yet, several studies have included some measure of prior knowledge in a regression analysis and found it to contribute directly to academic performance (Hailikari & Nevgi, 2009; Harris, et al., 2004; Ozsogomonyan & Loftus, 1979; Tai, et al., 2006; Whyte, et al., 2011). However, none of these studies included a measure of either self-efficacy or anxiety in the regression. Where self-efficacy has been included, findings concur with this study, and indicate that even if high school chemistry was a significant predictor, it was not as strong as chemistry self-efficacy, even if self-efficacy was measured early in the semester (Obrentz, 2011; Smist, 1993). In fact, no studies were found that placed the predictive power of prior knowledge (e.g. completing senior high school science course) above self-efficacy. When individual interviewees were asked to comment on the position of prior chemistry experience in the path model, Paula, Brett and Samuel expressed surprise, suggesting they expected it to play a more direct role. When asked how well the model reflected her experience, Paula noted that this aspect would have been different for her:

> Paula: I think it pretty much is, but I think the prior [chemistry experience] would have been different for me. I think it would have helped my academic, it would have helped directly. (*Individual Interview*)

However, Beth felt its position in the model was reasonable.

> Beth: No, that's right, there wouldn't [be a direct effect]. Because you could have done it beforehand and still not be confident, hated it and still won't do well. (*Individual Interview*)

This view was echoed by Sofia, who felt her bad school experience with chemistry limited the predictive effect on academic performance. The only direct predictive effect of prior chemistry experience in this study was on initial CS. It appears that the effect of prior knowledge on academic performance may be mediated by other factors included in the regression model. When Seery (2009) included semester test marks in the final step of his yearly academic performance regression model, prior chemistry knowledge ceased to be a significant predictor, probably because prior knowledge correlated strongly with semester test marks.

According to social cognitive theory, prior knowledge or capabilities can be poor indicators of performance because behaviour is powerfully influenced by beliefs held about the degree of prior knowledge, ability, difficulty and possible outcomes of effort (Bandura, 1997; Pajares, 1996). As such, "perceived self-efficacy mediates the effect of causal attributions" on academic performance (Bandura, 1997, p. 125).

Overall, it is clear that the inclusion of motivation variables such as self-efficacy and anxiety in a path model affords further insights into the prediction of academic performance, beyond those provided by cognitive capacity and prior chemistry experience, both of which failed to demonstrate any direct effect.

7.8 Summary of Academic Performance Findings in the Context of the Research Questions

Research Question One asked, "What role do demographic variables play in … academic performance?" Statistically, no relationship was found based on gender or age. In addition, very few interview comments were made in reference to learning with either of these variables. However, a small, negative correlation was found with work hours indicating academic performance was hindered by an increasing number of work hours.

Research Question Two asked, "How [do] … student perceptions of chemistry change over the course of the semester?" While minimal differences existed between academic performance groups at the beginning of the semester, final correlations between academic performance and perceptions were quite strong. Surprisingly, enjoyment for chemistry increased for all academic performance groups, not just for the high achievers as reported in the literature. However, the high achievers did experience a greater increase than the average achievers, who in turn, experienced a greater increase than the low achievers and these differences appear to be related to the perceived degree of difficulty. When the importance of chemistry to nursing was considered, the low achievers reported a decrease in relevance over the semester and were more likely to perceive chemistry as less relevant and contributing less to their competence as a nurse than the average and high achievers. The latter groups reported non-significant increases in importance of chemistry to nursing. Interview data revealed a positive relationship between relevance and effort.

Research Question Three stated, "What relationships can be established between self-efficacy, anxiety, prior chemistry experience and academic performance?"

Academic performance and prior chemistry experience Correlational, ANOVA and chi-squared data all support the notion that students with more prior chemistry experience perform better academically. SC students had statistically higher means than both BC and PC students. It could be argued that the superior performance of the SC group was due to higher academic capacity. However, ANOVA evidence suggests the differences in performance were more likely attributed to prior experience since a comparison of RPM scores failed to show any significant difference. The finding that a statistically significant correlation between prior chemistry experience and academic performance was only found for the low RPM group suggests that students with higher cognitive capacity are better able to overcome a lack of prior knowledge in chemistry, a subject where higher level reasoning skills are required. Indeed, aspects of the nature of chemistry itself played a substantial role in the learning experience of first-year nursing students. Students with prior experience had little difficulty with the unique language and representations of chemistry and generally enjoyed the logical and mathematical nature of the science domain. In turn, the study load for these students was reduced and less effort required. In contrast, many PC students struggled to reduce the complexities of chemistry and experienced difficulties navigating between the three aspects of chemistry (macro, sub-micro and representational), identifying a lack of foundation knowledge as a serious barrier to learning. Consequently, cognitive overload precipitated frustration.

The predictive model: self-efficacy, anxiety and academic performance Scores obtained in Test 1 and Test 2 were found to be the strongest predictors of academic performance based on Pearson product-moment correlation. However, all levels of analysis (i.e. correlational, ANOVA and multiple regression) revealed that the non-cognitive motivation variables of self-efficacy and anxiety were more potent predictors of academic performance than both demographic and cognitive capacity variables. In order to assess the ability of these statistically significant variables to predict academic performance, hierarchical multiple regression was applied. Cognitive variables RPM and prior chemistry experience entered in Step 1 explained 24% of the variance in academic performance, with CS3 and TA3 explaining an additional 20.4%. Overall, the model accounted for 47.5% of the variance in academic performance. In order to consider the indirect effects of significant variables, a path model was constructed. The model supported findings from previous research that indicted the mediatory role of self-efficacy for prior chemistry experience when predicting academic performance. Furthermore, the predictive effect of RPM was also largely indirect but mediated by both CS3 and TA3.

Research Question Four asked, “To what extent has a 3-day bridging course been beneficial to nursing students studying Health Science I?” Despite the BC group having a higher mean academic performance than the PC group (54.2 vs 46.6), this failed to reach statistical significance. Even so, when the distribution of scores in academic performance groups was examined based on prior chemistry experience, 52.3% of PC students were in the low performance group compared with only 33.3% of the BC students, and PC students were less likely to appear in the high performance group, both representing statistically significant differences. For the BC students, the bridging course played an important role in equipping them with some skills required for learning chemistry.

The following chapter focuses on the bridging course, identifying additional benefits of the course and considers the extent of its merit for nursing students with poor chemistry background.

8 THE BRIDGING COURSE

Chapter Overview

Previous chapters have considered various aspects of the bridging course in the context of self-efficacy, anxiety and academic performance. This chapter begins with a brief summary of those findings then considers differences in 'perceptions of chemistry' based on prior chemistry experience groups. Other aspects of the bridging course are then considered. Finally, implications for conducting future bridging courses will be highlighted as the discussion of the fourth research question is completed.

8.1 Summary of Findings to This Point

Chapters 5 to 7 have already contributed to **Research Question Four** which asks, "To what extent has a 3-day bridging course been beneficial to nursing students studying Health Science I?" and a summary of these main points follows. While the bridging course significantly increased the level of cognitive self-efficacy of attendees to a level comparable to SC students at the beginning of the semester, it appeared that it did little to allay chemistry test anxiety. However, focus group data showed that participants were generally less anxious early in the semester when compared with PC students, largely due to a reduction in cognitive load. Furthermore, there was a significant decrease in TA over the semester for BC students, which was not the case for PC students. In relation to academic performance, score distributions showed that the BC students were less likely to appear in the low performance group compared with PC students.

8.2 Prior Chemistry Experience and Perceptions of Chemistry

Descriptive statistics for perceptions of chemistry based on prior chemistry experience are recorded in Table 38 and illustrated in Figure 21 and Figure 22.

ANOVA tests were conducted to determine if 'levels of enjoyment' and 'importance of chemistry to nursing' differed between prior chemistry experience groups at T2 and again at T3. In addition, paired samples t-tests were used to determine if any change had occurred over the semester.

Table 38. Means (and standard deviations) for 'perceptions of chemistry' at T1, T2 and T3 based on prior chemistry experience groups

Perception of chemistry		PC	BC	SC
Level of enjoyment since last studying chemistry[a]	T1		0.39 (0.76)	
	T2	1.48 (0.89)	2.13 (0.99)	2.04 (1.18)
	T3	2.34 (1.10)	2.29 (1.27)	2.77 (0.82)
Importance of chemistry to nursing[b]	T1		2.77 (0.88)	
	T2	2.80 (0.90)	2.58 (0.85)	2.60 (0.82)
	T3	2.43 (1.02)	2.32 (1.01)	2.65 (0.94)

a. '0'= hated it, '4'=loved it   b. '0'=not at all, '4'=essential

8.2.1 Level of Enjoyment of Chemistry and the Bridging Course

A paired samples t-test showed a substantial and significant increase in the 'level of enjoyment of chemistry' as a result of attending the bridging course, $t(30)=7.371$, $p<.001$, $d=1.97$. The very low T1 mean for enjoyment occurred because 73% of bridging course attendees indicated they hated chemistry when they last studied it, most likely at school. Indeed, Figure 21 highlights the significant differences revealed by ANOVA at T2, $F(2,95)=4.536$, $p=.013$, $\eta^2=0.09$. The bridging course allowed attendees to begin the semester (T2) with a more positive perception of chemistry than the PC students, $p=0.027$, $d=0.70$, placing them at a comparable level to the SC students.

As a result of studying chemistry in Health Science I, paired samples t-tests showed that both the PC and SC students reported statistically significant increases in 'enjoyment of chemistry', $t(41)=4.184$, $p<.001$, $d=0.81$ and $t(24)=3.368$, $p=.003$, $d=0.72$ respectively. The slight increase in enjoyment during the semester for BC students failed to reach significance.

By the end of the chemistry component of the course, and despite SC students having a higher mean, ANOVA showed no significant differences in 'enjoyment' between any of the prior chemistry experience groups ($p=.197$). This is supported by previous research that showed no significant correlation between prior knowledge and the level of interest expressed in the second semester of a general chemistry course (Seery, 2009).

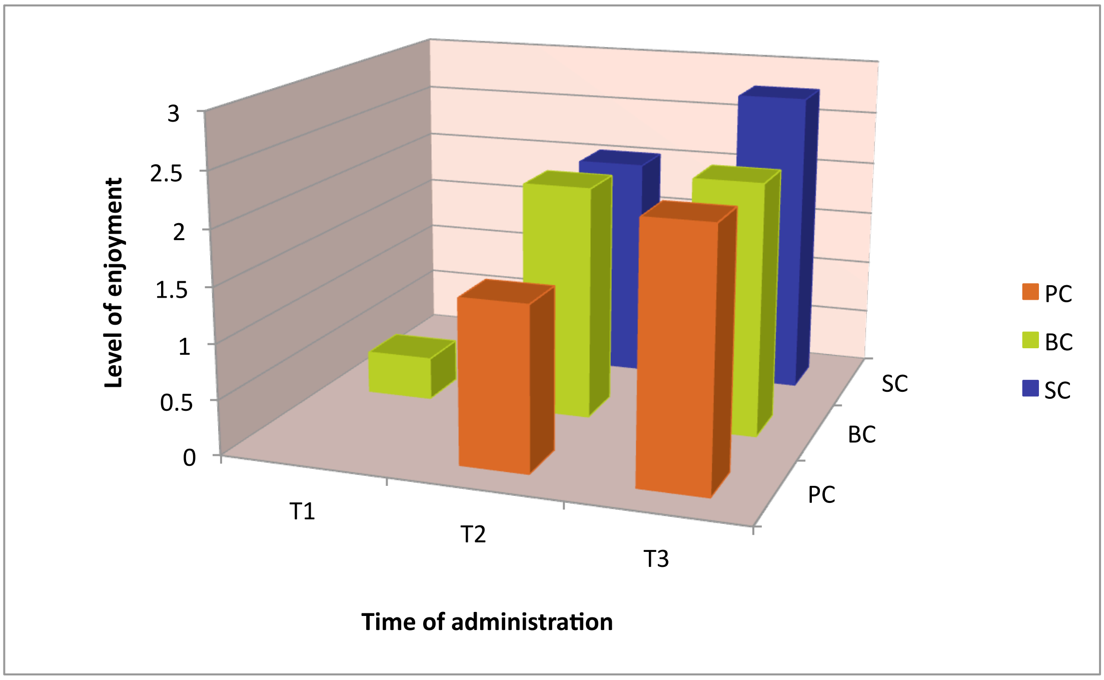

Figure 21. Changes in 'level of enjoyment when chemistry was last studied' based on prior chemistry experience

8.2.2 Importance of Chemistry to Nursing and The Bridging Course

Pearson product-moment correlations failed to show any significant relationship between prior chemistry experience and 'importance of chemistry to nursing' and paired samples t-tests showed that the small changes in this perception over time illustrated in Figure 22 failed to reach significance. Since the bridging course was designed to introduce basic chemistry concepts using everyday analogies with little emphasis on the nursing context, it was not surprising to find no change in perception of 'importance' after attending the bridging course. Beth, however, was an exception to this trend (going from '2' to '4') and was asked about her quantitative responses during her individual interview.

> Beth: Because in the bridging course, you could see the application by what we were learning. So, of course the application would have risen, unless you weren't paying attention … The chem. we were learning, surely you saw the connection with nursing. (*Individual Interview*)

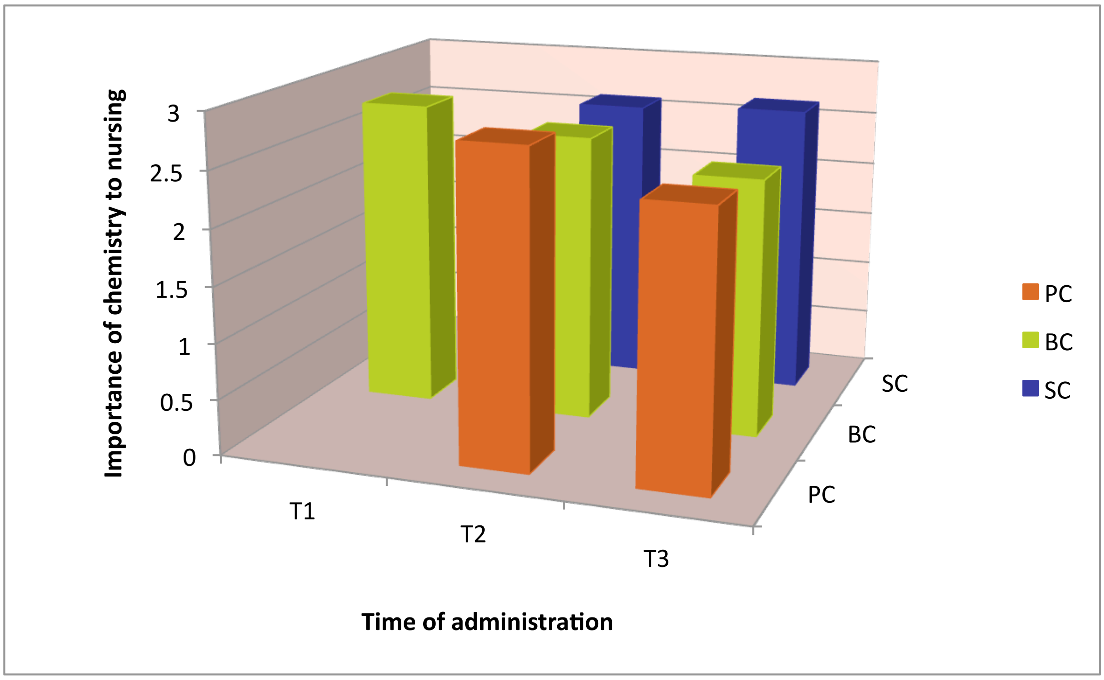

Figure 22. Changes in 'importance of chemistry to nursing' based on prior chemistry experience

8.3 Other Aspects of the Bridging Course

8.3.1 Bridging Course Survey Results

There were 31 participants in the 3-day bridging course in 2011: 14 at the rural campus and 17 at the city campus. Three failed to complete the survey form distributed at the end of the bridging course. In order to gain further insight into the experiences of students over the 3 days, students were asked to complete a feedback form at the end of the bridging course. Responses from 28 participants are summarised in Appendix 36.

Student responses for 'the degree of helpfulness of various aspects of the bridging course' are illustrated in Figure 23. It is clear that students found lectures, tutorials and connecting with other students the most valuable aspects of the course. Eighty-five point seven percent found the 'lectures' and 'tutorials' to be either very or extremely helpful, and 89.3% reported 'connecting with students' to be very or extremely helpful. 'Social interaction' emerged as an important category from focus group interviews on both campuses.

Bella: And you made friends too, you actually made friends over the three days.

All: *agree*
Bella: It just made everything so much easier.
Beth: Yes, it did, didn't it.

Indeed, when asked what was most helpful about attendance, some focus group interviewees placed the value of peer connection above foundation knowledge.

Brittney: I think just meeting people before you actually started.
Brett, Bronte: Yeh (*strong agreement)*.
Brittney: That helped me because I didn't know anybody, so that helped me heaps.
Brett: Yep, that was really -
Brittney: To meet people before we actually started, that was probably the biggest thing for me anyway.

Feedback reported from other orientation/bridging courses reported in the literature reveals that the establishment of peer connections is an important positive outcome from course attendance (Boelen & Kenny, 2009; Chevalier, et al., 2001; Fleming & McKee, 2005; Wischusen & Wischusen, 2007).

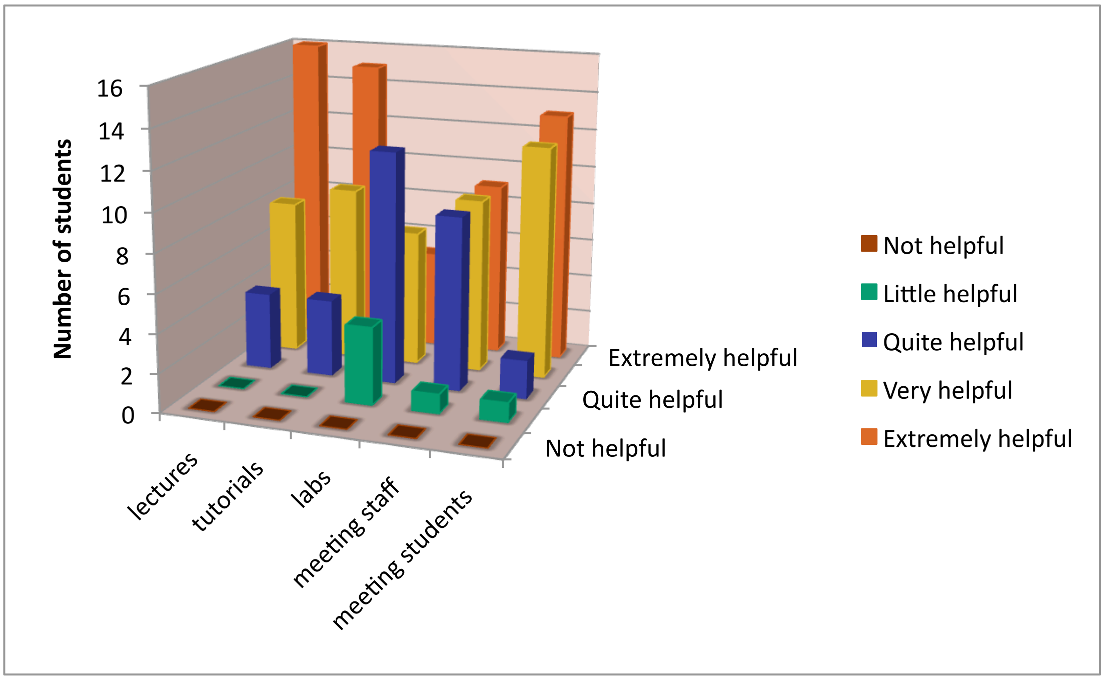

Figure 23. Student responses to the level of helpfulness of various aspects of the bridging course

As a result of attending the bridging course, 92.8% reported an increase in confidence in chemistry on the post-bridging course survey, a statistic supported by the changes in self-efficacy noted when comparing the T1 and T2 CS means. This supports confidence findings obtained from both the questionnaire and interview data from other similar types of bridging programs (Boelen & Kenny, 2009; Schmid, et al., 2012; Wischusen & Wischusen, 2007; Youl, et al., 2005). Sixty-four point two percent revealed that general anxiety levels towards chemistry had decreased.

An increase in interest in nursing was reported by 42.9%, with 46.4% indicating the bridging course made no difference to their interest levels. These results are illustrated in Figure 24.

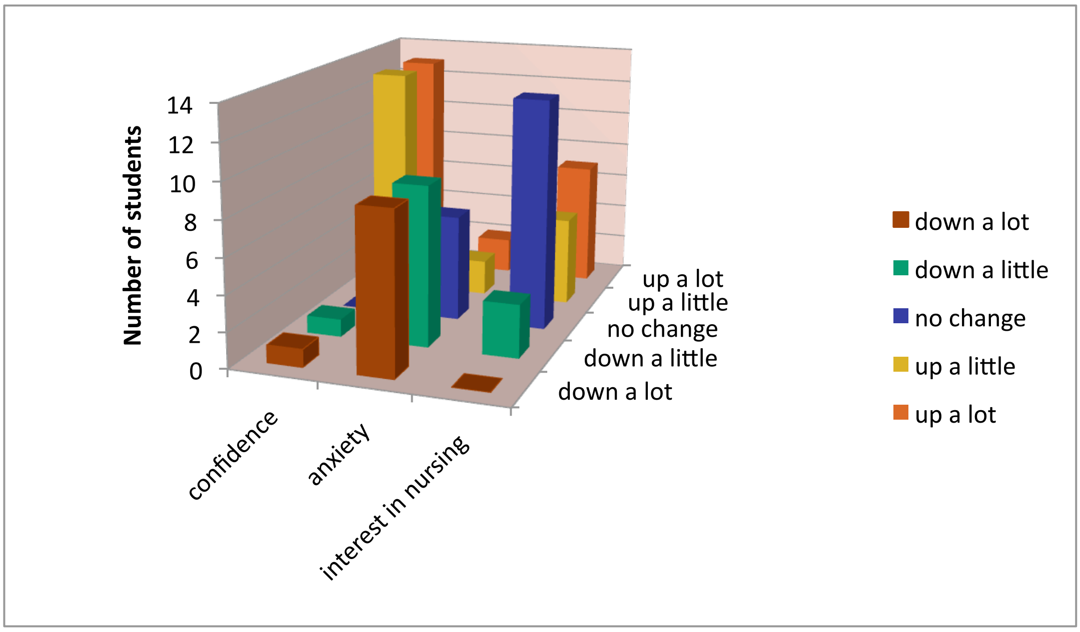

Figure 24. Changes in confidence, anxiety and interest in nursing as a result of attending the bridging course

8.3.2 Differences Based on Campus – The Effect of the Presenter

While lectures, tutorials and laboratories were led by the researcher on both campuses for Health Science I, this was not the case for the bridging course. Consequently, independent t-tests were conducted to determine if any differences in responses to the questionnaire, post-bridging course feedback survey and pre/post-test results arose based on campus for bridging course attendance.[23]

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[23] Recall from Section 3.3.1 that there were no significant differences (apart from age) in demographic and cognitive variables (i.e. RPM and academic performance) between campuses.

Self-efficacy, anxiety and perceptions of chemistry Independent samples t-tests showed no significant difference between campuses in dimensions of CNSS, CNAS and perceptions of chemistry items at T1 or T2.

Bridging course survey The distributions of responses for the bridging course feedback survey based on campus is recorded in Table 69 and Table 71 in Appendix 36. Mean scores for each campus are illustrated in Figure 25.

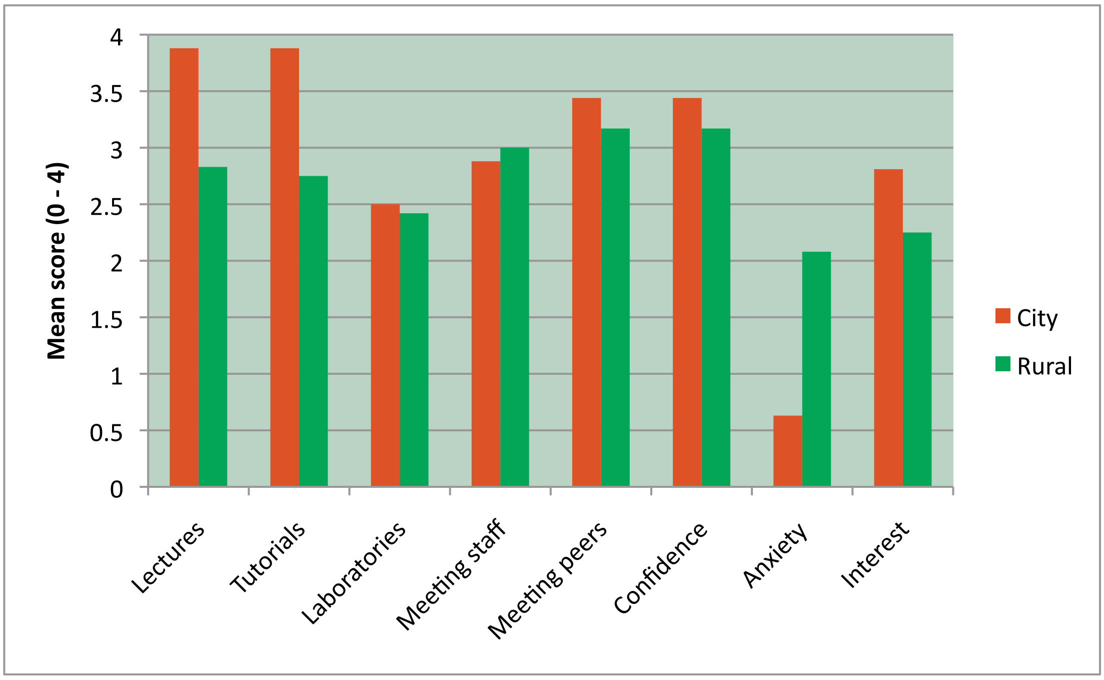

Figure 25. Bridging course survey results: means for the eight items based on campus

When independent samples t-tests were conducted to compare campus responses, significant statistical differences were noted for three of the eight items and these are recorded in Table 39. Compared with the rural campus, students who attended the bridging course on the city campus found the lectures and tutorials more helpful. In addition, the bridging course helped to abate general anxiety levels on the city campus to a greater extent than on the rural campus.

Pre- and post-test results All bridging course attendees completed the 10-question multiple-choice pre-test (found in Appendix 35) which was given at the beginning of the first session of the course. Results from the administration of the test at the end of the course were unavailable for six students. A paired-samples t-test was conducted to evaluate the impact of the bridging course on students' post-

Table 39. Significant differences between campuses for items on the bridging course survey

Item	City (SD) *N*=16	Rural (SD) *N*=12	Mean difference	df	*t*	*p*	*d*
1. Helpfulness of lectures	3.88 (0.34)	2.83 (0.72)	1.05	14.74[a]	4.648[a]	<.001	1.96
2. Helpfulness of tutorials	3.88 (0.50)	2.75 (0.45)	1.13	26	6.132	<.001	2.36
7. Extent to which anxiety changed[b]	0.63 (0.89)	2.08 (1.08)	-1.45	26	-3.921	.001	1.49

a. Levene's statistic was significant, equal variances not assumed.

b. Scores less than 2 represent a decrease in anxiety, 2 indicates no change, scores higher than 2 represent an increase.

test scores and indicated that there was a large and statistically significant increase in scores from the beginning of the course (*M*=2.84. *SD*=1.25) to the conclusion (*M*=7.40, *SD*=2.14), *t*(24)=10.19, *p*<.001, *d*=2.69. This trend was observed across both campuses. While an independent samples t-test showed no difference between campuses on the pre-test, (*p*=.239), this was not the case for the post-test, where city students (*M*=8.38. *SD*=1.59) had statistically higher scores than the rural students (*M*=6.67, *SD*=1.50), *t*(23)=2.633, *p*=.015, *d*=1.10. See Figure 26.

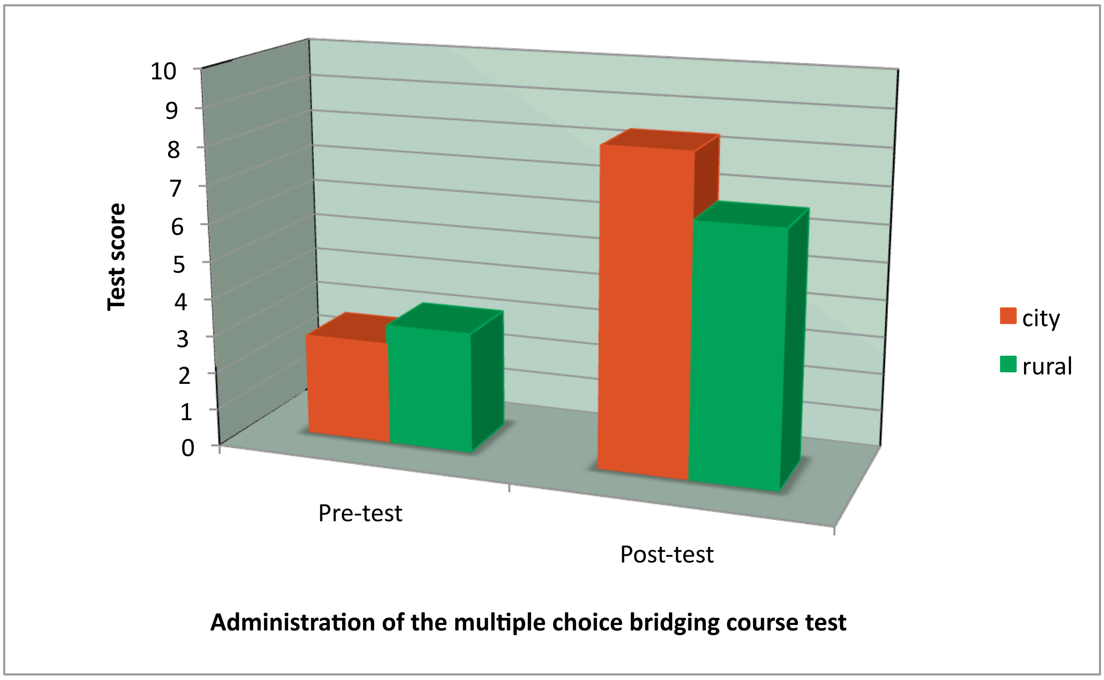

Figure 26. Mean pre and post-test scores for the bridging course, based on campus

Overall, the city campus bridging course attendees found lectures and tutorials more helpful, experienced a greater reduction in anxiety and had a higher post-test mean score than the rural group. A discussion of possible reasons for this follows.

The rural bridging course focus group was asked specifically to comment on their experiences in the bridging course. While most of the participants were positive about their overall experience, they did make some negative comments on aspects of course presentation. Two key notions related to 'connectivity' and 'reductivity' emerged that could help explain the significant differences between campuses.

Firstly, the proficiency of the presenter's 'exposition' skills influenced attendees' ability to connect with staff and engage in the learning process, illustrated by the following rural BC focus group excerpt:

> Bree: I think it was alright. I think if we possibly had, don't know how to say, like, a *better* teacher, not that he was bad or anything, but, the way he explained things, he'd just like, go, 'that's it'. It wasn't
> Bronte: thought out.
> Bronte: They didn't stay on one subject long enough.
> Bree: Yeah, for your brain to process it all.
> Bronte: It sort of, it was outlayed and then there was the answer at the end and
> Bree: the next
> Bronte: then they moved on to the next one. And go like blocks to get to the answer.
> Bree: Rather with you, like it was so much better because
> Brett: yeh, *laughing*
> Bree: Like everyone agreed, … I spoke to a lot of people about it and like, yeh, it's so much better with Kerrie.
> Interviewer: So, how different would your experience have been if I had taken the bridging course do you think? I mean, I know that's really hard to say.
> Bronte: I would have learnt a lot more.
> Brett: I would have really liked it.
> Bronte: I would have been able to take in and grasp a lot more.
> Bree: I think it's just because a lot of people feel more comfortable with you as well, rather than [presenter], because
> Brett: yeh …
> Bronte: … we had [tutor], and then he was contradicting what [presenter] was saying
> Bree: … Yep, and I was so confused then.

It should be noted, however, that one rural student wrote on the feedback form that the bridging course staff had been 'friendly, professional and helpful'. In contrast, 69% of the city students wrote unsolicited positive comments related to helpfulness, the quality of the teaching and how much they had enjoyed the course.

Secondly, rural students described how they felt unsupported in a number of ways. When a disturbance was occurring outside, staff failed to deal with it appropriately. In addition, organisational issues arose, particularly in relation to continuity of and support from teaching staff.

> Bree: It was annoying because [presenter] would come and go all the time -
> Brett: Yeh.
> Bree: and if we needed someone it was only one person and then we'd have to wait and, we never got our work done on time.
> Interviewer: OK. So there were some serious organizational issues there?
> Brett: Yep.
> Bree: So, maybe if they were there all the time or tried to be -
> Bronte: If they'd both been there, it would probably have been a little bit different.

The capacity of the presenter to explain for understanding and the need for students to feel supported influenced the ability of students to connect with personnel and engage in subsequent learning. Where the researcher intuitively took into account aspects of the Information Processing Model (A. H. Johnstone, 2006) when teaching, the less experienced presenter on the rural campus was less aware of the need to move slowly, provide scaffolding and use language and examples that students could relate to. This appears to be instrumental in the significant differences between campuses on perceived value of the lectures and tutorials. While a causal relationship cannot be established, it may have contributed to the significant difference in performance on the post-test.

8.3.3 T3 Final Questionnaire

During the last lecture of the chemistry component of Health Science I, students were invited to complete the T3 questionnaire (found in Appendix 9). Included on the last page were some Likert-type questions that students completed based on their prior chemistry experience group.

BC Student Reflections

Bridging course attendees were given an opportunity to reflect on the value of the bridging course in light of their chemistry experiences over the semester. Three questions were asked to assess the extent to which the bridging course was helpful.

Frequencies are recorded in Table 72 in Appendix 36 and represented graphically in Figure 27.

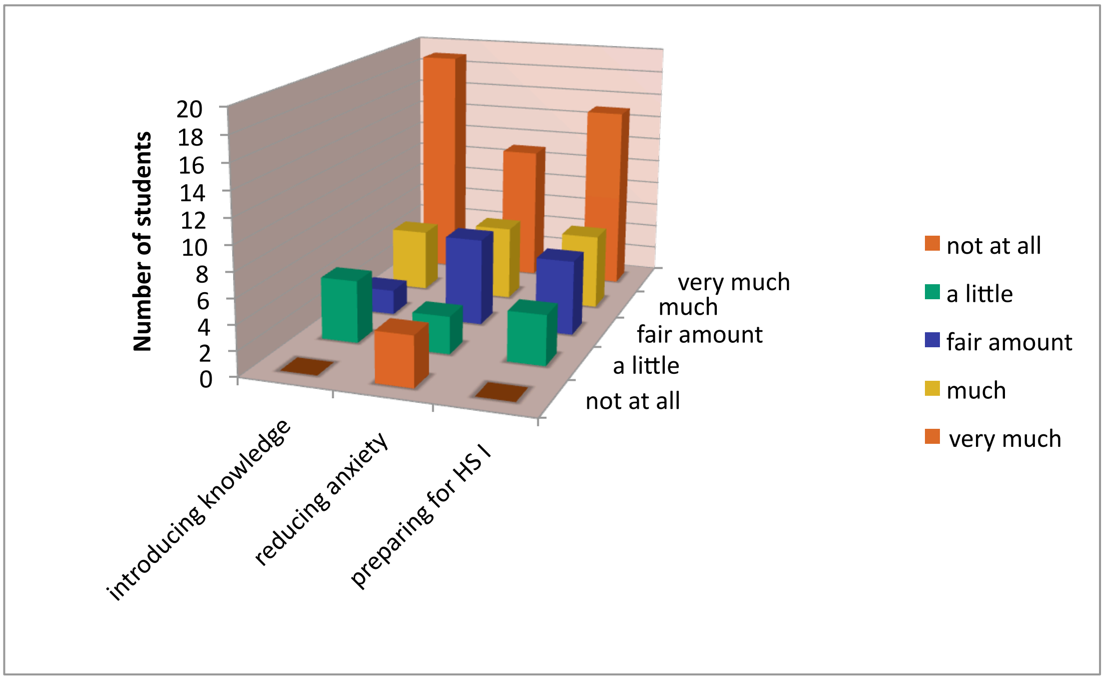

Figure 27. Student responses: the extent to which the bridging course was helpful in introducing knowledge, reducing anxiety and preparing for Health Science I (*N*=31)

Seventy-seven point four percent stated that the bridging course had helped either much or very much in introducing chemistry knowledge and 67.8% indicated it had helped either much or very much in preparing them for Health Science I. These percentages are similar to those obtained in other short bridging courses (Boelen & Kenny, 2009; Wischusen & Wischusen, 2007; Youl, et al., 2006). This strong endorsement for the bridging course was reflected in the interview data.

Brittney: It helped me heaps … I would have been so lost.

Bree: Doing the bridging course made it easier

Bella: I'd recommend it to everybody.
Beth: I think it's essential.
Becky: It's the reason I'm passing.

Beryl: And if I hadn't have done it, I would have felt that I'd already, like I'd come in late and not ever feeling that I was on the same page as everyone.

There were, however, some students who felt the bridging course was of limited assistance.

Bridget: … it was hard for me still, like, it didn't really help me much.

Fifty-four point nine percent of students felt it had assisted in reducing anxiety either much or very much. Note that this item did not specifically refer to chemistry test or laboratory anxiety, but rather anxiety in general. Chapter 6 has already demonstrated that TA was not reduced as result of bridging course attendance. Of the four students who felt it hadn't help to reduce general anxiety at all, two subsequently failed the course and the other two had very low anxiety levels to begin with.

There were strong correlations (r>.65) between the responses to the three questions in the questionnaire data, indicating that students who perceived the course to be helpful in introducing knowledge also felt it helped reduce anxiety and played an important role in preparing them for Health Science I. Interestingly, the only statistically significant correlation between academic performance and response to these items was for 'the extent to which the bridging course helped prepare for Health Science I', r=.398, p=.029, with better academic performance amongst those who felt better prepared for Health Science I as a result of bridging course attendance.

PC Student Reflections

In the T3 questionnaire, PC students were asked to comment on how helpful the bridging course could have been to them. Frequency distributions are recorded in Table 73 in Appendix 36 and illustrated in Figure 28. Approximately 67% felt that the bridging course could have been helpful by at least 'a fair amount', with approximately half expressing a strong desire for bridging course completion. There were strong, statistically significant negative correlations with academic performance for both questions - r=-.577, p<.001 for 'helpfulness', and r=-.614, p<.001 for 'desire to complete' - indicating that PC students who performed poorly were more likely to see the value of the bridging course. This was certainly the case for Pam, Paula, Paris, Polly and Phebe, all of whom were unaware that a bridging course was offered.

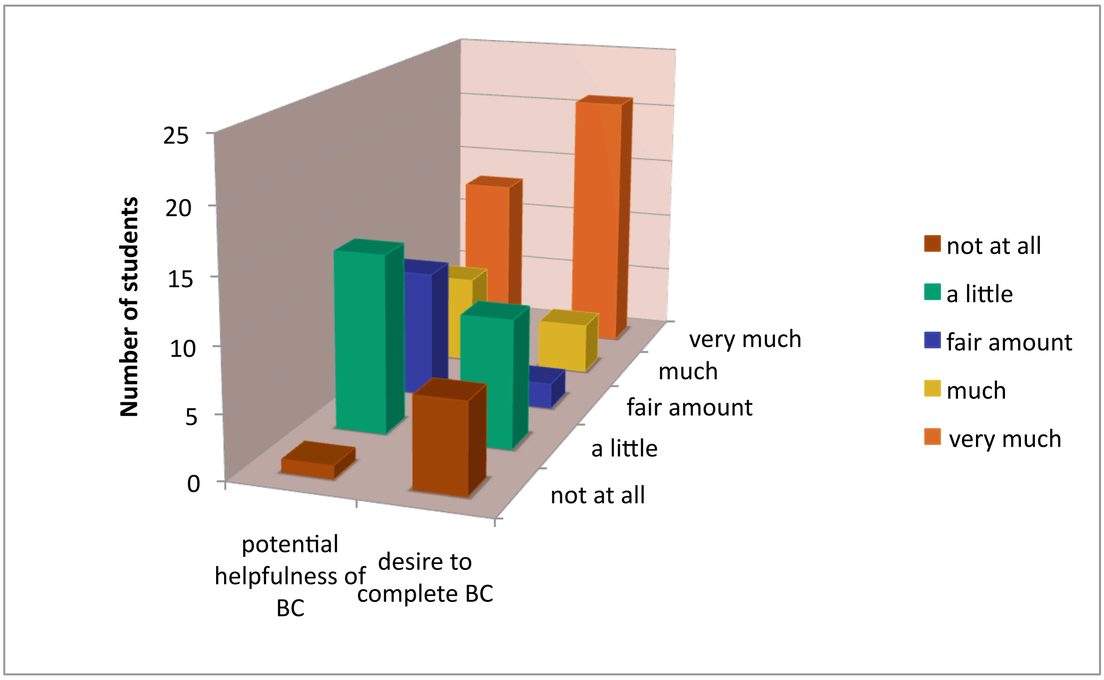

Figure 28. PC student responses to the degree to which they felt the bridging course might have been helpful (*N*=45)

Paula: Can I just add too, like I got the acceptance to get into the nursing course after the bridging course as well, so if I had known, I would have done that.
Pam: I didn't even know there was a bridging course.
Paris: This is technically my 2nd year because I'm part time, … and we weren't told the bridging course was happening. … we had no idea that it happened.

All five performed poorly academically and 'very much' wished they had completed the course, recognising the benefits it would have brought.

Phebe: I wish, like, I knew about it 'cause I would have done it.

Paris: I think it would have helped me a lot. Just having that better understanding of what I was walking into …

Paula: Familiarity in advance. Just, so you're prepared. So you get the … basic framework of it all.

In contrast, Paige, who was in the high performance group, indicated in the questionnaire that she felt the course would have been 'a little helpful'. Despite her excellent performance, she still indicated a 'fair' desire to complete the bridging course. Unlike the other ladies in her group, Paige "knew about the bridging course" but "thought there wasn't going to be that much [chemistry in the course]". On reflection, she wished the course had been compulsory.

> Paige: … I wish they said you had to do it 'cause then I would have done it and it would have been better. …I don't think anyone would be like, "oh, that was such a waste of time" … Everyone would be like "I'm glad I did that bridging course. I understand why that would need to be compulsory."

Other PC students, such as Pierce, Pippa and Prue, all in the average performance group, indicated in both interview and in the questionnaire that they were happy not to have completed the bridging course. Pippa explained why:

> Pippa: … My confidence was very low at the beginning, because I realized that a lot of the class who didn't do chemistry had done the bridging course … but then once I started to get the hang of it and started to, once we started to get into it, I didn't feel that I was at a disadvantage from anyone else. (*Individual Interview*)

As part of the T3 questionnaire, PC students were invited to give a reason for non-attendance at the bridging course. Responses are recorded in Table 74 in Appendix 36 and presented in Figure 29. Fifty-one percent stated they were unaware

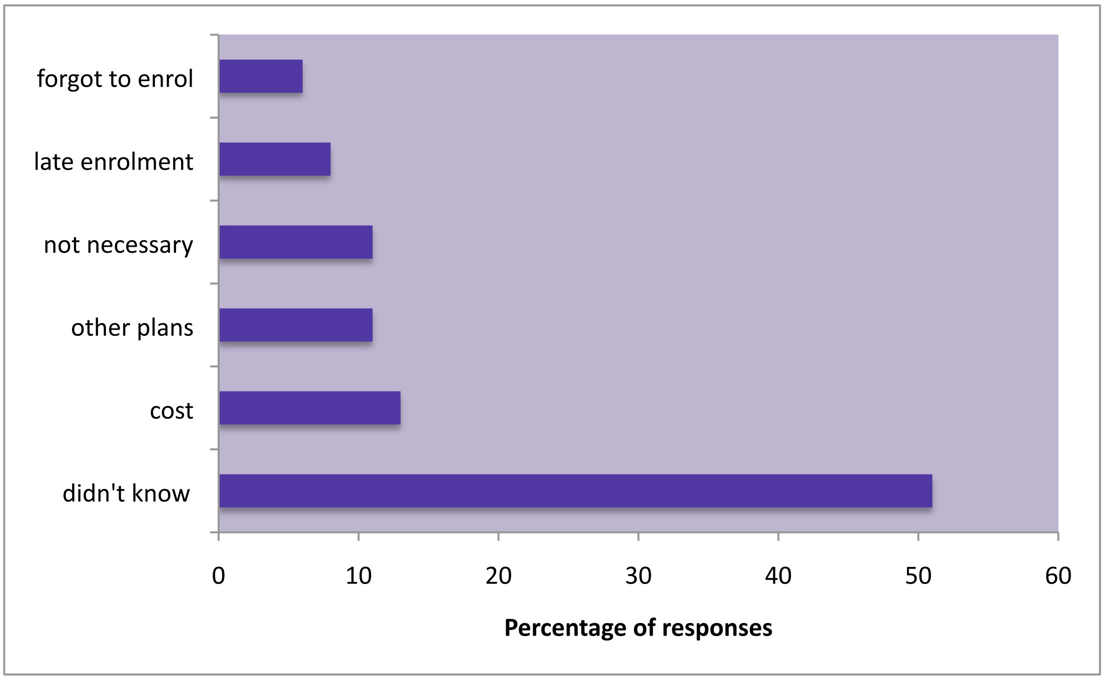

Figure 29. Reasons given by PC students for non-attendance at the bridging course

that a bridging course was offered[24] (compared with only 22% in the study by Schmid, et al., 2012) and 13% could not afford to attend. Eleven percent enrolled late and missed the course and another 11% had other plans. Only 8% chose not to attend because they did not think it was necessary. Apart from being unaware that a course was offered, the reasons given for non-attendance were similar to those found by Fleming and McKee (2005) for their nursing bridging course for mature-age students and for a bridging course in chemistry (Schmid, et al., 2012).

8.4 Implications of a Bridging Course

There is no doubt that problems encountered in studying chemistry are intensified without some type of prior knowledge (Kyriacos, et al., 2005). A number of suggestions have been made in the literature to ameliorate the disparity in prior science experience in a nursing student cohort. Setting minimal entry criteria has been suggested by some (C. Mills, et al., 2009), such as the completion of at least one senior science subject (Fenton, 2010). However, it must be acknowledged that this would exclude many potentially outstanding candidates from the profession. Others advocate intervention prior to enrolment (Chacko & Huba, 1991; Nicoll & Butler, 1996; Van Lanen, et al., 2000), possibly some type of intensive pre-nursing science course (Fenton, 2010; Gresty & Cotton, 2003; McKee, 2002; Whyte, et al., 2011). It is generally agreed that some strategy needs to be in place prior to the commencement of the study of bioscience (Fleming & McKee, 2005; Gresty & Cotton, 2003; McKee, 2002; Rutishauser & Stephenson, 1985).

In addressing **Research Question Four** through an assessment of the bridging course, it is clear that it was appreciated by the majority of students, a finding consistent with studies conducted on similar programs (Fleming & McKee, 2005; Penman, 2005; Rutishauser & Stephenson, 1985; Youl, et al., 2006). The benefits were perceived not only by attendees, but also by a number of PC students who wished they had been able to attend. Even though there was no apparent advantage in academic performance based on comparison of means over the semester, 87% of attendees stated that the bridging course had helped prepare them for Health Science I by at least a fair amount. Correlation data indicated that

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[24] The problem associated with lack of communication about the bridging course was subsequently resolved the year following the collection of data in this study. Consequently, bridging course attendance was much higher in the following year.

students who felt better prepared as a result of the bridging course did, indeed, perform better than those who were less enthusiastic about the benefits of such a course. In interview, a number of students (Becky, Beth, Beryl) associated academic performance with their attendance at the bridging course.

In addition, the bridging course may have, as noted by other researchers, contributed to retention (Chevalier, et al., 2001; Fleming & McKee, 2005; Wischusen & Wischusen, 2007). While this did not emerge from the interview data, anecdotal evidence from conversations with students in tutorials would suggest this was the case for some.

Overall, students began the semester with a more positive attitude to chemistry and an elevated sense of confidence in their ability to make sense of the chemistry ahead. While having little effect on the measures of anxiety using the CNAS, interview data supports previous research that shows BC students were more comfortable about starting their university degree (Boelen & Kenny, 2009; Penman, 2005; Rutishauser & Stephenson, 1985; Wischusen & Wischusen, 2007) and felt less anxious about material presented during the first few weeks of classes (Youl, et al., 2006).

There appears to be two key factors that facilitated a more positive start to the semester for bridging course attendees. Firstly, the presentation of chemistry fundamentals provided a foundation on which future concepts could be built (Youl, et al., 2005), reducing the complexities of the subject. Exposure to the language and the nature of chemistry in a less threatening environment allowed students to become accustomed to the representational and sub-micro world of chemistry and improved the proficiency of students to move more comfortably between the three levels of chemistry found in Johnstone's model (A. H. Johnstone, 2006). Knowledge and skills acquired in the course improved students' ability to filter out noise and make more sense of the incoming information during lectures, particularly early in the semester. Subsequently, the cognitive load experienced during the semester was reduced. Attendees had the advantage of repeated exposure to fundamental concepts and developed confidence in their ability to understand more challenging ideas. The acquisition of foundation knowledge also allowed students to spend more time during the semester studying for other subjects. Secondly, the course facilitated the establishment of peer connections, providing varying levels of both social and academic support throughout the course that persisted into the semester.

Several issues arose in relation to the course itself. Lectures and tutorials were seen as being equally valuable, indicating the importance of the scaffolding provided by lectures for mastery experiences in tutorials.

The value placed on the two, one-hour laboratory sessions during the bridging course by students was mixed.

> Beryl: It was good because I'd never been in one. I was really nervous with all the test tubes.
>
> Beth: I think you have to do it for people who've never been in a lab … You have to introduce to them what it's all about.
>
> Bernice: I have to say, we didn't really learn anything, it was just playing. … In Health Science I, it was like, wow, we were actually applying what we learnt.

Interestingly, the laboratories seemed to have made little impact on the rural campus bridging course focus group because they could barely remember even participating in them. The rationale for including laboratories was two-fold: to help reduce any chemistry laboratory anxiety by giving exposure to simple experiments, and to minimise the risk of cognitive overload in the afternoon having had intense lectures and tutorials each morning. On reflection, it would appear to have had a measure of success on both counts, but more deliberate investigation of this aspect of the course needs to occur.

In relation to the length of the course, Beth felt it was a good length.

> Interviewer: Did the bridging course have enough in it?
> Beth: I think it did have enough in it because you don't want to have it any longer because people won't do it. It's got to be attractive. "Oh, I can handle that." But if you said it's going to be two weeks full-time, people are going to go, "oh, for god's sake."
> Interviewer: Would you prefer half-days?
> Beth: No.
> Interviewer: Were you feeling saturated, mentally, by the end?
> Beth: No. No, because I felt it was exciting. (*Individual Interview*)

The constraints involved in accessibility of bridging-type courses prior to enrolment have been recognised by other researchers (Gresty & Cotton, 2003; McCabe, 2009a, 2009b). Given that the chemistry component of Health Science I is only for 7 weeks and is designed to simply give nurses a background in chemistry, it would seem that 3 days is sufficient to introduce students to some basic knowledge and skills, particularly when no prior knowledge is assumed for Health Science I.

The effectiveness of this bridging course was enhanced by the small size of the group, making it easier to establish not only connections with each other, but with the staff. Student comments highlighted the importance of experienced personnel with elevated exposition skills and an appreciation of the difficulties of chemistry for the novice in order to maximise the benefits of lectures and tutorials in the bridging course. Students need a supportive environment to facilitate a positive learning experience, build confidence and alleviate anxiety.

In summary, the 3-day chemistry bridging course was a positive experience for first-year nursing students enrolled in Health Science I and allowed them to begin the semester with cognitive self-efficacy and perception levels comparable to SC students. This was facilitated by the acquisition of essential foundation knowledge that reduced cognitive overload, particularly during lectures earlier in the semester, and underpinned the progressive development and construction of further chemistry concepts. In addition, students were more comfortable navigating between the various representations of chemistry. The subsequent reduced amount of effort allowed students to spend more time on other subjects. It appears that the opportunity to establish peer connections in a small, supportive environment reduced general anxiety levels. Despite the lack of statistical difference in mean academic performance between PC and BC students, BC students were more likely to appear in the high performance group and less likely to do poorly than the PC group. Overall, the bridging course substantially diminished the self-efficacy and prior knowledge gap between BC and SC students, allowing students to begin the semester on a more equal footing (Botch, et al., 2007).

The final chapter brings together the findings from Chapters 5 to 8 by identifying unique findings from this study. It makes recommendations for chemistry pedagogy in the tertiary setting, particularly for the novice, considers the limitations of the study and gives some direction for future research.

9 CONCLUSIONS AND RECOMMENDATIONS

This research sought to explore the chemistry experiences of first-year nursing students by considering the interplay of self-efficacy, anxiety, prior chemistry experience, and academic performance using a mixed method approach. Instruments were developed to track changes in self-efficacy, anxiety and various perceptions over both the bridging course and the 7-week chemistry component of Health Science I. In addition, the development of a qualitative model from the voices of participants added a contextual layer. In this final chapter, unique findings are highlighted in the research question framework, recommendations for improvements in the chemistry learning process are made, and limitations and opportunities for further research are outlined.

9.1 Response to the Research Questions

Research Question 1 "What role do demographic variables play in self-efficacy, anxiety and academic performance?" The findings reported in the literature concerning the influence of gender and age on self-efficacy, anxiety and academic performance in the domain of science are inconclusive. In this study, demographic variables were shown to be of little predictive use for a first-year chemistry nursing cohort.

Research Question 2 "How does self-efficacy, anxiety and student perceptions of chemistry change over the course of the semester?" This research challenges the notion that only the experienced or more able students can experience an increase in self-efficacy and enjoyment when studying chemistry at the tertiary level by demonstrating an increase in both constructs for the total cohort and for *all* prior chemistry experience and academic performance groups. See the summary in Table 40. In relation to test anxiety, the overall decrease for the total cohort (largely due to the decrease experienced by the high academic performers as shown in Table 40) is contrary to changes reported in the literature for general chemistry, where test anxiety tends to increase as a result of studying chemistry. In addition, the strength of the various correlations between CS, TA, 'enjoyment of chemistry,' 'importance of chemistry to nursing' and academic performance increased as the semester progressed. The relatively high, negative correlation between TA and 'importance of chemistry to nursing' measured at T3 is also a unique finding from this inquiry. The qualitative data illuminated the questionnaire results and provided some explanation for the changes observed in self-efficacy and anxiety over the semester. Connections made with the curriculum, the profession of nursing, the lecturer and peers, the possession of foundation knowledge, and the scaffolding of the learning process provided by the level of exposition and the lecture notes all appear to have played a key role in the experiences of the students, contributing to the changes observed. Finally, the lack of correlation for both CS and TA with 'importance of chemistry to nursing' and for TA with 'enjoyment of chemistry' for SC students was surprising and has not been reported in the literature. On the other hand, correlations were observed for the BC and PC students.

Table 40. Summary table of changes in key constructs from T2 to T1 and from T3 to T2 for the total cohort and groups based on prior chemistry experience and academic performance

	Total Cohort	Prior Chemistry Experience			Academic Performance		
		PC	BC	SC	Low	Average	High
CS2-CS1	0.56 (0.70) *d*=0.79		0.56 (0.70) *d*=0.79		0.18 (0.81)	0.86 (0.69) *d*=1.28	0.63 (0.51) *d*=0.82
CS3-CS2	0.83 (0.71) *d*=1.06	1.04 (0.75) *d*=1.53	0.48 (0.66) *d*=0.58	0.88 (0.52) *d*=1.31	0.62 (0.76) *d*=1.09	0.89 (0.72) *d*=1.22	1.00 (0.60) *d*=1.41
TA2-TA1	0.15 (0.74)		0.15 (0.74)		0.76 (0.67) *d*=1.12	0.06 (0.63)	-0.23 (0.53)
TA3-TA2	-0.27 (0.88) *d*=0.30	-0.10 (0.94)	-0.31 (0.73) *d*=0.32	-0.58 (0.86) *d*=0.61	0.11 (0.87)	-0.26 (0.71) *d*=0.33	-0.78 (0.84) *d*=0.81
En2-En1	1.74 (1.32) *d*=1.97		1.74 (1.32) *d*=1.97		1.60 (0.97) *d*=2.62	1.33 (1.66) *d*=1.33	2.18 (1.33) *d*=2.51
En3-En2	0.59 (1.24) *d*=0.54	0.81 (1.25) *d*=0.81	0.16 (1.24)	0.73 (1.12) *d*=0.72	0.08 (1.38)	0.78 (1.07) *d*=0.79	1.03 (1.00) *d*=2.23
Im2-Im1	-0.19 (1.17)		-0.19 (1.17)		-0.70 (1.06)	0.11 (1.54)	0.00 (0.89)
Im3-Im2	-0.23 (1.05) *d*=0.25	-0.36 (1.26)	-0.26 (0.82)	0.04 (0.89)	-0.89 (1.09) *d*=0.99	0.06 (0.88)	0.23 (0.81)

Note: Values for Cohen's *d* have been included for all statistically significant changes.
En = Level of enjoyment since last studying chemistry
Im = Importance of chemistry to nursing

Research Question 3 "What relationships can be established between self-efficacy, anxiety, prior chemistry experience and academic performance?" A plethora of correlations emerged from the quantitative elements of this study. The use of ANOVA and regression helped to clarify significant relationships and the relative importance of key constructs in academic performance. Cognitive self-efficacy and test anxiety (dimensions derived from factor analysis) together contributed an additional 20.4% to the variance in academic performance after controlling for cognitive capacity and prior knowledge. CS and TA acted as mediators for the influence of cognitive capacity and prior knowledge on academic performance. The qualitative component of the research has resulted in the emergent themes of 'connectivity', 'reductivity' and 'reflexivity,' giving rise to a model which demonstrates the dynamic and interactive effect operating within and across the themes and with 'learning and academic performance', extending previous research in this area and representing a novel way of thinking about the chemistry learning process. The research reported in this thesis supports the role educators play in cognitive engagement and improved learning outcomes, particularly with respect to exposition, and highlights the importance of foundation knowledge when studying chemistry.

Overall, this research lends further support to the guiding theoretical frameworks of this inquiry - social cognitive theory and cognitive load theory - by demonstrating the significance of non-cognitive motivational variables in the learning process, supporting the role of self-efficacy in learning as hypothesised by Bandura (1997) and adding strength to the importance of motivational constructs in prediction of academic performance beyond cognitive ability and prior experience. However, based on multiple regression analysis, anxiety appears to be more important for this nursing student cohort with respect to academic performance than one might expect from published research and from social cognitive theory.

In response to **Research Question 4**, "To what extent has a 3-day bridging course been beneficial to nursing students studying Health Science I?", the research presented in this thesis has shown the 3-day bridging course to be successful in preparing students for the chemistry component of Health Science I. The use of a psychometrically sound quantitative instrument has confirmed the suspicions of previous researchers (Youl, et al., 2005) that self-efficacy increases as a consequence of bridging course attendance, and represents a unique finding for this inquiry.

Improvements in both self-efficacy and enjoyment were achieved by providing an introduction to the language and key principles of chemistry in a supportive environment. This, in turn, reduced cognitive load and supported the construction of new chemical concepts throughout the semester. While no change in test anxiety was detected, qualitative evidence suggested that general levels of anxiety were somewhat ameliorated by attending the bridging course. Benefits in academic performance were noted for bridging course attendees when the distribution of scores in the low, average and high achievement groups was examined.

9.2 Recommendations for Implementation

The following recommendations for practice arise from this inquiry, particularly when teaching chemistry to novices. It should be noted, however, that while these findings (and hence recommendations) are derived from a first-year nursing cohort in a higher education institution for chemistry, there are wider educational implications for both secondary science and other tertiary science courses.

1. *Chemistry educators* It is recommended that presenters of chemistry to the novice be cognizant of the difficulties associated with learning chemistry based on the 'nature of chemistry model' and the insight it gives to cognitive overload. Evidence from this inquiry supports the key role the lecturer plays in enhancing the quality of students' experience in chemistry. Educators need to be more than just knowledgeable in the chemistry domain, but must be able to communicate effectively (J. Osborne, et al., 2003) by attending to sound pedagogical principles incorporating clarity in explanations, enthusiasm, approachability and a willingness to provide support to struggling students. In the context of nursing, it is also crucial to have an interest in clinical applications (Fenton, 2010; Kershaw, 1987; Thornton, 1997). This inquiry supports previous conclusions that teacher variables are more significant than curriculum design in attitude development (J. Osborne, et al., 2003) by activating interest and affecting learning, motivation and personal agency beliefs (Pintrich, 1994). Educators should also provide students with guidance on learning strategies and tactics required specifically for the study of chemistry, encouraging the adoption of deep approaches. The key role the lecturer plays in the development of personal efficacy cannot be overestimated, given the evidence cited from the interviews.

2. *The course* It is clear that the difficulty of chemistry for the novice needs to be somewhat ameliorated by reducing extraneous cognitive load. In addition, knowledge-building in chemistry requires considerable scaffolding. The provision of well-structured notes that encourage students to remain engaged in the learning process by completing diagrams and worked examples during lectures not only assists in these aspects of learning, but also contributes to anxiety reduction by providing an additional layer of support for students. Students should also be encouraged to form peer study groups.

3. *The bridging course* It is recommended that students without senior chemistry be encouraged to participate in a chemistry bridging course prior to the commencement of a nursing degree. A poor science background can be a mental barrier to learning science (Kershaw, 1987), particularly in chemistry, and while ever students are selected for a nursing degree without a strong science background (Strube, 1991), problems will persist. A bridging course is effective in preparing poor chemistry background students for Health Science I when delivered in a supportive environment by an experienced teacher cognizant of the difficulties faced by a chemistry novice. The bridging course serves to increase chemistry self-efficacy, provide sufficient foundation knowledge to reduce cognitive load and anxiety early in the semester, foster peer connections, influence affective perceptions such as enjoyment, and ultimately contribute to academic performance. A lecture followed by a tutorial session appears to be an effective format, providing mastery experiences which facilitate both learning and self-efficacy. The administration of both pre- and post-tests allows students to gauge their level of learning over the course. Given the depth of chemistry covered in this course, 3 days seems sufficient for a bridging course. However, a longer course may be necessary if more in-depth chemistry were to be studied and a stronger mathematical component required, as is the case for a general chemistry class.

4. *Predicting academic performance* Many papers advocate the use of self-efficacy and anxiety instruments to identify students for early academic intervention. This research has clearly demonstrated that measures taken at the beginning of the semester have limited use for this purpose. Instead, a short test administered as early as Week 3 in the semester would be a better indicator, given Test 1 in this inquiry was found to be the most potent predictor of final academic performance. This

would not only identify at risk students, but serve as a performance guidepost for those with little experience in chemistry.

5. *Severe anxiety* While social cognitive theory purports to reduce anxiety by increasing self-efficacy, it is recommended that students suffering from severe test anxiety be given access to support in the form of anxiety management strategies.

9.3 Limitations of This Study

There are several limitations to this study which include restraints in relation to three areas: methodology, generalisability and interpretation.

All research methodologies have some limitations associated with them. As a science educator with no nursing background, it is possible that my perspectives associated with this bias could have influenced both the collection and analysis of data. The 'teacher as researcher' influence during interviews may have had an impact on student responses, along with other unidentifiable context-specific variables. While independent samples t-tests showed no significant differences in CS3, TA3, academic performance and perceptions measured at T3 between those students who self-selected for interviews and those who declined, it is unknown what effect non-participants in the qualitative phase may have had on the overall inferences made in this inquiry. The CNSS and CNAS need to be subjected to confirmatory factor analysis with a different population (see J. W. Osborne & Costello, 2009). Students were placed in prior chemistry experience groups using broad criteria for chemistry background. As such, group classification may not be an accurate indicator of the quality of chemistry background and equivalent levels of knowledge cannot be assumed to exist across the members within each group. Finally, throughout the discussion of the findings, data from the 'confidence' and 'anxiety' categories have been triangulated with the more task and domain specific cognitive self-efficacy and test anxiety scales. While these sets of data are complementary, the 'confidence' and 'anxiety' qualitative data incorporate broader notions, hence limiting the triangulation potential in this inquiry.

In relation to generalisability, the application of this research to other institutions could be impeded by the use of a convenience sample and the unique nature of the Health Science I course at this institution. In addition, the instruments developed (particularly CNSS) are task specific and may not accurately reflect the chemistry self-efficacy of students in another course or institution. However, a rich description of site, situation and participants has been included, leaving transferability in the hands of the reader.

Interpretation of quantitative results in light of the literature has been hampered by the vast array of tools and definitions used to measure key constructs. Further, RPM as a measure of cognitive capacity is not used widely, limiting literature comparisons. Interpretation of the 'perceptions of chemistry' findings needs to be done with caution because they have each been measured using only one item. Interpretation of findings in gender bifurcation and bridging course campus comparisons are presented with a degree of caution because of small cohorts in these areas.

Finally, as with any research project in social science, it is not possible to take into account all the variables identified in the literature. Given that only 47.5% of the variance in academic performance was explained by the regression model, this inquiry does not purport to account for all significant factors, nor does it profess to claim cause and effect relationships. In addition, the themes and categories in the qualitative model are intended to be indicative rather than definitive facets of first-year nursing students' experiences with chemistry in this institution.

9.4 Avenues for Further Research

A number of suggestions for future research emanate from this inquiry.

While some perceptions of chemistry have been considered, a more comprehensive exploration of the role of perceptions using a psychometrically sound instrument is warranted, given the high correlations with key constructs in this study. After checking for co-variation with self-efficacy and anxiety, it would be valuable to include such measures in a multiple regression analysis to compare the predictive capacity with self-efficacy and anxiety. A similar study with a larger sample would allow structural equation modelling and could explore the direction of interaction between self-efficacy, anxiety, prior chemistry experience, perceptions and academic performance and allow causal links to be drawn. This could also accommodate further research into mediating factors for ability on academic performance, and allow a more complete model to be built. Given the unique findings from this study relating to academic performance groups, a larger sample would also allow for the comparison of multiple regression models for each performance group. The increase in CS and enjoyment for the low performance group also warrants further exploration.

Many students indicated difficulties with Anatomy and Physiology during focus group interviews. It would be helpful to determine the extent to which themes from the unique qualitative model elucidated in this study for chemistry applies to bioscience classes. Further research could also verify whether the model applies to general chemistry and other first-year science classes. In interview, a number of students expressed the view that a bridging course for anatomy and physiology would also have been helpful. An investigation into the effectiveness of such a course using the framework from this study could prove to be valuable, particularly in light of the trend in Australian universities to decrease the amount of chemistry included in nursing degrees.

A major area of interest would be an investigation, using similar variables, into other short chemistry bridging courses, perhaps for general chemistry. Further research to investigate perceived barriers for learning science would also be productive.

Given the range of student opinions expressed in relation to depth of chemistry in Health Science I and the tension reported in the literature between science and nursing, further research is required to give positive direction to the curriculum development process in the area of chemistry in nursing in Australia. Fenton (2010) reports that the contribution of science to nursing education is undervalued and recommends the 'Objective Observation of Practice' approach to guide curriculum design.

In relation to the bridging course itself, the continued inclusion of laboratory activities warrants further investigation. Laboratory activities in the bridging course were not as highly valued by many students and it would be helpful to determine whether students are better served by providing further opportunities to establish fundamental chemistry concepts and skills.

Tutorials have the potential to have significant impact on learning and performance in chemistry. Further research that considers the extent of engagement would be important, moving beyond mere attendance, along with an investigation into the relative strengths of a range of strategies employed for learning during tutorials.

Finally, a longitudinal study that tracks chemistry self-efficacy into the third year of nursing study and into clinical practice to determine the enduring nature of changes achieved during the first year would add a unique contribution to social cognitive theory and our understanding of self-efficacy.

9.5 Final Comments

This thesis provides educators with not just statistics relating to the interplay of chemistry self-efficacy, anxiety, prior chemistry experience, perceptions of chemistry and academic performance, but the voices of first-year students, representing *their* stories and experiences and demonstrating a nexus of factors that impact on learning chemistry at the tertiary level. It has demonstrated that first-year nursing students from the spectrum of prior chemistry experiences and abilities can enjoy the tertiary chemistry experience and increase their level of self-efficacy. The bridging course plays a vital role in enhancing enjoyment and self-efficacy for students with poor chemistry backgrounds by providing foundation knowledge and familiarity with the nature of chemistry. This thesis has provided evidence for additional ways in which improvements can be made to the learning process in chemistry education in a tertiary setting, particularly for the novice learner.

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Appendix 1. Health Science I schedule - rural campus

HESC14700 HEALTH SCIENCE I

Class program 1st semester 2011 – Chemistry Component

WEEK	MONDAY LECTURE 9 am	MONDAY TUTORIAL	WEDNESDAY LECTURE 8 am	THURSDAY LECTURE 9 am	THURSDAY LAB 10 am
1			Introduction Atomic structure	Atomic structure	*No lab*
2	Writing formula	*Atomic structure* *Writing formula*	Writing formula Organic molecules	Organic molecules	*No lab*
3	Polarity	*Organic molecules & Polarity*	Concentration & diffusion 1	Concentration & diffusion 2	*Organic molecules*
4	Concentration & diffusion 3	*Concentration & diffusion*	Acids & bases 1	Acids & bases 2	*Diffusion & osmosis*
5	Acids & bases 3	*Acids & bases*	Acids & bases 4	**TUTORIAL** Buffers & revision	*Nutrition*
6	**TEST 1**	*No tutorial*	Biomolecules 1	Biomolecules 2	*Buffers*
7	Biomolecules 3	*Biomolecules*	Biomolecules 4	Biomolecules 5	*No lab*
8	Reaction rates	*Biomolecules & Reaction rates*	No lecture	No lecture	*No lab*

Appendix 2. Chemistry Bridging Course schedule

TIME	DAY 1	DAY 2	DAY 3
8:30 - 9:00	Introduction		
9:00-10:00	**Lecture 1** • Classifying elements compounds, mixtures • Periodic Table • Atomic Structure • Maths: Scientific Notation	**Lecture 4** • The Mole & simple calculations • Basic organic chemistry	**Lecture 6** • More Equilibrium • Electronegativity & polarity
10:15-11:15	**Tutorial 1** • Symbols of elements • Electron configuration • Maths: scientific notation, calculator	**Tutorial 4** • Mole calculations • Organic molecules • Maths: more unit conversion	**Tutorial 6** • Equilibrium • Polarity • Revision
11:30-12:30	**Lecture 2** • Formation of ions • Intro to Writing ionic formulae	**Lecture 5** • Concentration • Chemical Reactions • Intro to Acids • Intro to equilibrium	**Lecture 7** • More Acids & bases • Particle theory
12:30-1:30	***LUNCH***	***LUNCH***	***LUNCH***
Day 1 1:30-2:10 Day 2 & 3 1:30-2:30	**Tutorial 2** • Formation of ions • Writing ionic formulae • Maths: review	**Tutorial 5** • Concentration calculations • Acids • Revision • Maths: unit conversion	**Tutorial 7** • Rev: equil • Acids & Bases • Particle theory • Maths: unit conversion
Day 1 2:20-3:10 Day 2 & 3 2:45-4:00	**Lecture 3 (2:20 pm)** • Writing ionic formulae (cont) • Covalent bonds: formation, writing formula (including O_2, H_2)	**Laboratory 1 (2:45 pm)** • Some chemical reactions - Metal + water - Metal + acid - Carbonate + acid	**Laboratory 2 (2:45 pm)** • Precipitation • Indicator colours • Acid + base: intro to titrations
	Tutorial 3 (3:20 pm) • Writing formulae: ionic & covalent • Maths: unit conv (vol)		

Appendix 3. Glossary of Terms and Acronymns

ACT	American College Testing
ANOVA	One-way between groups analysis of variance
BC	Bridging course chemistry. Students who completed the 3-day bridging course prior to Health Science I
Bioscience	Science related to biology. It may include anatomy and physiology, microbiology, genetics, chemistry, biochemistry, biophysics (Fenton, 2010)
CAEQ	Chemistry Attitudes and Experiences Questionnaire
CCSS	College Chemistry Self-efficacy Scale
CNAS	Chemistry for Nurses Anxiety Scale developed for this study
CNSS	Chemistry for Nurses Self-efficacy Scale developed for this study
CS initial	Chemistry cognitive self-efficacy measurements taken at T1 for BC students and T2 for PC and SC students.
CS1	Chemistry cognitive self-efficacy measured at T1. It represents the self-efficacy level of BC students before they begin the 3-day bridging course.
CS2	Chemistry cognitive self-efficacy measured at T2
CS3	Chemistry cognitive self-efficacy measured at T3
DCARS	Derived Chemistry Anxiety Rating Scale (developed by Eddy, 2000)
GPA	Grade Point Average
Initial	Measurements taken before experiencing any chemistry at this institution i.e. T1 for BC students and T2 for PC and SC students
IPM	Information Processing Model
LA initial	Chemistry laboratory anxiety measurements taken at T1 for BC students and T2 for PC and SC students.
LA1	Chemistry laboratory anxiety measured at T1. It represents the anxiety level of BC students before they begin the 3-day bridging course.
LA2	Chemistry laboratory anxiety measured at T2
LA3	Chemistry laboratory anxiety measured at T3

LS initial	Chemistry laboratory self-efficacy measurements taken at T1 for BC students and T2 for PC and SC students.
LS1	Chemistry laboratory self-efficacy measured at T1. It represents the self-efficacy level of BC students before they begin the 3-day bridging course.
LS2	Chemistry laboratory self-efficacy measured at T2
LS3	Chemistry laboratory self-efficacy measured at T3
LTM	Long term memory
MSLQ	Motivated Strategies for Learning Questionnaire
NCLEX-RN	National Council Licensure Examination of Registered Nurses. An exam required by all US Boards of Nursing in order to gain licensure as a registered nurse.
PC	Poor chemistry. Students who have not completed any chemistry beyond Year 10 at high school.
PCE	Prior chemistry experience. In this inquiry, three levels have been defined: PC (poor chemistry), BC (bridging chemistry) and SC (senior chemistry).
Physical science	Physics and chemistry
Questionnaire	The instrument given at T1, T2 and T3. It contains the CNSS, CNAS, and some items relating to perceptions of chemistry. For the T3 questionnaire, additional course feedback questions based on prior chemistry experience groups were included. See Appendix 9
RPM	Raven's Standard Progressive Matrix
SAT	Scholarship Aptitude or Assessment Test
SC	Senior chemistry. Students who have completed either Year 11 or Year 12 (or equivalent) chemistry at high school.
SCT	Social Cognitive Theory
SESS	Self-efficacy for Science Scale
SMQ	Science Motivation Questionnaire
Survey	The feedback sheet given at the end of the bridging course. See Appendix …
T1	Questionnaire measures of BC students taken prior to the commencement of the bridging course.
T2	Questionnaire measures taken at the beginning of the first lecture in

	Health Science I
T3	Questionnaire measures taken at the beginning of the last chemistry lecture in Health Science I (Week 7 of the semester)
TA initial	Chemistry test anxiety measurements taken at T1 for BC students and T2 for PC and SC students.
TA1	Chemistry test anxiety measured at T1. It represents the anxiety level of BC students before they begin the 3-day bridging course.
TA2	Chemistry test anxiety measured at T2
TA3	Chemistry test anxiety measured at T3
UAI	University Admissions Index. The primary criterion for undergraduate university entry for NSW Year 12 students.
WM / WMS	Working memory space
Year 10	The minimum educational level required before students can leave secondary school. (15-16 years old)
Year 11	The first of two senior years in secondary school. (16-17 years old)
Year 12	The final year of secondary school that results in possible admission to university. (17-18 years old)

Appendix 4. Ethics documentation

[INSTITUTION LOGO]

INFORMATION SHEET

The impact of a Chemistry bridging course on the self-efficacy, anxiety and academic performance of first year undergraduate nursing students.

You are asked to participate in a research study conducted by Kerrie Boddey BEd (Sc) (principal investigator) and A/Professor Kevin de Berg, Ph.D. (faculty supervisor) from the [Institution name] School of Science and Mathematics. The results of this study will be used in the dissertation leading to a Masters of Education (Research). You are being asked to participate in this study because you are enrolled in Health Science I at [Institution name].

The purpose of this study is to examine the degree to which a Chemistry bridging course impacts on Chemistry self-confidence, science anxiety levels and academic achievement in nursing students enrolled in the Chemistry component of Health Science I.

Your participation in this study is voluntary and will not influence the grade you receive in this course. You are free to withdraw at any time without affecting your relationship with [Institution name] and its staff.

You will be asked to complete a questionnaire (3 times over the course of the semester if you participate in the Chemistry bridging course and 2 times over the course of the semester if you do not participate in the Chemistry bridging course) at the beginning of class. There are several sections to this questionnaire and it will take approximately 15 minutes to complete. You will also be asked to supply some demographic data. By completing the questionnaire you are consenting to participate in the study.

In addition, you may be asked to be a member of a focus group to discuss issues related to confidence, anxiety and participation in the bridging course. These focus group discussions will be videotaped for later analysis. Your mid-semester Chemistry tests and final exam results will need to be accessed and this will require your permission. Only the principal investigator and faculty supervisor will view your data and responses will be held in strictest professional confidence.

This study does not pose any foreseeable risks or discomforts. Confidentiality will be protected at all times during data collection, analysis, presentation of the research report and any subsequent publication. Your name will not be associated with the research findings in any way. Since the principal researcher is also your lecturer, confidentiality will be maintained by the use of student ID numbers and data analysis will not be carried out by the researcher until final grades for the course have been determined.

You may not directly benefit from this research study. However, results will provide information to the science faculty to enhance curriculum implementation which will ultimately improve the delivery of Chemistry to nursing students at [Institution name].

If you have any questions or concerns about the research, please feel free to contact:

Kerrie Boddey (principal investigator)

A/Professor Kevin de Berg

This research project has been approved by [Institution name] Human Research Ethics Committee (HREC). [Institution name] requires that all participants are informed that if they have any complaint concerning the manner in which a research project is conducted it may be given to the researcher, or if an independent person is preferred, to the College's HREC Secretary [contact details given]

INSTITUTION LOGO

CONSENT FORM

Please sign this consent form. You are signing it with full knowledge of the nature and purpose of the procedures. A copy of the information sheet will be given to you to keep.

Signature of Research Subject

	Yes	No
I understand the nature and purpose of the procedures in this study. I have received a copy of the information sheet.	☐	☐
I agree to have my mid-semester tests and final exam results accessed.	☐	☐
If selected to participate in a focus group, I agree to have the discussion digitally recorded.	☐	☐

Student ID number: ______________________

Name of Subject (Student): ___________________________________

Signature of Subject (Student): ___________________________________

Date: ___________

Kerrie A. Boddey
Sessional Lecturer

A/Professor Kevin de Berg
Faculty supervisor

Appendix 5. Timeline for data collection

Time			Event
2010 (Semester 1)			Pilot Study: Collection of quantitative data
2011 (Semester 1)			
	T1	Wk 0	Day 1 of the Bridging Course: at the beginning - Questionnaire 1 administered - Pre-test administered Day 3 of the Bridging Course: at the end of the last session - Post-test administered - Bridging Course survey form completed
	T2	Wk 1	1st lecture: Questionnaire 1 administered at the beginning of the first lecture of Health Science I
		Wk 6	Test 1
		Wk 6	Raven's Standard Progressive Matrix test
	T3	Wk 7/8	Last lecture: Questionnaire 2 administered at the beginning of the last lecture of Health Science I. Permission gained to access academic records & record subsequent interviews.
		Wk 10	Test 2 (50% chemistry, 50% microbiology)
		Wk 9-11	Lunch time focus group interviews 10/5/11 City BC 12/5/11 Rural BC 17/5/11 City PC 19/5/11 Rural PC 24/5/11 City SC 26/5/11 Rural SC
		Wk 14	Final Exam
2012 (Semester 3)			Follow-up individual interviews (Phase 2) 24/5/12 Pippa 24/5/12 Beth 24/5/12 Samuel 24/5/12 Paula 1/6/12 Sofia 10/8/12 Brett

Appendix 6. Bridging Course Feedback Survey

Date: _______________ Student Number:_________________________

Feedback for Bridging Course Participants

Please do not skip any items. Your answers are confidential.

To what extent has each of the following aspects of the Chemistry Bridging course been ***helpful*** to you?

		Not helpful	a little helpful	quite helpful	very helpful	extremely helpful
1.	. the Chemistry lectures	☐	☐	☐	☐	☐
2.	. the tutorial sessions	☐	☐	☐	☐	☐
3.	the laboratory sessions	☐	☐	☐	☐	☐
4.	meeting the staff	☐	☐	☐	☐	☐
5.	connecting with fellow students	☐	☐	☐	☐	☐

		down a lot	down a little	no change	up a little	up a lot
6.	How has your overall confidence in Chemistry changed as a result of attending this bridging course?	☐	☐	☐	☐	☐
7.	How has your overall anxiety level towards Chemistry changed as a result of attending this bridging course?	☐	☐	☐	☐	☐
8.	To what extent has your interest in nursing been changed by attending the bridging course?	☐	☐	☐	☐	☐

9. What changes, if any, would you suggest for the Chemistry Bridging Course?

____

____

10. Are there any other comments you would like to make about the bridging course?

____

____

THANKS FOR YOUR HELP!

Appendix 7. Items used to develop the CNSS

Questionnaire	Item	Factor
CCSS	4, 6, 7, 14	Cognitive skills scale
CCSS	5, 20	Psychomotor skills scale
CCSS	8	Everyday applications scale
CAEQ	2, 6, 17	
SESS	2 items	Domestic application factor
SESS	1 item	Mathematics science factor
SESS	1 item	Science principles factor

Appendix 8. Questionnaires used for the pilot study

2010 (T1/2)

Date: ______________ Student Number: ________________________

Questionnaire

First year undergraduate chemistry students studying
Bachelor of Nursing program at [institution name]

Participation in this process is voluntary and confidential. Completing the questions is taken as your consent for participation in this trial study.

This questionnaire is designed to help us gain a better understanding of the kinds of things that create difficulties for nursing students in chemistry. In particular, the usefulness of the bridging course in preparing students for Health Science I.

You will be asked to complete it twice.

Please do not skip any items. Your answers are confidential.

PART A

NB: Please tick the appropriate box.

1. Gender: ☐ Male ☐ Female

2. Age: ___________

3. Previous chemistry experience (please tick ONE box indicating your *highest* level completed)

   ☐ university undergraduate course ☐ Year 12 ☐ Year 11 ☐ Year 10 or lower

4. What was your level of enjoyment when you last studied chemistry?

   hated it ☐ ☐ ☐ ☐ ☐ loved it

5. English: ☐ English is my first language ☐ English is my second language

6. Which cultural group do you identify with?

   ☐ Caucasian ☐ indigenous Australian ☐ Pacific Islander ☐ Asian

   ☐ African ☐ other

7. How well do you expect to do in chemistry this semester?

   ☐ Fail ☐ Pass ☐ Credit ☐ Distinction ☐ High Distinction

8. Please indicate your *previous* experience working in the health care industry.

   ☐ none ☐ < 6 months ☐ 6 months – 2 yrs ☐ more than 2 years

9. Previous qualification:

   ☐ None ☐ AIN ☐ EN ☐ Completed Degree

   ☐Other – please specify ______________________________

2010 (T1/2)

Part B: This part of the questionnaire investigates the *confidence* you have in undertaking different tasks.

Please indicate how confident you feel about….					
	Not confident				Totally confident
1. Explaining the structure of an atom.	☐	☐	☐	☐	☐
2. Explaining the properties of elements by using a periodic table	☐	☐	☐	☐	☐
3. Working with chemicals safely	☐	☐	☐	☐	☐
4. Interpreting graphs	☐	☐	☐	☐	☐
5. Proposing solutions to everyday life using chemistry	☐	☐	☐	☐	☐
6. Carrying out experimental procedures in the laboratory	☐	☐	☐	☐	☐
7. Reading the formulas of elements and compounds	☐	☐	☐	☐	☐
8. Achieving a passing grade in chemistry	☐	☐	☐	☐	☐
9. Explaining the relevance of studying chemistry for nurses	☐	☐	☐	☐	☐
10. After listening to a public lecture regarding some chemistry topic, explaining its main ideas to another person	☐	☐	☐	☐	☐
11. Explaining something you will learn in this course to another person	☐	☐	☐	☐	☐
12. Converting John's dietary intake of 2500 cal to kJ given that 1 calorie = 4.185 kJ	☐	☐	☐	☐	☐
13. Working out if a white spot on your overalls, caused by splashing it with bleach can be removed by machine washing	☐	☐	☐	☐	☐
14. Giving examples of common acids and bases	☐	☐	☐	☐	☐

2010 (T1/2)

Please indicate how confident you feel about….					
	Not confident				Totally confident
15. Reading a cake recipe and deciding what the raising agents are	☐	☐	☐	☐	☐
16. determining why the rake you left out in the rain has gone rusty	☐	☐	☐	☐	☐
17. preparing 2 litres of a salt solution of concentration 2 grams per litre	☐	☐	☐	☐	☐

Part C: This part of the questionnaire investigates the fear or apprehension you are experiencing AT THE MOMENT.

Please indicate how *frightened* you are about….					
	Not at all	A little	A fair amount	Much	Very much
1. asking a question in the chemistry class	☐	☐	☐	☐	☐
2. learning to convert Australian dollars to English pounds as you travel to the British Isles	☐	☐	☐	☐	☐
3. studying for a mid-semester Chemistry exam	☐	☐	☐	☐	☐
4. having a fellow student watch you perform an experiment in the lab	☐	☐	☐	☐	☐
5. memorising a chart of historical dates	☐	☐	☐	☐	☐
6. having your music teacher listen to you as you play an instrument	☐	☐	☐	☐	☐
7. studying for a mid-semester exam in nursing history	☐	☐	☐	☐	☐
8. memorising the names of elements in the periodic table	☐	☐	☐	☐	☐

2010 (T1/2)

Please indicate how *frightened* you are about….	Not at all	A little	A fair amount	Much	Very much
9. having a lecturer watch you perform an experiment in the lab	☐	☐	☐	☐	☐
10. asking a question in a history class	☐	☐	☐	☐	☐
11. having a fellow student watch you draw	☐	☐	☐	☐	☐
12. learning how to convert Celsius to Fahrenheit degrees	☐	☐	☐	☐	☐

Part D: How would you rate your anxiety levels about the following aspects of the chemistry component of Health Science I?

Please indicate how *anxious* you are about….	Not at all	A little	A fair amount	Much	Very much
1. the course in general	☐	☐	☐	☐	☐
2. the laboratory component of the course	☐	☐	☐	☐	☐
3. understanding the lecturer	☐	☐	☐	☐	☐
4. your chances of passing	☐	☐	☐	☐	☐
5. completing this degree course	☐	☐	☐	☐	☐
6. getting the required academic support and assistance from the institution	☐	☐	☐	☐	☐

Do you have any other specific areas of anxiety at this time you could identify?

____

____

____

THANKS FOR YOUR HELP

2010 (T3)

Date: ______________ Student Number:_______________________

Questionnaire

First year undergraduate Health Science I (Chemistry) students
[Institution name]

Participation in this process is **voluntary** and **confidential**. Completing the questions is taken as your consent for participation in this trial study.

This questionnaire is designed to help us gain a better understanding of the kinds of things that create difficulties for nursing students in chemistry.

Please do not skip any items.

PART A General Information

Please tick the appropriate box.

1. Gender: ☐ Male ☐ Female

2. Age: on 1st March, 2010 ________

3. Previous chemistry experience prior to Health Science I and the Bridging course (please tick ONE box indicating your highest level completed)

   ☐ university undergraduate course ☐ Year 12 ☐ Year 11 ☐ Year 10 or lower

4. What was your level of enjoyment of studying chemistry **this semester** in Health Science I?

   hated it ☐ ☐ ☐ ☐ ☐ loved it

5. If you completed Year 12 or its equivalent, please indicate when you completed it, the state (or country if completed overseas) from which you received your certificate and the tertiary entrance score achieved.

   Year: _______ State (or country): _________________ Score: _______

6. English: ☐ English is my first language ☐ English is my second language

7. Which cultural group do you identify with?

   ☐ Caucasian ☐ indigenous Australian ☐ Pacific Islander ☐ Asian

   ☐ African ☐ other (please state ____________________)

8. How well do you expect to do in chemistry **this semester**?

   ☐ Fail ☐ Pass ☐ Credit ☐ Distinction ☐ High Distinction

I would be happy to participate in a focus group (half hour discussion) in a few weeks time to provide further feedback on some of the issues being explored in this study. Yes ☐ No ☐

2010 (T3)

Part B **This part of the questionnaire investigates the *confidence* you have in undertaking different tasks**.

Please indicate how confident you feel about….

		Not confident				Totally confident
1.	explaining the structure of an atom.	☐	☐	☐	☐	☐
2.	explaining the properties of elements by using a periodic table	☐	☐	☐	☐	☐
3.	working with chemicals safely	☐	☐	☐	☐	☐
4.	interpreting graphs	☐	☐	☐	☐	☐
5.	proposing solutions to everyday life using chemistry	☐	☐	☐	☐	☐
6.	carrying out experimental procedures in the laboratory	☐	☐	☐	☐	☐
7.	reading the formulas of elements and compounds	☐	☐	☐	☐	☐
8.	achieving a passing grade in chemistry	☐	☐	☐	☐	☐
9.	explaining the relevance of studying chemistry for nurses	☐	☐	☐	☐	☐
10.	listening to a public lecture regarding some chemistry topic, then explaining its main ideas to another person	☐	☐	☐	☐	☐
11.	explaining something you have learnt in this course to another person	☐	☐	☐	☐	☐
12.	converting John's dietary intake of 2500 cal to kJ given that 1 calorie = 4.185 kJ	☐	☐	☐	☐	☐
13.	working out if a white spot on your overalls, caused by splashing it with bleach can be removed by machine washing	☐	☐	☐	☐	☐
14.	giving examples of common acids and bases	☐	☐	☐	☐	☐
15.	reading a cake recipe and deciding what the raising agents are	☐	☐	☐	☐	☐

Please indicate how confident you feel about….	Not confident				Totally confident
16. determining why the rake you left out in the rain has gone rusty	☐	☐	☐	☐	☐
17. preparing 2 litres of a salt solution of concentration 2 grams per litre	☐	☐	☐	☐	☐

Part C **This part of the questionnaire investigates the fear or apprehension you are experiencing AT THE MOMENT (i.e. in week 8 of semester 1).**

Please indicate how *frightened* you are about….

	Not at all	A little	A fair amount	Much	Very much
1. asking a question in the chemistry class	☐	☐	☐	☐	☐
2. learning to convert Australian dollars to English pounds as you travel to the British Isles	☐	☐	☐	☐	☐
3. studying for a mid-semester Chemistry exam	☐	☐	☐	☐	☐
4. having a fellow student watch you perform an experiment in the lab	☐	☐	☐	☐	☐
5. memorising a chart of historical dates	☐	☐	☐	☐	☐
6. having your music teacher listen to you as you play an instrument	☐	☐	☐	☐	☐
7. studying for a mid-semester exam in nursing history	☐	☐	☐	☐	☐
8. memorising the names of elements in the periodic table	☐	☐	☐	☐	☐
9. having a lecturer watch you perform an experiment in the lab	☐	☐	☐	☐	☐
10. asking a question in a history class	☐	☐	☐	☐	☐

Please indicate how *frightened* you are about….

	Not at all	A little	A fair amount	Much	Very much
11. having a fellow student watch you draw	☐	☐	☐	☐	☐
12. learning how to convert Celsius to Fahrenheit degrees	☐	☐	☐	☐	☐

Part D **How would you rate your anxiety levels about the following aspects of the chemistry component of Health Science I?**

Please indicate how *anxious* you are about….

	Not at all	A little	A fair amount	Much	Very much
1. the course in general	☐	☐	☐	☐	☐
2. the laboratory component of the course	☐	☐	☐	☐	☐
3. understanding the lecturer	☐	☐	☐	☐	☐
4. your chances of passing	☐	☐	☐	☐	☐
5. completing this degree course	☐	☐	☐	☐	☐
6. getting the required academic support and assistance from the institution	☐	☐	☐	☐	☐

Part E **Answer either Question 1 OR Question 2**

1. If you completed the Chemistry Bridging Course this year, how helpful was it in:

	Not at all	A little	A fair amount	Much	Very much
introducing chemistry knowledge	☐	☐	☐	☐	☐
reducing anxiety	☐	☐	☐	☐	☐

2. If you didn't complete the Chemistry Bridging Course this year, to what extent do you think the bridging course could have helped you with chemistry in Health Science I?

☐ ☐ ☐ ☐ ☐

THANKS FOR YOUR HELP !!

Appendix 9. Questionnaires used for the main study

2011 (T1/2)

Date: ______________ Student Number:______________________

Questionnaire for First Year Nurses in Health Science I

First year undergraduate chemistry students studying Bachelor of Nursing program at [Institution name]

- Participation in this process is voluntary and confidential. Completing the questions is taken as your consent for participation in this study. You may withdraw this data from the study at any time without penalty.
- This questionnaire is designed to help us gain a better understanding of things that may create difficulties for nursing students in chemistry.

Please do not skip any items. Your answers are confidential.

PART A Please tick the appropriate box.

1. Campus: ☐ Lake Macquarie ☐ Sydney

2. Gender: ☐ Male ☐ Female

3. Mode of study: ☐ Full time ☐ Part time

4. Age: ________ (as of the 1st March)

5. Previous **Chemistry** experience (please indicate your *highest* level of *Chemistry*)

   ☐ Year 12 Chemistry (or higher) (final year of high school) ☐ Year 11 Chemistry ☐ Year 10 or lower

6. What was your level of enjoyment when you *last* studied Chemistry? Circle a number.

   hated it 1 2 3 4 5 *loved it*

7. English: ☐ English is my first language (GO TO Question 8)

   ☐ English is my second language. How confident are you in studying in English?

   not at all 1 2 3 4 5 *totally confident*

8. Please indicate your previous experience working in the **health care** industry.

   ☐ none ☐ < 6 months ☐ 6 months – 2 yrs ☐ more than 2 years

9. Highest qualification in the **health care** industry:

   ☐ none ☐ Certificate III (e.g. AIN) ☐ Certificate IV (e.g. EN) ☐ endorsed EN

10. How well do you expect to do in **Chemistry** this semester?

    ☐ Fail ☐ Pass ☐ Credit ☐ Distinction ☐ High Distinction

11. How important do you think the study of Chemistry is to nursing?

not at all important	*slightly useful*	*quite important*	*very important*	*essential*
1	2	3	4	5

2011 (T1/2)

Part B: This part of the questionnaire investigates the *confidence* you have in undertaking different tasks in Chemistry.

Please indicate how *confident* you feel about….

		Not confident				Totally confident
1.	explaining the structure of an atom.	☐	☐	☐	☐	☐
2.	explaining the properties of elements by using a periodic table.	☐	☐	☐	☐	☐
3.	working with chemicals safely.	☐	☐	☐	☐	☐
4.	interpreting graphs related to Chemistry.	☐	☐	☐	☐	☐
5.	carrying out experimental procedures in the laboratory.	☐	☐	☐	☐	☐
6.	identifying an element or compound from its chemical formula.	☐	☐	☐	☐	☐
7.	achieving a passing grade in Chemistry.	☐	☐	☐	☐	☐
8.	explaining the relevance of studying Chemistry in a nursing context.	☐	☐	☐	☐	☐
9.	explaining something you will learn in this Chemistry unit to another person.	☐	☐	☐	☐	☐
10.	interpreting results from a Chemistry laboratory session.	☐	☐	☐	☐	☐
11.	choosing an appropriate mathematical formula to solve a Chemistry problem.	☐	☐	☐	☐	☐
12.	reading the procedure then successfully conducting a Chemistry experiment.	☐	☐	☐	☐	☐
13.	mastering the knowledge required in this Chemistry course.	☐	☐	☐	☐	☐
14.	interpreting the results of a pH reading for a patient.	☐	☐	☐	☐	☐
15.	correctly using the equipment in the Chemistry laboratory	☐	☐	☐	☐	☐

2011 (T1/2)

Part C: This part of the questionnaire investigates the fear or apprehension you are experiencing at the moment, with respect to Chemistry.

Please indicate how *anxious* you are about….

		Not at all	A little	Moderate amount	Quite a lot	Extremely
16.	performing a Chemistry experiment in the laboratory.	☐	☐	☐	☐	☐
17.	interpreting graphs or charts that show the results of a chemistry experiment.	☐	☐	☐	☐	☐
18.	studying for a Chemistry test or exam.	☐	☐	☐	☐	☐
19.	memorising Chemistry definitions and formulas.	☐	☐	☐	☐	☐
20.	walking into a lecture for Chemistry.	☐	☐	☐	☐	☐
21.	thinking about an upcoming Chemistry test one day before.	☐	☐	☐	☐	☐
22.	using the equipment in a Chemistry experiment.	☐	☐	☐	☐	☐
23.	identifying a substance from its chemical formula.	☐	☐	☐	☐	☐
24.	sitting a Chemistry test or exam.	☐	☐	☐	☐	☐
25.	reading the word 'Chemistry.'	☐	☐	☐	☐	☐
26.	solving a difficult problem on a Chemistry test.	☐	☐	☐	☐	☐
27.	waiting to get a Chemistry test returned.	☐	☐	☐	☐	☐
28.	listening to a lecture in Chemistry.	☐	☐	☐	☐	☐
29.	mixing chemicals in the laboratory.	☐	☐	☐	☐	☐
30.	picking up your Chemistry lecture notes to begin working on a tutorial assignment.	☐	☐	☐	☐	☐
31.	spilling a chemical.	☐	☐	☐	☐	☐
32.	getting the required academic support and assistance for Chemistry.	☐	☐	☐	☐	☐

THANKS FOR YOUR HELP!

T3, 2011

Date: _______________ Student Number:_________________________

Questionnaire for First Year Nurses in Health Science I

[Institution name]

- Participation in this process is voluntary and confidential. Completing the questions is taken as your consent for participation in this study.

Please do not skip any items. Your answers are confidential.

PART A

Please tick the appropriate box.

1. What was your level of enjoyment studying Chemistry *this* semester in Health Science I?

hated it				*loved it*
1	*2*	*3*	*4*	5

2. Paid work this semester:

   a. How many hours of paid work per week, on average, have you been engaged in while studying this semester?

      _____ hours/week

   b. If you have been employed, please indicate the type of employment

      ☐ nursing-related ☐ other

3. How well do you expect to do in **Chemistry** this semester?

   ☐ Fail ☐ Pass ☐ Credit ☐ Distinction ☐ High Distinction

4. How important do you think the study of Chemistry is to nursing?

not at all important	*slightly useful*	*quite important*	*very important*	*essential*
1	2	3	4	5

5. To what extent has your interest in nursing changed by studying Chemistry this semester?

decreased a lot	*decreased a small amount*	*has made no difference*	*increased a small amount*	*increased a lot*
1	2	3	4	5

6. To what extent do you think this chemistry course has contributed to your competence as a nurse?

not at all	*a little*	*a moderate amount*	*quite a lot*	*significantly*
1	2	3	4	5

7. I would be happy to participate in a small group discussion (half an hour) in a few weeks time to provide further feedback on my experiences with Chemistry this semester.

   Yes ☐ No ☐

T3, 2011

Part B: This part of the questionnaire investigates the *confidence* you have in undertaking different tasks in chemistry.

Please indicate how *confident* you feel about….

		Not confident				Totally confident
1. .	explaining the structure of an atom.	☐	☐	☐	☐	☐
2. .	explaining the properties of elements by using a periodic table.	☐	☐	☐	☐	☐
3.	working with chemicals safely.	☐	☐	☐	☐	☐
4.	interpreting graphs related to Chemistry.	☐	☐	☐	☐	☐
5.	carrying out experimental procedures in the laboratory.	☐	☐	☐	☐	☐
6.	identifying an element or compound from its chemical formula.	☐	☐	☐	☐	☐
7.	achieving a passing grade in Chemistry.	☐	☐	☐	☐	☐
8.	explaining the relevance of studying Chemistry in a nursing context.	☐	☐	☐	☐	☐
9.	explaining something learnt in this Chemistry unit to another person.	☐	☐	☐	☐	☐
10.	interpreting results from a Chemistry laboratory session.	☐	☐	☐	☐	☐
11.	choosing an appropriate mathematical formula to solve a Chemistry problem.	☐	☐	☐	☐	☐
12.	reading the procedure then successfully conducting a Chemistry experiment.	☐	☐	☐	☐	☐
13.	mastering the knowledge required in this Chemistry course.	☐	☐	☐	☐	☐
14.	interpreting the results of a pH reading for a patient.	☐	☐	☐	☐	☐
15.	correctly using the equipment in the Chemistry laboratory	☐	☐	☐	☐	☐
15b	understanding aspects of chemistry that may arise in future nursing classes.	☐	☐	☐	☐	☐

Part C: This part of the questionnaire investigates the fear or apprehension you are experiencing at the moment.

Please indicate how *anxious* you are about….

		Not at all	A little	A fair amount	Quite a lot	Extremely
16.	performing a Chemistry experiment in the laboratory.	☐	☐	☐	☐	☐
17.	interpreting graphs or charts that show the results of a chemistry experiment.	☐	☐	☐	☐	☐
18.	studying for a Chemistry test or exam.	☐	☐	☐	☐	☐
19.	memorising Chemistry definitions and formulas.	☐	☐	☐	☐	☐
20.	walking into a lecture for Chemistry.	☐	☐	☐	☐	☐
21.	thinking about an upcoming Chemistry test one day before.	☐	☐	☐	☐	☐
22.	using the equipment in a Chemistry experiment.	☐	☐	☐	☐	☐
23.	identifying a substance from its chemical formula.	☐	☐	☐	☐	☐
24.	sitting a Chemistry test or exam.	☐	☐	☐	☐	☐
25.	reading the word ‘Chemistry.’	☐	☐	☐	☐	☐
26.	solving a difficult problem on a Chemistry test.	☐	☐	☐	☐	☐
27.	waiting to get a Chemistry test returned.	☐	☐	☐	☐	☐
28.	listening to a lecture in Chemistry.	☐	☐	☐	☐	☐
29.	mixing chemicals in the laboratory.	☐	☐	☐	☐	☐
30.	picking up your Chemistry lecture notes to begin working on a tutorial assignment.	☐	☐	☐	☐	☐
31.	spilling a chemical.	☐	☐	☐	☐	☐
32.	getting the required academic support and assistance for Chemistry.	☐	☐	☐	☐	☐

Part D Please tick and complete ONE option only: 1 or 2 or 3

☐ **OPTION 1: I completed the chemistry bridging course**

How helpful was the bridging course in

	Not at all	*A little*	*A fair amount*	*Much*	*Very much*
a. introducing Chemistry knowledge	☐	☐	☐	☐	☐
b. reducing anxiety towards Chemistry	☐	☐	☐	☐	☐
c. preparing you for Health Science I	☐	☐	☐	☐	☐

OR

☐ **OPTION 2: I completed Year 11 or 12 Chemistry** (Chemistry senior high school)

	Inadequate		*Adequate*		*More than enough*
How would you rate your background chemistry knowledge coming into this chemistry course?	☐	☐	☐	☐	☐

	Not at all	*A little*	*A fair amount*	*Much*	*Very much*
To what extent do you think your senior high school chemistry studies helped you understand chemistry in Health Science I?	☐	☐	☐	☐	☐

OR

☐ **OPTION 3: I did NOT complete Year 11 or 12 Chemistry or the bridging course.**

	Not at all	*A little*	*A fair amount*	*Much*	*Very much*
To what extent do you think the bridging course could have helped you with chemistry in Health Science I?	☐	☐	☐	☐	☐
To what extent do you wish you had completed the bridging course?	☐	☐	☐	☐	☐

Why did you decide *not* to attend the chemistry bridging course?

____

____

____

THANKS FOR YOUR HELP!

Appendix 10. Focus groups: Effort & difficulty survey

	1 = none/ not at all								9=extremely high
1. How much mental effort is required for chemistry?	1	2	3	4	5	6	7	8	9
2. How much mental effort is required for sociology and psychology?	1	2	3	4	5	6	7	8	9
3. How difficult is the content in chemistry?	1	2	3	4	5	6	7	8	9
4. How difficult was it for you to learn the chemistry material?	1	2	3	4	5	6	7	8	9

Appendix 11. Focus group interview protocol

1. Fill in Cognitive Load questions: on scale of 1 – 9 (9=extremely high)
    a. How much mental efforts is required for chemistry / for sociology and psychology?
    b. How difficult is the content in chemistry
    c. How difficult was it for you to learn the chemistry material?

Bridging Course Groups only

1. Why did you choose to attend the bridging course?
2. Benefits of the bridging course:
    a. How did attendance at the bridging course help you in Health Science I?
    b. How would you rate the contribution of the bridging course to your success in this subject?
    c. What was most helpful about attending the bridging course?

3. Self-efficacy
    a. How did the bridging course affect your belief in your ability to learn chemistry?
    b. How did this change over the 3 days?
    c. What affect did the pre-test/post-test results have on your confidence in chemistry?

4. Anxiety:
    a. Did you feel anxious about chemistry before you started? Why/why not?
    b. How did your anxiety levels change over the 3 days?
    c. Did the bridging course help to reduce the anxiety you felt towards
        i. chemistry?
        ii. studying nursing?

5. Other questions relating to the bridging course:
    a. How useful were the **laboratory activities** in the bridging course? Did it enhance/hinder anxiety & self-confidence?
    b. Would a bridging course for physiology be as useful/necessary?

The Chemistry Course (for all groups)

1. Science/chemistry experiences at school:
    a. Why didn't you (or did you) select chemistry in Year 11 and 12?
    b. Describe your past experiences in science / chemistry. Did you ever witness gender discrimination?
    c. What has contributed to your perceptions of chemistry before you started this course?
    d. How have your past experiences in science affected your anxiety/confidence in chemistry this semester?

2. Did you know you would be studying this amount of chemistry in the course? What was your reaction when you realised you would be studying chemistry?

3. Self-efficacy:

    a. Describe how confident you felt at the beginning of the semester. What factors contributed to this?
    b. Were you confident in helping friends with chemistry?
    c. How did your belief in your ability to learn chemistry help determine choices made when studying this semester? e.g. time spent studying, effort, persistence.
    d. How has your confidence in chemistry changed over the semester? What has contributed to that?

4. Anxiety:

    a. Think back to first day of classes and how anxious you felt. How did your levels of anxiety in chemistry compare with sociology & psychology? What about now (i.e. at this time in the semester?)
    b. Do you experience anxiety in any other subjects?
    c. What were some key sources of anxiety throughout the semester
        i. in chemistry
        ii. generally?
    d. At what times did you feel particularly anxious? What factors reduced (or increased) anxiety to chemistry as semester went on?

5. Perceptions of chemistry:

    a. How important to you believe chemistry to be in nursing? Why/why not?
    b. Do you ever think about how chemistry is relevant to your career? At what times? Does this influence the effort you put into the subject?

6. PC group:
    a. Why do you (or not) wish you had attended the bridging course?
    b. How do you think the course could have helped you?

7. Others if time

    a. How valuable did you find the laboratory activities? Did this add/subtract to your confidence and anxiety?
    b. How valuable were the tutorials? Did this add/subtract to your confidence or anxiety?
    c. How does the work load in Health Science I compare with other subjects being studied this semester? Does this contribute to anxiety?
    d. What motivates you to study chemistry?

Final Questions

1. Do you think you've felt any pressure to answer in a particular way because I am the interviewer?
2. What have you gained from participating in this interview?

Appendix 12. Focus group participant data

Table 41. Focus group participant data

	Gender	Campus	Age	Work	CS			LS			TA			LA			Enjoyment			Importance			AP
					T1	T2	T3	T1	T2	T3	T1	T2	T3	T1	T2	T3	T1	T2	T3	T1	T2	T3	
Paige	F	C	1	6		1.4	3.3		3.0	4.0		2.6	1.5		1.2	0.0		2	4		3	2	H
Pam	F	C	5	27		1.7	1.1		3.0	3.0		2.5	3.9		2.2	2.0		3	0		4	0	L
Paris	F	C	3	30		0.8	2.0		2.8	3.0		1.9	2.4		1.6	1.0		1	2		2	2	L
Paul	M	C	3	12		1.2	2.8		0.0	2.0		1.6	0.9		1.2	1.4		2	3		4	4	H
Paula*	F	C	4	0		2.3	2.2		2.5	2.8		2.9	2.6		1.4	0.8		1	1		4	1	L
Phebe	F	R	1	35		0.6	1.9		2.3	2.8		3.5	2.9		1.6	0.0		0	1		1	1	L
Pierce	M	R	3	0		2.5	2.8		2.3	3.0		1.6	1.5		1.8	1.4		2	3		4	3	Av
Pippa*	F	R	1	10		2.3	3.2		3.3	3.8		0.8	0.8		1.0	0.2		2	3		3	3	Av
Polly	F	R	3	6		3.0	2.3		3.0	3.0		2.1	2.6		2.2	2.2		2	3		3	3	L
Prue	F	R	1	1		0.9	3.8		3.3	3.3		2.0	0.5		2.6	1.8		2	4		3	3	Av
Becky	F	C	2	0	2.3	2.8	3.3	2.5	3.5	3.5	2.5	1.3	0.6	1.8	1.0	0.2	0	3	4	3	2	3	H
Bella	F	C	1	12	2.4	2.1	3.2	3.5	2.0	4.0	1.6	2.0	1.6	0.2	0.2	0.2	1	3	3	3	2	2	H
Bernice	F	C	2	0	1.7	2.6	3.5	2.5	2.5	4.0	1.9	2.0	2.4	1.0	2.0	0.6	0	3	2	2	3	1	Av
Beryl	F	C	5	20	1.3	1.5	3.0	0.5	0.8	2.0	2.0	2.1	0.1	2.4	3.4	0.8	3	2	4	4	4	4	H
Beth*	F	C	5	0	1.2	2.0	2.8	1.8	2.0	3.0	1.9	0.9	0.6	1.6	1.0	0.2	0	4	3	2	4	4	H
Bree	F	R	1	10	1.5	2.1	2.9	2.0	2.8	3.0	1.9	2.6	1.6	1.8	2.0	0.8	1	3	3	3	4	4	L
Brett*	M	R	1	4	2.3	3.1	3.4	2.3	3.0	3.0	0.9	0.5	0.5	0.4	0.4	0.2	0	2	4	3	3	3	H
Bridget	F	R	1	0	0.5	0.5	0.3	0.8	1.0	0.0	0.9	0.5	2.3	0.4	0.8	3.0	0	0	0	4	1	1	Av
Brittney	F	R	1	0	1.5	2.3	2.5	3.3	3.3	2.8	2.1	1.1	0.9	1.4	0.2	0.4	0	3	3	3	2	2	Av
Bronte	F	R	5	40	1.7	1.3	1.6	2.3	3.3	2.3	0.75	2.5	2.4	1.0	1.8	1.2	2	2	4	4	2	2	L
Samuel*	M	C	3	2		2.8	3.7		3.3	3.5		1.4	0.6		0.4	0.0		4	3		3	3	Av
Sandy	F	C	4	20		3.3	3.5		3.8	3.3		0.6	0.8		0.8	1.0		3	4		4	4	H
Sarina	F	C	3	27		1.8	3.0		3.5	3.5		1.3	1.0		0.2	0.0		3	3		3	1	L
Simon	M	R	2	5		3.0	3.9		3.5	3.8		0.8	0.8		0.2	0.0		3	3		3	3	H
Sofia*	F	R	1	0		1.9	3.3		3.0	3.0		3.5	1.0		1.6	1.0		0	3		2	2	H
Sonia	F	R	1	0		1.4	3.2		3.0	3.8		3.3	1.6		1.4	0.2		0	2		1	1	Av
Soraya	F	R	1	0		2.5	3.5		3.5	3.8		2.9	0.8		0.8	0.8		0	3		2	4	H

* Names in **bold face** were individually interviewed in Phase 2 of this inquiry.
Campus: C=City, R=Rural. Age categories: 1=17-18 years old, 2=19-20 yo, 3=21-24 yo, 4=25-34 yo, 5=35+ yo
Work: average number of hours worked each week during the first part of the semester
AP (academic performance group): L=Low (<45%), Av=Average (45-69%) , H=high (70+%)

Appendix 13. Individual interview protocol

1. *[Students given the transcript to read]* Do you have any reflections you'd like to make about what you've just read?

2. You'll notice that in the group interviews, I asked whether your responses were influenced because of my role as your lecturer. How did you feel about the level of honesty you were able to give in your responses because other students were present during interviews?

Explain the three Prior Chemistry Experience groups to the participants.

3. Anxiety: test vs laboratory
   a. Two aspects of anxiety emerged from the questionnaire: test anxiety and lab anxiety. Do you see any difference between test & laboratory anxiety?
   b. Which were you more anxious about and why?
   c. Would the TA you experienced in chemistry be different from other subjects?

4. QUALITATIVE MODEL
   Show categories from the qualitative model from the Connectivity and Reductivity themes - one at a time. Include 'Goal orientation'
   a. What role did each of these circles play in your confidence and anxiety levels over the semester?
   b. How did each affect your academic performance?
   c. If you had to indicate the strength of the interactions, which ones would be stronger for you?

5. QUANTITATIVE MODEL
   Show the quantitative model.
   a. To what extent do you attribute your academic performance to confidence, test anxiety, natural ability, prior chemistry experience? Which paths would you say are the strongest for you?
   b. Similarly, role that PCE & ability play in SE and anx.

PC Interviewees

1. Initial TA: PC was higher than those who enrolled in the bridging course. Do you have any thoughts as to why?
2. Academic Performance
   d. To what extent did your lack of foundation knowledge affect your AP?
   e. Look at Figure 1. What do you think now?
   f. Why did your confidence still increase/stay the same over the semester, despite a poor performance in Test 1?

Pippa

1. Test anxiety: p2 – You said you were anxious at the beginning, but on p9 you said you weren't anxious until the test came. What was it that reduced your anxiety, and when did that occur? when do you start to experience test anxiety?
2. zCSAP = 1.17 i.e. overconfident! How do you account for the fact that you significantly overestimated your academic performance?

3. How do you think your levels of enjoyment and importance changed over the semester? [Ask especially about enjoyment, because interview clearly shows she enjoyed it a lot more in HS I. In the questionnaire, ‘enjoyment’ only slightly improved (2 → 3), Importance – didn’t change (3 both times).]
4. Do you think the bridging course would have given you any advantage at all?

Paula

1. How would you describe your confidence and anxiety levels at the beginning and end of the semester last year? Confidence and anxiety didn’t change very much for you over the semester, despite your struggles. Why was this?
2. zCSAP = 0.76 i.e. overconfident in assessment. How do you account for this?
3. You were accepted into nursing after the bridging course was conducted. How much do you wish you had done the bridging course? Do you think you would have passed 1st semester last year if you had done the course?
4. You repeated this subject in 2nd semester last year.
   a. Describe your experiences 2nd time around. e.g. why were you able to pass the 2nd time? What made the difference?
   b. How were confidence and anxiety levels the 2nd time? Did they change over the semester?
5. A number of comments you made during the focus group interview suggest that there were times where you felt unsupported. How do you think this affected your AP?

BC Interviewees

1. Test Anxiety:
   a. Can you explain why for many students, TA didn’t decrease as a result of attending the bridging course?
   b. Initial TA: PC was higher than those who enrolled in BC. Any thoughts as to why?
2. At the beginning of the first lecture, the confidence of BC students was higher than PC. However, by the last lecture, BC=PC again. What do you think may have contributed to this?
3. Academic Performance
   c. To what extent do you think the bridging course contributed to your AP? How do you think the BC group would compare with SC students? PC students? (NB – not as high as SC, and not significantly higher than PC students).
   d. Look at Figure 1 (Academic performance for prior chemistry experience groups). Given that the AP of BC students is not significantly different from PC students, what role do you think the bridging course played in overall academic performance?

Beth

2. Overall, you were very positive in the interview about both your experience with chemistry in HS I and the relevance it has to nursing. When you were studying for chemistry, what sort of things motivated you?
3. How did enjoyment / importance change as a result of BC attendance?
   a. You were one of the few for whom ‘importance of chemistry to nursing’ increased after bridging course attendance. Can you recall why?

   b. In the questionnaires, your enjoyment went from 0 before the bridging course to 4 after the bridging course. p16 - In interview, you said you would love to do more chemistry at uni. Do you still feel this way?
   c. p17 You said you loved chemistry because you got it. What role do you think this played in your perception of the importance of chemistry to nursing?
4. Effort to learn survey: 6 for chem., 1 for sociology. This was the biggest difference recorded by anyone. Could you explain the difference between the two for you?

SC Interviewees

1. Test anxiety:
   a. Initial TA for SC students wasn't lower than PC or BC students. Why do you think this was?
   b. The SC group generally experienced a decrease in TA, not other PCE groups. Why do you think this was?
2. Consider Tables 1 and 2:
   a. Table 1 (Pearson product-moment correlations at T3 between cognitive self-efficacy and 'perceptions of chemistry' variables for the three prior chemistry groups): Note that for enjoyment and expected result, all PCE groups showed a high correlation with CS. However, for 'importance of chemistry to nursing', this was not true for the SC group. Do you have any comments to make on that? Do you agree with these findings i.e. does your level of confidence influence how important you think chemistry is to nursing?
   b. Table 2 (Pearson product-moment correlations at T3 between chemistry test anxiety and 'perceptions of chemistry' variables): For TA, there were no significant correlations with any perceptions of chemistry for SC group! Why do you think this is?
3. Academic Performance
   c. Look at Figure 1 (Academic performance for prior chemistry experience groups). Note that SC students academically outperformed PC and BC groups. What do you put this down to?
   d. To what extent do you feel lecturer attributes – characteristics + ability to explain so you could understand – played a role in your AP?

Sofia

1. p 2 & 3: You agreed that high school chem. helped, even though you didn't have a good experience. How did it help – could you expand on this a little?
2. p 4: Apart from the way the notes were set out, why was chemistry easier in HSI than at school?
3. Your Test 2 result was poor compared to Test 1. Can you remember why you didn't perform as well in the second test?

Samuel

1. Do you remember what you got for chemistry in the HSC?
2. zCSAP = 0.73 (overconfident). What do you put this down to?
3. Everyone in your focus group said in interview (p 4) that confidence didn't really change over the semester. However, questionnaire data indicated that it did increase, especially for you David (2.8 → 3.7). How do you account for this?

Appendix 14. Item statistics for both CNSS and CNAS at T3 – Main Study

	Item Number	Mean	SD	Skewness	Kurtosis	Final Communalities
Chemistry Self-efficacy	1	2.96	0.89	-0.52	-0.07	.479
	2	3.16	0.80	-0.66	-0.11	.565
	3	*3.31*	*0.79*	*-1.22*	*2.03*	*.593*
	4	2.68	0.97	-0.40	0.11	.597
	5	*3.06*	*0.79*	*-0.86*	*1.56*	*.689*
	6	2.81	1.05	-0.58	-0.39	.574
	7	2.63	1.19	-0.56	-0.39	.686
	8	2.36	1.05	-0.33	-0.15	.540
	9	2.61	0.96	-0.40	-0.17	.609
	10	2.50	0.93	-0.43	0.17	.615
	11	2.30	1.09	-0.24	-0.50	.683
	12	*2.81*	*0.92*	*-0.62*	*0.38*	*.606*
	13	2.34	1.02	-0.14	-0.56	.713
	14	2.83	0.90	-0.60	0.56	-
	15	*3.06*	*0.84*	*-0.96*	*1.32*	*.640*
Chemistry Anxiety	*16*	*0.88*	*0.95*	*1.05*	*0.66*	*.717*
	17	*1.09*	*0.94*	*0.85*	*0.64*	*.669*
	18	2.00	1.21	0.07	-0.95	.799
	19	1.87	1.19	0.15	-0.84	.760
	20	0.63	1.00	1.54	1.39	-
	21	2.29	1.31	-0.09	-1.25	.670
	22	*0.75*	*0.97*	*1.35*	*1.46*	*.720*
	23	1.21	1.10	0.65	-0.36	.696
	24	2.30	1.27	0.02	-1.18	.797
	25	0.73	1.14	1.52	1.32	.575
	26	2.15	1.20	0.06	-0.99	.647
	27	2.03	1.33	0.13	-1.15	.658
	28	0.75	1.08	1.36	0.86	-
	29	*0.86*	*1.03*	*1.32*	*1.37*	*.777*
	30	1.06	1.18	1.01	0.11	.-
	31	*1.27*	*1.32*	*0.70*	*-0.71*	*.482*

Note: Italicised items represent the laboratory factors

Appendix 15. Factor analysis data for CNSS (Main Study)

Table 42. Comparison of eigenvalues from principal axis factoring for CNSS (T3) and criterion values from parallel analysis

Component Number	Actual eigenvalue	Criterion value from Parallel Analysis[a]
1	7.150	1.7119
2	1.808	1.5400
3	1.017	1.4152
4	0.689	1.3029
5	0.574	1.2057

a. Criterion value based on 15 variables, 101 subjects, 100 replications

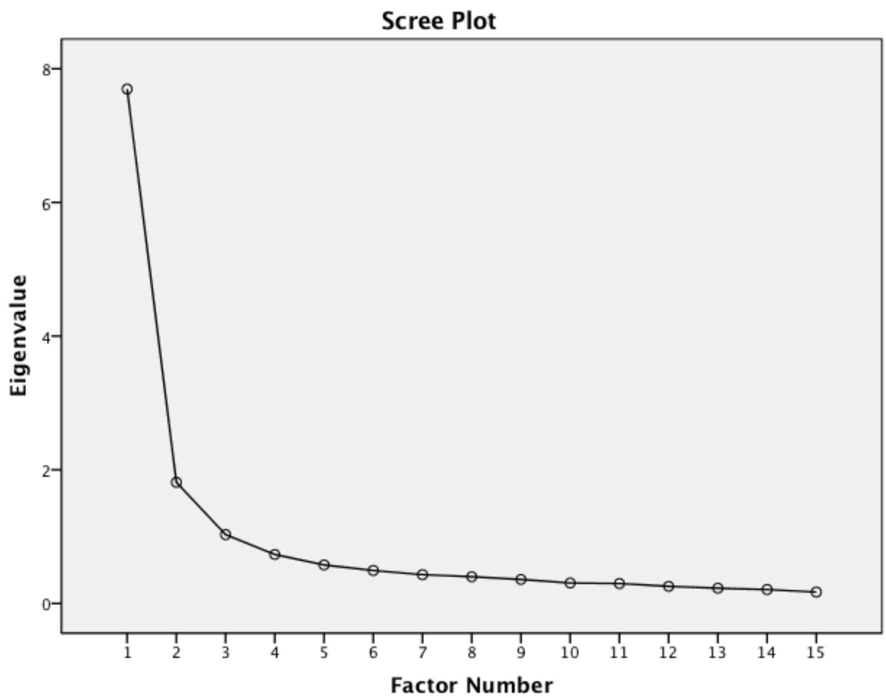


Figure 30. Scree Plot for factor analysis of CNSS at T3

Table 43. Varimax rotated factor structure of the CNSS questionnaire – Main study (T3, *N*=101)

Item		*Factor 1 CS* Cognitive Chemistry Self-efficacy	*Factor 2 LS* Chemistry Laboratory Self-efficacy
11	choosing an appropriate mathematical formula to solve a chemistry problem	**.819**	
13	mastering the knowledge required in this chemistry course	**.805**	
7	achieving a passing grade in chemistry	**.766**	
9	explaining something learnt in this chemistry unit to another person	**.745**	
8	explaining the relevance of studying chemistry in a nursing context	**.702**	
6	identifying an element or compound from its chemical formula	**.654**	.332
10	interpreting results from a chemistry laboratory session	**.598**	.438
4	interpreting graphs related to chemistry	**.570**	.452
1	explaining the structure of an atom	**.546**	
2	explaining the properties of elements by using a periodic table	**.493**	.389
5	carrying out experimental procedures in the laboratory		**.818**
15	correctly using the equipment in the chemistry laboratory		**.809**
3	working with chemicals safely		**.774**
12	reading the procedure then successfully conducting a chemistry experiment	.326	**.712**
	Total number of items	10	4
	Eigenvalue	7.150	1.808
	% Variance:	34.59%	24.01%
	Cronbach's alpha	.918	.875

NB: Loadings less than .3 have been omitted.

Appendix 16. Factor analysis data for CNAS (Main Study)

Table 44. Comparison of eigenvalues from principal axis factoring for CNAS (T3) and criterion values from parallel analysis

Component Number	Actual eigenvalue	Criterion value from Parallel Analysis[a]
1	8.671	1.7474
2	2.603	1.5837
3	0.870	1.4600
4	0.781	1.3501

a. Criterion value based on 16 variables, 101 subjects, 100 replications

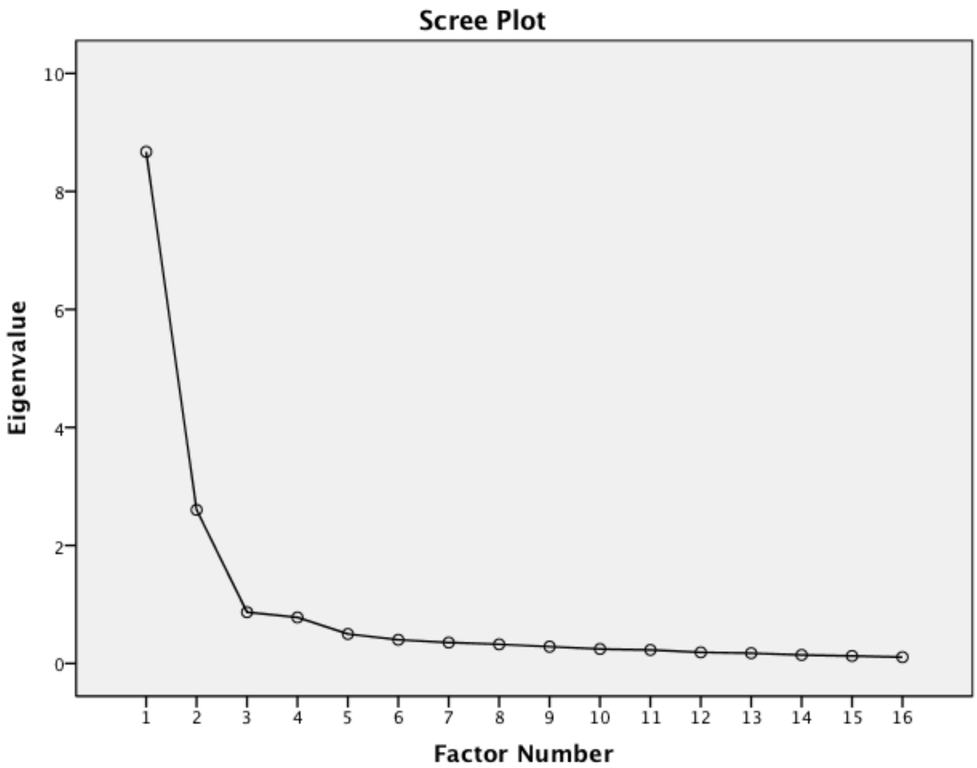


Figure 31. Scree plot for factor analysis of CNAS at T3

Table 45. Varimax rotated factor structure of the CNAS questionnaire (T3, *N*=101)

Item		*Factor 1 TA* Chemistry Test Anxiety	*Factor 2 LA* Chemistry Laboratory Anxiety
24	sitting a chemistry test or exam	**.912**	
18	studying for a chemistry test or exam	**.852**	
19	memorising chemistry definitions and formulas	**.834**	
27	waiting to get a chemistry test returned	**.803**	
26	solving a difficult problem on a chemistry test	**.781**	
21	thinking about an upcoming chemistry test one day before	**.775**	
25	reading the word ‘chemistry’	**.665**	
23	identifying a substance from its chemical formula	**.656**	.506
29	mixing chemicals in the laboratory		**.913**
22	using the equipment in a chemistry experiment		**.847**
16	performing a chemistry experiment in the laboratory		**.801**
17	interpreting graphs or charts that show the results of a chemistry experiment	.328	**.626**
31	spilling a chemical		**.598**
	Total number of items	8	5
	Eigenvalue	6.74	2.51
	% Variance:	40.07%	26.24%
	Cronbach’s alpha	.938	.869

NB: Loadings less than .3 have been omitted.

Appendix 17. Validity data for CNSS and CNAS

Table 46. Results for independent t-tests to investigate concurrent validity of the CNSS and CNAS based on initial scores

Factor	Chemistry experience	Mean	*t*	df	*p*
CS	No senior chemistry	1.43 (0.71)	5.012	99	<.001
	Senior chemistry	2.24 (0.73)			
LS	No senior chemistry	2.22 (0.96)	2.751	99	<.001
	Senior chemistry	2.81 (0.84)			
TA	No senior chemistry	2.04 (0.88)	.204	99	.839
	Senior chemistry	2.00 (0.95)			
LA	No senior chemistry	1.43 (0.72)	.038	99	.970
	Senior chemistry	1.42 (0.75)			

Table 47. Pearson product-moment correlations with academic performance to illustrate predictive validity of CNSS and CNAS

Factor		Pearson correlation Academic Performance
Chemistry Cognitive Self-efficacy	CS	.654***
Chemistry Laboratory Self-efficacy	LS	.185
Chemistry Test Anxiety	TA	-.597***
Chemistry Laboratory Anxiety	LA	-.203*

*p<.05, ***p<.001

Table 48. Pearson product-moment correlations between factors to demonstrate construct validity of CNSS and CNAS

		LS	TA	LA
Chemistry Cognitive Self-efficacy	CS	.570***	-.584***	-.293**
Chemistry Laboratory Self-efficacy	LS		-.159	-.312**
Chemistry Test Anxiety	TA			.404***
Chemistry Laboratory Anxiety	LA			

*p<.05, ***p<.001

Table 49. Comparison of Cronbach alpha coefficients for scales reported in the literature to demonstrate convergent validity of CNSS and CNAS

	Cognitive SE	Laboratory SE	Chemistry SE
CNSS	**.92**	**.88**	
CCSS (Uzuntiryaki & Aydin, 2009)	.92	.87	
CAEQ (Dalgety, et al., 2003)			.96

	Test Anxiety	Laboratory Anxiety
CNAS	**.94**	**.87**
	Evaluation anxiety	Handling chemicals
DCARS (Eddy, 2000)	.91	.89
DCARS (McCarthy & Widanski, 2009)	.91	.89
CLAI (Bowen, 1999)		.74 (mean)

Appendix 18. Example of initial provisional coding

Bernice	Just how calm and relaxed you were. Like, whereas, a lot of lecturers and teachers and so forth, when you get in, they stand behind the desk, and go 'let's just do it now'. Whereas you were like, 'hi guys'
Beth	you were more approachable
Becky	yea
Bernice	'Welcome to chemistry. You might be a bit worried but it's not going to be like that'. You were very approachable, whereas most teachers are *(moves hand across face – indicating they are faceless and non-emotional)*
Beth	Also, what you were teaching actually made sense.
All	yes, mmm
Becky	the way you said it. You said it in layman's terms
Beth	You did! Because I thought it was really going to be like … like another language,
Becky	yeh
Beth	and you just started talking about stuff that I - we could understand - and I thought, 'this is actually quite practical'
Bernice	You also brought it back to examples - like - day to day activities – like elements – whatever. And you said 'well, you could also relate it to this - like – day to day things we do everyday. And I sit there and go, 'oh well, now that I think about it, yea, that makes sense'
Beryl	The more we got into the bridging course, what we achieved in the morning, in the afternoon, and the end of the day, those sort of segments, the anxiety did drop because, yea, it was achievable with learning.
all	yea
Bernice	yea, it's like, you weren't sitting there going -
Beryl	it was achievable, you were on time, it was time specific, you delivered it really well, and with that, reduced people's anxiety
Beth	There's a lot of mystery about chemistry. Do you think that's it? People just don't really know what it is.
Bernice	Stigma attached.
Bella	I liked the fact that I was so anxious, but when I got into the room, everyone was on the same level as me, and by the end of it …
All	*enthusiastic yes*
Beth	people were there for a reason because they knew they knew nothing.
Bella	and by the end of it, we're all like, right, we're still on the same page, confidence had grown
Interviewer	you'd progressed together
All	*enthusiastic yes*
Bernice	actually, that helped as well because at the beginning you said to us, who's done chemistry and who's done so forth, and that also helps that as well, because I was sitting there going, I may not know anything but even if people

Appendix 19. Progression in the coding process

The following lists illustrate how the coding of the focus group interview data progressed with time, showing three early stages in the evolutionary process.

1. Early codes and categories

Nature of chemistry

Age

Gender

Confidence

Motivation for study

Preconceived ideas

- difficulty of chemistry
- have to be smart
- unknown realm
- like/dislike
- gender

Relevance

- to nursing
- to life

Social Connection

- sense of collaboration
- small group size
- with lecturer

Global inhibitors

- meeting people
- parking
- connection with lecturer
- finding correct location
- time to study
- lots to do
- size of class

Teacher influence

- teacher characteristics
  - approachable
  - personality -connection
  - funny
  - enthusiastic presenter
  - presentation style
  - pace
- clarity: expert
  - explanation skills
  - knowledge
- practical/useful
- relevant material

Foreign Language

- distilling chemistry as a foreign language
- chemistry is alien

Background knowledge

- existence of
- foundation
- repetition of concepts /revisiting

Anxiety

- information overload
- new concepts
- first test
- chemical/laboratory anxiety
- anxiety of chemistry

2. Additional codes and categories were added, including the emergence of the first theme.

- Connect – everyday life
- Connect – peers
- Connect – staff (lecturer, assistants)
- Connect – with nursing profession
- Connect – chemistry content
- Connect – theory with practice (tutorials, laboratories)
- Connect – chemistry the subject

- Pride in achievement / accomplishment
- Assessing capability
- Chemistry as alien
- Preconceived ideas of chemistry
- Control of learning – foundation, pace
- Prepared for learning
- Condition of learning
- Global inhibitors
- Explain for understanding
- Repetition
- Support
- Lab anxiety
- Chemistry anxiety
- Lack of experience
- Satisfaction
- Nature of chemistry
- Motiviation to study
- Assessment of pre-requisite knowledge
- Test anxiety
- Support
- Natural interest

---

3. Code structure following the emergence of the three themes and after initial transcription of five focus group interviews. This was prior to the entry of the focus group data into NVivo at which point the codes and categories were refined, tested for resilience and further amended.

Connectivity

Real-life situations	• everyday life • chemistry & profession (how much chem., nursing egs)
Curriculum	• chemistry the subject • chemistry content • labs • theory with practice (tutorials, labs) • anatomy & physiology • depth of chemistry
Social	• lecturer • student tutors • peers: working in groups, comparing with others • gender • family • support • school teacher

Self-reflectivity

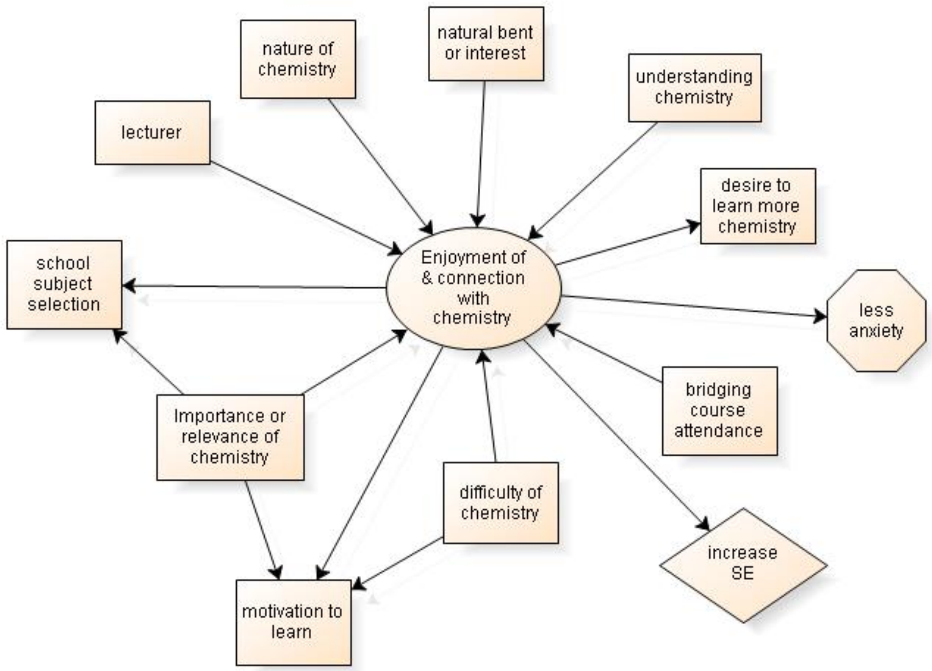
Self-assessment	• assessing achievement • assessing capability
Anxiety	
Natural interest	
Confidence	• (perhaps combine with self-assessment)
Preconceived ideas	• difficulty level of chemistry • specific • expectations of what's to come • what chemistry is • lecturer • from school
Motivation	• intrinsic (enjoyment, fun, challenge) vs extrinsic (career goal, pass, kill patient)

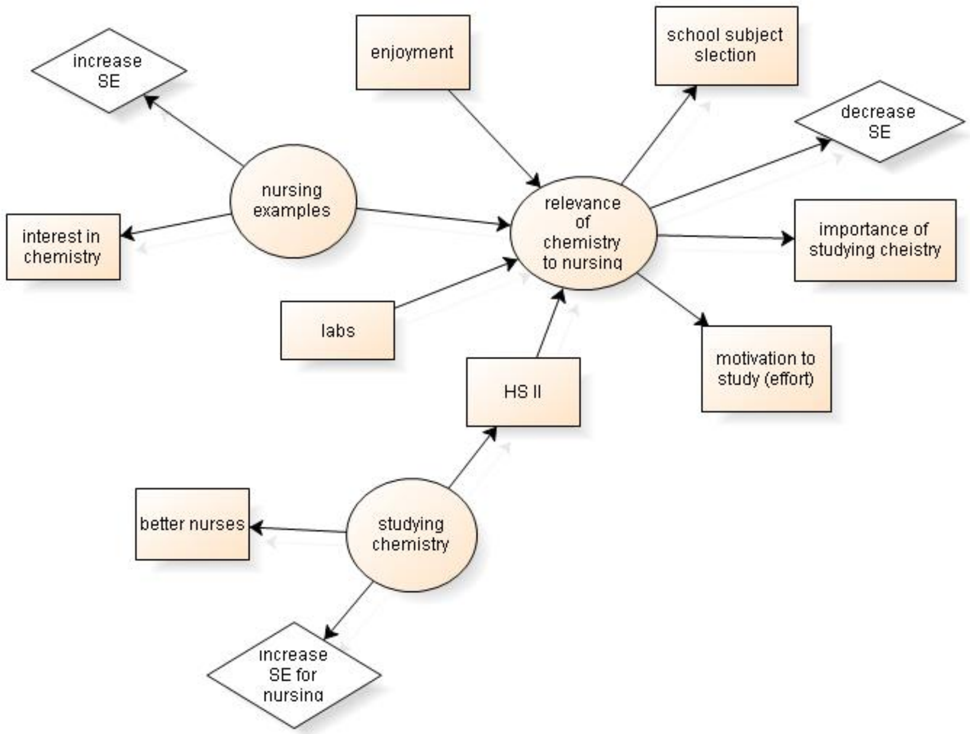
Reductivity

Explain for understanding	
Repetition	
Alien – foreign	
Nature of chemistry:	submicro, macro, representational
Control of learning	• foundation knowledge • pace of lesson • study load • Study breaks • Structure – book, lectures, course
Global inhibitors	• parking, age, class size, work load

The qualitative structure reported in Table 7 was finalised after the individual interviews.

Appendix 20. Sample of early flow charts constructed during the analysis of interview data





Appendix 21. Qualitative models for individual interviewees

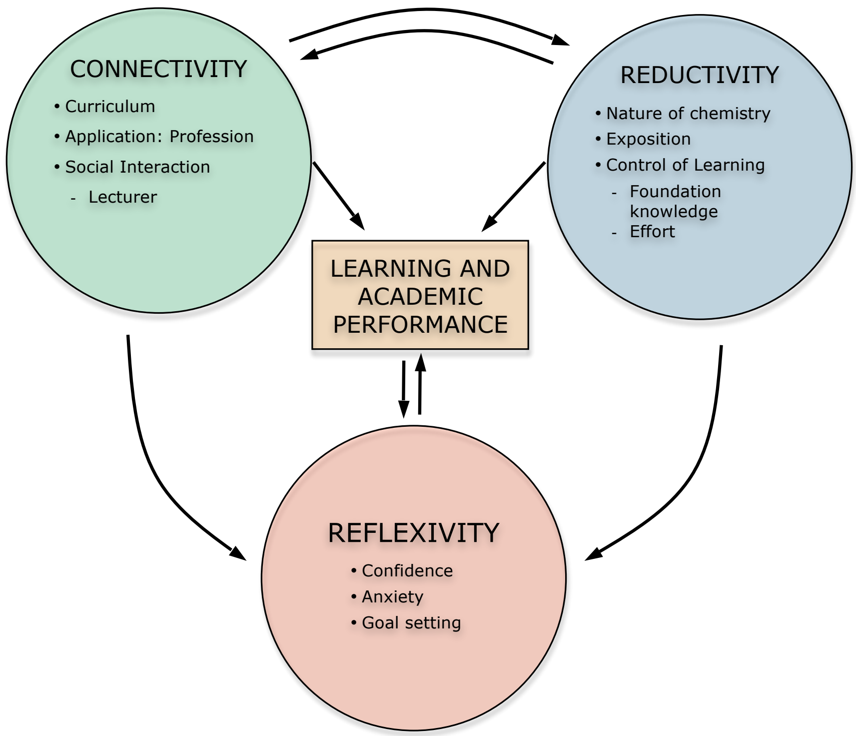


Figure 32. Qualitative model for Beth

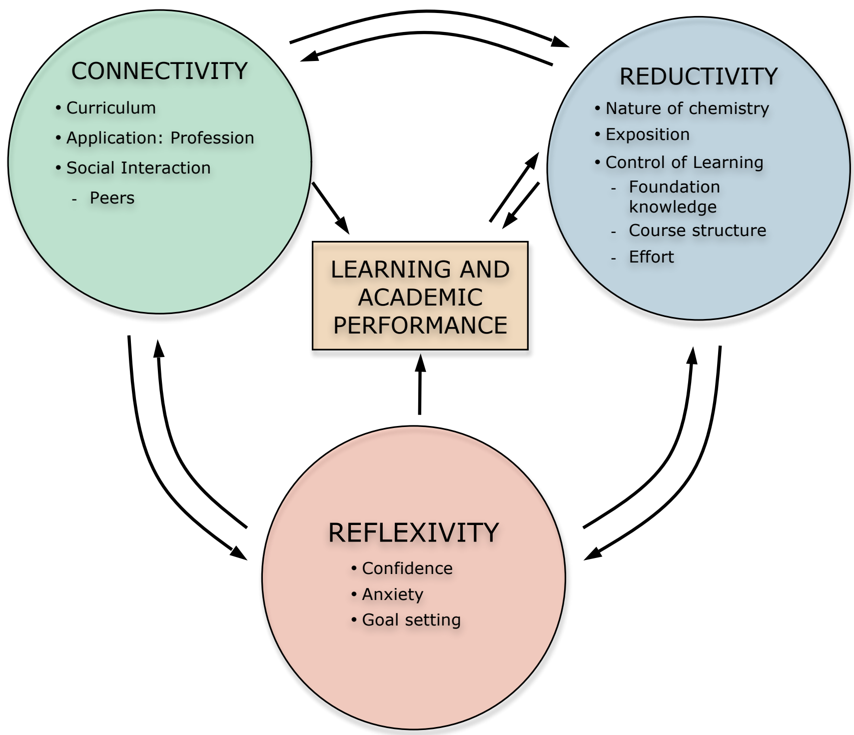


Figure 33. Qualitative model for Brett

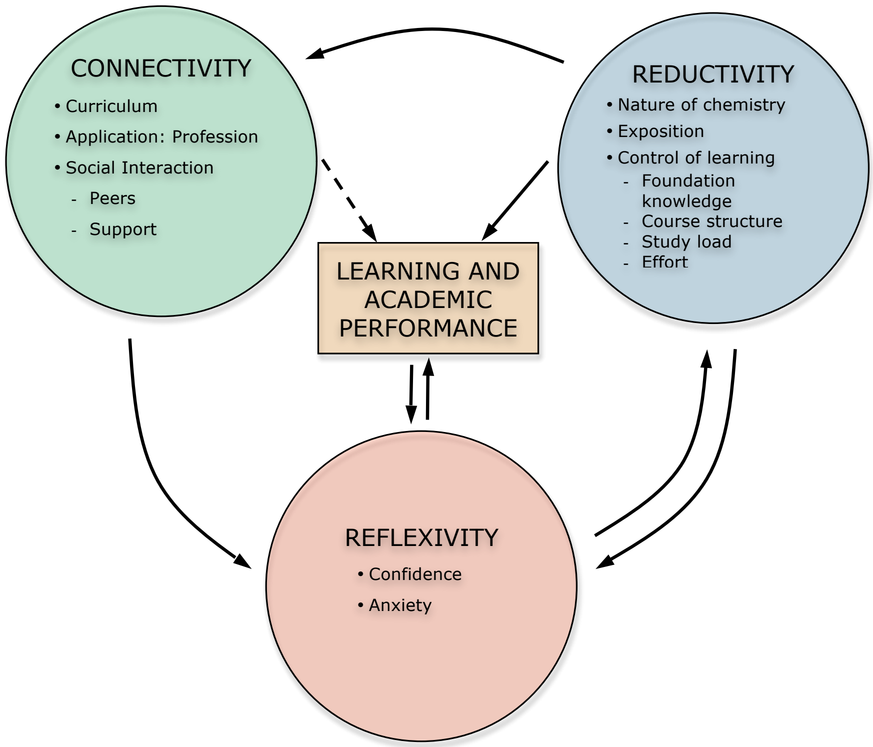


Figure 34. Qualitative model for Paula

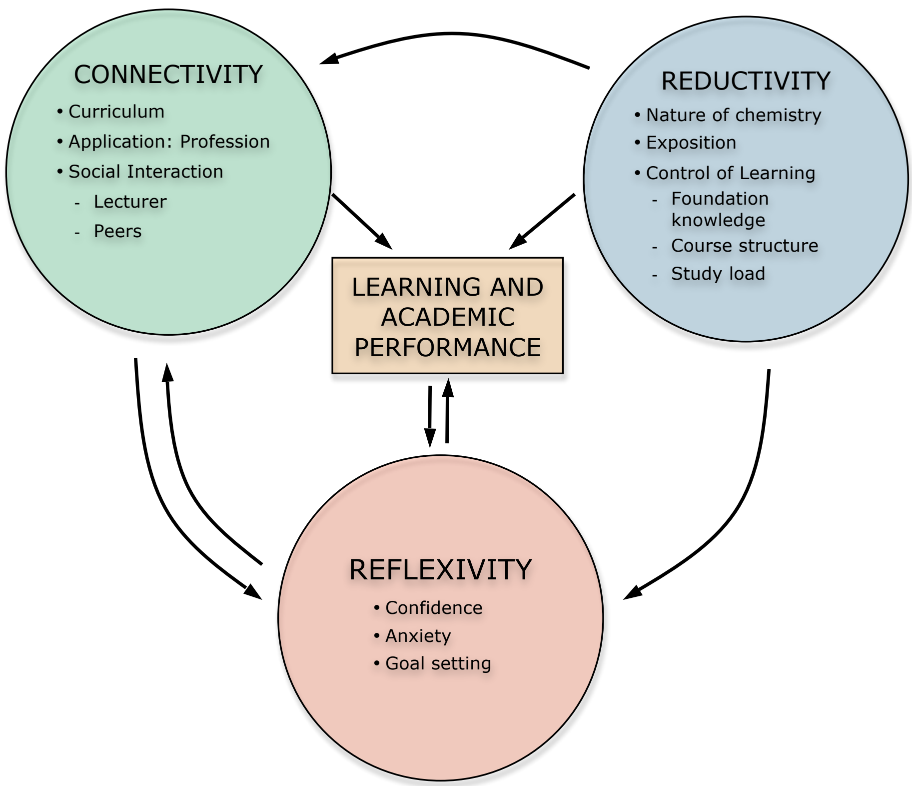


Figure 35. Qualitative model for Pippa

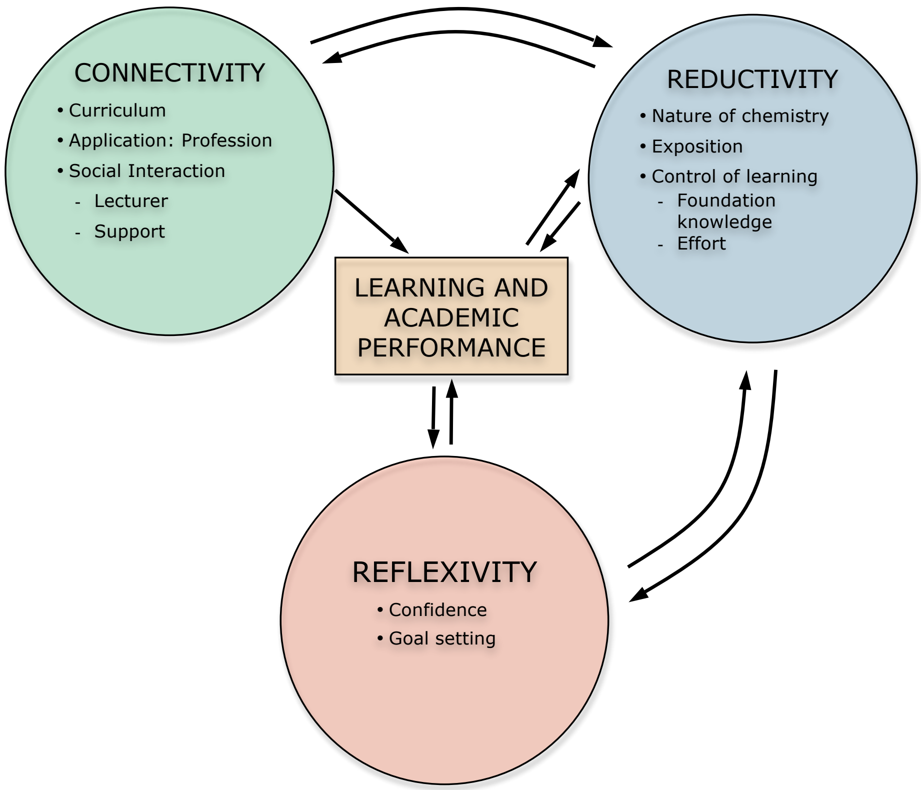


Figure 36. Qualitative model for Samuel

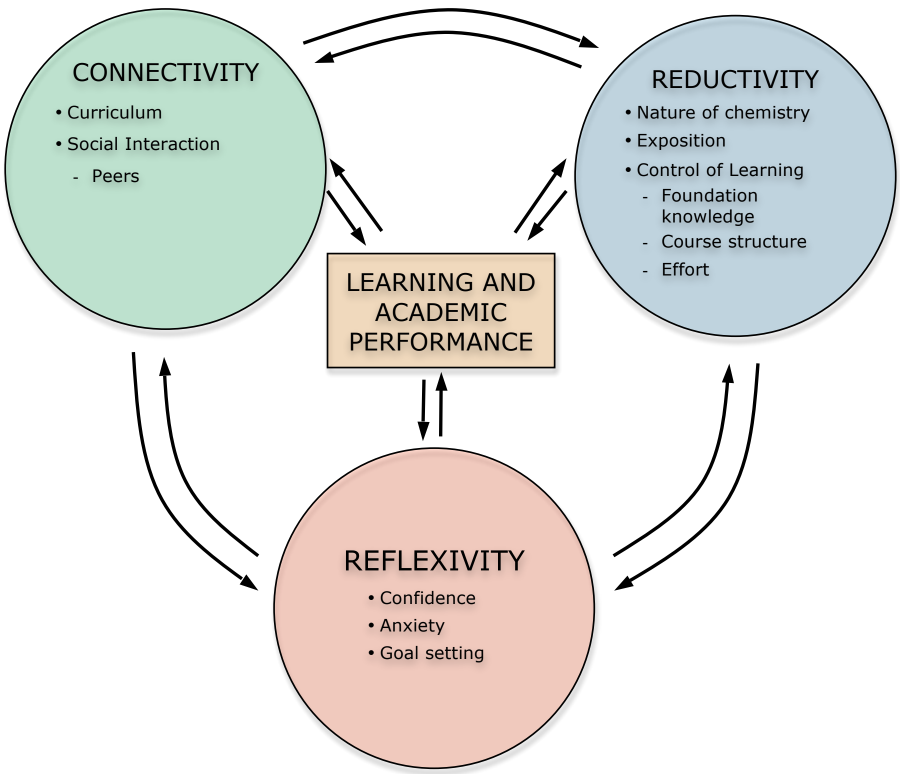


Figure 37. Qualitative model for Sofia

Appendix 22. Correlation matrices – initial and final measures

Table 50. Pearson product moment correlations for initial measures

	Mean	Age	WkHr	PCE	CS i	LS i	TA i	LA i	Enj i	Imp i	ExR i
Age	22.99										
WkHr	8.76	.347**									
PCE	-	-.195	-.214*								
CS i	1.64	-.152	-.125	.397***							
LS i	2.37	-.134	.047	.174	.666***						
TA i	2.03	.082	.001	-.146	-.172	.057					
LA i	1.43	.100	.051	-.056	-.147	-.126	.501***				
Enj i	1.28	.071	.130	.127	.414***	.197	-.183	-.021			
Imp i	2.74	.167	.110	-.085	.224*	.032	-.193	-.046	.236*		
ExR i	2.58	-.112	-.126	.216*	.385***	.121	-.128	-.006	.115	.096	
AP	55.63	.031	-.261**	.337***	.333**	.090	-.220*	-.133	.180	-.082	.336**

* p<.05, ** p<.01, *** p<.001

WkHr=hours of work per week, PCE=prior chemistry experience, CS=cognitive self-efficacy, LS=laboratory self-efficacy, TA=test anxiety, LA=laboratory anxiety, Enj=level of enjoyment, Imp=importance of chemistry to nursing, ExR=expected result, AP=academic performance

Note: Initial measures - scores at T1 for BC students and T2 for PC and SC students

Table 51. Pearson product moment correlations for measures taken at T3

	Mean	Age	WkHr	PCE	CS3	LS3	TA3	LA3	Enj 3	Imp 3	CoNur3	ExR 3
Age	22.99											
WkHr	8.76	.347**										
PCE	-	-.195	-.214*									
CS3	2.64	-.229*	-.241*	.340**								
LS3	3.06	-.164	-.109	.113	.570***							
TA3	1.82	.144	.212*	-.306**	-.584***	-.159						
LA3	0.97	.083	.040	-.075	-.293**	-.312**	.404***					
Enj 3	2.44	-.069	-.041	.143	.678***	.308**	-.582***	-.067				
Imp 3	2.46	.115	.003	.076	.465***	.215*	-.430***	-.041	.621***			
CoNur 3	2.23	-.012	-.058	.084	.539***	.210*	-.407***	-.052	.663***	.757***-		
ExR 3	2.78	.046	-.149	.293**	.728***	.276**	-.545***	-.175	.638***	.500***	.474***	
AP	55.63	.031	-.261**	.337***	.654***	.185	-.597***	-.203*	.577***	.435***	.437***	.704***

* *p*<.05, ** *p*<.01, *** *p*<.001

WkHr=hours of work per week, PCE=prior chemistry experience, CS=cognitive self-efficacy, LS=laboratory self-efficacy, TA=test anxiety, LA=laboratory anxiety, Enj=level of enjoyment, Imp=importance of chemistry to nursing, ExR=expected result, CoNur=contribution of chemistry to competence as a nurse, AP=academic performance

Appendix 23. Chemistry self-efficacy items: initial and final means and standard deviations, along with paired samples t-test results

Item	Initial Mean (SD)	Final Mean (SD)	Mean difference (SD)	*t*	df	*p*
1. explaining the structure of an atom	1.36 (1.15)	2.96 (0.89)	1.60 (1.19)	13.520	100	<.001
2. explaining the properties of elements by using a periodic table	1.37 (1.12)	3.16 (0.80)	1.79 (1.19)	15.187	100	<.001
3. working with chemicals safely	*2.54 (1.10)*	*3.31 (0.80)*	*0.76 (1.06)*	*7.230*	*100*	*<.001*
4. interpreting graphs related to chemistry	1.38 (1.04)	2.68 (0.97)	1.30 (0.95)	13.885	100	<.001
5. carrying out experimental procedures in the laboratory	*2.28 (1.11)*	*3.06 (0.79)*	*0.78 (0.94)*	*8.323*	*100*	*<.001*
6. identifying an element or compound from its chemical formula	1.36 (1.15)	2.81 (1.05)	1.45 (1.20)	12.230	100	<.001
7. achieving a passing grade in chemistry	2.31 (1.02)	2.63 (1.19)	0.32 (1.11)	2.970	100	.004
8. explaining the relevance of studying chemistry in a nursing context	1.56 (0.96)	2.36 (1.05)	0.80 (1.24)	6.401	100	<.001
9. explaining something learnt in this chemistry unit to another person	2.11 (1.11)	2.61 (0.96)	0.50 (1.14)	4.464	100	<.001
10. interpreting results from a chemistry laboratory session	1.72 (0.99)	2.50 (0.93)	0.78 (1.00)	7.892	100	<.001
11. choosing an appropriate mathematical formula to solve a chemistry problem	1.15 (1.10)	2.30 (1.09)	1.15 (1.22)	9.446	99	<.001
12. reading the procedure then successfully conducting a chemistry experiment	*2.11 (1.14)*	*2.81 (0.93)*	*0.70 (1.15)*	*6.085*	*99*	*<.001*
13. mastering the knowledge required in this chemistry course	2.09 (1.01)	2.34 (1.02)	0.25 (1.03)	2.430	99	.017
14. interpreting the results of a pH reading for a patient	2.12 (1.21)	2.83 (0.90)	0.71 (1.11)	6.468	100	<.001
15. correctly using the equipment in the chemistry laboratory	*2.55 (1.08)*	*3.06 (0.84)*	*0.51 (1.02)*	*4.994*	*100*	*<.001*

Appendix 24. Chemistry self-efficacy data based on gender

Table 52. Chemistry self-efficacy (SE): initial and final means (and standard deviations) for cognitive and laboratory dimensions for the total cohort and gender

Cohort		*N*	Chemistry SE initial	Chemistry SE final
Cognitive	*Total*	*101*	*1.64 (0.79)*	*2.64 (0.75)*
	male	9	1.79 (0.94)	3.00 (0.63)
	female	92	1.63 (0.78)	2.60 (0.76)
Laboratory	*Total*	*101*	*2.37 (0.96)*	*3.06 (0.71)*
	male	9	2.17 (1.17)	3.28 (0.59)
	female	92	2.39 (0.95)	3.04 (0.72)

Table 53. Changes in cognitive and laboratory chemistry self-efficacy from initial to final measures based on gender

	Gender	Mean change in self-efficacy (*SD*)	df	*t*	Significance (*p*)	Effect Size (Cohen's *d*)
CS	male	1.21 (0.47)	8	7.77	<.001	1.54
	female	0.98 (0.75)	91	12.457	<.001	1.27
LS	male	1.11 (1.01)	8	3.305	.011	1.26
	female	0.64 (0.81)	91	7.646	<.001	0.77

Appendix 25. Laboratory chemistry self-efficacy data

Table 54. Laboratory chemistry self-efficacy (LS): means (and standard deviations) measures initially, at T2 and T3 for the total cohort and groups based on prior chemistry experience

Cohort		*N*	LS initial	LS 2	LS 3
Total cohort		*101*	*2.37 (0.96)*	*2.51 (0.92)*	*3.06 (0.71)*
Prior chemistry experience	PC	44	2.32 (1.02)	2.32 (1.02)	3.03 (0.73)
	BC	31	2.09 (0.88)	2.55 (0.78)	2.96 (0.77)
	SC	26	2.81 (0.84)	2.81 (0.84)	3.26 (0.59)

Table 55. Pearson product-moment correlations between laboratory self-efficacy (LS) and various 'perceptions of chemistry' variables

		LS Initial	LS3
Level of enjoyment since last studying chemistry	Initial	**.197**	.019
	T3	.175	**.308****
Expected result in chemistry	Initial	**.124**	.080
	T3	.229*	**.276****
Importance of chemistry to nursing	Initial	**.032**	-.054
	T3	.076	**.215***
Contribution of chemistry to competence as a nurse	T3	.027	**.210***

* *p*<.05, ** *p*<.01, *** *p*<.001

Table 56. Pearson product-moment correlations between laboratory self-efficacy (LS) and academic variables

	N	LS Initial	LS3
PRM	85	.159	.302**
Academic Performance	100	.090	.185

Appendix 26. Chemistry anxiety items from the CNAS: initial and final means and standard deviations along with paired samples t-test results

Item	Initial Mean (SD)	T3 Mean (SD)	Mean difference (SD)	*t*	df	*p*
16. performing a chemistry experiment in the laboratory	*1.63 (0.89)*	*0.88 (0.95)*	*-0.47 (1.12)*	*-4.184*	*99*	*<.001*
17. interpreting graphs or charts that show the results of a chemistry experiment	1.63 (0.97)	1.09 (0.94)	-0.54 (1.12)	-4.771	99	<.001
18. studying for a chemistry test or exam	2.07 (1.15)	2.00 (1.22)	-0.07 (1.42)	-0.494	98	.622
19. memorising chemistry definitions and formulas	2.11 (1.20)	1.87 (1.19)	-0.24 (1.26)	-1.910	99	.059
20. walking into a lecture for chemistry	1.14 (1.56)	0.63 (1.00)	-0.51 (1.35)	-3.772	99	<.001
21. thinking about an upcoming chemistry test one day before	2.31 (1.11)	2.29 (1.31)	-0.02 (1.37)	-0.146	99	.884
22. using the equipment in a chemistry experiment	*1.28 (0.99)*	*0.75 (0.97)*	*-0.53 (1.04)*	*-5.107*	*98*	*<.001*
23. identifying a substance from its chemical formula	1.85 (0.98)	1.21 (1.10)	-0.64 (1.15)	-5.521	98	<.001
24. sitting a chemistry test or exam	2.44 (1.10)	2.30 (1.27)	-0.14 (1.38)	-1.016	99	.312
25. reading the word ‘chemistry’	0.98 (1.16)	0.73 (1.14)	-0.25 (1.18)	-2.127	99	.036
26. solving a difficult problem on a chemistry test	2.43 (1.08)	2.15 (1.20)	-0.28 (1.38)	-2.031	99	.045
27. waiting to get a chemistry test returned	2.32 (1.27)	2.03 (1.33)	-0.29 (1.34)	-2.171	99	.032
28. listening to a lecture in chemistry	1.19 (1.09)	0.75 (1.08)	-0.44 (1.15)	-3.801	99	<.001
29. mixing chemicals in the laboratory	*1.25 (0.89)*	*0.86 (1.03)*	*-0.39 (1.05)*	*-3.703*	*99*	*<.001*
30. picking up your chemistry lecture notes to begin working on a tutorial assignment	1.34 (1.04)	1.06 (1.18)	-0.28 (1.26)	-2.229	99	.028
31. spilling a chemical	*1.65 (1.12)*	*1.27 (1.32)*	*-0.38 (1.41)*	*-2.704*	*99*	*.008*

Appendix 27. Some anxiety tables: differences and changes

Table 57. Chemistry anxiety: initial and final means (and standard deviations) for the total cohort and gender

	Cohort	*N*	Initial Anxiety	Final Anxiety
Test	*Total*	*101*	*2.03 (0.90)*	*1.82 (1.02)*
	male	9	1.65 (0.86)	1.04 (0.65)
	female	92	2.07 (0.90)	1.90 (1.02)
Laboratory	*Total*	*101*	*1.43 (0.73)*	*0.97 (0.85)*
	male	9	1.24 (1.03)	0.91 (1.28)
	female	92	1.45 (0.69)	0.97 (0.80)

Table 58. ANOVA results for differences in test anxiety based on prior chemistry experience

Measure	df	*F*	*p*	η^2
TA initial	2, 98	3.210	.045	0.061
TA 2	2, 98	1.274	.284	-
TA 3	2, 98	5.146	.008	0.096

Table 59. Laboratory anxiety (LA) based on academic performance groups: means (and SD) for initial and final measures and changes in laboratory anxiety over the semester (final - initial)

Academic Performance Category	Mean $LA_{initial}$ (*SD*)	Mean LA_{final} (*SD*)	Mean change in LA (*SD*)	df	*t*	*p*	Effect Size Cohen's *d*
Total Cohort	*1.43 (0.73)*	*0.97 (0.85)*	*-0.46 (0.85)*	*99*	*-5.496*	*<.001*	*0.58*
Low	1.46 (0.74)	1.11 (0.90)	-0.35 (0.91)	35	-2.301	.027	0.43
Average	1.50 (0.68)	0.99 (0.90)	-0.51 (0.94)	31	-3.045	.005	0.64
High	1.31 (0.76)	0.76 (0.73)	-0.55 (0.66)	30	-4.531	<.001	0.72

Low = <45%, Average = 45-69%, High = 70+%

Appendix 28. Sample page from course notes

HESC14700 Health Science I

e.g. 3 9.01 g of water would represent 0.5 moles of water

e.g. 4 46 g of sodium represents 2 moles

To convert mass to moles:

$$\text{moles} = \frac{\text{mass}}{\text{molar mass}}$$

e.g. 5 How many moles in 64 g of glucose?

Exercises

2. Find the number of moles in 23.5 g of carbon dioxide.

NB: Expressing amounts of substances in moles rather than grams allows you to keep track of the ______________ of particles.

b) Molarity

We can now come back to concentration. Since concentration is the amount of solute dissolved per volume of solvent, and amount of solute can be measured in 'moles', concentration can be expressed in terms of moles/litre.

- A molar solution is 1 mole of the solute in 1 litre of *solution*.
- **Molarity**: the number of moles of solute per litre of solution

$$\textbf{molarity} \quad (M) = \frac{\text{number of moles of solute}}{\text{volume of solution in } \textit{litres}}$$

concentration =

NB: Units can be expressed as __________, _________ , or ____

Medically, concentration is often expressed in millimoles (one-thousandth of a mole) per litre: ___________ or _______ (see IV bag)

Table 5.1 Normal concentration range for some blood values

Parameter	Reference value
calcium	2.1 – 2.6 mmol/L
cholesterol	3.9 – 5.5 mmol/L
glucose (F)	3.6 – 5.5 mmol/L
creatinine	8.8 – 130 μmol/L

Appendix 29. Demographic statistics related to academic performance

Table 60. Academic performance statistics based on gender

		Number of cases	Academic Performance		Range
			Mean	Standard Deviation	
Total cohort		*100*	*55.63*	*19.86*	*9.5 – 92.7*
Gender	male	9	58.39	15.54	39.4 – 79.0
	female	91	55.36	20.26	9.5 – 92.7

Table 61. Academic performance statistics based on age groups

	Number of cases	Academic Performance		Range
		Mean	Standard Deviation	
Total cohort	*100*	*55.63*	*19.86*	*9.5 – 92.7*
17, 18	35	52.02	18.38	9.5 - 81.9
19-21	31	58.24	17.26	28.0 – 87.3
22+	34	56.98	23.28	17.4 – 92.7

Appendix 30. Focus group data: mental effort and difficulty levels

Table 62. Focus groups: mental effort and difficulty levels

Question	Group	N	Mean	SD	Range
1. How much mental effort is required for chemistry?	PC	10	7.70	1.16	6-9
	BC	10	6.90	1.45	4-9
	SC	7	6.29	1.50	3-7
	TOTAL	27	7.04	1.43	3-9
2. How much mental effort is required for sociology and psychology?	PC	10	4.50	1.43	3-8
	BC	10	5.20	1.99	1-8
	SC	7	5.43	1.40	4-8
	TOTAL	27	5.00	1.64	1-8
3. How difficult is the content in chemistry?	PC	10	7.10	0.99	6-9
	BC	10	6.70	1.25	5-9
	SC	7	5.71	1.11	4-7
	TOTAL	27	6.59	1.22	4-9
4. How difficult was it for you to learn the chemistry material?	PC	10	7.20	1.32	5-9
	BC	10	6.30	1.70	4-9
	SC	7	4.86	1.68	3-8
	TOTAL	27	6.26	1.77	3-9

The range of the scale was from ‘1’ (none/not at all) to ‘9’ (extremely high)

Appendix 31. Statistics for 'perceptions of chemistry' based on academic performance groups

Table 63. 'Level of enjoyment since last studying chemistry': Means (and SD) for initial and T3 and changes in enjoyment over the semester (initial to T3) based on academic performance groups

Academic Performance Group	Mean enjoyment *initial* (*SD*)	Mean enjoyment *T3* (*SD*)	Mean change (*SD*)	df	*t*	*p*	Effect Size Cohen's *d*
Total Cohort	*1.28 (1.13)*	*2.41 (1.10)*	*1.13 (1.31)*	*98*	*8.615*	*<.001*	*1.01*
Low	1.17 (1.03)	1.69 (1.10)	0.52 (1.30)	35	2.440	.020	0.49
Average	1.38 (1.10)	2.53 (0.95)	1.15 (1.08)	31	6.051	<.001	1.12
High	1.33 (1.32)	3.17 (0.65)	1.84 (1.23)	29	8.137	<.001	1.77

Low = <45%, Average = 45-69%, High = 70+%

Table 64. 'Importance of chemistry to nursing': Means (and SD) for initial and T3 and changes in importance over the semester (initial to T3) based on academic performance groups

Academic Performance Group	Mean import *i* (*SD*)	Mean import 3 (*SD*)	Mean change (*SD*)	df	*t*	*p*	Effect Size Cohen's *d*
Total Cohort	*2.74 (0.87)*	*2.45 (1.00)*	*-0.29 (1.21)*	*99*	*-2.400*	*.018*	*0.31*
Low	3.00 (0.86)	1.92 (0.94)	-1.08 (1.25)	35	-5.197	<.001	1.20
Average	2.44 (0.84)	2.53 (0.84)	0.11 (1.00)	31	0.533	.598	-
High	2.77 (0.85)	3.00 (0.93)	0.23 (0.88)	30	1.423	.165	-

Low = <45%, Average = 45-69%, High = 70+%

Table 65. ANOVA results for significant differences in 'perceptions of chemistry' from based on academic performance groups (low, average and high)

Perception	df	F	p	η^2
Initial Enjoyment when last studied	2,92	1.128	.328	-
Initial Importance of chemistry to nursing	2,93	0.956	.388	-
Initial Expected result in chemistry	2,95	3.334	.012	.089
T3 Enjoyment when last studied[a]	2,97	22.437	<.001	.316
T3 Importance of chemistry to nursing	2,97	12.397	<.001	.204
T3 Contribution of chemistry to competence as a nurse	2,97	12.179	<.001	.201
T3 Expected result in chemistry[a]	2,97	42.101	<.001	.465

a. Levene's test of homogeniety of variance was significant. However, ANOVA is reasonably robust when sizes of groups are reasonably similar (Pallant, 2007). In this case, N=36, 32, 32.

Appendix 32. Multiple regression assumptions

Assumptions of multicollinearity for multiple regression have been addressed in Section 7.7. Assumptions for linearity and normality are addressed here.

Figure 38 shows that points on the Normal P-P Plot lie in a relatively straight, diagonal line and scatterplot points are roughly rectangularly distributed with no systematic pattern indicating relatively equal variance, suggesting no major deviations for linearity, normality and homscedasticity (Pallant, 2007). To detect any outliers, examination of the scatterplot indicates no cases with a standardised residual >|3.3| (Tabachnick & Fidell, 1996). When the Mahalanobis and Cook's distances values were inspected, one case had a Mahalanobis value of 33.29 for academic performance, which is significantly greater than the critical value for six independent variables (22.46) (Pallant, 2007). In addition, this case had a standardised residual value of 3.3 when CS3 was made the dependent variable. This case was subsequently removed from the data set for the multiple regression, leaving 84 cases.

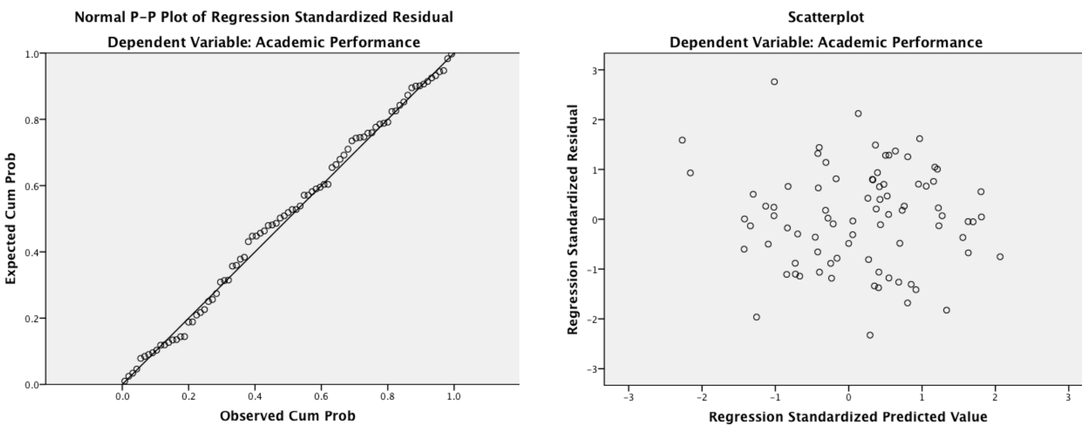


Figure 38. Preliminary graphs to facilitate analysis of assumptions for multiple regression with academic performance as the dependent variable

Appendix 33. Hierarchical regression data for initial and final CS and TA as dependent variables

Table 66. Standardized regression coefficients (β) of variables predicting T3 measures of CS and TA

Variables predicting T3	CS 3		TA 3	
	Model 1	Model 2	Model 1	Model 2
Step 1				
RPM	.429***	.406***	-.467***	-.409***
PCE[a]	.239*	.025	-.196*	-.167
Step 2				
CSi		.527***		.048
TAi		-.018		.429***
Total adjusted R^2	.272	.500	.282	.446
R^2 change	.289	.235	.299	.172
F change	16.500***	19.459***	17.101***	12.653***
df1, df2	2,81	2,79	2,80	2,78

a. PCE = prior chemistry experience
* p<.05, ** p<.01, *** p<.001

Table 67. Standardized regression coefficients (β) of variables predicting initial measures of CS and TA

Variables predicting initial CS and TA	β for CS i	β for TA i
RPM	.038	-.139
Prior chemistry experience	.402***	-.113
Total adjusted R^2	.149	.016
F	8.289**	1.658
p (for *F* change)	.001	.197
df1, df2	2,81	2,79

* p<.05, ** p<.01, *** p<.001

Appendix 34. Path effects: decomposition of effects in the estimated path model for academic performance

Dependent variable	Independent variable	Direct Effect	Indirect Effect	Total
Academic Performance	CS 3	.407	0	.407
	TA 3	-.322	0	-.322
	CS i	0	.214	.214
	TA i	0	-.138	-.138
	RPM	0	.297	.297
	PCE[a]	0	.086	.086
CS 3	CS i	.527	0	.527
	TA i	0	0	0
	RPM	.406	0	.406
	PCE	0	.212	.212
TA 3	CS i	0	0	0
	TA i	.429	0	.429
	RPM	-.409	0	-.409
CS i	PCE	.402	0	.402

a. PCE = prior chemistry experience

Appendix 35. Bridging course pre and post-test

Name / Student number: ____________________

Chemistry Quiz: Chemistry Bridging Course

This quiz is designed to allow you to see the progress you make as a result of attending the bridging course. Marks will not contribute to your grade in Health Science I.

You may use the *Periodic Table* and a *calculator* to help you answer these questions.

1. Which of the following consists of only metals?

   (a) lead, bismuth, bromine
   (b) molybdenum, xenon, silicon
   (c) uranium, zinc, barium
   (d) nitrogen, sulfur, arsenic

2. The nucleus of an atom contains

   (a) neutrons only
   (b) protons only
   (c) electrons and protons
   (d) protons and neutrons

3. Which element has the most stable electron configuration?

   (a) neon
   (b) hydrogen
   (c) sodium
   (d) oxygen

4. The chemical formula for sodium oxide would be

   (a) SO
   (b) NaO
   (c) NaO_2
   (d) Na_2O

5. The mass of 1 mole of K_2SO_4 is

   (a) 43.0 g
   (b) 86.0 g
   (c) 87.17 g
   (d) 174.27 g

6. What is the concentration of a solution containing 0.5 moles of sodium chloride dissolved in 200 mL of solution?

(a) 2.5×10^{-3} mol/L
(b) 0.1 mol/L
(c) 2.5 mol/L
(d) 1000 mol/L

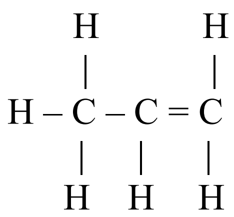
7. If the reaction A + B $\rightleftharpoons$ C + D is at equilibrium, what will happen if more C is added?

(a) the number of moles of D will increase
(b) the number of moles of B will increase
(c) equilibrium will shift to the right
(d) nothing will change because the rates of reaction will not change

8. How many milligrams is 0.045 g?

(a) 4.5×10^{-5} mg
(b) 0.045 mg
(c) 45 mg
(d) 4.5×10^{2} mg

9. Name the following compound:



(a) propane
(b) propene
(c) butene
(d) butanol

10. Which of the following bonds would be the **most** polar?

(a) H - F
(b) H - C
(c) O – N
(d) H – H

Appendix 36. Survey responses relating to the bridging course

Table 68. Survey responses to the "usefulness" of various aspects of the bridging course (*N*=28)

To what extent has each of the following aspects of the chemistry bridging course been ***helpful*** to you?	Not helpful	A little helpful	Quite helpful	Very helpful	Extremely helpful
1. the chemistry lectures	0	0	4	8	16
2. the tutorial sessions	0	0	4	9	15
3. the laboratory sessions	0	4	12	7	5
4. meeting the staff	0	1	9	9	9
5. connecting with fellow students	0	1	2	12	13

Table 69. Survey responses to the "usefulness" of various aspects of the bridging course based on campus attended (*N*=28)

To what extent has each of the following aspects of the chemistry bridging course been ***helpful*** to you?	Not helpful		A little helpful		Quite helpful		Very helpful		Extremely helpful	
	R*	C*	R	C	R	C	R	C	R	C
1. the chemistry lectures	0	0	0	0	4	0	6	2	2	14
2. the tutorial sessions	0	0	0	0	3	1	9	0	0	15
3. the laboratory sessions	0	0	1	3	6	6	4	3	1	4
4. meeting the staff	0	0	1	0	2	7	5	4	4	5
5. connecting with fellow students	0	0	1	0	1	1	5	7	5	8

* denotes Rural and City campus

Table 70. Summary results for the "effectiveness" of the bridging course to change confidence, anxiety and interest in nursing (*N*=28)

Question	down a lot	down a little	no change	up a little	up a lot
6. How has your overall confidence in Chemistry changed as a result of attending this bridging course?	1	1	0	13	13
7. How has your overall anxiety level towards Chemistry changed as a result of attending this bridging course?	9	9	6	2	2
8. To what extent has your interest in nursing been changed by attending the bridging course?	0	3	13	5	7

Table 71. Summary results for the "effectiveness" of the bridging course to change confidence, anxiety and interest in nursing, based on campus attendance (*N*=28)

Question	down a lot		down a little		no change		up a little		up a lot	
Campus	R*	C*	R	C	R	C	R	C	R	C
6. How has your overall confidence in Chemistry changed as a result of attending this bridging course?	0	1	1	0	0	0	8	5	3	10
7. How has your overall anxiety level towards Chemistry changed as a result of attending this bridging course?	0	9	4	5	5	1	1	1	2	0
8. To what extent has your interest in nursing been changed by attending the bridging course?	0	0	3	0	5	8	2	3	2	5

* denotes Rural and City campus

Table 72. Frequencies for bridging course feedback on the T3 questionnaire (*N*=31)

How helpful was the bridging course in	not at all	a little	a fair amount	much	very much
a. introducing chemistry knowledge	0	5	2	5	19
b. reducing anxiety towards chemistry	4	3	7	6	11
c. preparing you for Health Science I	0	4	6	6	15

Table 73. Frequencies for PC responses on the T3 questionnaire related to the bridging course (*N*=45)

	not at all	a little	fair amount	much	very much
1. To what extent do you think the bridging course could have helped you with chemistry in Health Science I?	1	14	10	7	13
2. To what extent do you wish you had completed the bridging course?	7	10	2	4	21

Table 74. Reasons for bridging course non-attendance by PC students (*N*=47)

Reason	*f*	% of respondents
Did not know the course was offered	24	51
Cost	6	13
Already had other plans	5	11
Did not think it was needed	5	11
Late enrolment (hence missed the course)	4	8
Forgot about it / Did not follow up	3	6

Note: These figures include responses from all PC students who completed the T3 questionnaire, not just those included in the quantitative analysis of the study.