IDENTIFYING AN APPROPRIATE SCIENCE CURRICULUM FOR UNDERGRADUATE NURSING IN NEW ZEALAND

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ABSTRACT

The depth and breadth of science knowledge that is required to educate registered nurses has been the subject of much debate, both nationally and internationally. Central to the debate is the lack of clarity on what science is required for nursing. Nursing students world-wide report anxieties and difficulties with learning science within nursing programmes. It has not been established if science is required for nursing, nor has it been established how science is used by nurses engaged in clinical practice. This research was aimed at examining the use of science in nursing practice and therefore identifying an appropriate undergraduate nursing science curriculum for New Zealand nursing schools.

To achieve this aim, a mixed method, interpretive, naturalistic approach has been employed involving interviews, surveys, observation studies and document analysis. The research had four phases; interviews with nine nurse educators and lecturers, written surveys undertaken by 71 registered nurses, observation and in-depth interviews with 17 registered nurses' in practice across the central and lower North Island, and document analysis. Nurse educators and lecturers were interviewed to gain their perspectives of the role of science in nursing. A Science Attitude and Self-Efficacy (*SASE*) survey included sections that focused on nurses' attitudes towards their nursing science courses, attitudes towards science in nursing, and probed their confidence in their own ability to use science in practice. Observations of nurses in their clinical practice were conducted over several hours and the nurses interviewed about their observed actions. The observed nursing actions and espoused science knowledge that were extracted from clinical practice were categorised into science and science-related topics which frame the breadth of content used in nursing practice, and the depth was ascertained by the level of complexity the nurse was able to articulate. Document analysis of curriculum information as well as Nursing Council of New Zealand standards for education, competencies and scopes of practice was also performed to ascertain the importance and relevance of science to nursing practice.

Nursing Council documents state that science is important for all levels of nursing practice, from patient observation, to clinical decision-making. Science knowledge assists the nurse when conducting risk analyses and when performing nursing care and assessment. A competent nurse needs to provide advocacy and education for a patient. To be effective at this, a nurse needs to be able to read, critique, understand and translate scientific information and be able to effectively communicate with other health professionals.

The majority of nurses in practice felt that science knowledge was the foundation for nursing practice, and that nurses require an in-depth knowledge of science. Nurses who had passed Level 3 secondary school science were more likely to have found studying nursing science courses easy, and had a positive attitude towards using science-in-practice. Those nurses who had a positive attitude towards science were more likely to use in-depth science knowledge in their nursing practice. Nurses who practice in areas where their decision-making is independent and autonomous were more likely to use more in-depth science to inform their practice. Nurses that had a less positive attitude towards science were more likely to have experienced difficulty studying science courses as a student, and were more likely to apply shallow science in their nursing practice.

The curriculum design processes within nursing schools may contribute to devaluation of science in nursing. Nursing lecturers were more likely to have a less positive attitude of science's relevance to nursing practice than nurses in practice. Some aspects of science's contribution to nursing were unrecognised and may explain why aspects of science-based knowledge and skills that were observed in clinical practice were not represented formally in the reviewed curricula. Nursing science curricula are often represented as discrete packages of science information, whereas in nursing practice, science is entirely integrated. As such, nursing science education needs to become integrated, but explicit within nursing, and its contribution and relevance to nursing more emphasised.

Trends in healthcare indicate that the nursing workplace of the future will require nurses to engage in more independent and autonomous practice in the community. This will require nurses who can engage with scientific material, as well be able to innovate and advance nursing practice, which has implications for nursing education. This thesis identifies an appropriate science curriculum for undergraduate nursing in New Zealand and contains recommendations for its implementation.

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“Caring is absolutely necessary, but there will come a point where you wouldn’t be able to help if you didn’t know science”

(Nurse participant)

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CHAPTER ONE
INTRODUCTION

Overview of the Chapter

This chapter is an introduction to the entire thesis. It begins with the background and justification for the project followed by the nature, scope and purpose of the inquiry. The assumptions and terms used in the thesis are then detailed and this is followed by a discussion of the significance of the inquiry. The chapter concludes with a description of the context and an outline of how the thesis is organised.

1.1 Background and Justification for the Inquiry

This thesis consists of an investigation into the New Zealand undergraduate nursing science curriculum as it informs and contributes to clinical practice. In selecting this area of research, I have been influenced by my teaching and learning experiences in New Zealand, as an undergraduate nursing science tutor, Head of Science and Head of a Department of Nursing and Health Studies, in a small regional institute of technology. My management experiences as a head of department of nursing also included leading it through a Nursing Council of New Zealand audit to regain accreditation and approval to continue to offer the undergraduate Nursing degree. One of the issues noted in the audit related to the teaching and learning of the science undergraduate courses, with particular focus on the role of science laboratories as a resource in the education of the undergraduate nurse. As a result of these experiences, I came to the view that the teaching and learning of New Zealand undergraduate science in nursing degrees is diverse, is subject to political and personal influences, and its importance and relevance in creating registration- and work-place-ready graduates is neither clear nor transparent. Although research indicates that the delivery of undergraduate nursing science education has similar issues all over the world (Davies, Murphy & Jordan, 2000; Jordan, Davies & Green, 1999; Larcombe & Dick, 2003; Wharrad, Allcock & Chapple, 1994), there is much debate as to its value and which content or teaching methodologies are most relevant or appropriate for nursing (Eraut, Alderton, Boylan & Wraight, 1995; Jordan & Reid, 1997; Larcombe & Dick, 2003; Morrison-Griffiths, Snowden, & Pirmohamed 2002; Thornton, 1997;

Trnobranski, 1996; Wilkes & Batts, 1991; Wynne, Brand & Smith, 1997). There appears to be a gap in the information relating science to clinical practice, and in particular the ability of graduate and registered nurses to adapt their clinical practice based on their science content or scientific process knowledge.

1.2 Nature and Scope of the Inquiry

This thesis comprises an in-depth investigation into scientific concepts and content that graduate nurses utilise in their clinical practice. It is a cross-age inquiry, and the sample consisted of practicing nurses from various regions within New Zealand (Wairarapa, Wellington, Taranaki and Central North Island). The registered nurses studied come from a variety of nursing backgrounds and include those who either qualified after hospital training or by studying a diploma or a degree (polytechnic or university) and some that gained post-graduate qualifications.

1.3 Purpose of the Inquiry

The purpose of this inquiry was to seek to understand and establish appropriate aspects of the science undergraduate nursing curricula that might contribute to safe and informed practice as a registered nurse, and might contribute to 'future proofing' the nursing workforce in times of rapid movement in technology and scientific knowledge.

The research question that guided this study was "What is the role of science in nursing practice?"

This question was underpinned by the following:

- Is science required for clinical practice?
- In what ways, if any, do registered nurses use science in their clinical practice?
- What is the role of science education in nursing education?
- What is the role of science educators in nursing education?

The research goals for this inquiry were to:

1. Establish the most appropriate aspects of undergraduate nursing science curricula that might contribute to safe and informed practice as a registered nurse.

2. Establish if nurses with high science self-efficacy are more likely to use science in their clinical practice.

3. Understand the political nature of the undergraduate nursing degree and the various tensions and pressures that affect curriculum development as it relates to science content and delivery.

1.4 Assumptions and Definition of Terms

The following assumptions are core to this inquiry:

1. Individuals are purposeful beings who construct knowledge in ways that are meaningful for them to enable them to understand the material world, and to manage their learning experiences.

2. The construction of knowledge by the learner is influenced by context, social interactions, peers and cultural background.

3. Learners may hold personal constructs that may be in conflict with scientific views and these may be difficult to alter; learners do not necessarily attribute these constructs a lower status than the scientific view.

4. Learners benefit by developing conceptual understandings that are either in broad agreement with the scientific view or are consistent with the scientific method.

A number of terms are used throughout this thesis. It is beneficial to define them as they apply to this thesis.

***Achievement based assessment* -** Assessment methodology that is based on the extent that skills, knowledge or abilities are demonstrated, usually described in the form of grades.

***Bioscience* -** Sciences that relate to biology and may include: Anatomy and physiology, microbiology, genetics, nutrition, biochemistry and biophysics. These subjects usually underpin pharmacology and pathophysiology.

Clinical Practice – Activities which include the observation, interaction and treatment of patients.

Curriculum - The learning experiences, content and assessments required to prepare candidates to meet the objectives of the course of study.

Competence - The integrated knowledge, attitude, skills, and judgment expected of the nurse of that level.

***Competency based assessment* -** Assessment methodology that is based on the demonstration of a set of skills, knowledge or attitudes.

***ITP* -** Institutes of Technology and Polytechnics

***Learning Outcomes* -** Statements of what a learner should understand or be able to do as a result of learning that occurred in the lesson/course. The format of a learning outcome is: verb, object, condition. For instance, *List* the *planets* in the *solar system*.

Lifelong Learning – An idea that learners should be equipped to be able to continue learning beyond the formal educational institution, throughout their lifetime.

***Level 1* -** Lowest level of qualification on the National Qualification Framework involving processes that are limited, repetitive, familiar and usually require recall of a narrow range of knowledge and skills under strict supervision conditions.

***Level 2* -** Low level of qualification on the National Qualification Framework involving processes that are moderate in range, familiar and usually requires limited choices involving routine responses that are operationally basic, from knowledge that is readily available under directed supervision conditions.

Level 3 - Level of qualification on the National Qualification Framework that involves processes that require a range of developed skills, within a range of familiar contexts, utilizing significant choices in procedure and employing relevant theoretical knowledge, interpretation of information and using some discretion and judgement under general supervision, and is aligned with the final year of senior secondary school.

Level 4 - Level of qualification on the National Qualification Framework that involves processes that require a range of technical or scholastic skills, within a range of familiar and unfamiliar contexts, utilising considerable choices in procedure and employing a broad knowledge base incorporating some theoretical concepts, analytical interpretation of information and using informed judgement in a range of concrete but unfamiliar problems under broad guidance and evaluation.

Level 5 – Level of qualification on the National Qualification Framework involving processes that require a wide range of specialized technical or scholastic skill, involving a wide choice of procedures in a variety of routine and non-routine contexts that employ a broad knowledge base, analytical interpretation of data within general guidelines. This level aligns with the first year of a degree.

Level 6 – Level of qualification on the National Qualification Framework involving processes that require a command of wide-ranging, specialised technical or scholastic skills, involving a wide choice of procedures in a variety of routine and non-routine contexts that employ a specialised knowledge base in more than one area, analysis and evaluation of information and ability to formulate responses to concrete and abstract problems within defined parameters. This level aligns with the second year of a degree.

Level 7 – Level of qualification on the National Qualification Framework involving processes that require a command of highly specialised technical, scholastic and basic research skills, involving a full choice of procedures from the major discipline in complex, variable and specialised contexts that employ a specialised knowledge base, analysis and evaluation of abstract data and concepts to create appropriate responses to resolve given or contextual problems within broad parameters. This aligns with the third year of a degree.

NCEA **-** National Certificate of Educational Achievement is the New Zealand national secondary school qualification and is based on standards based methodology.

Nurse Academic – A nurse who holds a postgraduate qualification and who tutors or lectures in a nursing degree programme of study within an educational environment

Nurse Educator – A registered nurse who provides clinical education for other nurses within the practice environment.

Nursing **-** Nursing encompasses autonomous and collaborative care of individuals of all ages, families, groups and communities, sick or well and in all settings. Nursing includes the promotion of health, prevention of illness, and the care of ill, disabled and dying people. Advocacy, promotion of a safe environment, research, participation in shaping health policy and in patient and health systems management, and education are also key nursing roles (International Council of Nurses, 2010).

NZQA **-** New Zealand Qualifications Authority holds authority for setting the standards for qualifications.

Preceptor **–** An experienced nurse who provides support and learning experiences to a nursing student in the clinical practice area.

Registered Nurse **-** A graduate nurse who has passed examinations for registration and continues to meet the competency standard as set by the Nursing Council of New Zealand under the authority of the Health Practitioners Competency Act 2003.

Standard based assessment – Assessment methodology with defined standards of knowledge, skills, abilities or attitudes.

Year 11 **-** Educational year group in secondary schools that usually aligns with three years of secondary school education (15-16 year olds).

Year 12 **-** Educational year group in secondary schools that usually aligns with four years of secondary school education (16-17 year olds).

Year 13 **-** Educational year group in secondary schools that usually aligns with five years of secondary school education (17-18 year olds).

1.5 Significance of the Inquiry

The findings from this inquiry are intended to provide nursing schools and educators with an understanding of the most appropriate undergraduate nursing science curriculum that will inform the clinical practice of the graduate nurse and contribute to 'future proofing' the nursing workforce in times of rapid movement in technology and scientific knowledge.

1.6 Context of the Inquiry

Undergraduate nursing training systems in New Zealand went through a full review in the 1970s resulting in the transference of nurse training from a hospital-based system (apprentice-based) to the tertiary polytechnic sector (education system) (Department of Health, 1988). By the early 1980s, nursing education in New Zealand was conducted at the undergraduate diploma level, and was mainly delivered by regional tertiary institutes (i.e., polytechnics). The *Education Amendment Act* was amended in 1990 permitting polytechnics and institutes of technology to award degrees when this had previously been the sole right of universities (Dougherty, 1999). Due to funding policies, more and more institutes began developing nursing degrees in preference to diplomas. By 1996, all pre-registration nursing programmes in New Zealand were degree based and 1998 the Nursing Council of New Zealand affirmed a policy that entry to register as a comprehensive nurse would include the being in receipt of a first degree (Isles, 2003).

Both the diploma and degree had elements of science in the curriculum and these were traditionally taught by science departments within the polytechnic system. In the mid 1980s, the polytechnics had viable numbers of students enrolled in science discipline programmes, and so nursing programmes were able to utilize resources and staff to deliver the science component of the nursing qualification. This was usually delivered using classical science delivery methods which included laboratory sessions. The nursing students usually had to perform very similar experiments as their science counterparts and this included wet chemistry, basic biochemistry, microbiology, microscopy and physics. Basic anatomy and physiology courses also included dissections, and various practical demonstrations similar to many science courses in the country at the time.

As the number of students enrolling in science programmes in the polytechnic sector started to decline, this created financial pressure for science departments in the sector. This was mainly due to the *New Zealand Certificate of Science* (NZCS) programmes becoming disestablished and replaced by the *National Diploma of Applied Science,* which did not gain the same industry support. As the first nursing academics started to gain graduate and then post-graduate qualifications, many institutes began to develop their nursing science curricula. Many nurses with an interest in science began to become more involved with the delivery of undergraduate nursing science and as such, the laboratory work became more anatomy related, and aspects of chemistry and physics were removed (Taranaki Polytechnic, 1999). Many nurse academics began to question the appropriateness of the science curricula as it related to nursing, and its delivery by ‘conventional’ science teachers (Larcombe & Dick, 2003). The Nursing Council of New Zealand (NCNZ), which approves undergraduate nursing degrees, loosely prescribes the scientific content that must be taught in the nursing degrees but it does not provide much guidance or information (NCNZ, 2005a). Laboratory teaching sessions are often considered to be an expensive component of science education due to the high cost of consumables and technical staff which created an extra financial pressure on departments. This meant that many nursing schools began to remove or decrease the laboratory sessions within their nursing programmes. This created considerable difference between institutes when comparing the science content, much of which is still currently evident (see Chapter Five).

During my role in 2006 as Head of Department of Nursing and Health Studies, I visited other nursing schools to investigate their laboratory components and science content that was within their undergraduate nursing degrees. Some nursing degrees such as that offered by the University of Auckland had common Year 1 health science papers and nursing students learn alongside the medical and science students. They then perform all the usual laboratories expected in this environment. In comparison, some small regional institutes had no science department, no specialised science teachers, and were more limited in their resources to provide science laboratory sessions to the nursing student. Some, like the Auckland University of Technology were also beginning to use e-learning to support their science components with limited practical laboratory opportunities and Northland Polytechnic have since been developing on-line learning nursing curricula (see Appendix A and Chapter Five). The Nelson Marlborough Institute of Technology's nursing degree had a collaborative team teaching approach to their science courses with both the science and the nurse teacher sharing the delivery of content and relating it to clinical practice in context by using case studies. There was therefore considerable variety in the delivery of the science subjects in nursing degrees across the sector.

When the nursing degrees were first developed, they were often done in conjunction with other institutes via the formation of consortium (Bennett, 1996; Taranaki Polytechnic, 1994a). Individual institutes began to develop their own curricula and pulled away from consortium arrangements to meet the needs of the regional area that they served, and their particular health workforce needs (Taranaki Polytechnic, 1999). New Zealand's nursing degree is a comprehensive degree that attempts to provide an overall theoretical grounding in many discipline areas including nursing, science and humanities as well as to meet the competencies (skills and attitudes) required to become registered for nursing practice (NCNZ, 2005a). This differs to some overseas models such as the United Kingdom where students choose their specialty areas in the pre-registration education programmes (i.e. adult, children/paediatric, disability and mental health) (National Health System, 2010).

Due to the diversity of healthcare settings in New Zealand and graduate destinations, nursing schools tend to refine their curricula to meet regional requirements. It is a requirement of the New Zealand Nursing Council that providers consult with stakeholders in regard to changes in curriculum (NCNZ, 2005a). These stakeholder groups (often called local advisory committees) are usually made up of regional nurse leaders, directors of nursing (local district health boards), rest-home managers, primary care nursing managers, community based health agencies, representatives from the disabilities and Māori health sector, as well as nurse academic staff and often students. In regions where a large centralised hospital exists, most nurse graduates start their working life in acute, hospital care settings. The stakeholders in this setting often lament the 'theory-practice' gap and require graduates that can perform in a busy ward with minimum supervision, taking on a full patient load in a competent manner (Eraut, Alderton, Boylan & Wraight, 1995; Fulbrook, Rolfe, Albrarran & Boxall, 2000). There is often pressure applied to nursing schools to increase the skill development (nursing practice competencies) of students which would result in a decrease in theory content.

When a new curriculum is designed, clinical stakeholders through an advisory committee 'approve' the content of the courses, but the content design is often done by the nursing or subject teacher. As such, when changes such as the removal of science content or laboratories is proposed, since it is not a practice related nursing skill, or not a nursing related course, the local advisory committee may not be equipped (with experience or knowledge) to provide sufficient advice. Although members of the local advisory committee will almost certainly have post-graduate qualifications, these nurse leaders would most likely have qualified for registration by gaining a diploma. As the first degree graduates have only been in practice for approximately a decade to 15 years, they are only starting to emerge as nursing leaders. It is not clear if an experienced science teacher with no nursing background can develop an appropriate curriculum to meet the needs of the comprehensive nurse in the diverse workplace. It is not clear if an experienced nurse with no science background or science post-graduate qualification can develop an appropriate science curriculum to meet the needs of the comprehensive nurse in the diverse workplace. Essentially, nursing schools do not appear to have a system that informs science curriculum decisions other than the personal influences of academic staff that are driving change.

1.7 The Organisation of the Thesis

This thesis is organised into seven chapters. The literature review is contained in Chapter Two which consists of a review of relevant literature of nursing education inquiries. Chapter Three provides the theoretical framework for this inquiry, examining the theories behind the main issues taken from the literature. This is followed by Chapter Four where methods and methodologies used in the inquiry are described and this includes a description of methodologies used in science education inquiries, with particular emphasis paid to naturalistic and qualitative means of inquiry and the relevance of the interpretivist paradigm. This chapter also describes the development of the self-efficacy survey, the interview and observation protocol, and a description of the data collection strategies employed. The data analysis procedures are also described along with a discussion of the measures taken to maintain the trustworthiness of the inquiry. This chapter concludes with consideration of the ethical issues relevant to the inquiry. Chapters Five and Six consist of the results of the data collection based on interviews and surveys, document analysis, as well as data analysis and discussion of results. The presentation of the results and discussions aligns with the research goals outlined in Chapter One. The thesis concludes with Chapter Seven where there is a discussion of the research findings and conclusions are drawn. Implications for teaching and learning in undergraduate nursing education are presented with suggestions for further research.

CHAPTER TWO
LITERATURE REVIEW

Overview of the Chapter

This chapter builds on chapter one and provides a review of literature for the thesis and discusses relevant studies in nursing science education, nationally and internationally. This is structured with a focus on the research questions presented in chapter one.

The chapter begins with a discussion of the history of nursing training and education in New Zealand, with particular emphasis on science content. This is then followed by a description of the evaluative studies of the effectiveness of the new nursing programmes and the development of issues within the nursing science courses. Next is a comprehensive analysis of the 'bioscience issue' both nationally and internationally, and a description of the perceived theory-practice gap. A discussion of further issues that complicate and contribute to the bioscience issue then occurs followed by the proposed requirements for the future healthcare workplace. These sections seek to establish the role of bioscience knowledge in the registered nurse's clinical practice and this is then related to patient outcomes.

A description of curriculum development and design then follows with particular emphasis on the development of the New Zealand nursing curriculum including the influence of external groups or authorities and a discussion of practices that exist within nursing schools. The chapter concludes with a justification for the study.

2.1 History of Nursing Training and Education in New Zealand

2.1.1 Hospital Training

New Zealand's first training school for nurses was established in Wellington Hospital in 1884 (Department of Health, 1988). Nurse training in New Zealand at the time was in the control of hospitals and was conducted in an apprentice type of training system, with its roots firmly in the tradition of Florence Nightingale (Carpenter, 1971). Legislation that provided for nurse registration was passed in 1901, and in 1904 registration was introduced for midwives. New Zealand was one of the first countries in the world to have a regulated, registered nursing workforce. In 1925 further legislation enabled the establishment of the Nurse and Midwives Board which was given responsibility for establishing standards for the registration and education of midwives and nurses. This board was renamed the Nursing Council of New Zealand in 1972 (Department of Health, 1988). Psychiatric nursing was developed separately, and nurses were first registered in 1907 as Mental Health Nurses under the authority of the Department of Mental Hospitals. This changed in 1944 when the psychiatric hospitals became the responsibility of the Department of Health, and psychiatric nurses were then registered by the Nurse and Midwives Board from 1947 (Department of Health, 1988).

A basic university nursing course was provided from 1925 at the University of Otago following recommendations by the New Zealand Trained Nurses Association. This was supposed to be a programme that lasted for five years, with two years spent in the hospital, but funds were cut for the programme after only two years and it was closed (Department of Health, 1988).

By 1970, New Zealand had 126 basic nursing programmes offering six types of nursing: general and obstetric (31 programmes), male (10 programmes), psychiatric (8 programmes), psychopaedic (4 programmes), 54 second level nursing programmes (later called ‘enrolled’ nurses) and 19 maternity programmes (Carpenter, 1971). These schools were based at 62 different New Zealand hospitals. In 1964, the Nurses and Midwives Board accepted a plan to review nurse education and have by 1970, nurse education directed into three streams; a degree programme, a general three year programme and a community nurse programme that included psychiatric nursing concepts (Department of Health, 1988). A study by Alma Reid, who was a director of the school of nursing at McMaster University in Canada, was commissioned by the New Zealand University Grants Committee in 1965. Her recommendations included that a basic degree programme should be established but this was not implemented (Reid, 1965). In 1969, the Department of Health commissioned the *Review of the Hospital Related Services in New Zealand* where it was recommended that some nursing programmes be conducted at university and others in the technical institute setting. However, no action was taken, and the reports generated little interest (Department of Health, 1988).

In the late 1960s and early 1970s, various health professionals including physiotherapists, occupational therapists, dieticians, social workers and medical technologists, began to examine the feasibility of establishing courses in educational settings such as institutes of technology or polytechnics (Dougherty, 1999). Discontentment with the hospital apprenticeship training system started in the mid-1960s and eventually in 1971, a World Health Organisation consultant, Dr Helen Carpenter, was contracted to provide the Department of Health with a report on the status of New Zealand nurse education. The training system for nurses in New Zealand was described by World Health Organisation consultant Dr Helen Carpenter in 1971 as being basically unchanged since 1884. One of the major factors that contributed to the decision to move nursing education out of healthcare-based training and into the educational arena, was the impression that the hospital-based nursing tutors did not have the breadth and depth of knowledge required to prepare students to deal with "advances that continue to be made in science and technology" (Carpenter, 1971, p. 15).

A committee was set up in July 1971, to consider recommendation 1.6 from Carpenter's report, which was that a committee be formed "to study the proposal for the development of colleges of health sciences for the preparation of nurses … and that this committee make recommendations [as] to the … most suitable educational setting" (Carpenter, 1971, p. 5). The committee was known as the '1.6 Committee' and reported to the Minister of Education. The Committee's report *Nursing Education in New Zealand* also stated that the "present nursing education provides inadequate preparation for the modern health care of patients …" (Department of Education, 1972, p. 3). The Committee recommended "that the curriculum include the following studies: physical sciences; chemistry, physics, mathematics, biological sciences: biology, anatomy, physiology, pathology, nutrition, microbiology and pharmacology" (p. 12) as well as humanities and nursing subjects. The Committee considered aligning the new nursing schools with teacher's colleges due to their experience with practicum and supervision, but it was felt that the teacher's college staff would not have the requisite knowledge necessary to take the nursing students through some theoretical studies such as the physical sciences. The Committee noted that an overseas nursing school at the British Columbia Institute of Technology required entry by the University Entrance Standard with specified science subjects, but that this was "higher than we would consider appropriate in the New Zealand setting" (p. 13). It was considered unlikely that a university would be willing to provide science courses below the Bachelor of Science level and that this usually requires successful completion of senior secondary school science study. The Committee recommended that educational settings that teach a wide range of courses (such as in a technical institute) were most suitable for nursing education for a variety of reasons including the fact that "facilities for the teaching of physical and biological sciences already exist" (p. 19). Carpenter also recommended in the Report the development of comprehensive nursing programmes, and the phasing out of the variety of nurse types (i.e. general, general and obstetric, psychopaedic, psychiatric, etc.). Nursing education started as a trial at the Wellington Polytechnic and the Christchurch Technical Institute in 1973, with training in hospitals continuing in parallel (Isles, 2003).

A newly elected government was reluctant to allow any further courses to be approved until a full evaluation of the trial programmes was conducted, and suggested that training within the hospital system could be improved by upgrading hospitals. In 1976 a National Party-led government came to power and after a full review of nursing education was conducted, it was decided that comprehensive nursing programmes were to be continued indefinitely and that the hospital system would be discontinued (Department of Health, 1988).

2.1.2 From Hospital Training to Institutes of Education

A report titled *An Evaluation of Nursing Courses in Technical Institutes* (termed the Taylor Report) evaluated the transition from hospital training across many years (Taylor, Small, White, Hall & Fenwick, 1981). In 1973, a survey of third year students who were then completing their nursing education in technical institutes was conducted and 33% of the students said that the main advantage of the technical institute (over the hospital system) was the availability of specialised tutors including those for non-nursing subjects such as science. This presumably was due to the in-depth knowledge of content that the technical institute science teachers held. This report notes that the students in the technical institute courses were receiving considerably more learning hours and diversity in exposure to science-related content than their hospital counterparts (Taylor et al., 1981). In the hospital-setting, students had about 100 hours dedicated to anatomy and physiology, and about 20 hours to microbiology compared with students in the technical institute who had about 315 hours on human biology, 81 hours on microbiology, 120 hours on chemistry, 30 hours on physics and about 15 hours on mathematics (i.e. 120 hours compared to 561 hours). The report also noted that the main differences in content between the technical institute-setting and the hospital-setting was that greater emphasis was placed on the biological and physical sciences in the technical institutes. It was an expectation that more physical science education would provide a better basis for nurse specialisation later in their careers, in comparison with the hospital programme (Taylor, et al., 1981).

The Taylor Report evaluated the transition from hospital training to the institutes of education over several years and one issue that arose quite early with the new programmes (within the technical institute system) related to the teaching of the science subjects (Taylor et al., 1981). Some students felt that these courses were not relevant to nursing practice. When students failed science examinations but did satisfactorily in other courses, nursing tutors were reluctant to fail them overall. Tutors started to question if the science courses were being taught at too high a level, or that the non-nursing tutors needed to make the subjects more relevant to nursing. Some institutes suggested that topics needed to be made more relevant to nursing and encouraged the non-nursing tutors to do so; others felt that nursing tutors needed to have more involvement in the science courses to bring out its relevance. Other suggestions from the Taylor Report included the consideration of entry criteria and that nursing programmes could be limited to those students with a background in science, or streaming students of similar abilities in the science classes. Students found physics and chemistry “the least interesting, the least useful, the most difficult, the least likeable, and the most in need of change” (Taylor et al., 1981, p. 61). The report authors said that this may be due to the method of teaching in subjects such as physics (in 1975), and they questioned the role of physics and chemistry in nurse education. They suggested that the nursing workforce needed to be studied to stipulate the level of physical science that was necessary or desirable for nursing. However, in spite of the above comments, students found non-nursing tutors to be approachable, and evaluations were considered satisfactory across all levels - as stated earlier, the availability of specialist teachers such as in science was noted as the main advantage (by students) over the hospital system. Nursing science could therefore be considered as both the main strength of the new system and the main weakness. This situation was mirrored in the United Kingdom with Davies, Murphy and Jordan (2000) reporting that "disproportionate number of problems have arisen in relation to the bioscience component in the curriculum" (p. 123).

One of the ways in which the Taylor Report described the new graduates was by the Slater Nursing Competencies Rating Scale (Wendelt & Stewart, 1975, cited in Taylor et al., 1981) and the Dyer Nurse Performance Description Scale (Dyer, 1967, cited in Taylor et al., 1981). The Slater and Dyer Scale of Qualities rate qualities considered most essential for nurses. Nurse Managers and supervisors evaluated the graduates using this system. Interestingly, the top qualities in the Dyer and Slater scales could require biological science knowledge (italicised in Tables 2.1 and 2.2) and this was considered an area of strength for the new graduates.

Taylor's evaluation report concluded that, compared with their hospital trained counterparts, graduates of the technical institutes were well suited to work in community health nursing and in more specialised areas of nursing, and that they were particularly strong in their breadth and depth of their theoretical knowledge. The report also concluded that they were more likely to gain registration and be retained in nursing practice (Taylor et al., 1981).

Table 2.1: Ten qualities from the Dyer scale rated "essential" or "very important" to nurses (Taylor et al., 1981, p. 192).

Quality	**Percentage of respondents rating quality as “essential” or “very important”**
Is vitally concerned about giving expert care to patient	91.3
Reacts promptly and appropriately in emergency situations	91.3
Observes and reports subtle changes in patient’s condition	90.3
Administers medication and/or electrolytic therapy accurately	87.9
Develops nursing care plans that reflect an understanding of the patient’s physical, emotional and mental functioning	85.0
Goes out of her way or uses special effort to meet or learn of patient’s needs	84.1
Administers treatments skilfully and with a minimal amount of discomfort to the patient	83.6
Avoids counselling or criticising people in front of others	80.1
Works well without supervision	79.1
Seeks and uses suggestions that improve patient care	78.7
	N = 213

KEY: *Italicised* box represents qualities that could require biological science knowledge.

Table 2.2: Fifteen qualities from the Slater scale rated "essential" or "very important" for nurses (Taylor et al., 1993, p. 193).

Quality	**Percentage of respondents rating quality as “essential” or “very important”**
Identifies physical symptoms and changes	94.8
Recognises physical distress and acts to provide relief for the patient	93.6
Carries out established technique for safe administration of medications and parenteral fluids	91.6
Responds appropriately to emergency situations	91.2
Demonstrates understanding of both medical and surgical asepsis	88.4
Recognises hazards to patient safety and takes appropriate action to maintain a safe environment and to give patient feeling of being safe	87.1
Reliable: Follows through with responsibilities	86.3
Carries out safety measures developed to prevent patients from harming themselves or others	86.3
Recognises and reports behavioural and physiological changes that are due to drugs	85.5
Gives full attention to patients	85.1
Adopts nursing procedures to meet needs of individual patients for daily hygiene and for treatments	83.1
Is a receptive listener	82.3
Approaches patient in a kind gentle and friendly manner	81.1
Communicates belief in the worth and dignity of man	81.1
Is self-directing: takes initiative and goes ahead on own	80.2
	N = 257

KEY: *Italicised* box represents qualities that could require biological science knowledge.

2.1.3 A New Era in Nurse Education

In the mid 1970s many technical institutes started health-related programmes, with the Central Technical Institute (Wellington) starting pharmacy as early as 1960, and occupational therapy soon after (Dougherty, 1999). The Auckland Technical Institute and the Otago Polytechnic started physiotherapy programmes in the 1970s. Nursing education started with a trial at the Wellington Polytechnic and the Christchurch Technical Institute in 1973 with hospital training continuing at the same time. By 1986, some 15 technical institutes were providing three-year comprehensive nursing courses and health-related courses contributed 44% of the technical institutes' fulltime enrolled student numbers, and nursing accounted for 75% of these students (Dougherty, 1999). Certainly, nursing programmes were a major source of revenue for the institutes and often considered the 'cash cow' of the sector. By 1983, all nursing education had transferred from hospital boards to polytechnics, and most hospital programmes had closed (Isles, 2003). Most polytechnics offered a three-year comprehensive programme (the Diploma of Nursing). Even small regional polytechnics such as the Taranaki Polytechnic, enrolled 48 students in its first intake (in 1982), and this increased steadily until 1988, by which time there were 260 students across the three years of study (Bennett, 1996).

The *Picot Report* written in 1988 reviewed education administration across the whole tertiary sector and contemplated the establishment of a coordination council for polytechnics and a state authority for validation of courses and qualifications (Department of Education, 1988). The *Education Amendment Act* of 1990 established the New Zealand Qualifications Authority (NZQA), and permitted polytechnics to award degrees, which up until then, had been the sole right of universities. Discrepancies in funding meant that institutes attracted less money for diplomas compared to degrees, and it soon became clear that degrees would become the most common qualification offered for nursing. Institutes that did not offer degrees, but offered a three-year diploma received less funding, and it was felt, would have difficulty attracting students (Isles, 2003). In Taranaki, the nursing degree was developed by Taranaki Polytechnic in conjunction with Southland and Wairariki Polytechnics (who formed a consortium) with links to

Charles Sturt University in Australia who acted as a mentor throughout the process (Bennett, 1996). By 1996, all pre-registered nursing programmes in New Zealand were at the degree level. In 1998, the Nursing Council of New Zealand affirmed that a comprehensive nurse could only gain entry to the register by acquiring a degree (Isles, 2003). With degree-level entry a requirement, the pressure then grew on current registered nurses to update their qualifications. There are reports of intense competition for specific positions and promotions with less experienced nurses who had more advanced qualifications and "by implication, an increased scientific knowledge" (Isles, 2003, p. 3).

2.1.4 Changes to Nursing Practice

The rapid increases of scientific knowledge and technological advancement in recent times has continued to have implications for the nurse in practice (Cree & Rischmiller, 1989). Nurses have had to assume more responsibility for patient care compared to previous generations and have had to develop their own ways of meeting patient needs. In the last 4 decades or so, nursing has begun to develop into an independent discipline (separate to that of medicine for example), while increasing its role in multi-disciplinary teamwork and increasing its status and recognition as a healthcare profession. In order to participate as an equal professional in a healthcare team, nursing has had to attempt to identify what knowledge is core to all nurses to form the foundation knowledge common for all nursing education programmes. Much of this foundation is built up from other discipline areas with nursing 'borrowing' scientific concepts, laws and principles from various scientific disciplines (i.e. sociology, psychology, physiology, pharmacology) and the role of science (physical and biological) in nursing education is still the subject of much debate.

As an autonomous profession, nursing has begun to rationalise and justify nursing practice based upon research (known as evidence-based practice) and within nursing research, there tends to have been an emphasis on prevention and protection within the maintenance of health, which includes advocacy and education for patients (Cree & Rischmiller, 1989). In order to act as an educator or patient advocate, a nurse would be required to be able to understand concepts and communicate them appropriately. Education of a nurse therefore involves understanding of health and illness, and knowledge of how to intervene in both. Some authors state that the key to modern nursing is being able to be adaptable in changing situations (Cree & Rischmiller, 1989: Longley, Shaw & Dolan, 2007). As developments in science and technology continue, nurses in autonomous practice may experience increased demands on their foundational bioscience knowledge. Their ability to adapt their practice and make well-informed clinical decisions could be influenced by their depth and breadth of their bioscientific knowledge.

To summarise, nursing in New Zealand has been subjected to significant changes over the last 4 decades including the conclusion of hospital-based training and the establishment of nurse education programmes within tertiary institutes (Department of Health, 1988). One of the reasons for change was the perception that the nursing tutors within the hospital-setting would not be able to prepare nurses for changes in science and technology (Carpenter, 1971). Issues with nursing science courses within the tertiary education-setting arose almost immediately with physics and chemistry being questioned as to its relevance to nursing practice, yet the in-depth science knowledge of the graduates was also considered to be a strength of the new system (Taylor et al., 1981). Nursing also began to develop into an autonomous profession, with nurses having greater responsibilities for patient care than before and working within a changing environment which has implications for the nurses' foundational knowledge base (Cree & Rischmiller, 1989) and the role of bioscience knowledge within nursing educational programmes.

2.2 The Bioscience Issue

Authors worldwide have called for research to determine the appropriate content and depth of bioscience knowledge required by nurses (Jordan, Davies & Green, 1999; Larcombe & Dick, 2003; Taylor et al., 1981; Wharrad, Allcock & Chapple, 1994). Nursing students worldwide report difficulties, anxieties and issues relating to bioscience (Davies, Murphy & Jordan, 2000; Jordan et al., 1999). Some authors (Wynne, Brand & Smith, 1997) have suggested that the movement of nursing education from the hospital-setting to higher education institutes (tertiary education) has actually strengthened the social and behavioural sciences rather than the biological sciences, resulting in a move away from scientific or medical attitudes. In the United Kingdom, Jordan et al.,(1999) suggest that 33% of nursing lecturers in one large department of nursing favoured reducing or even abandoning the bioscience curriculum as a way of reducing stress and examination failures for students. Wharrad et al. (1994) suggested that the movement away from bioscience may be due to a lack of consensus about what depth and detail is required to support nursing practice. The 'bioscience issue' in nursing education has been recognised for some time and it is clear that nurse academics, educators and scientists are divided when it comes to opinions on its causes, and to the value and role of bioscience in the undergraduate nursing curriculum.

2.2.1 National and International Perspectives

A lack of understanding about the role of bioscience in nursing education, and in nursing itself, has probably also contributed to a worldwide devaluation of bioscience within nursing. In the 1960s, many nurses found the scientific or medical approach inconsistent with concepts of holistic nursing which were emerging as a major influence in nursing academia and which tended to align more comfortably with sociology and psychology disciplines, and so these paradigms began to influence nursing research direction (Wynne, Brand & Smith, 1997). The development of nursing theories in the 1970s (mainly from the United States of America) also further contributed to the direction away from bioscience or 'medical' knowledge as nursing started to identify how it differed from medicine. Nursing links with academia were mainly through the behavioural and social sciences, allied to clinical or community nursing (Burke & Harris, 2000). As nursing developed an 'identity' and its academia grew, there appears to have been a systemic failure of nursing to recognise and own the bioscience knowledge. The clinical decision making (i.e., diagnosis and treatment) that utilises in-depth bioscientific knowledge is not identified as nursing but more attributed to medicine (Jordan, 1994). Examination of nursing research in the past 30 years suggests that the bulk of it is within the social science paradigm, with a humanistic focus of a "lived experience of illness" and "phenomenology of patienthood" (Davies et al., 2000, p. 130). There is a paucity of research done by nurses related to bioscience advances or content, and this suggests a reluctance to own bioscience as nursing content.

Some authors state that the exclusion of bioscience from nursing theory has led to a ‘theory-practice’ gap (e.g., Jordan, 1994). The theory-practice gap has been referred to in literature since 1932 and occurs when the ‘knowing’ of theory is removed from the ‘knowing’ of clinical practice - often referring to differences in what schools of nursing teach and what is used or required in practice. Some authors consider that the theory-practice gap can be attributed to differences between the kind of idealised or generalised practice advocated in educational settings, and that which is observed or pragmatically used in practice (Eraut, Alderton, Boylan & Wraight, 1995; Smeby & Vagan, 2008). This may also be due to novice nurses’ limited skills or other conflicts such as mentor preferences for practice being done a certain way, or even guidelines/protocols that may conflict with the idealised or generalised practice taught. Some mentors or nurses who have been in practice a long time may also consider the ‘theory’ or ‘textbook knowledge’ irrelevant to practice, possibly putting them in conflict with the new nurse. The theory-practice gap could also be attributed to the inexperience of a newly qualified nurse attempting to align theory with the practical requirements of the job (Eraut et al., 1995). Some of the most significant aspects of changing from an apprenticeship system in nursing education to higher education according to Eraut et al., (1995) include: teaching by non-nurses suggesting that they are ill-prepared to make optimal selection of content and provide authentic examples to use the knowledge; socialisation of nurse academics, perhaps giving practice skills lower priority over academic knowledge; knowledge that is examined is being framed within the norms of higher education - perhaps reinforcing theory over practice; and modularisation or segmentation of knowledge - which leaves the student to translate and apply it to practice. It has been suggested that if nurses were exposed to more science, apart from gaining confidence from more knowledge, they may also have a better understanding that knowledge is not static (but is subject to revision), which could provide them with perspective allowing them to work independently (Smeby & Vagan, 2008). Those students who hold a belief that science is not a static subject, and it is instead dynamic (where ideas change and develop) were found to be more likely to be able to use their scientific knowledge in an integrated manner (Songer & Linn, 2006).

2.2.2 The Value of Bioscience

As one examines literature related to the bioscience issue, it is clear that opinion is divided. Many authors attribute problems to non-nursing science teachers teaching inappropriate amounts of content, too in-depth and not in an integrated fashion that is meaningful or authentic for nursing practice (Taylor et al., 1981; Trnobranski, 1996; Thornton, 1997; Wharrad et al., 1994). On the other hand, many other authors forecast woeful inadequacies in nurse's abilities due to their lack of bioscience knowledge, and fear that graduates are not adequately prepared to make meaningful clinical decisions (Jordan & Reid, 1997; Larcombe & Dick, 2003; Morrison-Griffiths, Snowden, & Pirmohamed 2002; Wilkes & Batts, 1991). There are few scientists who have high level knowledge in their discipline area and are registered nurses, and few nurses who have acquired higher level knowledge in the discipline of science. This means that nursing bioscience does not have leaders who can navigate and effectively address the bioscience issue.

A study conducted in Auckland, New Zealand used a curriculum inquiry framework to investigate the perceptions of nursing students and nurse tutors in relation to bioscience in the nursing curriculum (Friedel & Treagust, 2005). Attitudes and self-efficacy data were obtained and it showed that nursing students had significantly more positive attitudes to bioscience than the nurse tutors. This is similar to work in the United Kingdom by Jordan et al. (1999) who reported that students valued bioscience more than the nursing lecturers did. The United Kingdom students felt that bioscience was one area that they felt was the most relevant to clinical practice, whereas the lecturers in general, did not agree. Student opinion of bioscience in other literature also rates it as one of the most useful topics (Kinsella, Williams & Green, 1999). One might have assumed that nurse tutors would have higher self-efficacy scores in bioscience than the students, given that they are teachers, but it seems this was not the case in the New Zealand study. It was found that some nurse tutors and clinical teachers (preceptors) may not have sufficient science background or bioscience knowledge to facilitate application of knowledge in the clinical setting (Friedel & Treagust, 2005). McVicar, Clancy and Mayes (2009) suggest that opportunities for bioscience learning in the practice setting is limited due to many nurse mentors (preceptors) having low confidence in, and a poor understanding of bioscience.

Work in England involving a survey of all educational institutes providing nurse education, suggests that nurses are inadequately prepared for their role in medication administration for a variety of reasons, including insufficient guidelines from nursing regulatory bodies, and a lack of consistency amongst educational establishments (Morrison-Griffiths et al., 2002). Leathard (2001) suggests that nurses tend to overestimate their knowledge of drug administration, adverse effects and legal aspects perhaps indicating that nurses may be unaware if their knowledge is inadequate. A rejection of the 'reductionist biomedical model' in favour of holistic models of nursing care, (with the concepts of caring rather than curing as a paradigm), may have contributed to a situation in which nurses are being inadequately prepared for some of their clinical responsibilities (Jordan et al., 1999). This is cause for concern as Lim and Honey (2006) say that increasing advances in technology, population changes and new modes of care delivery will result in new roles emerging for nurses that will have advanced spheres of practice and there has been some suggestion that nurses could replace junior doctors in some tasks.

Analysis of factors that may influence nursing students' achievement in the mental health aspects of a nursing degree show that the more positive outlook that a student had, and the more that they believed that their mental health studies would prepare them for clinical practice, the better their achievement in mental health courses was (Blackman, 2001). It was also found that students' achievement in mental health studies was associated with achievement in their first year science studies (anatomy and physiology and biophysical sciences). The literature is divided as to the predictability that success in science leads to success in nursing however some studies have suggested that success in nursing, is directly attributable to grades obtained in physiology (science) and pathophysiology (Alexander & Brophy, 1997; Bryd, Garza & Nieswiadomy, 1999). Some authors (McKee, 2002; Van Rooyen, Dixon, Dixon, & Wells, 2006) have found that progression through the nursing programme is found to be related to their pre-entry science background (senior high school science achievements) whereas others have found that there is no apparent link for mature students (Caan & Treagust, 1992).

2.2.3 Student Preparedness for Science Study

Many authors state that one of the main reasons why students have difficulties with the nursing bioscience topics is their lack of science knowledge at entry (Jordan et al., 1999; Davies et al., 2000; Jordan et al., 2002). It is suggested that students with Advanced (A) levels or GCSEs (United Kingdom) in sciences did not consider the science topics hard, and they generally progressed through the programme successfully (Jordan et al., 1999). Restructuring entry levels in favour of students who have 'A' levels in science is estimated to reduce the student numbers to approximately 5% of the usual intake. Some consider that students that would make good nurses may not have an academic background, and that high achievers do not always make the best nurses and may not be as caring as those less educated (Burke & Harris, 2000). Van Rooyen et al. (2006), reported that bioscience knowledge at entry into the nursing programme at Otago Polytechnic in Dunedin, New Zealand, had a strong relationship with academic success in year one bioscience courses; and that year one success was predictive of second year bioscience performance. A previous study in the United Kingdom reported that at one particular school, bioscience was causing the students less anxiety compared to other schools and this school had set 'A' level science as an entry requirement (Wharrad et al., 1994). McKee (2002) also established that previous biology study positively influenced the performance of a nursing student in biological science.

Some literature suggests that students may harbour negative attitudes towards science and maths related concepts when they enter the nursing degree (Larcombe & Dick, 2003), and Jordan (1994) suggests that the symbol-object dichotomy that can exist in science can cause difficulties for students. A nursing student with good reading skills could make sense of a psychology or sociological textbook more easily than a bioscience textbook due to the vocabulary used in it, (Larcombe & Dick (2003). A nursing student's science literacy capabilities may therefore impact on their ability to engage with the bioscience material.

A large Finnish study examined the mathematical skills of both student nurses and nurses in practice and those nurses with upper secondary school education in mathematics did better (in terms of drug calculations etc.) than those without it (Grandell-Niemi, Hupli, Puukaa & Leino-Kilpi, 2006). This further supports the concept that knowledge of science (and by association, maths) at entry may be advantageous to a nursing student.

2.2.4 Integration of Science in Nursing Practice

Nurses that experienced anxieties over mathematics and hence drug calculations were reluctant to admit that they had these issues, and tended to have coping mechanisms that involved the use of peers (checking calculations), suggesting a reliance on the ability of other nurse colleagues (Grandell-Niemi et al., 2006). If colleagues had numeracy issues, then they too may not be willing to admit it in the workplace environment, so errors could occur. Wilkes and Batts (1996, 1998) in Australia reported that when nurses in practice used their physical science knowledge they tended to rely on shared experiences with other colleagues to inform their actions. However, sometimes the advice of colleagues was in conflict with taught science concepts and that even nursing textbooks perpetuated inaccuracies in scientific concepts. Nursing students also tend to be intuitive rather than rational and so often cannot establish for themselves what is required for practice (Thornton, 1997). This may facilitate more reliance on colleagues in practice especially if that colleague appears to be competent and capable, so by default, may be perceived as having adequate knowledge and skill.

Jordan (1994) observed that there are elements of ‘learnt helplessness’ that result from intensive courses of study which do not relate directly to practice (such as science). The established delivery method of lectures and assessment techniques of examinations for science related topics may also contribute to superficial learning where students have difficulty relating rote learned facts to clinical situations. Cree and Rischmiller (1989) suggest that modern nursing needs to focus on the patient as an individual and as such, rote learning knowledge is not an appropriate way of preparing for practice. Yet, it has also been suggested that in order for learner-centred science instruction to be effective (which is most likely to occur in the clinical setting), students require a high level of scientific vocabulary and content knowledge, and this is commonly achieved by teacher-centred methods (Von Secker & Lissitz, 1999).

As approximately half of a nursing degree occurs in the practice-setting (clinical placement) and so some content will be learned in this environment, Morrison-Griffiths et al. (2002) highlight the issue that there are no controls over the learning outcomes, or the knowledge level of the mentor (preceptor). Prowse and Heath (2005) suggest that nurses develop their bioscientific knowledge mainly through the non-formal aspects of their studies, in work-based activities within the social context of the clinical placement. Yet, in Cape Town, South Africa it was reported that 57% of nurses in practice felt that their knowledge of pharmacology was inadequate for practice (Kyriacos, Jordan & van der Heever, 2005), possibly indicating that the learning that was occurring in practice was not developing their knowledge or their confidence in using that knowledge (self-efficacy) appropriately.

2.2.5 Tutor Preparedness for Teaching

Work in the United Kingdom found that most teachers of bioscience for nurses had only a first degree in a related subject, and few of them were nurses (Wharrad et al., 1994) (see also Table 2.3). Camiah (1998) also indicates that there are a large number of nursing tutors teaching with no degree qualifications, and that many tutors lacked basic skills in research. Nurse tutors teaching bioscience often do not hold a higher degree in bioscience, which raises questions about their ability to teach these subjects. In both the United Kingdom and New Zealand, the qualifications required for teaching degree level requires research-capable staff that have detailed and advanced level of knowledge in the specific area that they teach (Thomas & Davies, 2006), which is typically considered to be masters level education as a minimum when teaching an undergraduate degree (Lim, Honey & Kilpatrick, 2007). The New Zealand *Education Act* of 1989 defines a degree as an award that recognises the completion of a course of advanced learning that is taught mainly by people engaged in research. Section 6.6 of the NZQA document *Requirements for Approval and Accreditation of Degrees and Related Qualifications* (NZQA, 2003) states "staff …. (are) able to offer teaching that is informed by recent research" (p. 33). Many post-graduate nursing qualifications held by teaching staff in nursing schools are of a clinical nature, and few of these qualifications have a significant research component. It could be argued even a nurse academic with a postgraduate nursing or related qualification and with a significant research history in the field of nursing, could not qualify as having advanced learning and research appropriate for teaching bioscience or science related topics in a degree.

The Nursing Council of New Zealand (2005a) specifies in the document *Education Programme Standards for the Registered Nurse Scope of Practice* under section 4.1 that "nurse lecturers must be registered nurses with masters' degrees, or have qualifications in advance of the qualification being offered by the course ….. and have experience relevant to the areas in which they are teaching" (p. 6). Most universities would not consider a first degree to be appropriate for academic staff teaching science yet many nursing tutors teaching science only have a first degree in science. At tertiary levels lecturers or departments are expected to combine teaching with research, so that the lecturers can 'own' the knowledge. The Royal Society of New Zealand (RSNZ), in response to the Tertiary Education Commission, states:

> Where a researcher is playing a leading role in a field of research, they will invariably have a stronger command of the overall field than a passive observer and, having this stronger command, will teach more confidently. The standard of research can and should be internationally recognised, and this will form a benchmark for the quality of the degrees taught. (RSNZ, 2004)

Some of the criticism directed at bioscience education in nursing is due to it either being too simplified to a point of inaccuracy (Trnobranski, 1993), or too complicated and confusing to be meaningful (Wharrad et al., 1994). This may be directly related to who teaches the topic and how familiar and confident they are with it.

2.2.6 Diversity of Science Content across Nursing Schools

Since nurse education moved to higher education, diversity has developed in content hours, depth of content and methods of teaching bioscience both in the

United Kingdom (Wharrad et al., 1994) and in New Zealand (see Chapter Five). This diversity is cause for concern when nurses transfer between nursing schools, and also after graduation if they take on more responsible roles such as prescribing and running of clinics (traditionally a task of medical personnel) as there is no common base measure of knowledge (Larcombe & Dick, 2003). In the United Kingdom, it was found that pharmacology for example varied considerably, with some nursing schools offering no hours in pharmacology, and others up to 100 hours (see Table 2.3)

Table 2.3: Comparison of bioscience content in 16 undergraduate Nursing schools in the United Kingdom (Wharrad et al., 1994)

Bioscience Content	Quantity
Total amount of Bioscience teaching	Between 111- 700 hours
Physiology	Mean of 116 hours Range 20 to 224 hours
Anatomy	4 Universities taught 0 hours 0 to 200 hours
Microbiology	0 to 100 hours
Pharmacology	0 to 100 hours
Entry qualifications	5 institutes required 'A' level science 8 institutes required GSCE level science 3 required no science
Qualifications of lecturers	82.5% had first degree 71.9% had science PhD 15% nurse qualification

In an attempt to make biology more meaningful to nursing practice, some nursing schools have integrated it into their nursing courses to attempt to make it more contextual, but this may have created a situation where students may pass the course, but their knowledge deficiencies may not be identified or remedied (Morrison-Griffiths et al., 2002). For instance, it has been suggested that the integration of pharmacology may leave out basic concepts which "may have long term implications for the nurses' understanding" (Morrison-Griffiths et al., 2002, p. 453). Lim and Honey (2006) state that the integrated teaching model of pharmacology taught at their New Zealand institution "promotes the links between theory and practice" (p. 167). They suggest that an integrated curriculum approach places emphasis on the learning process, and it is the nurse's skill in assessment, evaluation and decision-making that is important. Hence, there is variety and diversity in the delivery of science, some nursing schools integrating it into their nursing subjects, others having it segregated and discrete as science courses.

There is also a tendency for some nursing schools to concentrate on the normality of health rather than emphasise disease when teaching the first year of the nursing degree which is where the foundational bioscience is usually taught (Gibson-van Marrewijk, Hipkins, Stewart, Dannenfeldt, Stewart & HcHaffie, 2008; Larcombe & Dick, 2003; Trnobranski, 1993). Perhaps this is to attempt to make a distinction between nursing and medicine and establish links with the concepts of health promotion and maintenance of good health. However, this creates limited opportunities to contextualise the bioscience. It is also difficult to relate the bioscience being taught to practice as often the student has not yet engaged in any practicum so has no experience to relate to (Gibson-van Marrewijk et al., 2008). Specialist science teachers are quite likely to attempt to engage students with stories of disease and historic breakthroughs (Larcombe & Dick, 2003) and placing limitations upon this may contribute to the perception that science taught in nursing is not relevant to nursing practice. This is a point of contention in my experience in many New Zealand nursing schools with a prevailing view that science teachers (non-nurses) should not teach disease, as they have no nursing knowledge of the nursing required for these conditions. A recent study at the Waikato Institute of Technology, New Zealand, attempted to use case narratives in some modules of the first year bioscience course to forge links between theory and practice and to make it more contextualised. One of the issues that arose in this study related to the students' lack of clinical experience (being first year students) and so not having enough experience to relate to the narratives, and also the science teachers had difficulties trying to narrate clinical relevance to 'normal' states, which is expected in the first year bioscience courses (Gibson-van Marrewijk et al., 2008).

This overall has created a considerable amount of diversity in the undergraduate nursing science curriculum both in New Zealand and overseas. This could create difficulties in cross-credit or transfer between undergraduate courses, but also in identifying a thorough foundation base for ongoing study and future practice.

2.2.7 Future Nursing Workplace

There are a number of authors who consider that the current genetics education in undergraduate nursing programmes is inadequate to prepare nurses for current practice, but more especially for anticipated changes in the future (Barr & McConkey, 2007; Burton & Stewart, 2003; Dawson, 1998; Gottlieb, 1998; Kutlenios, 1998; KMPG report, 2001; Longley et al., 2007; Williams, 1998). The identification of genes that are known to contribute to disease strongly suggests that genetics knowledge needs to be part of professional nursing practice as part of understanding risk factors that may affect an individual's health. However, various studies have shown that there are barriers to implementing genetics into nursing education including "lack of adequate genetic knowledge by most nursing faculty", and "limited numbers who view genetic content as important" (Maradiegue, 2008, p. 2). Dawson (1988) suggests that nurses should not be dispensing advice to patients as they tend to read articles without understanding or an appreciation of the limitation of the research – he argues that nurses often discuss theories or hypothesises as fact and therefore make incorrect conclusions. As medical practice utilises advances in technology, it becomes more and more important that nurses who act as the patient's advocate are able to educate the patient, and contribute to that patient's decision-making processes. Genetic testing is complicated and is fraught with ethical and often emotional consequences for the patient; making it imperative for the nurse to have adequate knowledge to enable them to support patients (e.g., impact of hereditary issues for patient's children etc.). Even ensuring that the patient can give informed consent requires the nurse to educate and have understanding of the implications of clinical test results. Awareness of laboratory issues is also important as nurses may be participating in obtaining genetic tests and reporting of results can often be left to a nurse who must be able to interpret the results and navigate the implications and decision- making process for the patient, or else the nurse may be unable to act as an informed advocate.

In 1998, the Ethics, Legal and Social Implications of the Human Genome Project committee (ELSI committee) hosted a meeting with representatives from the health workforce, which included editors of nursing journals. Dr Francis Collins, Director of the Human Genome Project had stated that all healthcare providers, including nursing and regardless of speciality, would need to integrate genetic knowledge into their routine practice. The purpose of the meeting was to discuss the implications of the Human Genome Project for the future of nursing education and practice. The editor of the Canadian Journal of Nursing Research stated that it is imperative that "nurses are adequately prepared in the sciences of genetics, molecular biology and biotechnology to respond to the health care of patients" (Gottlieb, 1998. p. 3). The editor went on to state that without genetics being a core course in all nursing curricula, the nursing workforce will find itself unprepared to deal with the requirements of the future workplace.

Many science publications state that an individual's genetic makeup can play a role in the potential susceptibility of a patient to complex human disorders. This includes disorders that are not necessarily acute (i.e., more likely to be treated in a hospital) but are chronic, hence more likely to be treated by healthcare workers that work within the community. This includes Alzheimer's disease, autism, colon cancer, coronary heart disease, diabetes, hypertension, obesity, obsession compulsion disorder, schizophrenia and substance abuse (potentially alcoholism, pathological gambling, smoking, carbohydrate craving) (Kutlenios, 1998). The community nurse is more likely to have a relationship with the patient's family and the community in which the patient lives and so is the most likely health practitioner that will encounter these disorders, and arguably is best placed to support and provide adequate and knowledgeable advice (Burton & Stewart, 2003). Analysis of risk factors, understanding families at risk (family history) and providing education and support such as aversion therapies all may require nurses to have a good understanding of the concepts of genetic terminology and basic genetics. Nurses will probably have to be able to provide education and support patients faced with environmental choices (i.e., biochemical predispositions, etc.). The New Zealand Nursing Workforce Strategy (2006) also suggests that the consumer (patient/client) of the future will have higher expectations and be more informed and engaged than they have been previously (Future Workforce, 2006). This potentially means that unless a nurse does up-skill, patients could be more knowledgeable than the nurse.

Recent work by Barr and McConkey (2007) examined self-reported genetics capabilities of nurses practicing as health visitors (community nurses) in the United Kingdom. It appears that health visitors had the least knowledge of genetics compared with other nurse specialists. An analysis of the bioscience curriculum for health visitors showed that no health visitor programme contained genetics (as of 1999). Yet, it is exactly this group of nurse clinicians that are more likely to be required to act as patient advocates in the community and would require the most advanced competencies. In 2001, the USA National Coalition for Health Professional Education in Genetics consulted extensively and developed core competencies in genetics for all professionals (National Coalition for Health Professional Education in Genetics, 2010). These were updated in 2005 and 2007. However this information has not gained a footing in the curriculum development process. The Nursing Council of New Zealand, for example, simply states that 'genetics' must be covered. Nicol (2002) reported that in New Zealand undergraduate nursing programmes, 66% of schools teach less than 10 hours of genetics content, and one school taught no genetics at all.

Apart from technological changes and developments in medical science, emerging infectious diseases and antibiotic resistant pathogens also present challenges to the future health workforce. The development of chemotherapeutic agents for the control of microbial pathogens has had a large impact on clinical medicine and nursing in the past. Gerhard Dogmagk discovered sulfa drugs in the 1930s, and Fleming published his first paper on penicillin in 1929. By the end of World War II, penicillin drugs were being widely manufactured and the impact on mortality rates was dramatic, with many diseases being completely controlled (Madigan, Martinko & Parker, 2000). Many microbial diseases are no longer perceived to be the threat to public health that they once were, due to effective chemotherapeutic treatment agents, increased understanding of microbiology (public health systems, hygiene controls and standard precautions in nursing care), and other medical advances such as vaccinations. Disease and the treatment and control of infectious diseases were of paramount importance for nurses in the early part of the 20th century. As these diseases became more contained and controlled, nursing became more focused on the social aspect of nursing care, and this is possibly one of the reasons why nursing bioscience knowledge began to become sidelined in favour of holistic philosophies. However, hospital-acquired infections are on the increase and arise from cross infection that occurs in the hospital setting. It could be argued that hospital settings have patients who are sicker, more immuno-compromised and susceptible to infection than in the past, and so the increased number of hospital-acquired infections do not necessarily relate to a lapse in standards. In a New Zealand nursing journal, Wilson, the New Zealand Nurses' Organisation (NZNO) Director, stated the "government health policies over recent years have created an environment in which so-called 'superbugs' that are resistant to antibiotics can spread more easily" (Wilson, 1996a, p. 8). Wilson stated that during a particular period of time that showed an increase in methicillin resistant *Staphylococcus aureus* (MRSA) cases, levels of staff were decreased and there was more of a reliance on unqualified carers. The following month's journal had a response to this article from Baeyertz (1996) who commented that when resistant organisms started to be present in hospitals in the late 1940s and 1950s, hospitals had fewer resources and were more fragmented and understaffed than the current system. He states that "the main answer to this at present is not so much funding, but more judicious use of antibiotics and the avoidance of laxity in the practice of the old, well-established nursing principles of infection control" (Baeyertz, 1996, p. 4). The NZNO National Director Wilson responded that "it is difficult to maintain those old nursing principles of infection control when nurses do not have time to wash their hands between patients" (Wilson, 1996b, p. 4). Wilson's response could indicate a reliance on protocol-driven practice where staff may not have the knowledge to make judgements on when it is appropriate to alter their clinical practice.

If nurses have an adequate understanding of microbiology, including the mechanisms of antibiotic resistance, modes of transmission and knowledge of host/pathogen interactions, they may be able find efficiency measures during times of pressure without compromising patient safety. The fact that nurses appear to have been unable to make judgements about when it is vital to practice asepsis and when a more pragmatic approach may suffice suggests that they are unable to adapt their practice, perhaps due to lack of knowledge. This situation has been mirrored in the United Kingdom where Cochrane (2003) conducted an audit examining hand hygiene facilities at one non-acute health provider; again, the stimulus was an announcement that healthcare associated infections had increased (Gray, 2003). The audit examined a number of physical barriers to good hand hygiene including types of soap, nail brushes, types of taps, availability of paper towels, and so on but there was no attempt to gather information or data relating to understanding of asepsis, modes of transmission or knowledge of microbiology from the audit participants. This appears to further suggest that nurses are protocol-driven more than having an ability to be adaptive and provide an informed level of expertise. In Cape Town, South Africa it was reported that 54% of nurses felt that they had an inadequate understanding of microbiology for clinical practice (Kyriacos et al., 2005). Trnobranski (1993) suggests that aseptic technique is a procedure that many nurses have relied on as a 'ritualistic routine' rather than the application of fundamental principles of microbiology. The New Zealand Nursing Workforce Strategy (2006) commissioned by the Nursing and Midwifery workforce strategy group also indicated that recent pandemic planning had identified a lack of nurses with infection control skills (Future Workforce, 2006).

The impact of medical technologies and costs on the future health care environment will probably mean that more health care will move away from hospitals, and into the community (Future Workforce, 2006; Taunton, 2010). New advances in medicine means that some commonly performed procedures that used to be performed in hospitals, are no longer required (e.g., treatment of *Helicobacter pylori* for peptic ulcers by pharmaceuticals instead of by operations), and these conditions can be treated within the community. Changes to procedures such as minimally invasive surgery will likely reduce the inpatient time in hospitals. Other advances in technology such as remote or instant biosensoring of vital signs or laboratory tests will all require adaptation of nursing practice. Nurses in practice will be expected to be a link between people and clinics (Wilson, 1999), and will be exposed to more technology. There is evidence of nurses in practice already have a 'black box mentality' when working with scientific instruments where they do not understand the scientific concepts that are being measured (Wilkes & Batts, 1991) so their ability to interpret and respond appropriately could be diminished.

If nurses of the future work in an environment that uses more technology than the present, their bioscience knowledge may be more taxed than it is in current practice. Combined with this, the future workplace may see nurses in autonomous practice with more responsibilities than nurses currently have, also potentially resulting in a reliance on higher levels of bioscientific knowledge. Patients are more likely to complain about mistakes in their physical care compared to mistakes with their psychological care (Jordan & Reid, 1997) and, mistakes with the physical care of a patient could potentially have more disastrous consequences for the patient.

2.2.8 Impact on Patient Outcomes

Nurses report that they find difficulties in applying their bioscientific knowledge in their clinical practice (Powell, 1989). "The most notable deficiency in the knowledge base [of the nurses] was in the area of biological science, where the level of knowledge seemed excellent, but the nursing application of this was absent" (Powell, 1989, p. 830). If nurses have difficulty applying their knowledge to practice, bioscience will have a limited ability to influence or have impact on patient outcomes. Jordan (1998) suggested that patient outcomes were significantly improved when nurses in practice undertook an extensive professional development course in bioscience (undertaken by a specialist scientist) that was followed up by continuous and deliberate attempts by the nurses to link the bioscience knowledge to their practice. After extensive bioscience teaching, the nurse in practice was able to 'own' the knowledge and apply it with increased confidence and could explain the scientific rationale behind their clinical decisions. These same nurses, who at the beginning of the course stated that 'nursing theories' were the main areas of knowledge that informed their actions in clinical practice began to attribute almost every aspect of their nursing care to their newly acquired and assimilated bioscience knowledge (Jordan & Reid, 1997). However, it was recognised that the participants whose practice was transformed by their knowledge of bioscience were "the profession's pacesetters, and their successes cannot be necessarily be generalised to their colleagues" (Jordan, 1998, p. 299). Other studies have also shown that extra bioscience education for the 'expert' nurse has been beneficial to patient outcomes (Atkinson & Tawse, 2007).

Eraut, Alderton, Boylan and Wraight (1995) state that "front loading of scientific knowledge [in nurse education] is exceedingly wasteful – without linkage to practice it is quickly forgotten and has to be repeated" (p. 119). They also stated that students need enough biological knowledge so not to be perceived as ignorant on their early clinical placements, as this may impair their 'acceptance' into the placement setting. The challenge then is to identify which aspects of traditional science that are relevant to nursing, and then teach in a way that ensures that the scientific principles are transferred into client care (Neyle & West, 1991).

The English National Board for Nursing, Midwifery and Health Visiting sponsored a research project to evaluate the contribution that biological and social sciences provided to clinical practice (Eraut et al., 1995). The study examined nurses in practice, and attempted to identify when nurses were using simple applications of knowledge such as assessing a patient's nutritional status, and when they have to adapt that knowledge to suit the particular situation or patient (e.g., the nutritional requirements of an elderly patient after surgery; or problem solving like when an elderly patient has diabetes or special cultural requirements). The study also acknowledged that nurses often require a deep understanding of knowledge, and be able to interpret it in a very specific way to determine the most appropriate action. An example of this, still using the nutrition analogy, would be the nurse relating dietary protein to biochemical information such as low blood proteins and albumin levels. Knowledge that this could cause protein-dependent oedema which further compromises peripheral tissues and could increase the risk of skin damage, and how then that could compromise the patient's resilience to infection could inform their nursing practice for this particular patient. It could be assumed that a nurse who was not capable of deriving the higher levels of thinking from the biological knowledge (i.e., nutrition) may be at risk of compromising their ability to enhance patient outcomes in their clinical practice. Jordan (1998) suggests that relevance to practice is only possible after bioscience is known with sufficient depth to be meaningful.

After a review of a number of clinical studies which highlighted limitations in patient physical care, Gould (1984) concluded that a lack of biological knowledge or a failure to apply that knowledge had placed patients at risk. It seems that patient care cannot be improved by nurses who have expert psychomotor skills but lack a background in science, any more than it can be improved by nurses who have expert theoretical knowledge but lack the psychomotor skills necessary to transform that knowledge into improved patient outcomes (Neary, 1997).

2.2.9 Summary

While there is an absence of an understanding of how bioscience knowledge informs clinical practice and decision making, students in undergraduate nursing education programmes will continue to experience difficulties and the contribution it makes to nursing will continue to be unrecognised. The diversity of science content that exists across nursing schools points to a lack of agreement over what constitutes the fundamental science knowledge base for nursing. Nursing over the past four decades or so has evolved into an independent discipline that has struggled to find its own identity, and this search for autonomy has possibly contributed to a devaluation of nursing bioscience knowledge.

Nurses and educators are divided as to what the role of bioscience in nursing is and many nursing schools experience difficulties with the science components of their nursing programmes. Different authors attribute student anxieties with science to the way that it is taught, or to who it is taught by. Negative student attitude and lack of confidence in their ability to do the science subjects could lead to difficulties in students being able to see the relevance of the knowledge or apply it to practice. These attitudes could persist into the clinical environment once nurses are qualified and working, potentially contributing to bioscience being unrecognised or unvalued.

Nurses tend to learn how to use knowledge for their clinical practice during their placements in the nursing environment. When nurse mentors (preceptors) have difficulty articulating their own science knowledge, or when they have poor knowledge, the relevance to practice and nursing could become unrecognised. Any bioscience knowledge that is shared in the clinical environment may also be in direct conflict with theoretical science taught in the classroom placing pressure on students to decide which is correct. Some authors (e.g. Jordan & Reid, 1997) have found that extensive bioscience education for the nurse in practice can result in positive outcomes for patients. This is probably due to the nurse being able to see the clinical relevance of the knowledge.

Nurses of the future will possibly need to rely on their own knowledge (as opposed to that of their colleagues and the wider healthcare team) to navigate the expected future healthcare environment as they may be engaged more in autonomous practice. They may have to incorporate scientific and technological breakthroughs into their own practice. If healthcare moves more into the community setting as workforce forecasts suggest, nurses will be operating more in isolation, and in these circumstances, nurses' lack of bioscience knowledge may impede their ability to influence positive patient outcomes. The depth and breadth of bioscience knowledge (what) as well as the timing within the nursing degree (when) needs to be examined, and this will have impact on nursing educational programmes and curriculum.

2.3 Curriculum

2.3.1 Curriculum Design Models

The nursing degree is a vocationally-based, applied degree that leads to registration with the Nursing Council of New Zealand. Normal established practice in the ITP sector (Institutes of Technology and Polytechnics) in New Zealand in regard to curriculum development and design is to consult with relevant stakeholders, draw up a graduate profile and then bundle content into packages (courses) which will be measured by assessment against learning outcomes. Within this design process, the student nurse must also be assessed against the Nursing Council of New Zealand Competencies (NCNZ, 2007b) where students are judged against predetermined criteria. Nursing degrees are designed to have a significant amount of clinical placement in the final year so that the student can demonstrate performance against these NCNZ competencies before a nursing school recommends them to the Nursing Council for admission to the register (students will still have to sit the State Final examination to be fully registered). Whereas the theory parts of the nursing degree are based on locally written learning outcomes that essentially drive the rest of the curriculum content. In these theory courses, students are assessed via achievement-based methodologies (as opposed to standard based or competency methodologies for the clinically based assessments) and the student receives a grade.

If curriculum can be thought of as a body of knowledge that is to be transmitted, (sometimes called the syllabus) the learning outcomes are then the objectives or the products of that knowledge. The Nursing Council of New Zealand is the syllabus-setting body, but does not prescribe the curriculum or the content in any detail, except for in general terms which leaves nursing schools to produce a graduate profile that aligns with the regional workforce, or with any specialty provision that the school could provide. It could be argued that a nationally prescribed syllabus could be an advantage for nursing where the focus is on content and consistency to a particular national standard (Nursing Council Scopes of Practice and Competencies) (NCNZ, 2005a; NCNZ 2007a). However, education that measures against set objectives seems appropriate for technicians, but it could be argued that this might not produce a graduate who is an autonomous decision maker who meets the needs of the current and future workforce.

The dichotomy that exists in most nursing schools with having to meet Nursing Council requirements for registration (that is, be deemed competent and a pass the state final examination), and the academic recognition required of a degree course of learning (accreditation by external bodies such as NZQA and ITPQ) makes curriculum development a more complicated process than for degrees in other discipline areas. Clarke (2003) states that "curriculum development …. nowadays is more an issue of constructing documentation – for presentation to a curriculum body – which will satisfy the minutiae of predetermined criteria" (p. 3).

The focus on objectives (competencies and learning outcomes) is based on a 'product model' of curriculum design, which has its roots based in the needs of business, (or industry) where curriculum is a way of standardising the end product – the graduate (Smith, 2000). This obviously has relevance to a vocational, applied programme; however, it potentially can neglect the importance of the journey of education – building confidence, learning how to learn etc. The process model of curriculum development is a design approach that develops through the "dynamic interaction of action and reflection" (Smith, 2000, p. 10) which appears on face value to be similar to that required for nursing practice (action and reflection). It has been suggested that the process model of curriculum cannot be subject to examination (assessment). Stenhouse (1975) suggests that examinations or assessment should not be the end result of learning (that is, passing the course), but are a by-product only. He suggests that assessment underestimates the students' actual ability, and that a student who does not engage with the learning activities in a curriculum that is developed by a process model, would not progress through the programme (irrespective of assessment) because it requires a commitment to educational aims which includes constant planning, acting and evaluation which is integrated into the education process (Grundy, 1987). The process model of curriculum design is heavily dependent on the setting of behavioural objectives and the focus is on the interaction of teachers, learners and knowledge. The process curriculum model that focuses on the development of the individual is probably best suited to producing a graduate that is capable of independent critical thinking and decision making; but a product model provides an element of confidence to stakeholders, policy makers and ultimately employers and registration bodies.

Informal learning, such as that which takes place in the workplace, or the clinical setting, is often not articulated as either product or process. The clinical practice part of a nursing degree tends to align towards the competencies of Nursing Council, in small, achievable and appropriate 'chunks' of experience. As such, a lot of the learning that takes place in the workplace would be part of a 'hidden curriculum' that is firmly rooted in the social context of the learning. Jeffs and Smith (1990, 1999) argue that curriculum is divided into formal and informal education. The product model of curriculum does not appear to be compatible with informal learning where the emphasis is on process and praxis.

Often, informal learning situations attempt to set out the essential features of the learning encounter in advance, but sometimes this is not possible as the activities and topics that may be involved will vary (Eraut, 2004). The setting of learning outcomes that are negotiated in the workplace may have limited value and may not be clearly related to desired outcomes such as competencies and often have the effect of keeping the student busy, without engaging in learning opportunities when they come along, simply because they came along.

In essence, the product model of curriculum is possibly not the ideal design model for nursing as the focus is more on the performance of activities. This possibly was appropriate for training nurses of the past where the focus was on the performance of tasks. Nursing of the future may need graduates who are able to make decisions, possibly in isolation, and as such, a process model of curriculum design where the focus is on the development of the individual is probably the most appropriate.

2.3.2 Curriculum Development in Nursing

Many nursing degrees in New Zealand were first developed by consortia of technical institutes (Bennett, 1996). These arrangements were commonly with overseas universities which tended to act as mentors in the process. Over time, individual institutes began to review their curricula to meet the needs of the regional area that they served (their particular health workforce needs). The New Zealand nursing degree is a comprehensive degree that attempts to provide an overall theoretical grounding for nursing and includes many discipline areas as well as all the requirements to become a registered nurse. This differs to some overseas models such as in the United Kingdom where students choose their specialty and gain their undergraduate degree in a particular area (National Health System, 2010). Due to the diversity of healthcare settings in New Zealand (University Careers Advisors of New Zealand, 2007) and possible graduate destinations, nursing schools refine their curricula to meet regional workforce requirements. The New Zealand Nursing Council expects that education providers will consult with stakeholders with regard to changes of curriculum.

These stakeholder groups (usually in the form of local advisory committees) are made up of regional nurse leaders from the district health board (regional hospitals), rest-homes, primary care agencies, community based health agencies, representatives from the disabilities and Māori health sectors, academic nursing staff, and often, students. In spite of this requirement, it has been estimated that 48% of staff members from educational institutes do not collaborate with the relevant nursing stakeholders when considering changes to their courses and this often leads to problems with implementing a programme as stakeholders do not have 'buy in' (Pardue, 2006).

In nursing, the movement of education from hospitals to institutes of education appears to have filled the nursing curriculum with content, and literature suggests that there is overcrowding (Dalley, Candela & Benzel-Lindley, 2008). Information required for health care is increasing all the time and there appears to not be enough time to teach it all. Dalley et al. (2008), suggest that when curriculum content is being updated, educators tend to just add more without removing old content, and hence little time is dedicated to lifelong learning concepts. Many nursing schools rely on teacher centred curriculum development and calls have begun to move away from massive amounts of content to teaching essential concepts and abilities which are appropriate for the healthcare environment. Essentially, the clinical stakeholders are probably more focused on the product of curriculum design (what the learner has to know and do) with little consideration of the process of education which may support nurses' in their future careers by being able to update, and apply new knowledge, as well as make informed decisions that will lead to good patient outcomes.

The development of curriculum occurs after the deliberation of philosophical beliefs and the examination of community needs, industry or sector trends and accreditation criteria. In the ITP sector, the development of a new curriculum is often then started by describing graduate profiles – what graduates need to know and be able to do, to meet the needs of the community - the 'product'. The expression of the learning outcomes then inform the content which can be bundled into courses. However, sometimes educators, in their endeavours to collaborate can forget their own professional knowledge of how to achieve outcomes. Where stakeholders or nurses in practice may have some ideas of what outcomes they wish to see in graduates, it does not follow that they also know the best ways to achieve those outcomes (Lawson, 2004). Although the product model of curriculum design is not necessarily the most ideal model to prepare nurses, the stakeholder expectations of graduates along with the expectations of Nursing Council for registration (pass state final examination and meet competencies) dictate a product model of curriculum design by forcing schools to ensure that students meet performance expectations. If emphasis is taken off the performance of tasks, nursing schools risk the stakeholder being concerned over the theory-practice gap where nurse graduates may not be able to perform the tasks in the workplace.

Clear and distinct boundaries between content (in the form of course bundles) can also increase the fragmentation of the curriculum with content becoming more 'pure' and less 'applied', possibly contributing to the theory-practice gap as students may have difficulty applying fragmented knowledge to their practice. In regards to the nursing courses that contain bioscience, the content may be considered quite distinctly different from the rest of the nursing courses and hence have more distinct boundaries, possibly contributing to a perception that it is less applicable (or applied) to nursing practice, or at least contributing to the difficulties students may experience with being able to integrate the knowledge into practice.

In general, the relationship between content in a curriculum can be examined by comparing the amount of teaching time allocated to content (Trnobranski, 1996). Students tend to attribute the time given to content with importance and it provides a crude indicator of status. When content is separated by distinct boundaries, there are usually strong boundary maintainers and subject loyalty is often a source of conflict and resistance to change in the curriculum development process (Keogh, Watson & Dick, 2007). Subject loyalty is systemically developed in students throughout their educational life and subject specialisation can emphasise differences. Nursing, in particular has many identities and this diversity can be a source of conflict, where coalitions can flourish and often stand in opposition to others. When extensive curriculum changes occur, there is often a desire to see their own subject or discipline represented or increased in the curriculum and so those that hold the balance of power are often best placed to increase their own interests. In a relatively recent curriculum review in a New Zealand nursing education provider, an independent facilitator was used to help moderate the balance of power (Keogh et al., 2007). However, even with a facilitator, the champions for bioscience may have limited influence if they are not nurses, and as nursing programme leaders have to be registered nurses (as expected by the Education Standards that lead to registration (NCNZ, 2005a) it is unlikely that bioscience teachers will hold positions of power or influence.

2.3.3 Socio-Political Aspects of Nursing Science Curriculum Development

In the late 1990s, science programmes throughout the New Zealand polytechnic sector started to decline in the number of enrolled students, placing financial pressure on science departments. Around the same time many nurse academics and students began to question the appropriateness of the science curricula as it related to nurses, and its delivery by ‘conventional’ scientist teachers. Robinson (1992) warned of the ‘anti-science’ movement that was beginning to emerge in nursing and suggests that it could be due to science’s close association with medicine, and the perception of being unfeeling or cold.

One New Zealand nursing school went through significant curriculum change due to the introduction of nurse practitioner roles into nursing and the perception that “these changes necessitated a change towards a more scientific orientation” (Keogh et al., 2005 p. 17). Yet, throughout the process of curriculum change, no particular stakeholder was identified for the science components. The majority of the change came from a premise that the old degree was too hospital and acute care orientated (medical) and that it was not keeping up with changes in nursing practice. Most of the discussions appear to relate to the need to increase clinical experience and opportunities to link theory and practice (Keogh et al., 2007), and did not appear to align with the original perception that the nurse practitioner role would need a more scientific orientation.

When a new nursing curriculum is developed, it is usually the stakeholders (regional healthcare agencies) who are asked to support or 'approve' the content of the courses, but the content design is often done by the nursing or subject teacher. As such, when changes such as the removal of science content or laboratories are proposed, since it is not a practice related 'skill', or a nursing related course, or even a clearly articulated learning outcome, it could be argued that the local advisory committee is not equipped to provide sufficient advice. Some aspects of delivery (such as using a science laboratory or not) are not necessarily discussed in open forum as they may not relate to the official, approved programme documents, nor may they be expressed in terms of 'product' or learning outcomes so changes may be covert. Although members of the local advisory group will almost certainly have post-graduate qualifications, these nurse leaders would have probably qualified for registration by training through the hospital setting where it would be certain that they did not engage in laboratory sessions to support their science learning, so may have no opinion as to their use in preparing nurses. As the first degree graduates have only been in practice for approximately 10 to 15 years, they are only starting to emerge as nursing leaders. According to a survey undertaken in 2000 of educational qualifications of New Zealand's nursing workforce, 64.5% of the workforce was hospital trained; 18.2% of registered nurses had a degree, 0.7% had masters and 0.1% doctorates (NCNZ, 2000). This survey also states that the majority of the nurses with degrees were in the under 30 year old age group (in 2000).

Thus, nursing schools may not have a system that can inform science curriculum decisions other than personal views of academic staff that are driving change. A study in the United Kingdom by Carr (2008) quotes a participant who makes comment on nursing education curriculum design:

> Let's do lots of psychology, sociology, throw all those things in. Don't do any biology because you can go away and learn that because it's all in books and we don't need to teach you that – to hang on a minute, the actual basis of care is physiology.
>
> (Carr, 2008, p. 124)

This comment suggests ongoing debate over the role of bioscience, and hence its value in the curriculum. As the science influence in the polytechnic system decreases due to the closing of the majority of science related programmes in the sector, the power to be able to influence nursing curricula in science related subjects in these institutes is being diminished. One of the problems with the development of nursing curriculum is lack of consensus about what nursing is, and hence what is the foundation knowledge (Trnobranski, 1997). This results in a vague foundation to start curriculum design. The focus of nursing therefore will ultimately be influenced by predominant philosophies of the time and be subject to a flawed curriculum design process that is complicated by ‘hidden’ aspects of the curriculum and is subject to individuals trying to control vested interests.

An example of this occurred in 1992 when the New Zealand Qualifications Authority together with the Nursing Council of New Zealand decided that cultural safety should make up to 20% of the questions in the state final examinations. Guidelines were then written on the teaching of cultural safety and by 1995 polytechnic students were spending between 2 and 16.6 % of their time on cultural safety (Dougherty, 1999). This became part of a bitter and public debate about how the Nursing Council had supposedly been influenced by extremists. The NCNZ set up a review committee consisting of the Human Rights Commissioner, Erihapeti Murchie and Massey University Associate-Dean Paul Spoonley, who wrote a report on the issues suggesting that there were major differences in content and relevance between the nursing schools around New Zealand. This in turn lead to clearer guidelines and the debate largely diminished. However this public and controversial scenario demonstrated the curriculum development process in nursing schools where content can be subject to variation and influence by individuals.

In summary, nursing qualifications have a number of external requirements they have to meet in order to be able to offer nursing education which leads to registration, including those required of the Nursing Council of New Zealand and NZQA or ITPQ approval bodies. There is the expectation that the qualifications would have been developed in close unison with the local workforce, and as such, the focus is usually on the product, or the graduate. Due to the nature of this type of curriculum design, it is possible that if science does not have powerful advocates or champions, or if the contribution that science provides to nursing is not recognised, alterations to nursing science courses could occur without much debate.

2.4 Summary

The first research question for this project asks if science is required for clinical practice. New Zealand's nurse training was established in 1884 and was modelled on the hospital-based Florence Nightingale system. Increasing discontentment with this apprenticeship system saw various reviews of nursing education take place. One of the reasons for change included the perception that increases in technology associated with healthcare would require students to have more in-depth science knowledge than the hospital apprenticeship system was able to deliver. Nurse education therefore moved permanently from hospitals to technical institutes, where science facilities and specialist personnel were already in place, implying that the science was required for nursing, but that the science being provided may not have been considered adequate.

This move saw nursing students receiving increased learning hours in the science related subjects compared to hospital based programmes and this was considered to be one of the strengths of the new programmes of study. However, these new programmes began to report issues relating to the science courses being too in-depth and too difficult almost immediately. Some of the comments relating to the science provision related to impressions that the science being taught was not relevant to nursing. Currently, some authors report that nurse graduates do not have appropriate bioscience knowledge to enable them to safely perform some of their duties. One of the aims of this research is to try to establish how registered nurses actually use science in their clinical practice, and how this can inform curriculum development and educational practice.

Further changes in the New Zealand education system led to the establishment of degree level education as the minimum requirement for nurse registration. This change also led to pressure on existing nurses in practice to advance their qualifications. This coupled with the increased technological and scientific knowledge led to a rise in the status of nursing. But, as nurse academia began to grow, nursing found a natural alliance with humanity based subjects rather than with science based subjects leading to rejection of reductionist 'medical' knowledge in favour of humanistic holistic concepts.

Curriculum developers in institutes of technology and polytechnics tend to be subject to political and personal influences. The system is driven towards what the student can do on graduation and so is 'product' or outcome based. The process of learning is not of paramount importance. Since science does not have powerful 'champions' in nursing schools, there is a possibility that its contribution may be further devalued and unrecognised, which may have an impact on the nursing workforce of the future. Establishing what the roles of science and science educators are in nursing education are also important outcomes for this thesis.

Nursing still struggles to find its basic knowledge base and there is much debate as to what nursing is, and how bioscience in particular contributes to nursing practice. As technology and science continue to advance and as healthcare continues to alter, nurses will need to become more autonomous decision-makers and potentially then, science will have a more important role in nursing. Examining the depth and breadth of science content required to inform curriculum development and to ensure that authentic science education plays an appropriate part of undergraduate nursing education in New Zealand.

CHAPTER THREE
THEORETICAL PERSPECTIVES FOR THE INQUIRY

Overview of the Chapter

This chapter consists of the second part of the literature review and provides the theoretical framework for the inquiry examining the theories behind the main issues taken from the literature. The chapter begins with a discussion of the requirements for nursing practice with particular emphasis on science. This is then related to learning that occurs in the workplace, and a discussion on what influences clinical decision making. Theories of science learning are discussed next including constructivism and socio-cultural influences that are relevant to nursing education. An analysis of literature describing various factors that impact on science learning including different modes of teaching and the use of alternative teaching pedagogies follows. Next, a discussion on how science teaching and learning can be influenced by self-efficacy occurs leading to other factors that may have impact on science learning including social-cultural influences that occur in practice and the purposes of science learning. The chapter ends with a summary of the theoretical framework for this investigation.

3.1 Nursing Practice in New Zealand

In 1966, Virginia Henderson described nursing as assistance to an individual (sick or well), by the performance of activities that contribute to health or its recovery (or to a peaceful death) that the individual would perform themselves, if they had the strength, will or knowledge (Henderson, 1966). It is considered that each country (or society) has its own unique health dynamic and that recognising the distinctive cultural, social and health dynamic is fundamental to the role of the nurse. The International Council of Nurses defines nursing as encompassing:

> Autonomous and collaborative care of individuals of all ages, families, groups and communities, sick or well and in all settings. Nursing includes the promotion of health, prevention of illness, and the care of ill, disabled and dying people. Advocacy, promotion of a safe environment, research, participation in shaping health policy and in patient and health systems management, and education are

> also key nursing roles. (International Council of Nurses, 2010, para. 1)

The Nursing Council of New Zealand (NCNZ) is the statutory authority that governs the practice of nurses. The Council's primary concern is that of public safety and it sets and monitors various standards relating to nursing practice. The legislative requirement that gives the NCNZ this authority is the *Health Practitioners Competence Assurance Act 2003* (previously the *Nurses Act 1977*).

The Nursing Council of New Zealand defines nursing practice as "using nursing knowledge in a direct relationship with clients or working in nursing management, nursing administration, nursing education, nursing research, nursing professional advice or nursing policy development roles, which impact on public safety" (NCNZ, 2008a, para. 3) and this highlights the diversity that exists in the nursing workforce.

New Zealand has established three layers of nursing – nurse assistants/enrolled nurses, registered nurses and nurse practitioners all of whom have different scopes of practice and expected competencies for practice. In essence, nurse assistants or enrolled nurses work under the supervision of registered nurses and nurse practitioners are expert registered nurses who work in a specific area. At the time of writing this thesis, the Nursing Council of New Zealand was in the process of reinstating enrolled nurses, and disestablishing the nurse assistant role.

3.1.1 Role of Science in Nursing Practice

According to the Nursing Council of New Zealand's scope of practice for registered nurses, nurses "utilise nursing knowledge and complex nursing judgement to assess health needs and provide care, and to advise and support people to manage their health" (NCNZ, 2008b, p. 20). This scope of practice includes the provision of "nursing interventions that require substantial scientific and professional knowledge and skills" (p. 3). In the Nursing Council of New Zealand's Education Standards for Registered Nurse Scope of Practice (NCNZ, 2005a), it states that registered nurses require "bioscience, social and behavioural science, pharmacology, pathophysiology, genetics and disease states" (NCNZ, 2005a, p. 5) in their educational programmes. The actual content of this is left up to the individual nursing schools to define.

Nurse practitioners are expert nurses who are required to have a clinically-focused master's degree (approved by the NCNZ), as well as meeting nurse practitioner competencies. In the scope of practice, it states that nurse practitioners diagnose and are able to order, conduct and interpret diagnostic and laboratory tests and administer therapies (NCNZ, 2008c). Nurse practitioners may also prescribe medicines but to do so they are required to have a prescribing component within their master's degree. The nurse practitioner competencies state that a competent nurse practitioner "Demonstrates an extensive knowledge base in specific area of practice and applies knowledge of biological, pharmacological and human sciences" (NCNZ, 2008c, p. 7).

While the Nursing Council of New Zealand's Education Standards for Registered Nurse Scope of Practice states that registered nurses require "bioscience, … pharmacology, pathophysiology, genetics and disease states" (NCNZ, 2005a, p. 5) in their educational programme, the Nurse Assistant Educational Standards require "physiological knowledge" (NCNZ, 2005b, p. 5). Note, that during the writing of this thesis, the nursing council was considering reinstating enrolled nurses, in preference to nurse assistants. In the Education Standards for Enrolled Nurse Scope of Practice it states that enrolled nursing programmes must provide "anatomy and physiology, wound-care, infection prevention and control, pharmacology" (NCNZ, 2010a, p. 7, 8). With no further definition or indication of content or depth of topic that would be required to meet any scope of practice, there is the possibility that schools and their stakeholders may interpret these requirements differently.

Since the role of science knowledge in nursing is not made explicit in the standards or competencies that regulate the nursing workforce, it is reasonable to assume that science content is in the curriculum to support nursing practice. All three layers of nursing practice (assistant/enrolled, registered and practitioner levels) appear to require science knowledge as science topics are stated in their education standards (NCNZ, 2005a; 2005b; 2008c; 2010a).

Nurse practitioners have greater responsibilities than that of a registered nurse, and the expert knowledge required to diagnose and interpret tests, administer therapies and prescribe medications would be reliant on higher levels of science knowledge than those expected from a registered nurse. However, this extra science knowledge does not appear to be compulsory in most of the educational programmes for nurse practitioners within the clinical masters' degree structure. Those that wish to prescribe have to complete an approved prescribing component within their masters' study but extra science knowledge does not appear to be compulsory, indicating perhaps an assumption that the science content in the undergraduate programme is sufficient. What is required to become a nurse practitioner is a minimum of four years of practice experience in a specific area (presumably the area of practice the nurse wishes to specialise in). It is possible that an assumption is being made that an experienced practicing nurse has gained the science knowledge that would be required to underpin the nurse practitioners practice, in the workplace, after these years of experience. It is another possibility that the extra science knowledge (above that required of the registered nurse) required to support expert clinical decision making is not established or recognised, and so is difficult to articulate into a curriculum.

To summarise, nursing practice is considered to have unique characteristics in each community, but that it involves the provision of care, advocacy, health promotion and education. Nursing has established three layers of nurses, all of which appear to require science education content and all of which appear to use science knowledge in their practice. The Nursing Council of New Zealand does not stipulate the detail required for this education, however registered nurses appear to have responsibility to make decisions on nursing care, and nurse practitioners appear to gain the complex science knowledge required to meet their scope of practice from their practice experience in the nursing workplace.

3.2 Learning in the Workplace

Informal learning as described by Eraut (2004) recognises the social impact of learning from other people, and that it takes place in a workplace setting that usually has another purpose, other than learning. Nursing is a programme that has approximately half of its undergraduate time in clinical practice and so the impact of informal learning has to be considered as does the continual development of practice through workplace experience, and its contribution to the education of the expert nurse or nurse practitioner.

According to Prowse and Heath (2005) workplace learning is a concept where knowledge develops though interactions between individuals in a social context and it is considered to be a product of culturally-organised activity carried out in social groups or communities of practice. A community of practice includes groups of people working together towards a common outcome with people using different skills and experience. Much of this learning is implicit, work-based and integral to everyday situations. Social and cultural influences are central features, as people construct knowledge through engaging in the social world. Clinical problem-solving in the nursing workplace setting is often a collaborative context (not individual) and is often narrative (Prowse & Heath, 2005). Nursing clinical practice can be described as where much of the 'knowing how' of nursing takes place and this should have impact on the 'knowing what' of theory. Clinical experience tends to reinforce learning of topics that are subject to discussion and critical appraisal in the workplace, but has limited impact on topics that are not subject to narration or scrutiny by colleagues (Leathard, 2001). Hence, during clinical placements or after graduation, some topics or content may not be enhanced by the informal learning process and will be limited by the knowledge held by colleagues and mentors. Eraut et al. (1995) suggests that students are given more scientific knowledge in institutes of education than they can learn to use in the time available. This then leads to the concept of 'irrelevance' as they begin to dismiss knowledge that they have not used, which may be further perpetuated by mentors or preceptors who may give it little priority.

It could be expected that socially transmitted learning is potentially undesirable in something such as nursing where technology and medical advances are so rapid, as it implies learning in one direction from the mentor/preceptor to the student (or novice nurse). This could undo student learning and also inhibit modernisation and flow from the research/academic environment to the practice environment. In an ideal situation the flow would be bidirectional but in a busy ward, where the core business is patient care, this may not be the case.

3.2.1 From Novice Nurse to Expert

The role and impact of mentors as the nurse progresses from being a novice to an expert should not be overlooked. Mentors (or preceptors) vary considerably in their qualities yet excellent mentor support is vital through the reflective process, especially as students/novices may have defective assumptions (Field, 2004). The type of clinical placements that students complete at different stages in their undergraduate education appears to be important as students gain confidence through their managed experiences. The main personal attributes that appear to support success for a novice nurse includes high levels of technical expertise (experience), emotional intelligence (confidence) and cognitive capabilities (thinking and decision making) (Scott, 2003).

Some professional educational programmes have used models of intellectual development (see Table 3.1) proposed by Felder and Brent (2004) based on work by Magolda (1992), to compare types of cognitive development (or capabilities) that could be expected from professionals. Clinical decision-making in nursing practice could align with these stages of development as the practitioner moves from novice to expert. The graduate nurse (novice) is probably functioning at the ‘transitional knowing’ stage where they work according to protocol, but it could be argued that they should be performing at the ‘independent knowing’ stage where they are able to adapt their practice for the individual patient. It could be argued that the expert nurse should be functioning at the ‘contextual knowing’ stage where they can use all tools available to recognise patterns and make decisions in unexpected situations.

Models of intellectual development have been used to evaluate engineering students at two different engineering schools (Felder & Brent, 2004). Students entering first year are generally still reliant on the concept that authorities are the sources of truth (or knowledge) hence were at the ‘transitional knowing’ stage. It was found that the average change of the engineering student over four years of college was only one level, with most of this occurring within the last year. The author noted that these two engineering schools promoted active learning (project based and problem-based learning) and so suggested that other schools would be less efficient than this at increasing the students’ level of intellectual development.

Table 3.1: Models of Intellectual Development (Felder & Brent, 2004).

Absolute Knowing
Absolute knowing can be described as a construct where knowledge is certain, positions are either right or wrong, authorities have the truth and have the responsibility to communicate it, the students job is to rote learn and repeat knowledge. Within this, most men (mastery pattern) tend to raise questions to make sure their information is correct and will challenge any versions that differ from their version of the truth. Women (receiving pattern) tend to take in and record the information passively, without questioning or challenging it.
Transitional Knowing
Transitional Knowing can be described as a construct where some knowledge is certain and some is not; authorities have the responsibility to communicate the certainties; students have responsibility to use their own judgements about uncertainties. More men than women (impersonal pattern) tend to make judgements using a logical procedure prescribed by authorities; expectation is to fully utilise procedure regardless of clarity of reasoning or quality of supporting evidence. Women tend to (interpersonal pattern) base judgements on personal feelings and intuition and tend to distrust logic and abstract reasoning.
Independent Knowing
Independent knowing can be described as a construct where most knowledge is certain, students take responsibility for their own learning rather than relying on authorities or personal feelings. They collect and use evidence to support judgements but often do so superficially, believing that when knowledge is uncertain, conclusions can be reached by using the correct procedure. Men tend to (individual pattern) rely on objective logic and critical thinking and challenge positions to establish truth and make moral judgements. Women tend to (inter-individual pattern) rely on caring, empathy and the understanding of others' positions as bases for judgements.
Contextual Knowing
Contextual knowing can be described as a construct where all truths are contextual, students take responsibility for making judgements, acknowledging the need to do so when there is uncertainty and ambiguity. They use all sources of evidence in the process, objective and intuitive, and remain open to changing their decisions if new evidence occurs.

Facilitating movement through the various layers of knowing represented in the models of intellectual development would require students to have increasing levels of confidence, experience and knowledge. Designing a curriculum that can increase a student's emotional intelligence and technical expertise would also require knowledge of the types of cognitive capability that supports decision making in the clinical environment.

The different gender patterns within the different stages of knowing are also of interest as most nurses are female (93.8%) (NCNZ, 2002). As it appears that registered nurses have responsibility for clinical decision-making (as opposed to nurse assistants or enrolled nurses), then these models of intellectual development can provide an indication as to how the nurse may use the bioscience knowledge in practice. That is, a nurse at the lower levels of intellectual development may rely on rote learning of knowledge, and may follow protocols without question. A more intellectually developed nurse may tend to make judgments based on intuition, and may distrust the medical or scientific model (logic, abstract thinking), possibly preferring to use caring, empathy and an understanding of the others position to make judgements. Also, as a nurse practitioner is an expert nurse and potentially functioning at the 'contextual stage of knowing', their ability to use all tools to make decisions would include using bioscience knowledge. The indication that nurses in practice might rely on empathy and caring as a basis for making judgements (independent knowing stage) aligns with other literature about expert nurses and their clinical decision-making (Radwin, 1995).

3.2.2 Clinical Decision Making

Nursing and medical literature that addresses clinical decision making tends to classify decision making into two broad models (Luker, Hogg, Austin, Ferguson, & Smith, 1998). The first is a scientific, analytical approach which involves logical analysis, where probabilities for outcomes are assigned a numerical value relating to importance. It is understood in this model that not all knowledge may be available at the time the decision has to be made and so there are elements of risk where a practitioner has to decide if benefits of a decision will outweigh the risks. The other model of decision making relies on intuitive knowledge gained by past experience rather than objective sources of knowledge. There are always elements of uncertainty in the clinical decision-making process and it could be argued that nurses take fewer risks with their decision-making than medical doctors do. With the expectation that nurses will become more independent practitioners and autonomous decision-makers this will increase the risk associated with decisions, and the knowledge that a nurse would be required to draw upon.

Lim, Honey and Kilpatrick (2007) advocate that the education of nurses to become nurse practitioners (a recognised postgraduate, post-registered nursing professional who may gain prescribing rights and can practice in a certain area of speciality) also requires them to develop skills in clinical reasoning and clinical based decision-making. They propose a framework that is based on three tiers - the first tier being knowledge, the second tier being application of the knowledge and the top tier being decision-making. This implies that a current, experienced registered nurse may not have the decision-making capability required for higher level practice, yet according to the registered nurses' scope of practice, it is registered nurses who have responsibility for decision-making and so it could be assumed, that this should already be part of the professional skill set of a registered nurse, irrespective of any ambition to become a nurse practitioner.

Dreyfus and Dreyfus (1986) proposed a five stage model of skill acquisition as professionals move from novices to experts. Benner (1982) aligned these five stages of skill acquisition to nursing practice and suggested that the novice tends to have no or limited experience to draw upon, so many of their decisions are based on procedures or guidelines. The second stage of skill acquisition, 'advanced beginners' tend to see the individual becoming more reflective than the new novice, and beginning to recognise what is important, and what is not, as they move towards competence (stage three). When competent, the practitioner tends to feel more responsible for their actions than an advanced beginner. Proficient practitioners (stage four) tend to use intuition and know-how but also are more analytical in their judgements and more able to identify the important actions to take. The expert has the ability to alter their practice due to their knowledge of the individual situation, with the decision-making being intuitive and often unconscious (Pritchard, 2007).

An expert nurse has experience to draw upon and their decision making is often intuitive (Benner, 1982), however this intuitive decision-making and experiential practice basis is not necessarily based on scientific information, but is more grounded in social-context of repeating actions that have worked before, or have been observed to work when other experts do it. There is no guarantee that the expert nurse's decision-making process results in favourable patient outcomes. Hamm (1988) utilised the same stages of transition as Benner but related them to medicine instead of nursing decision-making, suggesting that the novice thinks analytically by working through guiding principles, whilst the expert clinician can make decisions intuitively. Hence, he linked the two theories of decision making into the one process, making the analytical, scientific model a process utilised by the novice practitioner and the intuitive model utilised by the expert. Decision-making will ultimately consist of analytical and intuitive aspects. Hamm suggests that the more information and time that is available, the more analytical the decision making process will be. The use of guidelines and practice protocols in nursing removes the analytical decision making process from the novice nurse to some extent, possibly providing some quality assurance and removal of some risk.

Botermans (1996) examined the training requirements of psychotherapists, whose training traditionally consisted of didactic methods of instruction, case supervision and personal therapy. He suggested that most established professions such as medicine and law study curricula starting from basic knowledge to operating concepts, moving into technical and practical skills that the profession operates under a defined context. He found that 'micro' training and the use of treatment manuals (guidelines) provided a method to control the integrity of treatment delivery and he indicated that these could also form the basis of training to provide continuous control over performance, until the novice psychotherapist gained more experience, developed their confidence, and moved from a novice towards an expert practitioner.

Successful nurses are considered to have attributes that include high levels of technical expertise, cognitive capabilities and emotional intelligence. This often includes the ability to recognise patterns in complex situations and to adjust accordingly (Scott, 2003). There is also a suggestion that the decision-making process of the nurse is influenced by how well the nurse knows the patient. Radwin (1995) suggests four stages of decision-making, from 'empathy' when the nurse is not familiar with the patient, to an ability to balance preferences with difficulties where a nurse can individualise the interventions due to familiarity of the patient. The development of evidence-based practice in nursing should minimise the risk associated with clinical decisions as the policies and guidelines that nurses follow should be based on research - but this has implications for the nurses' knowledge base to interpret and analyse literature and research. Some authors suggest that nursing practice is still experiential, rather than research-based (Camiah, 1998; Fulbrook, Rolfe, Albarran & Boxall, 2000). The intuitive nature of expert nursing practice appears to be based on the ability to detect changes in the patient's condition and this is enhanced by experience. Radwin (1998) suggests that knowing the patient is core in such decision-making processes and that the confidence of the nurse increases with experience. The experienced nurse tends to ask more relevant questions, be able to listen and intuitively observe changes in condition. Experiential knowledge of patients in similar situations had relevance to interventions chosen by previous experience (Radwin, 1998) however, in situations where the nurse has limited experience; their knowledge of bioscience information should support their decision-making ability. This would be so, if not directly in terms of recall, then in terms of being able to source, read, critique, understand and apply information and evidence.

3.2.3 Summary

The informal learning situation that occurs in clinical practice in undergraduate nursing degrees is dependent on the knowledge and skills and on the nurse mentor or preceptor. Looking at models of intellectual development, competent and proficient nurses tend to make judgements based on their intuition and they may even have a distrust of empirical information, preferring instead to make decisions based on their experience, and their knowledge of the patient. In these situations, nurse students may find that bioscience knowledge is not used by expert nurses, or at least, not clearly articulated as many expert nurses may make decisions almost unconsciously.

However, expert nurses should use all available tools to inform their decisions, (according to models of intellectual development) which include utilisation and consumption of research as well as analysis of evidence. Especially in situations where the nurse has had no direct experience, nurses will need to access scientific knowledge to aid their clinical decision-making.

If nurses in practice (especially those who act as mentors or preceptors) are more able to recognise and articulate their science behind their nursing actions, nurses are more likely to recognise it as a collective, and perceive it as a valued part of clinical practice, which in term may go some way towards addressing the bioscience issue. In order to support nurses to be able to use bioscience knowledge in their practice, it would be valuable to provide nursing students with appropriate authentic teaching and learning experiences that includes the integration of knowledge which informs their clinical decision-making. This will likely give the student confidence in the clinical setting, and this will probably lead to improved patient outcomes. In order to consider how to enhance such learning experiences, a discussion on the various theories of learning is appropriate.

3.3 Theories of Learning

People tend to have a particular way of understanding the world – this is often referred to as a "worldview" or paradigm. Any paradigm or belief set is based on some underlying principles that tend to represent that particular way of looking at the world. For instance, a person with a realist view typically considers that social reality is external to the individual and that knowledge and the knower can be independent of each other. These assumptions may be considered to be objectivist (positivist) in nature. Whereas, others may hold views that social reality is more a product of the individual's cognition, and that knowledge is related to the knower, or even that knowledge is dependent on the knower. These assumptions may be considered to be subjectivist (anti-positivist) in nature (Cohen, Manion & Morrison, 2007).

Within education, there are four main learning theories: behavioural, cognitive, constructivist and socio-cultural and each learning theory tends to align with a particular worldview or paradigm. For instance, behavioural learning theories tend to focus objectively on the observable aspects of learning – that is, they tend to be outcome focused and do not account for any internal processing that might be associated with a particular activity (Jarvis, Holford & Griffin, 1998). Teaching activities where reward (good grades or examination marks) or punishment, is used to reinforce behaviours are based on the underlying principles of behaviourism.

Cognitive theories look beyond behaviour to attempt to explain how the brain and memory work to promote learning (Jarvis, et al, 1998). Teaching methods that are supported by cognitive theory would focus on the learner, giving consideration of cognitive load (time it takes to absorb and think), stages of development and would use techniques that would facilitate learning, brain function and memory. However, these theories consider that knowledge is independent of the person, and more an aspect of brain function.

Constructivism is a paradigm within cognitive theory that views learning as a process in which the learner actively builds or constructs ideas or concepts from their experiences (Tobin, 1993). These constructs can be validated as 'knowledge' and are often influenced and revised by experience, and social-cultural expectations. Teaching methods that align with constructivism include cognitively active teaching opportunities (as opposed to passive where information is provided) that provide allowance for the student's own experiences. These theories align with assumptions that acknowledge that knowledge is dependent on the knower.

Socio-cultural theories of learning acknowledge that knowledge is a cognitive activity influenced by social and cultural processes, often within a community of actively thinking individuals (Bandura, 1986). Teaching strategies that align with these theories of learning tend to use techniques that encourage active learning in group situations within authentic contexts (including language and symbolism central to the social group). These theories suggest that knowledge is related to the context of the knower.

Any of these theories can be used in instruction and curriculum as curricula in the tertiary sector can use a blend of learning theories: behavioural (grades, rewards, qualifications, employment, graduate profile, learning outcomes), cognitive (learning hours, self-directed hours, memory techniques), constructivism (facilitated teaching techniques, active learning experiences, student-centred, acknowledgement of prior learning, socially mediated), and social-cultural theories of learning (use of peers, internship, work experience, cooperative and authentic learning experiences).

In terms of nurses' learning science, the traditional teaching methods and curriculum design processes tended to have been driven by behavioural theories of learning resulting on the focus being on the product – learning outcomes, grades, and employment. In terms of an analysis of the bioscience issue and the criticisms that some of the issues are caused by the way it has traditionally been taught, the next part of the chapter contains a more detailed discussion of constructivism as a theory of learning.

3.3.1 Constructivism

Traditionally, the teaching of science has been dominated by a view that learning is a passive process, where teachers transmit their knowledge into the 'empty' head of the student (Cobern, 1993). No real account was taken of the student's own grasp of concepts being taught as it was considered that the 'correct' version would be transmitted from the teacher, replacing any incorrect version that the student had. This led to teaching methods that were very teacher focused, as the teacher was considered to be the only one that had the knowledge, and who could transmit it. However, in the 1970s this view began to alter as new cognitive theories began to emerge which challenged the concept of passive learning. These new theories considered that students do not arrive in class as 'empty headed vessels' but they have their own version of concepts, knowledge and scientific ideas that they have developed. Sometimes, this 'knowledge' may differ from a considered 'correct' version, and this can be very difficult to change (Driver, 1981). This knowledge has been built up or constructed through their individual experiences and via social interactions. These new views on how learning occurs lead to the development of constructivism as a theory of learning.

Constructivism derives from cognitive psychology and states that learning occurs in a cumulative way through problem solving in everyday situations. Each individual constructs an individual knowledge base that builds on existing knowledge (Prowse & Lyne, 2000). This theory suggests that knowledge is built up in the mind of the individual and is not transmitted passively from the teacher to the learner, and this has implications for teaching methodologies. An individual's construct and viability of that knowledge can be tested against considered 'correct' knowledge or by assessment. There is therefore no single correct way to think or know something, but the application of that knowledge may be verified against expected norms, theories or against expected outcomes. This implies that there is no real event or truth, but that an individual constructs a version of that event or truth that enables them to explain, recall, predict or apply 'knowledge' to a particular purpose. If that application of the knowledge is appropriate to the purpose, then that knowledge or construct is verified. Therefore, we would expect different models or constructs to be most appropriate in different contexts.

When an individual is constructing a knowledge base, they are influenced not only by their own experiences and grasp of the concepts, but also by the presence of other people. Knowledge construction therefore has a social contribution and can be thought of as a particular way of knowing, depending on the influence of others. What is thought of as being 'correct' is also then socially determined. This can also have a cultural influence and so ways-of-knowing can be influenced in multiple ways such as; women's ways-of-knowing, indigenous people's ways-of-knowing, and so on (Tobin & Tippins, 1993). Knowledge construction then is a cognitive activity influenced by social and cultural processes, often within a community of actively thinking individuals. This has impact on science teaching and learning because students typically end up sharing the scientific explanation of the teacher (or the textbook) when, depending on their own experiences, background and culture, they may not find the explanations plausible (Cobern, 1993). Learning science may also be 'culturally foreign' to some students, and

Cobern (1993) attempted to describe this by using seven logico-structural world view categories (see Table 3.2) based on research that "critically examined the cultural form in which western science is embedded" (p. 61). A student's view of the world may be something between the alternate view and the scientific view, and some aspects may be completely compatible, while others may be completely incompatible with the scientific view.

This suggests that students may come to a science class with preconceived ideas of how the world works, and some of those ideas will have been formed or constructed via social influences and may be in conflict with desired outcomes. One also has to look at the social influences of the community that the student is joining - that is, the student body, and ultimately, the workforce. Within the nursing workforce, many of the attributes that are listed in Table 3.2 as 'alternative views' may be considered to be desired qualities for a nurse (such as holism, passion, social or humanistic and personal) and therefore for nursing.

Table 3.2: Example descriptors for logico-structured world view categories (Cobern, 1993).

Logico-structural Categories	Science Instruction	Alternative Views
The Others (Everything other than self)	Materialistic Reductionistic Exploitive	Holistic Social/humanistic Aesthetic Religious
Classification	Natural	Natural Social Supernatural
Causality	Mechanistic Teleonomic	Mystical Teleological Contextual

Relationship	Objective Nonpersonal	Subjective Personal
Self	Dispassionate Independent Logical	Passionate Dependent Intuitive
Time and Space	Abstract formalism	Participatory medium Tangible

Social learning therefore is a significant part of the nursing education context. Apart from the social influences that a student encounters in the classroom, approximately half of an undergraduate's time studying is in clinical practice where they are mentored with a nurse in practice – commonly referred to as a preceptor. Knowledge generated by social mediation is usually jointly constructed and distributed over the entire social system rather than being held just by an individual participant (Salomon & Perkins, 1998). In nursing, the focus falls on the collective to acquire more knowledge, understanding and skill and may involve the formation of internal procedures based on commonly held assumptions. This may have implications for nurses' use of bioscience in the workplace.

3.3.2 Social Constructivism

In terms of pedagogy, constructivism does not suggest any particular way of teaching however it is most commonly associated with activities or approaches that promote active learning. Constructivism considers that each learner is an individual with unique experiences, culture, needs and background and is often complex and multidimensional. Further influences include the social community that is either part of the background of the learner or may be a community that the learner is trying to become part of (workforce, education institute, culture). This concept of social constructivism emphasises the importance of the learner being actively involved in the learning process, and does not place the responsibility of learning on the teacher. Learners look for meaning and regularity to order the events of the world to construct their own internal version of these events and will often be influenced by the social group around them (von Glaserfeld, 1989). Learners will often look for validation of their constructs with peers, or important members of their community. Hence, in an educational setting, these social validations should be encouraged, because a construct that is not shared by their social setting or community will unlikely to be maintained or be considered to be authentic or valid. Vygotsky (1978) suggests that the most powerful learning event is one that includes an activity – to enable the learner to construct their version of reality of the event, and dialogue – to enable the learner to validate their version of the 'truth' with a member of their social community. The learner and the facilitator are usually equally involved in the process, and will therefore include the background, values, and culture of the facilitator as well (Holt & Willard-Holt, 2000). Learners compare their new construct or version of the 'truth' with that of the teacher and/or fellow students, and gain a new, socially-verified version – often called knowledge. Active learning that includes approaches that involve learning with others, fit with this belief system.

Social constructivism thus suggests that teachers should facilitate learning, and not teach or deliver content, with the focus being on the learner, not the teacher. The facilitator should be able to direct the learning experience to challenge the learner's thinking. Duffy and Jonassen (1992) indicate that delivering content in a de-contextualised manner does not give learners the skills to apply the knowledge to authentic activities as they are not working in the complex, interrelated environment that determines how and when the knowledge is used. Authentic or situated learning experiences therefore should take place in context, within a similar culture to the applied setting (Brown, Collins & Duguid, 1989) and should not be divided into compartments or subjects, as often the knowledge required or problem faced is complex with various dimensions and perceptions (Ackerman, 1996). The learning experience should attempt to reflect the complexity of the environment that the learner will function in at the end of the learning.

The ability of the learner to sustain the motivation for learning and to continue revisions to their constructs and to continue to reformulate and test their version of 'reality' is also dependent on their own motivation and confidence. If the learner has had positive experiences beforehand where they have managed to master problems or activities, then they are more likely to continue to revise their constructs and learn. These internal influences of competence or confidence are often more powerful to the learner than the external rewards, acknowledgements or punishments. By experiencing success, the learners gain confidence and motivation to continue to be engaged in more complex challenges. Vygotsky (1978) suggests that learners are challenged when activities are slightly above their current level of development. This suggests that learning activities should enable a progression through scaffolding processes which are monitored and facilitated by the teacher, with continuous feedback to enable further development. Vygotsky's zone of proximal development suggests that providing learners with experiences that are within their capabilities (with guidance as appropriate) will encourage and advance the individual's learning (Vygotsky, 1978).

Ernst and Colthorpe (2007) found that when a second year physiology class was split into two cohorts – one with a strong science background and the other with no science background, both cohorts were taught using interactive lecturing and it was found that students with limited prior knowledge who traditionally performed poorly, achieved similar outcomes as those students with a science background. This possibly indicates that active and interactive teaching methods can have more positive outcomes for students engaging in science learning, in comparison to traditional teacher centred or objectivist teaching methods.

3.3.3 Constructivism - Novice and Expert Learners

Some cognitive scientists dispute that constructivism is appropriate for novice learners, stating that novices do not have the necessary underlying mental models to benefit from less structured, active learning and facilitated teaching approaches (e.g., Mayer, 2004). Mayer maintains that students should be cognitively active (not to be confused with behavioural activity) during education sessions and that teachers should guide them. Guidance can be gradually removed (faded guidance) as learners gain confidence and knowledge (Sweller & Cooper, 1985).

Often, pure discovery learning techniques are considered to be part of constructivist instructional design, yet it has been suggested that pure discovery learning techniques are not as effective as guided discovery (Mayer, 2004). Interestingly, some authors suggest that discovery learning actually aligns with behaviourist learning theories as the process of trial-and-error or problem-solving derives satisfaction for the learner (Jarvis, Holford & Griffin, 1998). Critics of constructivism describe constructivist methods as unguided methods of instruction and suggest that novice learners need to have structure (Kirschner, Sweller and Clark, 2006). It has been suggested that novice learners get easily distracted with activities (Sweller, 1988) and a well-designed, structured learning environment is considered by some authors (e.g. Jonassen, 1997) more appropriate for novice learners who have little or no prior knowledge of the content being delivered. The provision of scaffolding for more complex problem solving appears to be more appropriate for advanced learners (see Table 3.3). Advanced learners or those with more experience of the content can experience expertise reversal effect when they are subjected to well-structured learning environments (i.e. worked examples) as these tend to be less effective for this group (Kalyuga, Ayres, Chandler & Sweller, 2003).

Table 3.3: Scaffolding of learning environment
(Jonassen, Mayes & McAlesse, 1993).

Novice Learners (Unfamiliar with content)	**Advanced Learners** (Familiar with content)	**Expert Learner**
Learning Environment: Well structured domains Skill based Literal coding	**Learning Environment:** Ill-Structured domains Knowledge-based	**Learning Environment:** Elaborate structures Schematic patterns Interconnected knowledge
Initial (introductory) knowledge acquisition	Advanced knowledge acquisition	Expertise
Teaching model: Practice Guided examples	**Teaching model:** Apprenticeship Coaching	**Teaching model:** Experience Decision making

Nursing is a very socially-orientated career, with clinical decisions often being verbally narrated and based on prior experiences and observations (Radwin, 1995). Traditional science classes in nursing undergraduate education tend to rely on didactic teaching techniques which do not often encourage active learning, discussion or authentic experience and does not tend to take into account the prior knowledge or experience of the learner (Wharrad, Allcock & Chapple, 1994; Thornton, 1997).

3.3.4 Sociocultural Views

Sociocultural views of learning attempt to describe the relationship between thinking and the situation that this thinking occurs in. Situations can be cultural, institutional and historical; they may be complicated and even have their own language or jargon (Wertsch, del Rio & Alvarez, 1995). Learning is considered to be socially situated and that implies that learning can occur by participation in a community of practice (Wenger, 1998). The dynamic and interactive aspects of the community's knowledge provides emphasis on the performance of the team – which can include any combination of people, surroundings or tools and not so much to do with an individual's knowledge (Nakhleh, Polles & Malina, 2002). Social facilitation of an individual's learning whilst in the community usually involves informative feedback, challenge, guidance and encouragement. From a sociological perspective, knowledge as a social construct is actively developed and modified in response to practical experiences. This implies that people who hold the knowledge tend to organise and assemble it with like-minded people with common concepts of validity. Finding out what counts as legitimate educational knowledge within a particular community would also require the social organisation of knowledge in educational institutions and workplace settings to be taken into account. As nursing bioscience learning takes place within the context of nursing, both within educational establishments and within healthcare environments, establishing how bioscience knowledge is validated within the two different social groups (education and healthcare) could have an impact on what should be taught and how.

3.3.5 Fundamental Patterns of Knowing in Nursing

If knowledge is a cognitive activity influenced by social and cultural processes within a community of actively thinking individuals, it is then relevant to discuss literature that provides an analysis of nurses 'ways-of-knowing'. Carper (1978) is considered a seminal piece of work that considers what nursing knowledge is.

Carper (1978) states that:

> The body of knowledge that serves as the rationale for nursing practice has patterns, forms and structure that serve as horizons of expectations and exemplify characteristic ways of thinking about phenomena. (p. 13)

Understanding these ways-of-knowing is essential for the teaching and learning of nursing with particular focus on what it means to know, and what kinds of knowledge are most valuable to nursing. An analysis of the conceptual and syntactical structure of nursing knowledge distinguished four patterns of knowing (Carper, 1978). These established patterns of knowing include the science of nursing, the art of nursing, the importance of self, and ethics. Within the pattern of knowing that is empirically based (i.e., the 'science' of nursing), Carper (1978) suggests that there is general agreement that there is a critical need for knowledge about the empirical world. This knowledge is systematically organised into theories and laws that enable description and allows prediction of phenomena that are of special relevance to nursing. Carper suggests that this pattern of knowing does not show the same degree of highly integrated abstract and explanations of more mature sciences but that this is appropriate. Nursing knowledge has been described as a collection of subjective attitudes which is not considered to be scientific nor is it based on following scientific method (Flitter, 1976). The focus of 'nursing science' appears to be the synthesis of conceptual structures and theories to represent new perspectives for considering health and wellness in relation to the human experience, which should be verifiable and susceptible to modification and revision. Within this concept lies the 'borrowed' knowledge base of psychology and bioscience for example. In particular, the representation of health as more than just the absence of disease, with it being a dynamic state which alters over time and according to circumstances, which allows observation, description and classification of variations of health and wellness as expressions of the human experience. This includes physiological and psychological responses, which serve as cues to interpret the range of normal health variations. This also includes the understanding of the significant factors that promote or inhibit changes in health status. Examples of this include knowledge of human anatomy and physiology which can explain a person's level of wellness at any particular time as having a relationship between internal and external interactions. Homeostasis is a scientific concept that considers that systems (in the human body) will adapt and respond to environmental demands and re-establish steady state or homeostasis. Understanding how this alters during the lifespan (developmental models) is important in order to understand the cues that allow the nurse to interpret the range of health variations. This focus on health and wellness may be the reason why most nursing schools tend to populate the first year nursing science curriculum with concepts of physiological normality, moving towards pathophysiology (altered health across the lifespan) in the second year (see Chapter Five).

The other patterns of knowing that are relevant to nursing includes aesthetics, or the art of nursing (Carper, 1978). In the apprenticeship training style, nursing was closely associated with the acquisition of knowledge by imitation, and the art of nursing was more associated with gaining practical skills. However, knowledge gained in this way is made visible through the action that a nurse takes to provide for a patient, which enables that patient to restore or extend their ability to cope with their situation. Carper suggests that it is perceptions of the patients' needs that constitute the art of nursing, not just recognition of needs. This means that a nurse is creative in designing effective and satisfying nursing care for individual patients. This concept is holistic – care for the whole person. This pattern of knowing appears to be based on empathy. The more skilled a nurse becomes in perceiving and empathising with the lives of others, the more understanding they will have with alternative modes of perceived reality (Carper, 1978), giving a nurse wider choices in providing care that is effective and satisfying.

As nursing requires interpersonal interactivities between the nurse and the patient, this relationship is considered to be very influential in how the patient copes with illness. The term 'therapeutic use of self' suggests that nurses' knowledge of themselves and of the client is primary in the therapeutic relationship (Carper, 1978). This concept implies passionate participation from the nurse where the patient is not an object and where the nurse attempts to forge an authentic personal relationship with the patient that is not predetermined by beliefs or stereotypes. The concept of each person being a unique 'self' who may not adhere to generalised categories is important in establishing this relationship.

The fourth way of knowing that has relevance to nursing is ethics (Carper, 1978). Health care treatment and promotion of health is fraught with ethical and moral decision making. Nursing is a series of planned actions that implement defined goals, and the setting of action and goals may involve choices which may have moral conflict. A common goal in nursing is to maintain or restore health by assisting patients to achieve a state in which they are independent. Often however, independence may not be possible for a patient, and the moral choice for the nurse is to support the patient in this knowledge. The concept of health often has implicit value statements and it may be considered that a person who cannot live independently is not healthy. The ethical aspect of nursing involves an understanding of different philosophical positions and frameworks as well as various differences in the notion of obligation (Carper, 1978).

Understanding these ways-of-knowing is essential for the teaching and learning of nursing with particular focus on what it means to know, and what kinds of knowledge are most valuable to nursing.

3.3.6 Summary

With regard to designing teaching and learning experiences for a science course within a nursing programme, it is important to consider the different theories of learning that may underpin a curriculum and instructional design. Within that is a consideration of the different paradigms that can influence a curriculum and teaching techniques that may be used in the teaching and learning activities, which includes an understanding of how the knowledge gained would be used and validated in the workplace. Knowledge that is shared as part of a community (i.e., nursing) is more likely to be valued, recognised, incorporated and retained. As science knowledge is often considered to be isolated somehow from practice, it is necessary therefore to represent the knowledge in a way that can achieve community validation and relevance. An understanding of nurses ways-of-knowing also places perspectives on the 'what' and 'why' that is currently in the nursing curriculum (science, art, interpersonal communication and ethics). Recognising how novice students build their constructs and how they apply them as they progress in confidence is also relevant to this study, as well as considering nursing students to be novices both to science learning and to the nursing setting (workplace and educational setting).

3.4 Science Teaching in Nursing

The way science is taught or delivered tends to have a big impact on student learning. The literature suggests that science students tend to prefer active learning such as discussion with the teachers or class, experiential or creative science and having a lesson memorable and entertaining, but staying within the context of the topic being taught (Tobias, 1990). There are a number of reasons why these student preferences are not common place in educational faculties. In nursing, for example, many nurse tutors who teach bioscience may not have the knowledge base to facilitate discussions or engage in creative science nor have in-depth background in the topic in order to make it entertaining, and a non-nurse tutor may have difficulty with relevance and context. However, there is also a perception of overcrowding in the nursing curriculum with time being a major limiting factor and probably the major reason why delivering according to student preferences is not realised (Dalley, Candela & Benzel-Lindley, 2008; Davies, Murphy & Jordan, 2000).

3.4.1 Traditional Delivery Methods

Due to the perception of an overcrowded curriculum, lecturing is the primary mode of delivery of science courses in many nursing programmes (Dalley, Candela & Benzel-Lindley, 2008; Davies, Murphy & Jordan, 2000). Tutorial classes, compared to lectures, tend to provide more opportunity for discussion and social interaction within the context of the topic and so may be favoured by students providing they perceive the staff member as approachable (Bennett, Rollnick, Green & White, 2001). Davies et al. (2000) analysed the efficacy of each teaching method to promote learning with understanding in one United Kingdom institution and attempted to establish the method's usefulness in relation to nursing practice. The bulk of the information was delivered via lectures which were usually between one to three hours in length, and the classes were broken up into smaller groups (no more than 20 students) for tutorials. Students tended to find the tutorial or small group work more useful (78%) but lectures and laboratory work were considered by 73% to still be useful. However, the three hour lectures were not popular with students, with the main complaint being that they are "too intense and by the end of three hours, most of us were dozing off" (p. 126). The main problem with lectures according to Davies et al. (2000) was the perceived inability to ask questions, to clarify or simplify and many students had issues with asking questions in front of the class. The main value of the lecture appeared to be the provision of an overview of content. Some students favoured structured sessions where there was no ability to question but these students probably had high anxiety and may not have been independent learners. Some students respond well to learner-centred teaching, finding it more mentally and emotionally engaging, particularly in laboratories, but others dislike such an approach and prefer a teacher-dominated style of teaching. It has been suggested that one reason students prefer teacher-centred instruction is their desire to establish exactly what teachers think it is important for them to know, particularly when assessment is largely dependent on summative examinations (Mulligan & Kirkpatrick, 2000).

While laboratory classes appear to be relatively popular with traditional science students, possibly because it allows them to work like a 'real scientist', using equipment, wearing a lab coat, and using jargon (Bennett, Rollnick, Green, White & Mumba, 2001; Niedderer & Psillos, 2002), the role of the laboratory in nursing science teaching has never been fully established. It differs from that of a classical science student because it could be argued that nursing students do not have to gain competency in the use of science equipment, and the students probably would not regard the laboratory tutor as a nursing mentor (unlike science students who might see laboratory teachers/tutors as role models). The laboratory session can be an opportunity to engage in the active and creative process of experiential learning which may support science learning for nurses, and it may also provide nursing them with scientific and analytical thinking skills which could be important for problem-solving. However, laboratory classes may not necessarily be effective sources of learning. For instance, teaching ‘experiments’ are often designed with unrealistic or highly predictable outcomes, that do not engage students cognitively (Tobias, 1990). These ‘experiments’ may also be considered tedious and dull by the student so they are unlikely to prepare properly for the class, (pre-read procedure, etc.) and considering that nurses do not have to become competent at experimental design, nor gain competence with equipment, the type of ‘experiment’ needs to be carefully considered. Students may also find it difficult to link ideas presented in lecture to the laboratory environment or session. Some authors suggest that conceptual learning is minimally achieved via laboratory work and that this requires post teaching to ensure that is effective, with teacher-student interaction which provides guidance, rather than guidance by laboratory manuals (Becu-Robinault, 2002; Beney & Séré, 2002). Guillon and Séré (2002) also suggest that short project work where students can take responsibility for the choice and the definition of the project, and then present it by short presentation, allows for authentic debate, and provides students with the tools for data processing and for confrontation.

Davies et al. (2000) suggest that “students could be grouped for laboratory sessions and tutorials on the basis of entry qualifications” (p. 130), implying that the teaching and learning occurring in the laboratory and the tutorial was of value and could be more tailored towards the students individual needs. Davies et al. (2000) report that the United Kingdom nursing school in their study made the decision that laboratory work contributed to active learning, allowing students to investigate physiological parameters for themselves, and having the added effect of increasing motivation. It was also considered that the laboratory session facilitated the transfer of skills developed in the laboratory to the clinical area. This institute therefore re-introduced laboratories to the pre-registration nursing programme to encourage active learning and experiential/explorative learning (Davies et al., 2000). Larcombe and Dick (2003) reported that a clear advantage of the specialist biologist (over the nursing tutor) is having ready access to laboratory facilities. In their work, laboratory sessions were designed with particular relevance to nursing. Students were given overview lectures but emphasis was on the laboratory session where attendance was compulsory.

Students worked in small groups in a round robin format where they would conduct small experiments that were designed with a nursing focus. For example, students used gas analysers to conduct a small re-breathing experiment and then had questions that related it to physiology and symptoms (e.g., feeling short of breath as carbon dioxide levels rose), and then relating this to blood levels. Covert learning included infection control, measurement and units, record keeping, health and safety and use of technology as well as nursing observations of patients in hypoxia. Other laboratory classes used in this nursing school included labelling human skeleton bones which introduced anatomy, as well as ethics and discussions on death and dying. The laboratory logbook required numeracy and literacy skills, problem solving and information technology. Other laboratory sessions developed transferable skills such as asepsis, appreciation of microbial control and the use of personal protective equipment. These laboratory classes were taught in a nurse/science specialist team which also allowed role modelling of working in multi-disciplinary teams, which is important in modern nursing, and also allowed the nursing staff to begin to 'own' the bioscience knowledge and gain an appreciation for the relevance to nursing.

In general, science education in nursing programmes is traditionally delivered by lectures, tutorials and laboratory sessions although the relevance of each to producing work-ready registered nurses who can apply science in their practice is not known. The role of the traditional laboratory session in nursing education has also been challenged with some nursing schools seeing it as relevant with some important modifications from that expected in classical science education, but many have reduced it or removed it from their curriculum, as its role in producing work-ready registered nurses is not established or articulated, creating diversity across schools (see Chapter Five). In the Nursing Council of New Zealand's policy guidelines for the accreditation of institutes seeking to establish a school of nursing, clause 5.3 states that the resources that the school must supply include: "material, information technology facilities and skills laboratories for learning science and nursing skills" (NCNZ, n.d., p. 1) but that is open to interpretation by the schools as to if that requires schools to have science laboratory sessions. As science education has been the topic of much debate and the source of much student angst, many schools have tried alternative ways of delivering science content, and not just at nursing schools.

3.4.2 Alternative Pedagogies to Didactic Delivery

Debate about the most appropriate methods to educate medical doctors is dominated by opposing positions of teaching science content, versus teaching practical skills (Marckmann, 2001). Essentially the underlying question of whether medicine is considered to be a science, or not, seems to be at the root of the debate. Does the epistemological status of medicine differ from that of science – certainly medicine can be methodical and scientific and is based on scientific knowledge, but does that make it a science? With the main goals for medicine being improving health outcomes for patients, Marckmann (2001) argues that providing opportunities for medical students to be exposed to clinical experience is just as important as the provision of scientific knowledge.

There are a variety of studies that examine the effectiveness of alternative ways of delivering science content in health based professional courses (i.e., medical, dentistry) such as using technology (Forester, Thomas & McWhorter, 2004; Granger & Calleson, 2007; Jones, Olafson & Sutin, 1978). Often, technology has been using computer aided instruction and audiovisual resources which replaced traditional lectures and/or dissection classes (for medical students). It was found that the students were learning the material or the content using these alternative methods instead of lectures, tutorials and dissection classes and were able to gain similar results (in summative assessment) to the traditional approach (Jones, Olafson & Sutin, 1978). What is not known, however, is how well this knowledge becomes applied in the clinical setting. Granger and Calleson (2007) report that loss of the dissection laboratory affected medical students' comprehension and retention of material as well as their ability to use content in problem solving. Students appeared to improve their performance when simulations or technology was teamed with opportunities for discussion such as laboratory work or tutorials (Forester, Thomas & McWhorter, 2004; Granger & Calleson, 2007). This may be due to the student being able to concentrate on the experience or content having learned the appropriate vocabulary and background, and so was able to interact more meaningfully with the instructors. The students in the Forester et al. (2004)

study reportedly valued the time with instructors in the laboratories the most, and disliked the web-based anatomy programme. When the University of Melbourne introduced problem-based learning into their medical school, it necessitated a reduction in lectures and students were taught by laboratories, tutorials and multimedia teaching resources. These students said that the most useful method of instruction was the dissection class as it allowed them to work with three-dimensional structures that deepened their understanding and helped with recall (Azer & Eizenberg, 2007).

Interestingly, it was found that very few nursing students liked to utilise technology based learning supports (Davies et al., 2000). Few looked further than their required text book for information and only 9% used the supplementary computer software associated with the textbook. In unpublished work, Fenton reported that nursing students engaged in year one courses that were web-supported were very reluctant to investigate links and associated web resources and preferred to use the associated written guides, summaries or topic quizzes.

Problem-based approaches to learning have a long association with experience-based education. Having students learn through the experience of solving problems has been shown to help with learning content and thinking strategies. Problem-based learning (PBL) is an instructional method where students learn through facilitated problem solving. Often the problem is complex and may not have a single correct answer. Students often work in collaborative groups to problem solve and engage in self-directed learning and apply this new knowledge to the problem (just-in-time learning) and then reflect on what they have learnt (Hmelo-Silver, 2004). This approach can help students develop flexible knowledge, effective problem solving skills, self-directed learning, effective collaboration skills and intrinsic motivation. Problem-solving could also be described as a way of preparing students for their workplace community where they learn to see the world in a particular way and participate in the collective problem-solving using the tools of the community (e.g., jargon, perspectives, protocols) (Field, 2004).

There has been concern expressed that PBL techniques can create deficiencies in medical students' basic science knowledge. However, Prince, van Mameren, Hylkema, Drukker, Scherpbier and van der Vleuten (2003) reported in their study of medical students that there was little difference in outcomes when compared to traditional teaching methods and a medical school in Manchester suggests that students were able to continue to improve and build on their basic science knowledge past graduation (O'Neill, 2000; McCrorie, 2000). A study of dental students in the United Kingdom supported this, although the student group studied had a high proportion of female and mature students and the authors felt this may have influenced the outcome – that is, they were more diligent students (Last, Appleton & Stevenson, 2001). The development of clinical reasoning of medical students in Switzerland was studied and the authors concluded that in order to ease the transition to clinical, students should have the opportunity to practice their decision-making and reasoning processes on standardised and typical problems before encountering real patients with more ill-structured problems (van Gessel, Nendaz, Vermeulen, Junod & Vu, 2003). Problem-based learning has had critics who suggest that it is too open-ended, with students getting confused by tangents (Srinivasan, Wilkes, Stevenson, Nguyen & Slavin, 2007; Yoshioka, Uchida & Kozu, 2003) and that guidance through authentic clinical examples is more effective. Problem-based learning could be considered to be resource intensive and synonymous with small group teaching which has implications on resources and may affect the financial viability of the programme within institutes (Denny, Weber, Wells, Stokes, Lane & Denieffe, 2008). Some education institutes therefore have moved towards case-based learning instead of using problem-based learning approaches.

Case-based learning is a guided inquiry method and provides more structure than problem-based learning. The University of California has two medical schools (one in Los Angeles, and the other in Davis) and was able to conduct a comparative study on the two approaches (case-based and problem-based) the results of which suggest that the students overwhelmingly preferred the case-based learning over the problem-based learning (Srinivasan et al., 2007). However, the study did not evaluate which method was better at producing practicing physicians. The main reason for the preference appeared to be a perception that case-based studies had fewer unfocused tangents than the PBL programme. Many nursing programmes have made changes in their curriculum delivery to problem-based learning, enquiry-based learning, clinical-located learning, multidisciplinary learning and instructional design using multiple-intelligence theory - all in an attempt to alter teaching practices from traditional tutor-centred delivery methods to student-centred methods and to try and produce graduates capable of critical thinking; however, little has been done to ascertain if this has translated into improving teaching and learning for nursing students or improved clinical practice (Denny, et al., 2008).

There are many studies that suggest that science concepts are more meaningful and relevant to students when they are engaged with actively with explanatory ideas or evidence that they can relate to the everyday world or involve contexts that are relevant to their future or planned careers (Ebenezer & Zoller, 1993; Waldrip, Prain & Carolan, 2006). Medical students who had to engage in physics laboratory work as part of their medical studies were found to develop conceptual knowledge more effectively when using a well structured task that was contextual to medicine and contained opportunities for regular interpretation by the student, which moved slowly towards more complexity (guided) (Theyβen, Schumacher & von Aufschnaiter, 2002). There is much literature discussing how nursing students tend to engage more with content when the material appears to be within a perceived relevant nursing context (Morrison-Griffiths et al., 2002; Davies et al., 2000; Prowse & Heath, 2005). The literature suggests that students' tend to gain a deeper understanding when they investigate authentic problems, rather than simply reciting back isolated facts. It has been suggested that students who consider knowledge as dynamic (as opposed to the static recall of facts) tend to apply and integrate that knowledge more (Songer & Linn, 2006) as well as be able to build up confidence in their own abilities to engage with content to practice autonomously (Smeby & Vagan, 2008).

3.4.3 Science Self-efficacy

Self-efficacy refers to an individual's belief in their own capabilities to organise and execute action required to manage a particular situation (Bandura, 1995). Efficacy beliefs influence how people think and feel about themselves which in term influences action. Bandura suggests that such beliefs contribute significantly to motivation and achievement, and appear to have four main forms of influence: they are through mastery of experience, vicarious experience, social persuasion and by understanding of the physical state.

The ability to master experiences appears to provide authentic evidence to an individual that they do have the ability to succeed in a particular situation (Bandura, 1982; Gist, 1989) and builds up an individual's history of success. Failures can undermine personal efficacy towards a particular activity especially if failure occurs before an individual has built up a history of success. Providing mastery experiences involves cognitive, behavioural and personal tools (i.e., self regulation) for managing appropriate actions in a particular situation. Once people have achieved a sense that they have the ability to succeed, they are more resilient to setbacks.

Another way of improving an individual's self-efficacy towards a particular activity is by vicarious experiences, mediated by social models. When people see similar people to themselves succeeding and persevering, they may become convinced that they too will succeed. However, observations of failures or exposure to people who are not perceived as being peers or similar, can undermine self-efficacy. An example of this is exposing a group of nursing students to a successful mainstream science student. They may not relate to the science student who chooses to study science, and then may reinforce negative attitudes. A successful model can assist those struggling with low self-efficacy perceptions by providing effective skills and strategies that enabled them to manage the environmental demands.

Social persuasion is another way to improve a person's perception of their ability in a given situation. People who are encouraged (via verbal feedback) tend to give the situation more effort compared to people who have self-doubts and little support (Litt, 1988). However, it is important that this feedback is realistic as over inflated encouragement can lead to disappointment. People who have self-doubt tend to constrict their activities, avoid challenges and give up quickly (Bandura, 1995). To improve self-efficacy it is important to raise people's beliefs in their own capabilities but also to provide structure where they can succeed and measure success in terms of improvement, not necessarily against others.

The influence of physiological and emotional states, such as reaction to stress, is another important factor in building up self-efficacy (Bandura, 1995). Some people may interpret a stress reaction as a validation of poor performance. Mood has an obvious influence where a person in a positive mood may be more resilient and motivated compared to a person who is despondent (Kavanagh & Bower, 1985). Hence, to improve self-efficacy towards a particular task, people have to know what they are in for – for instance, in a physical activity, sore muscles and aches and pains may be part of the process that they will need to work through. Sleep deprivation due to study habits may negatively affect mood for example. If a person can be supported to interpret their bodily signals positively, it can play an influential role in preparing the person. People's beliefs in their own coping abilities affect how much stress or depression they feel when they are in difficult situations.

Some nursing schools have used the concept of self-efficacy towards performing science tasks to design a tool to attempt to predict nursing students' academic performance in first year science subjects (Andrew, 1998). After analysis they report that students that were the most successful in science tended to have a higher mean school biology score, than a less successful group. This may have had something to do with their successes in school biology providing them with mastery experiences where they could visualise being successful at science, resulting in greater confidence in their abilities to engage with the science material. This is in agreement with other studies that found academic success in senior high school science was linked to success in the nursing science courses (Davies et al., 2000; Jordan et al., 1999; Van Rooyen et al., 2006; Wharrad et al., 1994). However, some studies have found that success in nursing science was not linked to senior high school science success – for example, mature age students with no background in science are able to perform as well as those who had passed publicly-examined biology at school (Caon & Treagust, 1993). This may be explained if these students were found to have high levels of self-efficacy towards-using-science and a positive attitude-towards-science.

Motivation and confidence in a subject tends to support successful learning outcomes as students who were successful earlier on may have more confidence and motivation to remain successful in later endeavours. Caon and Treagust (1993) report that students who were unsuccessful in their science courses tended to be those with a low opinion of their ability in science and who were not convinced of the relevance of it to nursing. This concept of 'self-efficacy' can be described as a personal expectation about ones' ability to successfully perform a specific task or behaviour, and the measurement of self-efficacy may then be predictive of academic success (Bandura, 1986).

Wilke (2003) found that students' confidence towards learning physiology was improved when they were taught using active learning techniques. It was found that the students taught using these techniques acquired significantly more content knowledge and confidence than those students in the control group (who were taught using traditional didactic methods). These active learning techniques probably influenced the students' self-efficacy towards the physiology tasks as they provided mastery and vicarious experience, probably within an encouraging social context. Science self-efficacy is reportedly influenced by language and mathematical ability as well as academic attitudes (Harvey & McMurray, 1994), and students with a low mean academic self-efficacy and low grade point average were found to be more likely to withdraw from nursing courses. A study by Andrew (1998) suggests that nursing students were not confident in performing many science tasks, particularly those involving physics and mathematics, and that student motivation and academic performance appears to be influenced by the student's own personal judgements. However, it has been suggested that student attitude-towards-science in fact is not easily changed (Schibeci, 1989). This implies that, for example, a student who has a personal judgement that science is boring, hard or irrelevant, may have difficulty changing their attitude, and becoming confident and motivated. Interestingly, self-efficacy towards a particular task has been shown not to be influenced by other variables such as self-esteem. Lent, Larkin and Brown (1986) found no correlation between science self-efficacy and general self-esteem in undergraduate science students. Subject examinations that are designed specifically to be easy to pass and therefore are intended to build students' confidence about their ability and thus increase their self-efficacy for content are reported to be effective interventions (Chang & Bell, 2002). This has relevance for the education of nurses as many science courses are assessed by examinations (see Chapter Five) – when possibly, tests and examinations should be being used to build confidence in the student's ability to engage in the subject material, enhancing their self-efficacy towards using science in nursing by focusing on the student development process, as opposed to what the student can recall (the product of the examination).

People who have high self-efficacy tend to set high goals and commit to them and visualise positive outcomes and scenarios (Bandura, 1995). People with self-doubt tend to visualise failure scenarios. People who regard themselves as having high efficacy attribute their failures to not enough effort or some other situation, whereas those with low self-efficacy tend to regard failure as being due to their low ability. Realistic and achievable goal setting is therefore an important part of increasing self-efficacy towards particular activities

Science is a subject that many students who are considering becoming nurses may not have had success in before and they may have difficulty visualising themselves as being successful at science tasks. Self-efficacy is a concept that relates to an individual's belief in their own capabilities to manage a particular situation (such as study or use science) and as such, an understanding of some of the factors which positively influence science self-efficacy may contribute towards nursing students being more successful in their science courses or being more confident in using science knowledge in their clinical practice.

3.4.4 Social Factors Impacting Upon Science Learning

Women's career aspirations for example are often influenced by family, educational systems, occupational practices, media and culture (Hackett & Betz, 1981; Jacobs, 1989); and as such, many women may not perceive that they have the ability to succeed in science. This has an impact for science in nursing as the majority of the nursing workforce and student body is female. Bandura (1995) suggests that many women choose not to pursue careers in scientific or technical fields because of their lack of belief in their quantitative and technical capabilities.

It is therefore important to realise that young females in particular may have self-limiting psychological impediments on their abilities or suitability for some situations that may be ingrained. Increasing personal self-efficacy towards using science via social persuasion and the provision of active experiences that support mastery via appropriate achievements and goal setting could support a positive change in attitude for female students.

Studies of secondary school coeducational and single sex institutions found no statistically significant differences between male and female student science self-efficacy (Rowe, 1988) although males generally have higher mathematics self-efficacy than females. A study of tertiary psychology students' mathematics and science self-efficacy suggests that differences between genders are more a function of different levels of interest in the subjects themselves (Lent, Lopez & Bieschke, 1991). However, DeBacker and Nelson (1999) suggest that females' perceived ability in science contributes significantly to predicting outcome measures for females, but not for males. Jones, Howe and Rua (2000) found gender influences in career choices at primary school age, where females tend to be more interested in 'helping other people' and tend to have science linked activities related to animals, health and disease compared to boys who tended to want to make money, control other people and have science activity interests that were more technology based. Parental influences may also contribute to subject choices at secondary school level and this may be a particular driver for young girls considering nursing as a career.

Furthermore, inherent beliefs that nursing is about caring, and that science is not (with medicine being about curing), may further contribute to a negative attitude towards science especially if the prospective young nurse has nurses within their own family. Older nurses in particular may have been practicing in the community for years and may consider that they did so successfully without science, and so may contribute to the family influences that may devalue the contribution or value of science (Strube, 1991). These same advisers may give inappropriate advice on the secondary school education required for entry into nursing school. It has been found that parents have an important role in the development of science-attitude in students (George & Kaplan, 1998), and the home environment of non-science majors provides little exposure to science or science-related activities (Gogolin & Swartz, 1992), with females being more likely than males to be influenced in their career choices by parental opinion (Dawson & O'Connor, 1991).

Strube (1991) suggested that many young women who choose nursing as a career may find it very difficult to consider thinking or talking about science. They tend to hold preconceived ideas that scientists are: masculine, contrasting with feminine perceptions of nursing; intelligent, contrasting with perceptions that nurses lack knowledge; and are emotionally inhibited, contrasting with kindly nurses (Lumb & Strube, 1993, p. 90). These ideas tend to support their perception that a nurse just does not 'do' science. It appears that female students respond better to female science teachers (Jarvis & Pell, 2002), and this may be explained by positive role modelling and challenging preconceived ideas about scientists. Understanding the relevance and the role and purpose of science in nursing could positively influence student attitudes towards learning and using science in practice.

3.4.5 Purposes and Roles of Science Learning

Duggan and Gott (2002) analysed the science knowledge that was used in six different industry settings where scientific knowledge appeared important. They found that workers lower down in the organisational structure were required to follow protocols that were often designed to standardise procedures and minimise the risk of errors. Nursing has a large amount of protocol-driven procedures that could have been designed to standardise procedures and minimise the risk of errors. Duggan and Gott (2002) also found that workers who operated at these levels often had a limited knowledge of the principles that underpinned the protocols. These workers may then not understand any potential impact of not following procedure or protocols. As workers gain promotion and achieve positions of higher status and responsibility within the workplace setting, they also gained more insight into the operations and the reasons for protocols or procedures.

Chin, Munby, Hutchinson, Taylor and Clark (2004) suggest that senior secondary school students engaged in vocational programmes could be successful in the workplace without seeing any connection to their classroom-learned science. The authors note that when the purpose of the science differs (i.e., workplace activity compared to passing examinations) the difference then impacts on the constructs or substance derived from the activity. As it is already known that nursing students and nurses in general tend to have difficulty integrating their bioscientific knowledge (delivered by traditional methods) into their clinical practice, the differences in purpose of the two situations (one is passing assessment; the other is patient outcomes) may contribute to the problem. Often the students on workplace programmes and in nursing programmes may not have been successful in school science. Chin et al. (2004) concluded that "the use of scientific knowledge in the workplace does not necessarily depend on the worker thinking about general scientific theories or principles in his or her everyday tasks" (p. 121). The science tended to be integrated into the protocol or procedures of the workplace. Technology present in the workplace may actually hide the science, so technology increases in the nursing workplace may increase the devaluing of bioscience in nursing, as its contribution may become less recognised.

3.5 Summary

Literature worldwide has attempted to theorise why nursing students encounter so many difficulties with the undergraduate bioscience courses. It is difficult to ascertain from prescribed documents (Nursing Council of New Zealand) what role science has in nursing education or practice. The main theme from the literature suggests that science knowledge informs clinical decision-making and that is the main point of difference between a registered nurse and a nurse assistant or enrolled nurse who also practices nursing.

Various themes emerge from the literature including the suggestion that undergraduate nursing programmes fail to teach nursing students how to integrate knowledge into practice, perhaps due to a reliance on didactic teaching methods. Many of the criticisms of science teaching within undergraduate nursing programmes have related to attitudes and anxieties to both the content and the way it is taught. Many nursing schools are using alternative pedagogies and delivery methods to attempt to engage students to assist in their learning including the use of supporting technology, problem-based learning, case-based learning, narratives and application of multiple intelligence theories but it is not clear if these enhance the integration of science knowledge into practice. These alternative pedagogies tend to align with constructivist learning theories and as such appear to be focused more on student-centred, active learning approaches and attempt to create a greater likelihood that the student will absorb, construct and hence integrate the concepts being taught. However, none of them address what science is actually required and to what depth a practicing nurse needs to draw upon this knowledge.

Literature also suggests that students who enter nursing degrees with high levels of secondary school science (or some background in basic sciences) do not suffer the same anxiety levels as the other students; this is probably due to familiarity with basic scientific vocabulary and concepts, and possibly greater levels of science self-efficacy or confidence and motivation in the subject. It is also established that some students do not consider that they have the ability or the confidence to engage in science study due to their preconceived ideas and anxieties of what science is, and who does it. The concept of a 'scientist' and 'science' could also appear to be foreign to a nursing student, creating barriers to learning as well as an individual's own confidence in and motivation for the subject.

The ability to make clinical decisions may be impaired if the nurse is not confident in their ability to problem-solve using all the information available, including scientific information. Decision making appears to be enhanced by experience, confidence and knowledge. In order to establish what nurses need to know to make decisions, it is important to establish what kinds of knowledge is valued, and understand what may influence, devalue or diminish this knowledge.

3.5.1 Theoretical Framework for Study

It seems clear that that nursing students find science difficult. Nursing science courses are traditionally taught using didactic methods, and are in isolation from nursing practice and in particular, clinical decision-making. Yet, supporting clinical decision-making appears to be the main reason that science content is in the curriculum – so that patient outcomes can be enhanced by scientific knowledge that a nurse can apply to an individual patient. This includes biological knowledge of patient's health, knowledge of how the body responds to illness or altered health states in that patient's particular stage of life and hence, an understanding of what may influence positive patient outcomes (in terms of biological care) under a particular set of circumstances. Paramount to this is the ability of the nurse to detect changes in the physiology of the patient. All nurses, no matter what level of care is being provided (assistant, enrolled, registered or practitioner) have a responsibility to observe and interpret changes in the patient's state. Registered nurses have the responsibility to undertake a nursing assessment and make decisions on nursing care that is based on the change of status. This establishes then that all levels of nursing require enough scientific knowledge to be able to observe basic human physiology and report it. Nursing science appears to relate to the ability of the nurse to recognise patterns and to respond appropriately to those patterns, to the benefit of the patient.

Expert clinical decision-makers appear to have knowledge, confidence in their own judgements and experience (recognising patterns and responses that worked before). However I suggest that experience (either self experienced or by proxy via recommendations from other more experienced nurses) appears to be the most value to new nurses as they attempt to negotiate the workplace which is in reality, very protocol driven, and hence does not make much room for innovative practice. Innovations in nursing care are most likely to occur from independent minded practitioners who are capable of independent thought and have enough knowledge to challenge protocols. Currently, the biological science behind nursing decisions may either by unrecognised (not considered to be based in science) or unvalued (not considered to be important to nursing).

Confidence in terms of acknowledging and using science based knowledge has also been established as an issue for many nurses. Many nursing students have issues when it comes to studying science and these may be quite deep seated and hard to influence. It is not established if nurses with higher levels of self-efficacy for using-science-in-practice (hence confidence) use scientific knowledge more (than those with lower levels of self-efficacy) to inform their clinical decision-making and hence inform their practice. Changing the name of science courses to something more acceptable or integrating the science into nursing topics has been suggested as one way of 'hiding' the science and so ensuring that students attempt to engage in it without realising that they are learning scientific concepts. However, when confronted with the realities of basic biology, chemistry or physics, some students will still evoke a negative response, no matter what heading it is taught under. Examination of nurses' clinical practice, and in particular, the knowledge that is accessed for clinical decision making (the depth and breadth) is required. Alongside this, an examination of confidence levels (self-efficacy) should occur to see if it influences the type of knowledge used when making clinical decisions. Understanding how this knowledge is applied will also inform curriculum development and will contribute to answering the research question.

The research question "What is the role of science in nursing practice?" can be further developed into:

R1: Is science required for clinical practice?

R2: In what ways, if any, do registered nurses use science in their clinical practice?

R3: What is the role of science education in nursing education?

R4: What is the role of science educators in nursing education?

Finally, the following table consists of exploratory questions/ statements (E) or ideas that underpin this thesis as derived from the research questions (R) and objectives. These exploratory statements are to guide specific areas of focus for the research and are not testable statements. They also provide a framework for the next chapter which discusses the methodology used in this thesis.

Table 3.4: Research and Exploratory Questions

What is the role of science in nursing practice?
R1: Is science required for clinical practice?
Exploratory questions: E1: Do all levels of nursing clinical practice require patient observation? E2: Is science knowledge required for patient observation? E3: Do nurses need science knowledge in order to practice competently? E4: Is science knowledge required for clinical decision-making? E5: Do registered nurses carry responsibility for clinical decision making? E6: Does Nursing Council of New Zealand require all levels of nurses to have scientific knowledge? E7: What are the perceptions of nurse educators about the relevance of science to nursing? E8: What are the perceptions of nurses in clinical practice about the relevance of science to nursing? E9: Will future nursing practice require nurses to be involved in more autonomous clinical decision making?
R2: In what ways, if any, do registered nurses use science in their clinical practice?
E10: What science knowledge, if any, is required for patient observation? E11: What science knowledge, if any, is required for competent clinical practice? E12: What science knowledge, if any, is required for clinical decision-making? E13: How is science recognised and validated in the clinical setting? E14: Do nurses in practice recognise the science behind their clinical practice? E15: Are nurses in clinical practice confident with their ability to use scientific knowledge in practice? E16: Does a nurse's attitude towards science affect their ability to use

scientific knowledge in practice?

E17: Does the science used in clinical practice align with conventional constructs?

E18: Does the science required to inform clinical practice align with conventional science nursing curricula?

R3: What is the role of science education in nursing education?

E19: What is the basic requirement (depth, breadth of content) to support patient observation?

E20: What is the depth and breadth of content required for competent practice?

E21: What depth/breadth of content is required for clinical decision-making?

R4: What is the role of science educators in nursing education?

E22: Establish appropriate authentic experiences for active learning.

E23: Establish an appropriate method of curriculum design.

E24: To provide structure, scaffolding and appropriate challenges to the learner.

E25: To provide opportunities for mastery to increase confidence.

CHAPTER FOUR
METHODOLOGY

Overview of the Chapter

This chapter consists of a description of the methodology employed in this inquiry. It begins with an overview of the methodological approaches that are common in science education inquiries then follows with a discussion on approaches used in this study. Next is a discussion on the appropriateness of the methods and protocols that were used in the investigation including document analysis, surveys, observations and interviews. Then a description follows of the procedures and measures taken to ensure that the data is dependable and that the inquiry is trustworthy, followed by a discussion of ethical implications.

4.1 Science Education Research

Any research that is undertaken has a basic set of principles that the study aligns with. This basic set of principles (paradigm or belief set) represents a particular worldview which is usually based on underlying principles derived from various ontological and epistemological assumptions that represent that particular worldview. All paradigms have three parts – ontology, epistemology and methodology.

In particular, a person with a realist view or ontology would typically subscribe to an objectivist epistemology. That is, they consider that knowledge and the knower can be independent of each other. Whereas a person with a relativist view or ontology would typically subscribe to a subjectivist epistemology, where they would consider that knowledge is related to the knower or even dependent on the knower (Cohen, Manion & Morrison, 2007). These different worldviews also dictate different methodologies used in research – that is, ways in which information may be found.

Within the social sciences, there exists a number of belief sets or paradigms that a researcher may align with. Positivism is a paradigm that suggests that knowledge can only be acquired through direct objective observation and experimentation and this is the belief system common to the physical sciences (Burrell & Morgan, 1979). In social science, positivism implies that the researcher is an observer and interpreter of social reality (Cohen et al., 2007). However, the positivist view and its associated methodologies have had strong criticism in education research, with authors believing that positivism fails to take into account the nature of the subject and the 'human experience'(Guba & Lincoln, 1989). Anti-positivists say that a researcher must share the same frame of reference as the subject to interpret their world, as they see it. Post-positivism ideas therefore suggest that human knowledge is not based on unchallengeable foundations, but that it is subject to conjecture, revision and development.

Traditionally, research in science education has been dominated by quantitative methodological approaches which have used empirical positivistic techniques to try to establish predictable laws and principles (Filstead, 1979). The realist view that knowledge and the knower were independent of each other prevailed. However, qualitative methodological approaches commonly associated with anthropology such as ethnographical studies (using observation and interview tools) have become more common in education research as they attempt to establish the point of view of the subjects being studied. The relativist view that knowledge and the knower are inter-related has become more common even in science educational research. Often the term 'qualitative' is taken to refer to the type of data that is being collected (with implications on how it is collected), but for some researchers it is more of an overarching concept where 'quantitative research' has been taken to refer to positivist-based or realist enquiries. Often, the terms 'naturalistic' and 'qualitative' are interchanged. The term 'naturalistic' usually refers to an inquiry that is undertaken in the participants' natural environment and so has clear roots in anthropology (Cohen et al., 2007). A study that seeks to understand the subjective world of the individual is then said to be interpretive (Cohen et al., 2007) which suggests that the researcher is attempting to interpret the world view of the subject, using methods or tools that would be commonly associated with ethnographic studies such as interviews, narratives and observations.

Naturalistic/constructivist enquiries can use both qualitative and quantitative methodologies. Qualitative and quantitative methodological approaches have advantages and disadvantages: qualitative methods allow the researcher to study selected issues in depth and detail without being limited by predetermined criteria, whereas quantitative methods tend to enable comparison and provide statistics. A mixed method approach therefore has the advantage of allowing the researcher to be able to interpret quantitative data within the framework of a qualitative issue (i.e., being able to understand what the numbers may mean and place perspective upon them). Gathering data from different sources using different methods also allows the researcher to validate data, and when the methods used to gather data are both qualitative and quantitative, the study becomes more convincing, and trustworthy.

When engaging in an enquiry, the paradigm that the researcher is viewing the phenomena or issue from will often dictate the inquiry methods used to collect or extract data. Methodologies and methods are different however – methodology relates to the overall paradigm, worldview or guiding strategy that the researcher considers is most appropriate to the question, and method refers to the specific tools or techniques used to discover or extract the data (Guba & Lincoln, 1989). This means that two researchers may use the same methods or tools, but their ontological and epistemological beliefs may be completely different. Realist-objectivist research usually uses interventionist methodologies – that is, experimenting and manipulation, seeking to remove all contextual influences. Whereas, relativist–subjectivist research attempts to understand a situation by interpreting different data sources in context, in order to identify themes.

In terms of belief systems, constructivism represents an epistemology that suggests that knowledge is internalised and that individuals create mental models to replicate their version of 'reality' based on their own unique experiences and interpretations (Tobin & Tippins, 1993). It also suggests that 'reality' is not a concrete substance, but that everyone holds a unique representation of 'reality' which is subject to revisions, reconstructions and reinterpretations. This has particular relevance to education, where learners (or users of the knowledge) may have minimal or poorly formed constructs or models that may be revised by experience.

There are many variations of constructivism and although there is no universal agreement amongst its followers, there is consensus about the fundamental basis of constructivism (Tobin, 1993). That is, an individual's knowledge represents their own personal mental construct. Another aspect of constructivism that is agreed is that it is the most appropriate way of recognising context in both individuals and groups (Wheatley, 1991). To understand learning, the focus needs to be on the activities of the learner (or the user of the knowledge), not on the subject being taught (Hein, 1995). In order to understand learning therefore, this has to include some understanding of the learner (the user of the knowledge), their points of view, contextual background, prior learning experiences, and any social influences that may occur. Constructivist based research then aligns with subjectivist epistemology, where the knower and knowledge are considered to be interlinked, and the ontology is relativist. This places the knower as an active participant in the retention or formation of knowledge and research of that knowledge (Guba & Lincoln, 1994). It also places the researcher in the same frame where they attempt to interpret the worldview of the participant and take meaning from it.

In essence, to describe the most appropriate context to frame a curriculum for undergraduate nursing science, research using interpretive methodologies utilising a mixed method approach is the most appropriate. An inquiry that seeks to understand the rationale behind individuals' and groups of individuals' (nurses) actions (nursing practice) would be best supported by a naturalistic study (undertaken in the individual's own environment). Methods used such as observation (in the individual's own environment), interview (to attempt to interpret the knowledge of the knower), survey (to examine self-efficacy and attitude and to provide some context and quantitative data) along with document analysis provide the data sets to be interpreted.

4.1.1 Cross-Age Inquiry

If the focus of a science education inquiry is to examine the learner's understanding of concepts and how these evolve, then the researcher may undertake the investigation across particular points in time. Longitudinal studies involve investigating the learning experiences of participant(s) across a period of time that may span over years, and these may involve only a few participants. The main focus of these types of studies is to attempt to understand how learner's concepts develop over time. Central to this enquiry is to develop an understanding of how science education can inform clinical practice, and in particular, the clinical decision-making of registered nurses. An alternative way of examining learners' understanding is by conducting a cross-age inquiry. Cross-age inquiries investigate cohorts of participants of different ages or age ranges and this produces a 'snap-shot' view of the population being studied (Cohen et al., 2007). Cross-age inquiries can provide information that indicates changes in strategies or attitudes that may have occurred as a result of changes to educational policy over time and can therefore be useful for curriculum development, making it appropriate as a method for gathering data for this study.

4.2 Data Gathering Methods

As stated earlier, a relativist-subjective research inquiry gives weight to the relationship of the knower to the knowledge. As such, research that seeks to understand the rationale behind individual and groups of individuals' (nurses) actions (nursing practice) would be best supported by a naturalistic study undertaken in the individual's own environment. Methods used such as observation (in the individual's own environment), interview (to attempt to interpret the knowledge or perceptions of the knower), survey (to examine self-efficacy, attitude and influences on knowledge construction) and document analysis provide contextualised quantitative and qualitative data which can be analysed and interpreted.

Table 4.1 provides an introductory summary of the research design and methods used as well as an indication of participants in each phase and the following section discusses each method used in more detail.

Table 4.1: Summary of Data Methods Used in Study

Phase	Data Collection Method
Phase One: Interviews with nurse educators and lecturers	Structured, formal interviews.
Phase Two: Written Survey - 71 registered nurses in active practice	*Science Attitide and Self-Efficacy Survey* (*SASE*) Tool
Phase Three: Observation Studies of 17 nurses in active practice (taken from survey population)	Observation studies (field notes) and follow-up informal, unstructured interviews
Phase Four: Document Analysis	Detailed analysis of Nursing curriculum documents, teaching and learning materials

4.2.1 Document Analysis

Document analysis is a useful method of gathering data in educational inquiries and can serve to reinforce data taken from interviews or observations. It is considered to be particularly useful when access to participants is difficult (Lincoln & Guba, 1985). In this inquiry, document analysis is used as both background information and to enhance the reliability of the study. In general terms, document analysis has limitations due to documents or materials being possibly incomplete or missing at the time of analysis which means that a particular focus may be overlooked or aspects are not aligned appropriately. Information is also restricted to that which is already known or that which already exists, which can be a limitation, but in the context of this study, is an advantage as it provides background for the study. Another draw back of document analysis is that it does not really enable the learner's voice or perspective to be evaluated, however this is not the purpose of using the method in this instance. As this study is about identifying an appropriate science curriculum for nurses, then examination of documents that relate to that curriculum as it has existed, is relevant. None of these documents were developed for the purpose of this enquiry, but were already in existence at the time of the study. Due to the nature of science in nursing education in New Zealand, with different schools producing different curriculum documents, using different pedagogies, and teaching different amounts of content it was appropriate to analyse the following documents:

- Curriculum documents from New Zealand Nursing Schools (as approved by relevant authority, such as: Academic Board, Institute of Technology and Polytechnic Quality, and Nursing Council of New Zealand);
- Textbooks that support nursing curriculum
- Nurse competency documents (Nursing Council of New Zealand); and
- Timetables and course outlines from New Zealand nursing programmes (to attribute time/weight of content).

These documents represent the undergraduate nursing curriculum (as it applies to bioscience content) as it existed in New Zealand during the time of the study and as such, are a 'snap shot' of a sample of the New Zealand nursing curriculum. Due to the nature of the documents, it was possible to track the changes in the curriculum development process in regard to the bioscience courses and as suggested earlier, this serves as background information and provides a source of quantitative information to the inquiry.

The documents examined also provided background information and context for the development of the tools and questions used in this study. Using the Nursing Council competencies and nursing school assessment documents it was possible to build a list of nursing actions that potentially could be supported by science knowledge (see Appendix D).

4.2.2 Science Attitude and Self-Efficacy (SASE) for Nursing Survey Tool

Often, surveys are used to gather large scale data in order to make generalisations and can be a source of quantitative as well as qualitative data (Cohen et al., 2007). A survey can target a large population and does not have to be limited by geography and also has the advantage of being anonymous. One of the limitations of surveys as a research technique is that they can only provide information on the questions asked, and that respondents may not provide accurate or honest answers (even when anonymous). As written surveys have to be self instructional (that is, people must understand the instructions on the survey form as they are not able to be explained by a researcher), they are also subject to the participant having reasonable levels of literacy and being able to understand the intent of the questions. In the context of this study, the survey was extensively piloted which included the use of a literacy expert. The pilot participants included a retired nurse educator, a current nurse lecturer, a nursing science lecturer, a secondary school science teacher, a senior high school student, an administrator, a librarian and a learning support tutor with specialty in literacy. Also, as the designated audience was registered nurses, it was anticipated that literacy would not be an issue.

The survey used was one that attempts to ascertain practicing nurses' confidence in using science knowledge (self-efficacy) and their attitude to science in nursing and learning, and as such is referred to as *Science Attitude and Self-Efficacy (SASE) for nursing survey* (see Appendix B). As the practicing nursing community is one that is registered, regulated, monitored and subject to external audit including the requirement for annual practicing certificates, and various reporting systems against the Nursing Council of New Zealand's competencies it is anticipated that the nurses surveyed were not deficient in their practice.

4.2.3 Development of questions for SASE-for-Nursing survey

Literature suggests that integration of science knowledge into practice may not be a deliberate intention and that it is more likely that decisions are intuitive (see Chapter Three). For this reason, an overview of factors that may contribute to application of science knowledge into nursing practice was considered (Figure 4.1) and this included attitude-to-science and self-efficacy-toward-using-science (both may be influenced by science learning experiences). Together these may contribute to a nurse's belief of science's relevance to nursing. Confidence in their own ability to apply scientific knowledge in nursing practice is possibly influenced by education, the workplace, and nurse's own attitude towards science in nursing.

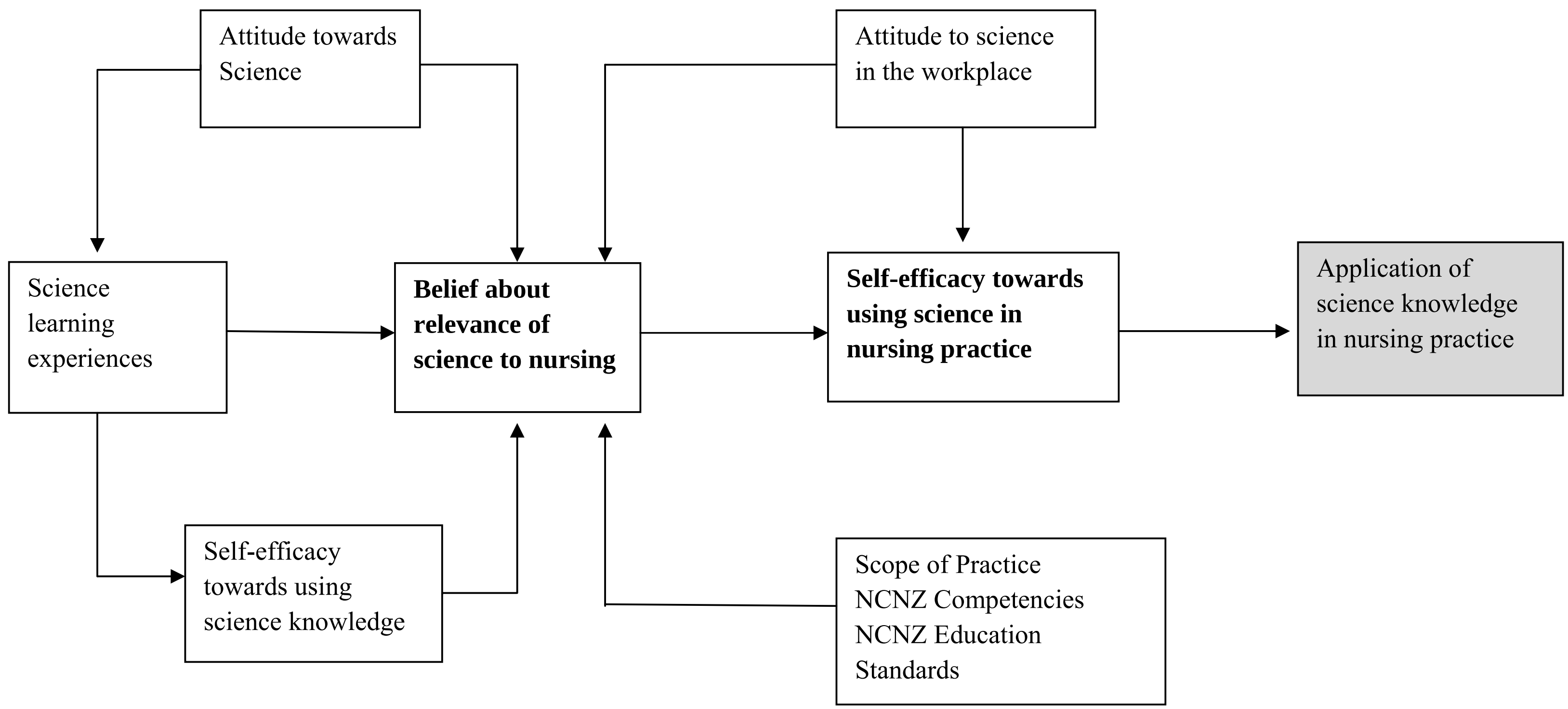

Figure 4.1: Diagram showing factors that may influence the application of science knowledge in nursing practice

The attitude and relevance questions in the *SASE-for-Nurses* survey were aligned to previous studies examining these issues (Andrew, 1998; Andrew & Vialle, 1998) and also to likely antecedents that could contribute to the application of science knowledge into nursing practice (see Figure 4.1).

The *Science Attitude and Self-Efficacy Survey (SASE) for Nursing* tool was structured under a series of constructs/headings including the participants' secondary school science subjects, qualifications, and clinical experience as well other demographic information. The attitude towards science education as a nursing student section and the relevance section were formulated to contain statements that were variously positive and negative to ensure that participants were not tempted to tick down a column, but had to consider the question.

Nursing Council of New Zealand documents show that there appears to be three layers of nursing practice – observation, competent practice involving clinical decision-making, and decision-making in unusual or more complex circumstances (see chapter three). It appeared as though science information could inform all layers of practice, with accurate observation of objective data and patterns (vital signs for instance) being the most basic layer. The self-efficacy questions were then formulated to focus at the registered nurse in practice, who has responsibility to direct nursing care and make clinical decisions for that care, based on knowledge of the patient and the patients' circumstances. Standard, routine decisions could be guided by clinical experience – that is, knowledge that this practice has worked well under these circumstances before, without having to know why or how. Unusual circumstances are more likely to evoke a decision-making process that requires more knowledge and may require more explanation to the patient if the nurse is to act as a knowledgeable and effective advocate. For this reason, the questions are formulated in a way that would test the nurse's confidence to provide this information in an integrated, contextual manner that relates directly to nursing practice.

The *SASE-for-Nursing* survey included questions that related to tasks that required science knowledge in a nursing context (see Appendix B). The questions were formed after a thorough document analysis of nursing competencies for registered nurses (NCNZ, 2007b), nursing skills required of undergraduate nurses by graduation (taken from curriculum documents) and the science that may lie behind the nursing practice using nursing and science textbooks (Bergquist & Pogosian, 2000; Burton & Englekirk, 1996; Coleman & Huskey, 1993; Crisp & Taylor, 2001; Farrell, 2005; Jarvis, 2000; Lehne, 2001; Ochs, 2001; Marieb, 2001; Morello, Mizer, Wilson & Granato, 1994; Thibodeau, & Patton, 2007; Watson, 1999; Walsh, 2002) (see Appendix D). These helped to inform the types of questions that might be appropriate for the purposes of the *SASE-for-Nursing* survey. These skills in the survey questions were checked and revised by nursing educators to ensure that they were realistic and current as well as reflected clinical practice expected of a registered nurse. When examining nursing skills taught in nursing schools and analysing what science knowledge may underpin the skills (Appendix D), at a fundamental level all the science knowledge was aligned to three general categories. These were: biochemistry, cell biology and microbiology. Loosely, fundamental sciences that were categorised as 'biochemistry' were the physiology of molecules including the basic physics and chemistry of the human body which could be viewed as the precursors to physiology, nutrition, pathophysiology and pharmacology. 'Cell biology' included immunology (recognition of self and non-self), cell to cell communication, genetics, growth and repair, aggregates of specialised cells forming tissues, and organs and organ systems to organism level (anatomy). 'Microbiology' relates to the interactions in the body including the balance between health and disease. Use of the word 'science' in the *SASE-for-Nursing* survey was deliberate as many nursing schools use different terms and names for their courses. As physics, chemistry and maths are fundamental sciences that inform all bioscience, and as this inquiry is attempting to identify the layers of science that inform clinical practice, the term 'science' was used to be inclusive of the relevant physical and biological sciences.

4.2.4 Trial of questions for SASE-for-Nursing survey

The *SASE-for-Nursing* survey was trialled using both science and nursing experts and this was followed up by interviews to ensure that the questions were realistic for nursing practice and that they examined the underlying constructs appropriately. Other trialists included participants with no science or nursing background as well as an adult literacy expert who were used to ensure that the questions were as unambiguous as possible (n = 4). Initial trialists had difficulties with the five point Likert scale of “strongly agree”, “agree”, “neither”, “disagree” or “strongly disagree” for the questions in the attitude and relevance sections. Some of the questions such as “The readings required for science were easy” were not able to be answered with any of the five options for some participants. When interviewed, the problem appeared to relate to the length of time since studying for their nursing qualification and if they could remember enough to answer the question, as such, no response on the Likert scale was suitable. Further trials and debriefing interviews had the available responses of “strongly agree”, “agree”, “disagree” or “strongly disagree” then “not sure” as the option for situations when the participant is either unable to answer or neither agrees nor disagrees. The “not sure” box was located slightly to the right of the other choice boxes. One trialist indicated that she wanted to choose the middle road (“neither agree nor disagree”) which was in the first trial set but that option was not available the next iteration. During the interview, it was discovered that by not having the “neither” middle option available, it made the participant re-read the question and apply an appropriate answer, resisting the impulse to be non-committal. For example, for the question “I found the science course(s) easy”, some trialists discussed how they would have chosen “neither” because they didn’t want to admit to finding the course hard, nor thought that it wasn’t really hard, but it wasn’t easy either, so “agree” didn’t fit. However, when “neither” was removed as an option, it forced them to realise that “disagree” was the correct response – that is, they disagreed that it was easy, which was what the question was asking.

In the self-efficacy section, the five point Likert scale of “very confident”, “confident”, and “neither”, “unconfident and “very confident” also caused problems. Some trialists participating were choosing “neither” and on interview, they discussed that they were actually unconfident. On further discussion participants in the trial said that the “neither” box did not seem to be appropriate but felt that they had various degrees of confidence. These questions were reconstructed with a continuum scale of 10 between “very confident” to “very unconfident”. Bandura (1986) suggests that a scale of less than 10 reduces the sensitivity of the tool, however, this also implies some level of precision. Most self-efficacy tools use a five scale Likert measure (Andrews, 1988; Friedel &

Treagust, 2005) or seven scale measures (Coll, Dalgety & Salter, 2002). An argument against using a scale with more than five responses relates to the perceived sensitivity of the task, that is, a scale of 7 or 10 implies that there is a distinction between one response or another – and hence a level of sensitivity. For this study, the continuum response to questions was trialled alongside the Likert scale questions for the self-efficacy component only. All participants in the trial favoured the continuum of 10, as it seemed "to fit better" with the response they wanted to give. The Likert scale responses were aligned with the continuum scale and they corresponded for each trial participant and it was noticed that where a participant had ticked the "very confident" scale in the Likert responses, in the continuum they ticked on or near (within 1 or 2 values) the "very confident" side. When interviewed, the respondents were able to clearly articulate why that was. Responses included "I am very confident, but it depends who my audience was" (trialist #5) or "I am confident that I could do this task, but I may have to look some things up first" (trialist #2) (participant ticked "confident" in the first version and ticked the continuum 3 or 4 values in from "very confident" side in the second version). One participant ticked all "confident" boxes but then varied her responses in the continuum making a distinction between the responses. On interview, the participant was able to clearly articulate reasons for the responses e.g. "it's been a while since I did this task" that affected their confidence, but overall the responses matched with the "confidence" boxes in the Likert scale. There is the possibility that they put more thought into the responses the second time around (so considered more carefully) and so some trialists did the continuum version first with the same results. As stated earlier, all favoured the continuum.

Another issue with the *SASE-for-Nursing* survey that was picked up immediately after the first trial was the position of the response boxes for the demographic section. Some participants were ticking their ethnicity as "Asian" when in fact they were European. When interviewed, the participant was surprised to find that they had done that. As all the attitudinal and self-efficacy questions require the response to be to the right of the text, whereas the demographic information required the response to the left of the text, this section was rearranged to have the question or text first, then the response box. The division between responses in terms of white space was also amplified to ensure that the responses were distinct. Consecutive trials showed that this removed the issue. Also, although the ethnicity responses were taken from the NZ Census categories (where there is no NZ European), some participants expressed displeasure at not having it as a section so the "European" section was altered to be a "NZ European/European" box. Tasks in the survey were formulated from texts specifically written for nursing students and occasionally based on scenarios from critical thinking question sections in the textbooks (see Appendix B). However, all of these textbooks were from international origins, although some had Australasian editions. One question was removed after review by nursing experts as it contained tasks that may have been outside of the scope of practice of a registered nurse in New Zealand.

During the trials, feedback was received about the term "self-efficacy" which was a heading in the survey. According to Bandura (1986), there is the possibility of false positives (in terms of inflated confidence) when a participant knows what this term means. Therefore, the words "attitude" and "self-efficacy" were removed from the tool to ensure that the titles had fewer implications. Also, in the instructions for the self-efficacy questions, the words "Please answer honestly – there are no right or wrong answers" were included to try and encourage realistic answers and reduce the likelihood that a respondent would answer the questions with what they think they should be confident in, especially since they were based on nursing practice.

The basic categories of science (biochemistry, cell biology and microbiology) taken from the underlying nursing skills analysis (Appendix D) formed the three basic themes for the self-efficacy questions. Further trials were undertaken to determine if the questions were able to differentiate between those who were confident in the task and those that were not. In particular, participants who were not part of the target population (had no nursing or science background) participated in the trial by doing the survey and tended to mark the "very unconfident" or "unconfident" compared to the science experts who tended to mark the "very confident" side. The clarity of the questions was established by interview and by a trialist who was an expert in adult literacy. Trial participants were asked what the question was asking to ensure that the participant had understood the question as it was meant. Any questions with ambiguities were reformulated or edited. Subject experts were used to ensure that the questions used were examining the underlying constructs and this was established by informal, unstructured interviews. Nursing experts were used to ensure that the questions related to clinical practice and nursing education were realistic. All tasks related to self-efficacy-to-using-science-knowledge were in a nursing practice context.

Some self-efficacy questions were focused towards using science skills – not just content knowledge. For instance, the practice related questions under the 'microbiology' section relate to aseptic technique (science skill) as well as knowledge. As the self-efficacy questions relate to doing a task, it is possible that a nurse in practice may respond "very confident" that they could do a task (or the science skill) which may not be related to confidence in the underlying content knowledge. During the trials of these questions, it was found that some participants (nurses) did indeed feel confident in their ability to do the task due to their confidence in their underlying skill, (i.e. look up the information or perform asepsis). On questioning, this did correlate with confidence in their knowledge of the content involved but there appeared to be a greater affiliation with the skill. The explanation of the science behind it may not have been correct according to conventional explanations, but the confidence in their skill to perform the task and their confidence in the explanation (knowledge) appeared to correlate. Conversely, when a trial participant responded with a "not confident" to a question – it was found during the follow up interview that they may have had some understanding of the science knowledge behind it, or even a good understanding, but were not confident that their knowledge was appropriate to the task, or even that they had enough confidence to do the task properly based on their knowledge underlying it (see Figure 5.11, Chapter Five).

4.2.5 Selection of Participants for SASE Survey

The survey was distributed to nurses in the community and private clinical setting by mail (taking addresses from the telephone book) and directly within the Taranaki District Health Board by nurse managers, after discussion with the Director of Nursing. Some surveys were also distributed at nursing education sessions. This system ensured that there would be a reasonable chance of having representation from all practice areas, as the distribution numbers and returns from the various practice areas were closely monitored. The survey was supported by a letter outlining information relating to the requirements for ethics approval (in terms of how the data would be used etc.) and to assure the nurse that the survey information was anonymous (see Appendix C). Nurses posted the completed survey directly back to the researcher using a self-addressed, stamped envelope. Those that had opinions or interests in the topic may have elected to participate where as the people who were indifferent may have chosen not to participate. The information derived from the survey provides some descriptive statistics that provides a quantitative background to the study and are representative of the pool of nurses from which the observations were taken, at the time of the study, but may not be representative of the population of registered nurses.

The participants for the survey were taken from across the lower and central North Island of New Zealand – namely, Taranaki, Manawatu, Wairarapa, Wellington, Hawkes Bay and Bay of Plenty. Within these geographical areas, it is likely that nurses in practice will have been educated by different nursing schools, and some may not have been educated in New Zealand at all but may have achieved New Zealand registration since arriving in the country. These respondents were engaged in a variety of types of clinical practice. The *SASE-for-Nursing* survey also contained questions that extracted information about the nurse's science and nursing educational background as well as demographic information and questions that relate to their perspectives of both their science courses when they studied and of science's relevance to nursing practice.

Out of a total of 186 surveys sent out/distributed, 71 were received (39% response rate). Of the respondents, 97% were female and most identified as NZ European/European (93%) with 6% identifying as Māori. See Chapter Five for more discussion on participants.

4.2.6 Observations

Observation is a technique that can uncover characteristics of groups and individuals that may be impossible to discover by other means (Bell, 1999). In this type of study the focus is to look beyond events and to try to identify the significance of actions. Traditionally, observation is undertaken by researchers where they do not seek to manipulate the activities or the participants. When researchers know in advance exactly what they wish to observe, the observation can be structured in advance (Cohen et al., 2007). This way, the observer is looking for specific phenomenon and can record them in a structured manner such as a tick sheet or other means of recording data. A structured observation is systematic and can allow numerical data such as comparisons between settings, frequencies of events, chronological events and various other calculations. Naturalistic observations occur when the researcher takes an insider role to the group being studied and are often recorded by quick, fragmentary jottings of key words or symbols. In these situations, the context of the observation is important that is, setting, action, and the situation.

In this thesis, the science that occurs in a nurse's clinical practice may not be recognised by the participants and so a less structured approach is appropriate, so that events of significance can be identified by the researcher, when they occur, as they occur. In this way, issues may emerge from the observation. To do this, the observer is known by the participants as the researcher but contact with the actors during the session is minimal. It was also assumed that knowledge use (or practice behaviours) may not be the same in different clinical situations, so events of significance that may have occurred in other environments with different actors were still recorded. One of the limitations of using observation as a method for interpreting action is that the researcher may make assumptions about what it was they observed or what the action was for. For this reason, the observational studies included follow-up interviews where participants confirmed the action as observed by the researcher. Notes taken during the session were expanded upon as soon as possible after the session by interview and verified with the participant (in terms of actions that were undertaken).

An analysis of nursing skills taken from nursing school curriculum documents that align with both the scope of practice for registered nurses and the Nursing Council of New Zealand competencies for registration was undertaken. A table aligning the science knowledge that might inform the nursing skill (see Appendix D) was developed and this was checked by nursing content experts and science teachers to ensure that the skills and the aligning science knowledge were valid.

This table was populated by all possibilities irrespective of depth of content, and was created to try and support the identification of nursing skills that potentially could have been informed by science knowledge and this also informed the coding of the skills and events seen during the observation sessions. The actual observations were recorded in the form of field notes that were transcribed into descriptions of events, and matched with responses from the follow-up interviews.

Analysis of the data taken from the observations included translating the events of significance (actions or behaviours in clinical practice that would seem to require science knowledge) into science concepts. For example, a nurse putting on gloves when attending a patient can be taken as a significant event because it may indicate action taken because of knowledge of microbial hazards and hence infection control or it could just be representative of a nurse following protocol. Also, a nurse attending another patient without putting on gloves could also be a significant event as it could represent knowledge of microbiology (understanding the risks to this particular patient) or lack of knowledge (placing the patient at risk).

The knowledge behind these significant events that were observed in practice were then the subject of interview with the participants to draw out the reasons for the actions, and to identify the knowledge (content, depth and breadth) that the participant had in regard to that situation. For the observed events, interviews helped to ascertain if the science knowledge required by the participant to carry out the observed action was either absent (participant followed learned protocols or procedures with no idea of significance or relevance and so science knowledge was not required or utilised); was based on shallow knowledge only (could appreciate that a concept or concepts were relevant but could not articulate details); or that the science knowledge required was deep (could articulate the relationship between the action and the science and/or could extend the knowledge relationship further than the obvious). Using this system, the layers of information and understanding that are required to conduct the action were be explored.

With observational studies, it is possible that a researcher may record or observe only aspects of the action – almost a cherry picking of activities depending on the focus of the study. For this reason, observational data has limitations, including the ability of the researcher to identify events and to treat all events objectively. The observed person may also alter their normal activities depending on what they think they are being observed for – ideally, this would be avoided by ensuring that the researcher has sufficient contact with the participant, so that the participant is comfortable in the researcher's presence and goes about their activities as normal.

The observations involved 17 nurses and took place in a variety of practice areas which included: theatre, oncology, outpatients, accident and emergency, critical care, emergency medicine, acute psychiatric care, chronic aged care, intensive care unit, district, wound, primary health, general practice, aged and rural nursing. However, the practice that was actually observed occurred in: general practice, accident and emergency, theatre, nurse operated clinics, health expos, outpatients, district, medical, chronic aged care and acute psychiatric care. These occurred in cities (New Plymouth and Palmerston North), small towns (Hawera, Taupo, Masterton, and Carterton) and rural areas of the central and lower North Island of New Zealand. This resulted in just under 35 hours of observed clinical practice with individual observations ranging from 1 hour (n = 1) to 4 hours (n = 1), with the majority being of 2 hours duration (n = 7), and six lasting for between 2 and a half to three hours. This also resulted in a further 20 hours of unstructured interviews following the observations sessions which ranged from 20 seconds to 54 minutes in duration. One nurse participated in two observations on two different days. All nurses were observed while they were interacting with patients. As such, the patient's verbal permission was sought each time and the researcher signed confidentiality documents for the healthcare provider. (See section 4.5).

4.2.7 Interviews

Interviews are used to ascertain an individual's knowledge base on a particular subject or concept or perception of events. The researcher can then attempt to identify themes or relationships between the individual's personal constructs and the issues being investigated. Hence, interviews are a useful qualitative method to enable investigation of concepts in education.

There are four types of interviews: the informal conversational interview, the general interview guide approach, standardised open-ended interview, and the closed, fixed-response interview (Patton, 2002). The informal conversational approach has no predetermined questions and allows free conversation; the general interview guide approach allows free conversation but has some structure that ensures that the same information is extracted from all participants. The standardised open-ended technique is where all participants are asked the same questions, in the same way, but questions are posed in a way that is open (as opposed to closed, yes or no type questions). The closed, fixed type of interview allows participants to choose answers from various alternatives. A variety of interview techniques were used in this study. A standardised open-ended interview was used when interviewing nurse educators and nurse lecturers whereas the informal conversation approach was used for follow up interviews after the observation sessions.

No matter which interview technique is used, the interviewer must attempt to achieve a relaxed atmosphere that allows the interviewee to feel free to be spontaneous and to state their own beliefs or views (Cohen et al., 2007). The interviewer then can keep the conversation moving while being non-judgemental and non-committal as not to influence the conversation. The interview is conducted at a relaxed rate that allows the information to flow and to show the interviewee that their thoughts and opinions are valued, which encourages deep thinking responses instead of shallow ones. The interviewer can clarify any areas of ambiguity and is able to spontaneously develop questions to explore unexpected themes from the conversation. These questions are kept to a minimum, are open ended, neutral, simple (pose one issue only), are clear with no jargon and are unambiguous. Questions should make the participant think deeply and examine all their concepts and experience or "select from among that person's full repertoire of possible responses" (Patton, 1990, p. 296). Ideally, an interview should let the participant speak freely, as this lets the researcher search for genuinely revealing remarks. These spontaneous remarks can be cross-checked by further questions to enable the researcher to gain a deeper understanding of the concept that is being investigated and may allow the depth and breadth of knowledge to be discovered. The standardised open-ended interview is the most structured of the interview approaches used. Each subject is asked questions in a defined, set sequence with set words. The biggest advantage of this method compared to a written questionnaire or survey is that the participant has the ability to clarify any ambiguity that exists in the question set.

4.2.8 Nurse Educator/Lecturer Interviews

The nurse educator/lecturer interviews were all conducted using the same open-ended questions to all participants (i.e. structured). This was achieved by following a written format which ensured consistency of questioning for each participant but still enabled clarification of statements (see Appendix E). Some participants approached the researcher as they were interested in participating and others were invited by the researcher to ensure that various perspectives were represented. All nine participants identified as European/NZ European and eight of the interview participants were female and one was male. For this reason unisex pseudonyms were mainly chosen to protect the identity of the participants. Out of the ten participants, five were nurse educators/senior nurses who also were also preceptors in the clinical environment, four of whom worked in the acute care sector, and one worked in the community sector. The five nurse lecturers had various specialty areas including: community, rehabilitation, paediatrics, acute care and pharmacology. The interviews took place in their own environment (that is the educational institute or the health care setting where they worked). The interviews were between 16 and 43 minutes in length depending on the participant's responses with the average length being 30 minutes. All interviews were recorded onto a digital recording device and then transcribed. Participants viewed the transcripts and made corrections when necessary.

4.2.9 Observation Follow-Up Interviews

The general interview approach (also known as the semi-structured approach) was used after observation sessions where the questions were derived from notes taken during observation. Sometimes, due to the nature of the work the participating nurse was doing, short, informal conversational interviews were used in order to extract information on events immediately after they occurred. Essentially the main difference relates to how much structure is exhibited in the interview – the informal conversation interview has spontaneous generation of questions and natural conversation techniques. This approach is common in ethnographic studies and is often combined with observation (Cohen et al., 2007). As all nurses who participated in the observation stage were actively involved in clinical practice, some interviews took place immediately after an event (if possible without distracting the nurse from her duties and responsibilities) otherwise interviews were conducted at the end of a period of time when the nurses became available to talk. In this type of interview approach, the questions are not necessarily in any particular order, and the question may be worded differently and vary from participant to participant – as indeed the topics vary depending on the incidents being discussed. All responses were recorded using a digital recorder and then transcribed.

The observation follow-up interviews (which had no predetermined questions to remain as open and spontaneous as possible) had some initial structure as they tended to follow a basic question guide ensuring that for each activity, the information retrieved was as consistent as possible. This usually took the form of 'set' questions to establish the depth of information that the participant was using in carrying out observed tasks but the actual topic of questioning varied and allowed free flowing conversation. The 'set' questions related to "why" or "what" – that is, why did you ask/do (action/task); what were you looking for? What does this mean? So, the interview format used after observation of nursing practice was initially a general interview approach, but also took an informal, conversational approach.

In this inquiry, significant events that were observed in practice constitute the main themes of the less structured interviews. The observed significant events were described to the participant for the purposes of verification and then open ended questions on the specific events were asked. The responses were able to then be grouped according to emerging themes. The unstructured interviews that followed the observed nursing practice of 17 nurses resulted in 20 hours of unstructured interviews which ranged from 20 seconds to 54 minutes in duration.

4.3 Data Analysis

Analysis is important to try to establish validity and meaning from raw data. This involves the data being aggregated, grouped, aligned and transformed in some manner which can then lead to interpretation to attribute meaning. Commonly, quantitative data, for example, is analysed employing statistics. Descriptive statistics summarise the data set collected, but do not necessarily infer any values or judgements on the population that they were drawn from, they simply describe the groups or aggregates of data. Although descriptive statistics can be used to calculate or describe population parameters, the sample size must be unbiased and of a reasonable size in order to represent the population as a whole (Cohen et al., 2007). The larger the sample size, the more accurate the estimation of the whole population. As this study used a mixed method approach, the data analysis employed a blend of data analysis techniques. Within the *SASE-for-Nursing* survey there were questions that resulted in data that was analysed using quantitative analytical methods such as descriptive statistics (mode, mean, standard deviation, and confidence limits).

The self-efficacy questions which utilised a ten point scale interval were analysed on the assumption that each participant that selects the same interval does so because they have a similar strength of belief and that the weighting between each interval is perceived as similar by all participants. With regard to the self-efficacy question scores, the value of 1 was assigned to "very unconfident" responses and 10 to "very confident" and so the self-efficacy score coded for the response (between 1 and 10) was assigned to the particular value indicated within the continuum. Hence, statistical analysis of scores showing a mean score nearing 1 shows very weak self-efficacy in using fundamental science knowledge (biochemistry, cell biology and microbiology) in nursing practice, for example, with analysis on the self-efficacy scores on the three different areas of science possible.

Correlation studies can attempt to show if there is relationship between two data sets. They can indicate a predictive or suggest a causal relationship but this is not sufficient on its own to demonstrate the presence of an actual relationship or be predictive of a relationship. Correlation does not imply causation. The Pearson correlation coefficient, for example, attempts to describe the degree of the linear relationship between two data sets (Cohen et al., 2007). Further analysis of the survey results from this investigation included correlation studies between the attitudinal parts of the survey or self-efficacy response data and other parameters such as high school science courses or clinical practice experience, for example. These can lead to inference and interpretation of meaning. The Pearson correlation coefficient is the value which can indicate if, mathematically, there appears to be a linear relationship between two data sets. When interpreting this coefficient, a value of 1.0 to 0 is expected, with 0 indicating no relationship between the two sets of data and 1.0 indicating a linear relationship (which could be positive or negative). Values between 1.0 and 0 can be described as showing a small or weak relationship (such as between 0.3 to 0.1), medium relationship between 0.3 and 0.5 and a large or strong relationship when values are 0.5 to 1.0. Cohen (1988) warns that these interpretations are subjective, and are dependent on context and purpose. A correlation of 0.8 may be considered very high in social science but may be considered very low when establishing relationships between variables in a law of physics, for example.

With the qualitative data gathered from the observations and interviews, the analysis includes identification of general themes by matching, comparing, ordering, contrasting and aggregating notes, then moving towards more focus and more specific clustering (Cohen et al., 2007). Using actual quotes and thick descriptions of observed actions aligning with categories can provide some framework for inference of meaning.

With regard to the structured interviews, the recorded responses were able to be compared across the participants as the same questions were asked to them all. Various themes or patterns were able to be identified and grouped to try and reflect on participants' views. Analysing categorised responses then leads to inference and possible explanations of meaning.

Within this study, the qualitative data gathered from the observations and open-ended interviews, were analysed by progressive focusing (Stake, 1981) – that is, once coded, the general themes were grouped, sub-grouped and contrasted in order to try and make sense of the data in terms of the participant's view of the situation. These groupings or categories can be further described with thick descriptions using quotes and narratives of action that align with the groupings or categories. In particular, participant-validated transcripts taken from field notes from observation studies were inspected for statements and events of significance that revealed science behind clinical practice. These explanations of actions and the knowledge behind the actions or practice were then analysed, deconstructed and categorised to enable depth (layers and complexity of information) and breadth (variety of topics) of content that would support the end result (i.e. the clinical act).

Curriculum documents were also subjected to data analysis using an audit approach. That is, keywords were identified in the documents that related to the subject of interest and in relation to the prescribed documents required for nursing education (Nursing Council of New Zealand standards for education and aims, objectives and philosophies of the approved curriculum documents). As the documents analysed were not written for the purposes of this study, and many were historical and had been approved by external bodies (such as Nursing Council of New Zealand and NZQA or ITPQ), the assumption was that the documents may be symptomatic of the larger population and were actual documents that were used to produce nursing graduates. The curriculum documents analysed also had supportive documents (other than that of the curriculum) which narrated the justification for change and these were also able to be analysed to provide further interpretation, explanation and meaning.

4.3.1 Recognition of Events of Significance in Observation – Analytical Framework

As the literature review suggests, bioscience in nursing practice may be hidden, devalued, or unrecognised. The theoretical components of undergraduate nursing science courses that make up the formal learning outcomes (as suggested by curriculum documents) include biochemistry, anatomy, physiology, genetics, microbiology, pharmacology and pathophysiology and these are the main topics that observation sought to identify through recognition of 'significant events'.

These topics may not be obvious in the actions of the nurse but must be recognised by the researcher.

Microbiology, genetics and biochemistry including nutrition are the main scientific disciplines that the researcher has a background in and so there may be a greater tendency to recognise events within those discipline areas than in others. However, microbiology and biochemistry have some content alignment with physiology, pathophysiology and pharmacology and have a common foundational science (basic chemistry, physics, basic biological concepts) so the researcher is confident that most 'significant events' will be recognised, but accepts that more subtle events may not have been recognised. The ability to analyse those events and deconstruct the knowledge base that would enable the significant (or subtle) event is therefore dependent on the content knowledge and experience of the researcher. As this project is interpretive, the researcher attempted to interpret the viewpoint of the participant. Where 'significant events' were recognised within concepts that are not within the researcher's expertise, then these were validated by other experts (i.e. pharmacist) to confirm that they were significant events – that is, that the actions are dependent on scientific knowledge. Experts were also used to deconstruct the layers of knowledge that would have been required to enable that action or event, to identifying the depth and breadth of a topic or concept that is appropriate for the purposes of curriculum design.

In summary, data analysis when using mixed mode methodology serves to produce structure to the data that can then lead to interpretation, explanation and meaning. While statistics can provide some description of the sample size and may be able to describe some mathematical relationship (i.e. correlation), it still requires the researcher to interpret and provide meaning. With qualitative data, the thicker the description from the participants, the more likely the researcher can support the interpretation with content and quotes which aid in ensuring that the meaning inferred or speculated is trustworthy, and that the story told 'rings true'.

4.4 Validity and Reliability

4.4.1 Trustworthiness of Educational Inquiries

The traditional means of judging the rigor of a research inquiry is by reference to the concepts of validity and reliability. Both quantitative and qualitative research has to be valid – it has to measure what it set out to measure. With qualitative data concepts of honesty, richness, depth of information, triangulation and the objectivity of the researcher can address issues of validity (Cohen et al., 2007). In terms of reproducibility and predictability, how authentic were the data – how real was it in representing the phenomena being studied? With quantitative data, validity is improved by appropriate sampling, use of instruments and statistical analysis.

There are several types of validity: internal, external, and construct validity. Internal validity of an inquiry is about how well the explanation given by the research is supported by the data – how well the findings match reality. In a naturalistic inquiry, these transpire into questions of confidence – how authentic are the data, how able was the researcher to report the situation accurately and credibly? Lincoln and Guba (1986) suggest that credibility can be increased by a variety of ways including triangulation, peer debriefing (using a disinterested peer) and using participant validation to correct factual errors and assumptions. In positivist research, the main threats to internal validity are those that relate to testing, instrumentation, statistical regression and selection. External validity relates to the ability of the research to generalise the findings to a wider, target population. In positivist research, this often relates to variables, controls, and samples but for naturalistic researchers the concept of generalisation is more fraught due to the unique nature of human behaviour. For naturalistic research, the concepts of comparability and transferability (Lincoln & Guba, 1985) address external validity by assessing how typical the situation was, and then to identify comparative groups where findings may be transferable. The thicker the description of the situation studied, the more likely the issues of transferability and comparison can be assessed. Construct validity is also an issue for this type of inquiry. In particular, being able to demonstrate that the categories used, and the constructs examined (and deconstructed) are meaningful to the participants themselves, and that descriptions reflect the way in which they actually experienced the phenomenon, which can be addressed by participant validation.

4.4.2 Credibility

Credibility of a study can be increased by prolonged engagement, persistent observation, peer debriefing, negative case analysis, participant validation, or triangulation (Lincoln & Guba, 1985). Prolonged engagement provides opportunity to establish rapport and trust with participants, increasing the likelihood that the researcher can identify issues and represent them appropriately without distortion and participants providing honest information. Persistent observation increases the likelihood that the researcher has appropriately identified the characteristics and elements that that are most relevant to the issue being studied. Peer debriefing (with a disinterested peer) helps the investigator to test the honesty of working assumptions and next steps in the process. Negative case analysis involves attempts to establish theory that relates to every case and allows revision of a hypothesis. Participant validation (member checking) provides participants with the opportunity to clarify, confirm or add information taken from observations or interviews. It is important to ensure that the constructs taken from participants are representative of their outlook and worldview. Triangulation involves using various methods to collect data and taking information from various sources in order to cross-check and assess the authenticity of findings. Aligning with credibility is the concept of dependability. Ensuring that information, events, and descriptions are auditable and can act as stable pieces of data increases the dependability of the data. That is, ensuring that data collected is appropriate to the phenomenon being studied, and is representative and realistic to the community being studied.

4.4.3 Confirmability

Research findings should be able to be confirmed by others, and should not be subject to influence by the researcher. In positivist studies, objectivity is usually achieved by experimental design, use of controls and strict adherence to conditions and methods. However, in naturalistic inquiries, the confirmation of the study lies with the reader’s scrutiny of the raw data. Ensuring that data and information is auditable (can be traced throughout the process) allows the reader to assess the dependability and the credibility of the situation studied, the information elicited from the study, the authenticity of the information, events, situation and environment, and hence is able to confirm its version of reality.

4.4.4 Transferability

Generalisability translates in naturalistic studies to transferability and describes how the research findings might be applied to other situations. In positivist inquiries, sample selection, size, type and instrument design are important for the findings to be generalised to a group or population. However, in naturalistic inquiries, the ability of the findings to be transferred to another group is assessed by the reader, in terms of the reader making judgement that the process was able to represent the situation being studied, that it relied on participants own words and concepts and it made sense, in terms of the people and the situation described. Transferability can then also apply to the process, in that the methods used could make sense of similar events or people in other situations (Maxwell, 1992). The constructivist researcher provides a rich description of the context of the inquiry and detailed descriptions of methodology and interpretation: it is then up to the reader to decide if the findings are relevant, appropriate and representative of the group studied. This usually requires thick descriptions (detailed account of field experiences) that are highly descriptive, and often incorporating extensive pieces of verbatim reported transcripts in order to be transparent, and increase the likelihood of transferability (Lincoln & Guba, 1985).

4.4.5 Triangulation

Many authors suggest that triangulation is the most effective method of increasing credibility of a naturalistic inquiry (Patton, 1990; Guba and Lincoln, 1989; Bell, 1999; Cohen, Manion & Morrison, 2007). Triangulation can involve using various methods to collect data, or taking information from various sources in order to cross-check and assess the authenticity of findings. This increases the likelihood that comprehensive and balanced information is elicited in the research process. When the various data are both qualitative and quantitative it enhances validity, credibility, dependability, transferability and interpretation, as the researcher is able to more clearly identify important themes and minimise trivial ones. Like many lenses, more information taken from various sources, using differing methods, allow the appropriate images to crystallise into focus.

There are many forms of triangulation common in practice including data triangulation, investigator triangulation, and methodological triangulation (Denzin, 1970). Data triangulation relates to taking information from different types of data sources such as: time, space (that is, environment or situation), and from different levels such as individuals or types of groups of people. Investigator triangulation suggests changing the investigator during data collection to attempt to reduce or identify any subjective bias that may occur (placing a lot of emphasis on the ability of the team of investigators to work and communicate appropriately). Methodological triangulation can either be achieved by using the same method on different occasions using multiple strategies, or by applying different methods (such as observation and interviews) to examine the same issue.

The ideal outcome of triangulation for an inquiry is that of convergence where the data taken from the various methods provide consistency of information to agree to a conclusion. Inconsistency can occur if one set of results does not completely confirm the findings of another and contradiction occurs when data appear to disagree and hence remove the ability to provide plausible explanation. It is important to realise that findings that fail to converge may not be invalid but may direct further inquiry that elicits deeper understanding of the studied phenomenon in a similar way that in positivist research, a negative result is not an invalid result, but instead leads to further hypothesis and conjecture.

4.4.6 Measures Taken in this Study to Enhance Trustworthiness

Trustworthiness was enhanced throughout this study by a number of means. In particular, data was taken from the same source (or participant body) by three different methods – that is, by survey, observation and interview. This enabled triangulation to occur. Other members of the community were also interviewed (educators/lecturers) for their perspectives. Overarching information was extracted via document analysis (relevant to the context and community studied) which also provided quantitative data and served as background and context.

There were greater numbers of the nursing community involved in the written survey (71 respondents) than in the observation phase (17 observations). All 71 respondents were registered nurses in clinical practice, with current annual practicing certificates. The targeted pool of recipients for the survey was registered nurses in active clinical practice. According to a survey published in by the Future Workforce Group (2006), the number of comprehensive, registered nurses that held an annual practicing certificate in New Zealand in the year 2004, was in the vicinity of 20,000 compared to a total of approximately 47,000 nurses in practice (with qualifications other than comprehensive nursing). There were still about 8,500 nurses that were registered, and still practicing in areas of single registration (limitations on their practice such as obstetric only or psychiatric only) with a further 17,000 general and obstetric nurses (limitation on their practice) who qualified under the old apprenticeship scheme (Future Workforce, 2006). Put more simply; 44% of the registered nurses in clinical practice in 2004 were comprehensively trained, with 56% having limitations on their practice.

In New Zealand, the only way of entering the register is to have a degree and be comprehensively trained. The focus of this study was to investigate different practice and attempt to identify appropriate science curriculum for comprehensive training, even though it is understood that most of the current nurses in practice are not comprehensively trained. In 2004, 16.7% of nurses were practicing in primary health, 13.6% in aged care, 8.8% in mental health, and 43.5% in secondary and tertiary care. That is, 82.6% of nurses were in practice with the remainder being in administration or education. So, in terms of the first phase of the data collection (the survey), respondents were sought from the various areas of practice with appropriate portions to each area of practice (i.e., respondents from primary health, aged care, mental health and acute care). Limitations of this study therefore relate to the ability of the sample to represent the population as a whole (due to size and mix of participants).

The observation and interview phase involved nurses who had already participated in the survey phase of the study, and were available and able to commit to the observation and interview. Each observation and interview was transcribed and analysed soon after completion which also enabled the researcher to continually examine the goal of the inquiry to discover how and what science is used in clinical practice. This is consistent with the constructivist nature of this study where theory is dynamic rather than static. Member checks were achieved by participant validation of transcripts after observation and interview and involved the participant inspection of written transcripts and participants writing of clarifications when appropriate. Dependability for this study was achieved by ensuring that all data was auditable, and by use of thick and detailed descriptions.

The influence of the researcher on the participant was minimised by information provided before procedures took place and by the researcher conducting an objective, non judgemental observation of the nurse. As such, subtle messages, such as writing notes during an event may cause the nurse to feel anxious about what is being written and so great care was taken to ensure that the observation was as unobtrusive as possible. The nurse's primary focus during the session is the patient and the researcher tried not to distract from that. Also, because of the nature of the study, that is, science, and because it is known (via the literature review) that many nursing students have concerns and anxieties over science and maths, it was made clear (in written and verbal form) that the nurse's ability was not being assessed. It was also important that participants did not provide answers to questions (knowledge-based questions) or perform actions that they thought the researcher may like to hear or see because of the subject matter being science. It is possible that participants altered their practice due to the presence of a researcher and this is a possible limitation of the study. In order to attempt to avoid this, observation was done by prolonged engagement so that the participant was able to relax and engage in their work as usual, as well as use of non judgemental questions, including questions relating to if a particular action or way of conducting nursing care was usual, under all circumstances. There was also the possibility that the researcher was not able to identify all the significant events in practice and this too is a limitation of the study. The ability of the researcher to identify significant events during observation was enhanced by the creation of the nursing skills and science table (see Appendix D) which enabled the researcher to identify nursing actions that may have science knowledge or skill underpinning it.

Triangulation was achieved by comparisons with information taken from document analysis, survey information and with the data taken from the observational and interview studies to see how or if science knowledge was translated into practice. Methodological triangulation was addressed by using the same method on different occasions (observations) or different methods on the same person (survey and observation).

4.5 Ethical Considerations

A number of ethical issues were identified and addressed before the commencement of this study. The potential issues identified included participants feeling coerced into participation, confidentiality of the participants' identity and opinions that were expressed during the study and confidentiality of the patients who were present at the consultations. These ethical concerns were addressed in the following manner:

- An ethical application was made to the University of Waikato's Human Research Ethics Committee, and was approved.

- Participants were approached via a written letter that included information about the research (see Appendix C).

- Interviews were transcribed and participants provided with written transcriptions so that they could correct if appropriate. All data was securely stored and will be destroyed three years after completion of the project.

- Nursing actions observed in clinical practice were confirmed by participants so that they could validate and correct what was recorded during observation, if required.

- Participants had the right to decline the written request to be involved in the study. No coercion was employed. Participants had the right to withdraw from the study at any time.

- Participants' identity was protected by means of codes. Any reports of the research attempt to employ the use of unisex pseudonyms. Reports of the research are to be written in such a way that it will not be possible to identify individuals.

- Little harm was anticipated. The harm comes from time taken up in completing the *SASE-for-Nursing* survey or interview. Interviews were conducted at agreed times, at places of mutual agreement.
- Participants had the right to view transcriptions and may contact the researcher as necessary (contact details will be provided).
- The participant owned the raw material collected, and their requests regarding the material were honoured. Participation in the research was structured to not impact academically or professionally on the participants.

During the observation, data were extracted from the clinical setting. As such, the researcher was obligated to sign privacy agreements with the clinical provider to ensure that any issues that arose during the observation relating to the patient being attended to by the nurse being observed would remain confidential. Permission from the patient was also sought verbally before each consultation. Permission was also sought from the nurse's manager and workplace and all health and safety and confidentiality expectations were fully complied with. Also, the nurse's primary focus during the session was the patient and the researcher attempted to not distract or interfere with that.

4.6 Summary

The most appropriate methods to identify a curriculum for undergraduate nursing science employ naturalistic and interpretive methodologies utilising a mixed method and cross-aged approach. To attempt to understand the rationale behind individuals' and groups of individuals' (nurses) actions (nursing practice), were the methods used to gather data (such as observation of practice and interview) were undertaken in the individual's own environment. Methods such as observation and interview were used in this study to attempt to interpret the knowledge of the knower. The survey was used to examine self-efficacy towards-using-science-in-practice and attitude towards-nursing-science, as well as provide some quantitative data for analysis. Document analysis also provided context and background to the study.

In order to attempt to maximise content validity all instruments were based on a sound theoretical framework (Chapter Three) and evaluation of the main factors that may lead to application of science knowledge in practice (Figure 4.1). In particular, attitude-to-science (interviews, *SASE-for-Nursing* survey), science learning experiences (*SASE-for-Nursing* survey, interviews), self-efficacy-towards-using-science knowledge (*SASE-for-Nursing* survey), belief about relevance of science to nursing (*SASE-for-Nursing* survey, interviews), attitude to science in the workplace (*SASE-for-Nursing* survey, interviews, observations) all possibly contribute to the nurse's ability to apply science in practice.

In order to ensure that the data gathered and the interpretation of that data was trustworthy, the survey was piloted (for clarity of understanding and for accuracy of construct) and adjusted accordingly, while the trustworthiness of observations was maintained by prolonged observation periods, to increase the likelihood that the actions observed were representative of normal practice, and the use of non-judgemental interview techniques to establish knowledge behind the actions. For the interviews, data was transcribed and validated by participants before they were analysed.

Data analysis is important to be able to infer meaning from the above data sets. With quantitative data, descriptive statistics provided some analysis of the survey data (n = 71) which can be used to compare and align (correlation studies) with some of the qualitative data extracted from the observations (n = 17) and nurse lecturer/educator interviews (n = 9), but these may not be generalisable to the nursing population as a whole (due to sample size). The qualitative data was analysed by categorising and refining of categories of actual verbatim comments (as explanations of the science behind the nursing practice), along with detailed descriptions of the situation and context, which provided an element of trustworthiness.

Potential ethical concerns were identified and addressed before the commencement of the study and this included avoidance of coercion, informed consent, considerations of confidentiality (for the participants and the patients involved in the nurse consultation) and security of information.

The following chapter describes more fully the participants that were involved in each part of the study and establishes the diversity that exists in New Zealand nursing schools in terms of the depth and breadth of science content, with particular focus on curriculum development and rationale for change.

CHAPTER FIVE
RESULTS -
ROLE OF SCIENCE IN NURSING CLINICAL PRACTICE

Overview of the Chapter

The first part of this chapter contains a detailed description of the participants involved in each phase of the study. This description outlines the participants' clinical practice areas, experience and educational background. This allows some analysis and comparison of data later in the chapter. The remainder of the chapter focuses on an examination of the role of science from a number of perspectives. Firstly, to establish if science is required for nursing practice an analysis of documents important to nursing education with particular emphasis on science is described. These include Acts of legislation, Nursing Council of New Zealand documents as well as curriculum resources from undergraduate nursing schools. The chapter then includes a description of the nursing workforce and an analysis of New Zealand science curriculum and developments that have occurred in nursing schools over a period of years. The chapter next provides a discussion of nurses' perceptions of science's relevance to nursing and their attitudes towards both learning science as an undergraduate student and their attitudes towards using science in practice. The chapter concludes with presentation of findings about nurse participants' self-efficacy towards using science-in-practice and finally, a summary of all the issues discussed.

5.1 Description of Participants

This study was conducted in phases and nurses, nurse educators and nursing lecturers were involved in the different phases. The first phase of the study was the interviews, and involved nine nurse educators from the clinical environment as well as from the tertiary education sector. The next phase of the study was the survey which involved 71 registered nurses engaged in clinical practice throughout the North Island of New Zealand. The third phase of the study was the observation phase and involved 17 nurses who responded to the survey indicating willingness to participate in observations of their work (one nurse was observed twice on two different days). This was undertaken in a variety of practice settings in the North Island of New Zealand.

5.1.1 Nurse Educator Interview Participants

The majority of the nurse educators who participated in the interview phase of the study were in the 40-49 year age group (n = 5) with two in the 50-59 year old category and a further two in the 60 plus age group. All identified as European/NZ European and eight of the interview participants were female and one male. This is similar to the national workforce where 40% of nurses are over 50 years of age (NCNZ 2010b).

Of these nine educators, all except one were registered nurses who had between 20 and 41 years of clinical practice experience. One participant who was not a nurse but was responsible for teaching the science papers in a nursing school had 15 years clinical experience as a health professional and 5 years in a formal teaching role. Most of these participants had been in education for many years (see Figure 5.1).

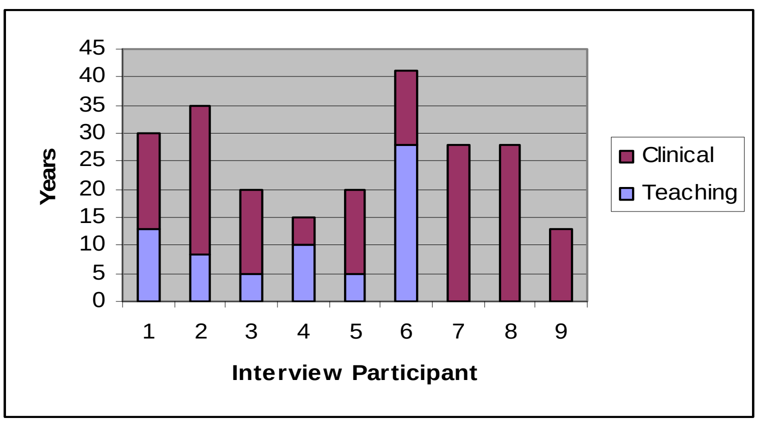

Figure 5.1: Interview participants' clinical and teaching experiences

These participants together represented nearly 70 years of formal teaching experience in undergraduate nursing education. Three of the participants had no formal teaching experience but were clinical educators in the practice setting and another one held a clinical education role in a hospital setting that involved teaching clinical skills to undergraduate students, and to nurses who were already registered.

The areas of clinical practice that these participants had experience in included paediatrics, critical care, care of elderly, rehabilitation, disability, orthopaedics, cardiothoracic surgery, ICU, private practice, maternity, community, health promotion, renal, neurosurgery, burns, general medical, district nursing and palliative care. In other words, a wide range of clinical practice experience was represented by the participants.

5.1.2 Survey Nurse Participants

The registered nurses that participated in the survey phase of the study were in practice areas across the middle to lower North Island including Taranaki, Bay of Plenty, Hawke's Bay, Manawatu, Wairarapa and Wellington. The majority of participants (n = 33) were in the 40-49 year age category (46%), two participants were in the 20-29 year group (3%), 17 were between 30-39 years old (24%), 15 were in the 50-59 year old age group (21%) and 4 were 60 plus (6%). This is similar to the national workforce where 40% of nurses are over 50 years of age (NCNZ 2010b).

Of the respondents, 97% were female and most identified as NZ European/European (94%) with 6% identifying as Māori (compared to 8% in the national workforce) (NCNZ, 2010),

The survey respondents indicated areas of practice that they had the most experience in and many of them indicated that they had worked in a variety of practice settings over the course of their career. These included: accident and emergency, acute mental health, aged care, child health, chronic care, critical care, district nursing, general practice, intensive care, medical, occupational, oncology, orthopedics, paediatrics, palliative care, post-operation, primary health, psychiatric, renal/dialysis, rehabilitation, rural nursing, surgical, theatre, women's health and wound-care. A wide range of clinical practice experience was represented by these participants.

At the time of the survey, most nurse participants were working in the primary health sector (48%), followed by the hospital or acute area (32%), then aged care and mental health (7% each) and 6% in administration or in education. The average years of clinical practice was 16, with the most common response (mode) being 30 years. The range covered from a few months (new graduate) to 45 years of clinical experience. The participants represented just over 1000 years of clinical experience in total.

The majority of survey participants gained nursing registration initially through studying and qualifying for the Diploma in Nursing (41%), followed by those who gained a degree (35%), and nurses who qualified by hospital training (24%). The number of nurses in the current workforce who entered the register by qualifying with a nursing degree is 37% according to 2010 workforce statistics (NCNZ, 2010). Over half of the respondents (55%) gained further qualifications after becoming registered and these ranged from certificates to masters degrees, with 6% who were still engaged in active study during the time of the survey.

Most participants (48%) had studied secondary school science subjects at NZQA Level 2[(1)] or equivalent (such as 6th Form Certificate or University Entrance) with fewer (17%) having studied Level 3[(2)] or equivalent science courses. Twenty seven percent of nurses had studied only Level 1[(3)] science courses at secondary school. The most common school science subject passed was biology (51%), with reportedly no passes in chemistry or physics alone and 16% in general science. Some nurses ticked more than one box indicating that they had passes in more than one subject, such as biology and chemistry (7%), biology and physics (6%) and biology and general science (13%). However, there were about 8% of respondents who it seems did not pass any science course at senior school, as they did not respond to the section questioning about passes (as opposed to studying) or they did not remember, or they chose not to respond to that question.

5.1.3 Observation Participants

The nurses who participated in the observation phase had clinical experience in a variety of practice areas. These included: theatre, oncology, outpatients, accident and emergency, critical care, emergency medicine, acute psychiatric care, chronic aged care, intensive care unit, district, wound, primary health, general practice, aged and rural nursing. However, the practice that was actually observed occurred in: general practice, accident and emergency, theatre, nurse operated clinics, health expo, outpatients, district, medical, chronic aged care and acute psychiatric care. These occurred in cities (New Plymouth and Palmerston North), small towns

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[1] NZQA Level 2 refers to the fourth year of secondary school (Year 12).
[2] NZQA Level 3 refers to the fifth year of secondary school (Year 13).
[3] NZQA Level 1 refers to the third year of secondary school (Year 11).

(Hawera, Taupo, Masterton, and Carterton) and rural areas of the central and lower North Island of New Zealand.

Most of the observation participants (n = 17) were in the 40-49 year age group (n = 9) with 4 in the 30-39 age category, two in the 50-59 group and two participants were over 60 years old at the time the survey was collected. Fifty percent of these nurses qualified as nurses by gaining a degree, 25% of them by a diploma, and the remainder by training in the hospital.Those nurses who gained entry to the register by qualifying with a degree did so between the years of 2000 and 2009 with one qualifying in 1987 (from the United Kingdom). In comparison with the survey population, nurses with degrees were more common in the observation group than in the survey (degree qualified nurses comprised of 35% of the survey respondents). Of these observation participants, eight had achieved further qualifications past initially qualifying as a nurse and three were actively studying. This is similar in proportion to the survey population. Further qualifications achieved by the nurses included post-graduate certificates, diplomas and one held a masters degree, all in nursing related areas. Most observation participants were female and 94% of them (16 people) identified as NZ European/European and one person as Māori.

In terms of secondary school science, there were equal numbers of nurses who participated in the observation phase who had studied the equivalent of Level 1 science (35%) as studied Level 2 science (35%). There were four observation participants (24%) who had studied no science at all at secondary school, and only one had studied and passed science subjects at Level 3 (6%). This means that the observation population was similar to the survey population in that most nurses had Level 1 or Level 2 science course passes (with less Level 2 than the survey population which had 45%), but the group studied had less Level 3 science passes that the survey population. There were proportionally more nurses who had no secondary school science passes in the observation studies (24%) compared to the survey population (8%). The most common subject that was achieved (irrespective of level) was biology, followed by general science, which is similar to the survey population.

5.2 Science Required for Nurses' Clinical Practice

Nursing practice and the education of nurses is controlled by a regulatory body, namely the Nursing Council of New Zealand. The Council's primary concern is that of public safety and it sets and monitors various standards relating to nursing practice, including the educational standards that nursing schools have to meet and these are regularly monitored by the Council in order for a nursing school to offer nursing education. It also monitors the competence of the workforce, setting the expected scope of practice required by nurses to remain registered. These documents are then interpreted by nursing schools during the curriculum development process in the schools. The nursing school curriculum documents are in turn approved by the Nursing Council. As such, an analysis of the Nursing Council and nursing school curriculum documents focusing on the science content requirement is appropriate to establish a perspective on the science required for nursing practice.

An analysis of the curriculum documents that represented the history of one nursing school's undergraduate curriculum (as it applies to science content) was undertaken as a 'snap shot' of the development of the New Zealand nursing curriculum over the last 25 years. Due to the nature of some of the documents, it is possible to track the curriculum development process with regard to the science courses, which serve as background information for the enquiry. An analysis of current nursing school science content and delivery methods was also undertaken, tracking the changes to the science content over a period of 3 years (see Appendix A).

5.2.1 Regulatory Body Requirements for Clinical Practice

The Nursing Council of New Zealand (NCNZ) is the statutory authority that regulates the practice of nurses. The legislative requirement that gives the NCNZ this authority is the *Health Practitioners Competence Assurance Act 2003* (previously the *Nurses Act 1977*). Section 118 of the Act sets out the functions of the NCNZ as an authority and these include:

- Prescribing the qualifications required for scopes of practice and accrediting educational institutions and programmes
- Authorising the registration of health practitioners

- Reviewing and maintaining the competence of health practitioners
- Setting standards of clinical competence, cultural competence and ethical conduct to be observed by health practitioners of the profession
- Setting programmes to ensure the ongoing competence of health practitioners
- To promote public awareness of the responsibilities of the authority

(NCNZ, 2007a, p. 2)

Nursing in New Zealand currently has three levels of nursing – nurse assistants/enrolled nurses, registered nurses and nurse practitioners, all of whom have different scopes of practice and expected competencies for practice (Tables 5.1 & 5.2). In essence, nurse assistants work under the supervision of registered nurses and nurse practitioners are expert nurses who work in a specific area.

In the Nursing Councils' Guidelines for Direction and Delegation (of nursing practice), a registered nurse is able to delegate nursing care responsibilities to nurse assistants or unregulated healthcare workers within a set of conditions outlined in the guidelines (NCNZ, 2008b). These conditions relate to the capability of the assistant or health care worker, the competence and experience of the delegating registered nurse and the complexity or stability of the condition of the patient/client/service user. When the differences in the scope of practice for nurse assistants and registered nurses are examined, the main points of difference appear to relate to responsibility and autonomy of nursing practice.

The registered nurse can "delegate to and direct enrolled nurses and nurse assistants" and practice "independently and in collaboration with other health professionals" (NCNZ, 2007b, p. 4) compared to nurse assistants who can "provide planned nursing care under the direction of a registered nurse" (NCNZ, 2007c, p. 9; see also Table 5.1). Registered nurses also utilise "nursing knowledge and complex nursing judgement" and "provide comprehensive nursing assessments" (NCNZ, 2007b, p. 4) whereas nurse assistants "assist registered nurses to deliver nursing care" but are still expected to "observe and report changes" (NCNZ, 2007c, p. 4). In essence, nursing care does not appear to be dependent on the carer having degree level knowledge as all nurses are required to observe and report changes in the patient and have knowledge of physiology.

Table 5.1: Comparison of the Competencies for Nurse Assistants and Registered Nurses

(NCNZ, 2007b, 2007c)

Note: Highlighted and italicised areas indicate similarities in content.

Enrolled Nurse or Nurse Assistant	**Registered Nurse**
Domain one: **Professional responsibility**	**Domain one:** **Professional responsibility**
Competency 1.1 *Accepts responsibility for ensuring that his/her nursing practice and conduct meet the standards of the professional, ethical and relevant legislated requirements.*	***Competency 1.1*** *Accepts responsibility for ensuring that his/her nursing practice and conduct meet the standards of the professional, ethical and relevant legislated requirements.*
Competency 1.2 *Demonstrates the ability to apply the principles of the Treaty of Waitangi/Te Tiriti o Waitangi to nursing practice.*	***Competency 1.2*** *Demonstrates the ability to apply the principles of the Treaty of Waitangi/Te Tiriti o Waitangi to nursing practice*
Competency 1.3 Recognises own scope of practice and the registered nurse responsibility and accountability for delegation of nursing care.	**Competency 1.3** Demonstrates accountability for directing, monitoring and evaluating nursing care that is provided by nurse assistants, enrolled nurses and others.
Competency 1.4 Demonstrates accountability and responsibility within the health care team when assisting or working under the direction of the registered nurse.	***Competency 1.4*** *Promotes an environment that enables client safety, independence, quality of life, and health*

Enrolled Nurse or Nurse Assistant	Registered Nurse
Competency 1.5 *Promotes an environment that enables client safety, independence, quality of life, and health.*	***Competency 1.5*** *Practises nursing in a manner that the client determines as being culturally safe.*
Competency 1.6 Participates in ongoing professional and educational development.	
Competency 1.7 *Practises nursing in a manner that the client determines as being culturally safe.*	
Competency 1.8 Practises in a way that respects each client's dignity and right to hold personal beliefs, values and goals.	
Domain two: **Management of nursing care**	**Domain two:** **Management of nursing care**
Competency 2.1 Provides planned nursing care under the direction of a registered nurse.	**Competency 2.1** Provides planned nursing care to achieve identified outcomes.
Competency 2.2 Is accountable for ensuring that nursing care provided to clients is within scope of practice and own level of competence.	**Competency 2.2** Undertakes a comprehensive and accurate nursing assessment of clients in a variety of settings.

Enrolled Nurse or Nurse Assistant	Registered Nurse
Competency 2.3 Demonstrates practice that supports best health outcomes for clients.	**Competency 2.3** *Ensures documentation is accurate and maintains confidentiality of information.*
Competency 2.4 *Ensures documentation is accurate and maintains confidentiality of information.*	**Competency 2.4** Ensures the client has adequate explanation of the effects, consequences and alternatives of proposed treatment options.
	Competency 2.5 Acts appropriately to protect oneself and others when faced with unexpected client responses, confrontation, personal threat or other crisis situations.
	Competency 2.6 Evaluates client's progress toward expected outcomes in partnership with clients.
	Competency 2.7 Provides health education appropriate to the needs of the client within a nursing framework.
	Competency 2.8 Reflects upon, and evaluates with peers and experienced nurses, the effectiveness of nursing care.
	Competency 2.9 Maintains professional development.

Enrolled Nurse or Nurse Assistant	Registered Nurse
Domain three: Interpersonal relationships	**Domain three: Interpersonal relationships**
Competency 3.1 Establishes, maintains and concludes therapeutic interpersonal relationships.	**Competency 3.1** Establishes, maintains and concludes therapeutic interpersonal relationships with client.
	Competency 3.2 Practises nursing in a negotiated partnership with the client where and when possible.
	Competency 3.3 Communicates effectively with clients and members of the health care team.
Domain four: Interprofessional health care & quality improvement	**Domain four: Interprofessional health care & quality improvement**
Competency 4.1 Collaborates and participates with colleagues and members of the health care team to deliver care.	**Competency 4.1** Collaborates and participates with colleagues and members of the health care team to facilitate and coordinate care.
Competency 4.2 Contributes to the evaluation of client care.	**Competency 4.2** Recognises and values the roles and skills of all members of the health care team in the delivery of care.
	Competency 4.3 Participates in quality improvement activities to monitor and improve standards of nursing.

According to the Nursing Council of New Zealand's Scope of Practice for Registered Nurses, nurses "utilise nursing knowledge and complex nursing judgement to assess health needs and provide care, and to advise and support people to manage their health" (NCNZ, 2008b, p. 20). This scope of practice includes the provision of "nursing interventions that require substantial scientific and professional knowledge and skills" (p. 3). To achieve the requirements set by various scopes of practice, the Nursing Council of New Zealand sets educational standards for nursing schools to meet. In terms of science, the educational standards for registered nurses require programmes to contain "bioscience, social and behavioural science … pharmacology, pathophysiology, genetics and disease states" (NCNZ, 2005a, p. 5) (see also Table 5.2). In comparison, the educational standards for nurse assistants' states that "physiological knowledge" is required (NCNZ, 2005b, p. 5).

Table 5.2: Comparison of the Theory Content for Nurse Assistants and Registered Nurses

(NCNZ, 2005a, 2005b)

Nurse Assistant Education Programme	**Registered Nurse Education Programme**
The content includes: **Theory:** • the articles of the Treaty of Waitangi • cultural safety • *physiological knowledge* • psychosocial skills and knowledge • practice skills and knowledge • communication skills • legal and ethical knowledge. **Practice:** • practice experience in situations that do not call for complex nursing judgements.	The content includes: • the articles of the Treaty of Waitangi • cultural safety • Māori health • professional nursing practice • *bioscience*, social and behavioural science • health systems and policy • nursing assessment and nursing practice decision making • therapeutic communication skills • *pharmacology* • *pathophysiology, genetics and disease states* • health promotion • ethics and law • research and evidence based practice • organisational and supervisory

	skills and leadership • information technology **Practice content must include:** • primary health care including: -maternal and infant health, child, adolescent and family health, adult health, elderly health • medical and surgical nursing • disability, mental health recovery and rehabilitation/continuing care • mental health nursing

Note: Italicised areas indicate the science content

An analysis of 14 nursing schools' curriculum documents showed that the majority of the physiology taught in the undergraduate nursing degree leading to registration is taught in the first year of the degree (Level 5), with pharmacology, pathophysiology and disease states usually being taught at Level 6 (year 2) (see later in Table 5.3). Nurse assistant and enrolled nurse programmes are usually approved at sub-degree level (Levels 4 or 5). Hence, in terms of levels, the expected knowledge of physiology by a registered nurse may not be substantially different from that of an assistant or an enrolled nurse. NCNZ Education Standards require nurse assistants to have about 300 or so hours (out of 1000 in total) in theory content, whereas registered nurses have at least 2000 hours (out of 3600 hours in total) in theory. Due to the nature and amount of theory content required in the registered nurses programme (see Table 5.2), it is possible that the physiology component could be similar in size and content to an assistant's programme, depending on how individual schools interpret these education standards. As the enrolled nurses' programme is Level 5 and they must include in their education "anatomy and physiology" (NCNZ, 2010a, p. 7, 8) it is possible that this too may be very similar to the registered nurses' programme. The NCNZ standards do not provide much guidance to the depth and breadth of science required for each scope of practice.

The ability to undertake nursing assessment (describe progress and ascertain deviations from expected outcomes) and use nursing judgements (analyse and interpret the individual needs of the client to achieve the best outcome) is a requirement and responsibility of the registered nurse. The registered nurse appears to be the clinical decision maker; hence the difference in the nursing 'practice' of the two levels of nursing (assistants and registered) appears not to be related to psychomotor skills (doing nursing tasks) or interpersonal skills (ability to relate to the patient/client/service user) or in roles of safeguarding dignity (understanding phenomena of patient-hood and socio-cultural implications) or in promoting independence and health (supporting best health outcomes), but in decision-making. In fact, when the criteria for nurse assistant competencies are compared with the competencies for registered nurses (Table 5.1), there are many identical areas (shaded and italicised). The main point of difference in the competencies relate to assistants and enrolled nurses taking direction, and registered nurses giving direction with responsibility for assessment and management of patients/clients/service users and the facilitation and coordination of care.

Nurse practitioners are expert nurses who are already registered and are required to have a clinically-focused master's degree (approved by the NCNZ). Yet few postgraduate programmes of study which are approved by the Nursing Council have compulsory science courses. Therefore, the science knowledge required by a registered nurse at graduation, combined with the requirement for nurse practitioners to have a minimum of four years of experience in a specific area of practice presumably is be considered enough science for the nurse practitioner to practice in their field of specialty. Registered nurses are expected to perform "nursing interventions that require substantial scientific and professional knowledge and skills" according to the registered nurse scope of practice, whereas nurse practitioners need to demonstrate extensive knowledge in their chosen field of specialty and apply "knowledge of biological, pharmacological and human sciences" that will enable the nurse practitioner to perform diagnosis, conduct and interpret diagnostic and laboratory tests and administer therapies (NCNZ, 2008c, p. 2). For a nurse practitioner to be competent and able to demonstrate extensive science knowledge, this implies that this is most likely gained from clinical experience (with a requirement to have a minimum of four years of experience) and not from formal science education.

It is difficult to ascertain the importance of science knowledge to nursing practice within the Nursing Council documents. It appears that clinical management and decision-making are the main point of difference between nurses who practice and are registered, and those who are not registered. Clinical experience and a master's qualification in a particular area of speciality are the main distinctions between registered nurses and nurse practitioners.

Although science is required by the Nursing Council for all levels of nursing practice, the science needed to support the various layers of nursing and clinical decision-making is not clearly articulated and may be open to interpretation during curriculum development processes. While the science requirements for nursing practice are not understood, the problems with identifying the depth and breadth required for a curriculum will continue.

5.2.2 Nursing Workforce

There were an estimated 46,700 registered nurses and 8,200 enrolled nurses/nurse assistants holding current practicing certificates in New Zealand in 2006 (Future Workforce, 2006). The Nursing Council of New Zealand reports that there were 40,616 active nurses who hold annual practicing certificates and working in the New Zealand in 2008 (Workforce Information, 2009) which is a decline from 2006. The majority of the nursing workforce is in the 40 – 49 and 50-55 age group, with 40% of nurses being over 50 years old (NCNZ 2010b). The Nursing Council states that it is aware of the rapidly moving practice environment where nurses are increasingly being required to perform extended practice roles in increasingly expanding, diverse and complex environments (NCNZ, 2008a). The Prime Minister of New Zealand, in a statement to Parliament on 9 February 2010 stated that "over time, patients will see more hospital-type services delivered closer to home" and that Government wanted "closer integration of hospitals and community-based care" (Key, 2010, p. 21). Workforce surveys have informed nursing workforce strategies for District Health Boards which have led to a priority in developing the nursing workforce in community, rural and primary health services. This has been a long term trend as 25 years ago, 85% of nurses worked in a hospital, whereas currently, only half the nursing workforce is in the hospital environment (Cook, 2009).

According to a survey of educational qualifications of New Zealand's nurse workforce undertaken in 2000, 64.5% of registered nurses were trained in the hospital environment and only 18.2% of nurses with a current annual practicing certificate had degrees (NCNZ, 2000). Of these degree qualified nurses, 54% were in education (not directly involved in patient care or clinical practice) and a further 34% were in professional advisory or policy development capacities and not in direct clinical practice. This suggests that only 4% of nurses in active 'hands-on' practice held degrees. In 2010 this is reported as having increased to 37% (NCNZ, 2010). It is likely that this will continue to increase as all new nursing graduates entering the workforce are required to have degrees, but these numbers are not available to confirm this. The New Zealand College of Practice Nurses found in a recent on-line survey found that 85% of its members in the nursing workforce were hospital trained (Calverley, 2009) however, membership to the college is not compulsory so does not represent the whole nursing workforce.

Since the role of science knowledge in nursing is not made explicit in the standards or competencies that regulate the nursing workforce, it can only be assumed that science theory is taught in nursing schools to support nursing practice. It is my experience that nursing science curriculum documents often state that the purpose of the nursing science courses is to provide sound theoretical foundation for nursing practice. However, it appears that currently, nurses are able to practice nursing without much formal science education (64.5% of the nursing workforce in 2000 was hospital trained and in 2009 one survey indicated that 85% of the current clinical workforce is hospital trained) (Calverley, 2009; NCNZ, 2000). The majority of degree level nurses appear to have taken up education or advisory roles (88%), not necessarily remaining in the 'hands-on' nursing workforce (NCNZ, 2000). It could be argued, however, that they therefore are more able to influence nursing practice (writing protocols, policies and providing education) and show leadership to others in these roles.

With the future nursing workforce possibly involving nurses more in community practice (see Chapter 2.2.7), nurses will need to be able to make decisions in isolation, and hence may be required to have the same level of knowledge as the current leaders and policy makers, or be able to challenge and question those leaders and policy makers. Although formal science knowledge may not appear to be required for 'hands-on' practice (other than for observation of change using basic physiology), it appears implicit in the ability to make clinical decisions which registered nurses are required to do. While Carper (1978) suggested that nurses' ways-of-knowing includes nursing science where the focus is on the synthesis of conceptual structures and theories to represent new perspectives for considering health and wellness in relation to the human experience (see Chapter Three), it appears as if the focus for nursing science should be on its application to clinical decision-making. Nursing decision-making has tended to be collaborative with a reliance on other colleagues so a move to more community healthcare could require nurses to be more autonomous in their decision-making.

It is not established if the differences in the science prescription (in the form of education standards) from Nursing Council for assistants/enrolled nurses and those for registered nurses adequately reflect the differences in responsibility. Nurse practitioners have greater responsibilities than a registered nurse, and the expert knowledge required to diagnose and interpret tests, administer therapies and possibly prescribe medications must be reliant on higher levels of science knowledge than those expected from a registered nurse, yet there is no compulsory science requirement in Nurse Practitioner education (as prescribed by NCNZ education standards). Hence, the depth and breadth of science knowledge required to inform clinical decision-making for a registered nurse is not well articulated in the prescribed education standards from the Nursing Council, and hence would be up to the interpretation of each individual nursing school during curriculum development.

There has been concern expressed over the work readiness of new graduate nurses and it has been suggested that there exists a "disconnect between nursing education and practice" (Future Workforce, 2006, p. 23). The basis for this is that it is considered that a newly graduated nurse requires a prolonged period of time in the workplace before they are considered to be able to handle a fulltime nurse's workload. This perceived disconnect has required the addition of New Entry Graduate Programmes in various district health boards to try and bridge the gap by preparing and supporting new graduates in their work. However, new graduates may simply need time to adapt to the complex environment that is the clinical workplace, this may not be a reflection on their education but more on their socialisation within the workplace. The theory-practice gap could also be due to an inability of the nurse graduate to integrate and use their theoretical knowledge. A common objective for nursing educators is to produce graduates that are capable of critical thinking, yet a common requirement for industry is the production of work-ready graduates that can immediately begin nursing practice. These tensions come together in curriculum development.

5.2.3 Curriculum Development in Nursing Science Education

When developing programme documentation for approved nursing undergraduate degrees, it has been my experience that nursing schools tend to write graduate profiles or outcome statements that closely relate to the standards and competencies required by the registration body responsible for ensuring safe and competent nursing practice (in New Zealand this is the Nursing Council). A search on the internet brings up nursing programme graduate outcomes worldwide that contain outcome statements that state that graduates must be able to: "communicate effectively", and provide "competent" and "safe nursing care". These graduate outcomes also tend to state that graduates will be capable of "critical thinking", as schools of nursing who offer degree level study have to meet the requirements of the relevant educational authorities (i.e. *Education Act, 1989* in New Zealand) and often the graduate outcomes contain elements of life-long learning concepts such as problem-solving, research skills and critical thinking. This may be one of the tensions between nursing schools and the nursing workforce, where nursing schools try to produce safe and competent nurses (which are those aspects of the curriculum which are skill based and competency focused), as well as the requirements to meet a degree, which are more of an academic nature.

The education standards for nursing schools require schools to write and review the curriculum in consultation with “nurses in practice, tangata whenua, health agencies and other key consumer stakeholders in the community” (NCNZ, 2005a, p. 4). Nursing schools look towards the nursing industry or workplace to support or initiate required changes. In terms of science, it is uncertain how able the local advisory group or key consumer stakeholders would be able to provide advocacy for the nursing science components required in the degree. As all programmes that lead towards registration are approved by the Nursing Council of New Zealand, approval suggests that the programme of study has met the appropriate education standards, including the provision of science (see Table 5.2). It is important therefore to examine the changes to a nursing curriculum over time to see if the alterations made to the science provision are based on rationalisation of how science informs a nurse’s clinical practice.

5.2.4 Historical Analysis of Changes to Nursing Science Curriculum

Document analysis of nursing curriculum documents (from 1986 to 2009) from one nursing school in New Zealand shows various iterations of science content, assessment and allocation of hours. In 1986, the Diploma of Nursing curriculum in this particular nursing school had a conceptual framework in the first year that included a component of ‘Human Science’. The document states that this component (along with the other four components: behavioural science, primary health, nursing studies-equilibrium and nursing studies-disequilibrium) provides the basic foundation on which Year 2 and 3 of the diploma were built. Within this component of ‘Human Science’, the content was microbiology, living chemistry, human biology (introductory concepts), body homeostasis and pharmacology. It states that “implicit in this representation is that students constantly recall and build on the foundation knowledge” (Taranaki Polytechnic, 1986, p. 7). It goes on further to state that the physiological need of patients “encompasses the basic survival requirements to humans in order to maintain biological homoeostasis and life itself” (p. 7) and that there is a requirement for a nurse to “protect oneself from physical harm including mechanical, chemical, thermal and bacteriological” (p. 10). This Year 1 component of human science was assessed by six hour long tests worth 5% each, one 10% assignment and four two hour exams worth 15% each. Further examination of the document with regard to content details shows that the material expected to be covered was quite detailed (see later in this section). Admission to Year 2 depended on receiving a pass of an average of 60% in this component referred to as the ‘physical science’ component (even though the strand was called ‘Human Science’) (p. 28).

In the same curriculum document in Year 2, science learning included under ‘physiological needs’: oxygenation, circulation, hormonal regulation, nutrition/fluid and electrolyte balance, elimination, nervous integration, sensory stimulation, mobility, protection and reproduction (Taranaki Polytechnic, 1986). In Year 3 of the diploma, the document notes that physical and physiological needs are related to various aspects of nursing such as the operating theatre, coronary units and so on. One of the objectives of the programme of study was to “demonstrate the principles of physical and social science which relate to nursing practice” (Taranaki Polytechnic, 1986, p. 15).

In 1988, the comprehensive nursing curriculum (as opposed to obstetric and general previously offered) from the same nursing school was approved by the Nursing Council and this replaced the previous version of the diploma in nursing (Taranaki Polytechnic, 1988). The ‘physical science’ paper assessment had now changed to two tests of two hours each and two tests of one hour each, all of which were ungraded and reported either a pass or a fail only (compared to the previous version of the diploma where students were expected to achieve a certain grade before they could progress). Also, significantly, the requirement to progress to Year Two now only required a pass in the “physical science” component (still called Human Science) as opposed to the previous version of the diploma which required an average of 60% to be granted entry into Year Two (Taranaki Polytechnic, 1988, p. 36). However, there appears to be no changes to the science content over this time, only a loosening of requirements for progression, and less assessment.

In 1992, the curriculum document at the same nursing school started referring to ‘biological sciences’ which consisted of anatomy and physiology, cellular chemistry, introduction to microbiology and drug calculations. This document also states that the biological science component was taught with 273 tutored hours and 60 self-directed hours (total of 333 hours). The basis of this document was to augment an application for approval from the Nursing Council and most of the discussion related to Māori cultural studies and various other nursing theories. No elements of the science papers (human/physical/biological) at any year level appear to have been challenged by the Nursing Council auditors even though the changes to these areas were quite considerable (reduction of hours, reduction of content as is detailed later).

The Diploma of Nursing in the same nursing school underwent further alteration in 1994 and noticeably, there was no mention of science in the graduate profile or objectives (Taranaki Polytechnic, 1994a). Instead, more prominent are aspects of the Treaty of Waitangi[4] and the educational concepts of lifelong learning. Within the curriculum document, the biological science strand contains modules of Introductory Anatomy and Physiology for Nurses, Introductory Chemistry for Nurses and Introductory Microbiology for Nurses in Year One (Taranaki Polytechnic, 1994a, p. 12). It also suggested that Year 2 and 3 papers have science integrated into the nursing knowledge and practice papers. In this document, the Introductory Anatomy and Physiology paper has 110 hours of lecture, 40 hours of tutorial, 50 hours in a laboratory, and 70 hours self-directed learning (270 hours total). The introductory chemistry paper had 20 hours of lectures, and the introduction to microbiology paper had 12 hours of lectures, three hours of tutorial and six hours in the laboratory. This is a total of 320 hours of science learning (a decline from 1992), 242 of which had tutor contact (as opposed to 273 hours in 1992).

The main changes in content over the years since 1986 related to the depth of content required. For example, with the knowledge of the cell, previous curricula (Taranaki Polytechnic, 1986) required a description and a list of the function of mitochondria, nucleus and cell membrane including transport through the cell membrane; where as in the 1994 curriculum, only cell membrane, cytoplasm and nucleus were required to be identified and explained (Taranaki Polytechnic, 1994b, p. 55). A second example of changes to the science curriculum was in genetics and inheritance. In the 1988 curriculum version, explanation of how

[4] Treaty of Waitangi is foundation document of New Zealand - a treaty between the British Crown and Tangata Whenua (first people) signed on February 6, 1840.

DNA influences heredity and definition of basic terms of inheritance (homozygous, dominant, recessive, etc.) were required, including the calculation of inheritance according to Mendelian theory, explanation of inheritance of ABO and Rhesus blood groups, as well as sex inheritance and sex-linked characteristics (Taranaki Polytechnic, 1986). In 1994, the requirement was to "show an understanding of inheritance" demonstrating that the "basic concepts of genetics are understood" (Taranaki Polytechnic, 1994b, p. 59). The assessment required the nursing students to sit three 90 minute multi-choice and short answer questions of which the student had only to pass two out of the three. Within the chemistry module, the 1988 version of the curriculum required learning about atoms, bonding, energy, metabolism, macromolecules, buffers, ATP, Co-enzyme A, anabolism, and catabolism (Taranaki Polytechnic, 1988) whereas the 1994 version required only that students were to "demonstrate an awareness of chemistry" p. 62. The 1994 version required that concepts of molecular chemistry be identified and described (atoms and molecules) and that the cellular chemistry affecting physiology is also identified and described (ions, acid-base macromolecules) (Taranaki Polytechnic, 1994b, p. 62). The microbiological component of the 1988 curriculum required knowledge of the major types of microorganisms, growth requirements, normal flora, gram positive and gram negative bacteria, control, disease process including transmission, pathogeneticity, epidemiology and immunity (Taranaki Polytechnic, 1988). The 1994 curriculum required "an awareness" of the four major types of microorganisms, methods of microbial control including sterilisation and disinfection, and includes "concepts of infection and the disease process" (Taranaki Polytechnic, 1994b, p. 65). In the evaluation by the Nursing Council for approval of the curriculum, the 1994 document has a "yes" response next to the question "Is the content specific to New Zealand and does it include biological and physical sciences?" (Taranaki Polytechnic, 1994b, p. 2). That appears to be the only evaluation of the science component required for approval even though it was again, a substantial change of content and further reduction in the assessment requirements for progression.

In 1994, the Taranaki Polytechnic sought approval to offer the Bachelor of Nursing in conjunction with Southland and Waiariki Polytechnics with links to Charles Sturt University in Australia. No reference to science is present in the aims or the objectives of the curriculum. The new curriculum had a strand called 'Science for Nurses' (Taranaki Polytechnic, 1994a). The modules in this strand included Anatomy and Physiology, Science for Nurses, Nutrition and Over the Counter Pharmacology for Year One. In Year 2, a module of Altered Anatomy and Physiology, one for Microbiology and one for Pharmacology were evident. The Anatomy and Physiology component in Year 1 had a total of 120 hours (50 hours of lectures, 30 of tutorials, 30 laboratory and 10 self-directed hours). The Science for Nurses component had 30 hours of lectures, 20 hours of tutorials, 30 hours of laboratories and 10 hours of self-directed hours (total of 90 hours). Nutrition consisted of 30 hours in total, 10 of which were lectures, and 5 were tutorial with the remainder being self-directed. In Year 2, Altered Anatomy and Physiology required 60 hours in total (20 lecture, 10 tutorial and 20 laboratory hours, with the remainder being self-directed). The microbiology course had 30 hours, 10 of which were lectures and 10 laboratory hours with the remainder being self-directed. The Year 2 pharmacology paper had 30 total hours of learning allocated to it. This totals 330 hours across two years (260 hours of tutor contact) a slight increase in hours allocated to the 'Science for Nurses' strand compared to the science strand in the previous diploma curriculum The assessment for Anatomy and Physiology was three short answer and a multi-choice test; Science for Nurses was assessed by one test; Nutrition by a food diary and analysis and Pharmacology by practice assessment. The Microbiology in Year 2 was assessed by a test and the Altered Anatomy and Physiology course by application to nursing knowledge. The Anatomy and Physiology course in the degree required students to "describe the structure and function of the human body from a cellular, tissue, organ and systems perspective: understand the relationship between systems and discuss the concept of homeostasis and its relevance to nursing" (Taranaki Polytechnic, 1994a, p. 52). The textbooks used as references were also altered compared to the diploma curricula, with more textbooks recommended, although the books recommended for the diploma course were still recommended for the degree. The Science for Nurses paper introduced basic concepts of physics as well as chemistry, biochemistry and microbiology which were taught after the Anatomy and Physiology paper. In Year 2, the microbiology paper required “critical analysis of potential problems in Aotearoa/New Zealand which occur as a result of spread of infection” (Taranaki Polytechnic, 1994a, p. 149).

In 1998, a revision of the Bachelor of Nursing curriculum at Taranaki Polytechnic saw the Anatomy and Physiology and Science for Nurses papers combined into the one paper in Year 1 (Taranaki Polytechnic, 1999). The resulting combined paper was assessed by two tests only. The rationale for change stated that the courses had common content and that combining the courses reduced repetition, the number of assessments and provided a “greater emphasis of nursing context rather than pure anatomy and physiology” (Taranaki Polytechnic, 1999, p. 3). Significantly in the description rationalising change it stated “new staff appointment – registered nurse with M.Sc” (p. 3). This new staff member had in fact, a Masters in Science (Nursing) with 7 credits in chemistry, 8 credits in anatomy and physiology and 4 in microbiology in the “lower division course work” and no obvious experience in science education according to the staff profile (Taranaki Polytechnic, 1999). Previously, the staff profiles associated with the curriculum and approval documents indicated that the staff who taught on the science papers had science qualifications and experience. The Year 2 Altered Anatomy and Physiology paper became “Altered Health Status” which was assessed by essay and the Year 2 microbiology paper disappeared while the pharmacology paper was assessed by an open book examination.

In 2003 the Bachelor of Nursing underwent further revisions (Taranaki Polytechnic, 2003). The Science for Nurses course subsequently contained reduced hours - 170 hours totally (30 in laboratory and 120 in lectures) with no other papers dedicated to science content. This was a significant decline from 330 hours in 1994. The Year 1 Nutrition course had components in cultural significance to food and its relationship in social, emotional and spiritual behaviour which includes the ability to state the properties of food groups in relation to health. In Year 2, the papers Altered Health Status and Pharmacology were still considered to be part of the Science for Nurses strand but the focus was very much part of health status and nursing assessment and care. Further alterations to the curriculum saw one 15 credit Anatomy and Physiology paper and one 15 credit paper that contained no reference to physics or basic chemistry and was called 'Bioscience'. The paper on nutrition was removed in its entirety (Taranaki Polytechnic, 2003). The curriculum was altered further which included changes such as the amalgamation of both science courses into one large 30 credit paper, and then further splits (after feedback from students that it was too intense) and various iterations of assessment, including the removal of laboratory components (due to the closure of the science department) all with limited rationale as evidenced in the approval and curriculum documents and Nursing Council of New Zealand audit records.

In summary, a historical examination of curriculum for nursing education at Taranaki Polytechnic shows that science content has changed over time. The Diploma of Nursing in 1986 had arguably the most comprehensive science content with deliberate intentions to integrate the knowledge into nursing practice. Various iterations after that time saw less science content (breadth), with less depth required, removal of science as an explicit objective of the programme, less assessment requirements and less teaching hours with limited rationale recorded for these changes. This was a case study of only one nursing school and it may not be reflective of other nursing schools, but may be symptomatic of others. However, all iterations of the curricula were approved by the Nursing Council of New Zealand because the required content was met, possibly indicating that the Council itself has not been able to clearly identify or articulate the science required for producing registered nurses. It may also show that the Council takes a flexible approach towards change in the science area or places more value on the other nursing aspects of the curriculum. It may also indicate that the nursing auditors themselves lack knowledge of what science is required for nursing practice, as they appear to have been satisfied by minimal rationalisations for change (in this case), or they may have simply been seeking that consultation occurred, or that a rationalisation was provided, without making judgement as to how appropriate the changes were.

5.2.5 Comparison of New Zealand Nursing School Science Curricula

A comparison of 14 New Zealand nursing schools' science content was performed to establish the diversity across New Zealand and to capture the changes made to the science courses over a period of three years between 2006 and 2009 (see Table

5.3). These topics do not include nursing courses and it is possible that some science content may be covered in nursing courses, but this information was not provided. More detail is provided in Appendix A. There was considerable diversity in the topics taught.

Table 5.3: Comparison of 14 Nursing Schools (A to N) between Years 2006-2009

	New Zealand Nursing Schools Curricula 2006 – 2009													
	A	B		C		D				E	F	G	H	
		Yr1	Yr2	Yr1	Yr2	Yr1	Yr2	Yr3	New	Yr1	Yr1	Yr1	Yr1	Yr2
Chemistry	●	√		●	●					●	√	√	√	
Genetics	●			●	●	√			√	●		√		
Cell biology	●			●	●	√			√	●			√	
Microbiology	●	√	√	●	●	√	√		√	●	√	√	√	
Immunology						√					√	√	√	
Biochemistry	●	√	√	●	●					●	√	√		
Physics	●	√		●	●					●			√	
Anatomy	●	√	√	●	●	√	√		√	●	√	√	√	√
Physiology	●	√	√	●	●	√	√		√	●	√	√	√	√
Pain											√			
Nutrition	●			●	●	√			√	●	√	√	√	
Over the counter meds	●	√		●	●					●				
Drug administration	●	√		●	●					●				
Pathophysiology	●	√		●	√		√	√		√				√
Pharmacology	●	√		●	●		√		√	√	●	●	●	√
Measurement									√					
Observation									√					
Health history									√					
Laboratory sessions (hours)	60	●		●		70			●	28	18	20	46	
Use of simulation technology									√					
Common first year classes *	√			√										
Taught by scientists	√	√		√						√	√	√	√	
Taught by Nurses				√						√	√		√	
Hours taught	●	●		●		●			100	100	●	100	●	
Curriculum change		√1		√2		√3				√4				

Key: The 14 schools are denoted a letter between A to N; Yr indicates Year level

Notes on curriculum:

* Common first year papers means that nursing students are in the same class as other students such as Bachelor Health Science
1 Changes from school B include updating currency and review of time allocation and contextualization of topics due to student feedback indicating that the courses are very challenging to students
2 Changes include science courses no longer being taught by scientists
3 Changes across the whole curriculum – see "new" column
4 Reduction in laboratory sessions to 12 hours. Change due to preparation for Nurse practitioner roles.
● Information not provided

	New Zealand Nursing School Curricula 2006 – 2009												
	I		J			K		L		M		N	
	Yr1	Yr2	Yr1	Yr2	Yr3	Yr1	Yr2	Yr1	Yr2	Yr1	Yr2	Yr1	Yr2
Chemistry								√					
Genetics			√			√	√		√				
Cell biology			√				√	√					
Microbiology	√	√		√						√	√		
Immunology				√						√	√		
Biochemistry	√	√						√					
Physics													
Anatomy	√	√	√				√	√	√	√		√	
Physiology	√	√	√				√	√	√	√		√	
Pain													
Nutrition													
Over the counter meds													
Drug administration													
Pathophysiology		√			√						√		√
Pharmacology		√		●		√	√		●		√		●
Measurement													
Observation													
Health history													
Laboratory sessions (hours)	30		24			●		15		●		7	
Use of simulation technology								√					
Common first year classes												√	
Taught by scientists	√		√					√		√			
Taught by Nurses			√					√				√	
Hours taught	●		●			200		●		●		●	
Curriculum change								√5				√6	

Key: The 14 schools are denoted a letter between A to N; Yr indicates Year level

Notes on Curriculum:

* Common first year papers means that nursing students are in the same class as other students such as Bachelor Health Science
5 Change due to movement away from medical model of delivery
6 Change from scientists teaching to nurses
● Information not provided

NOTE: For more information see appendix A.

For example, only five of the nursing schools taught chemistry and six did not teach any chemistry (a further three schools did not provide this information). Some nursing schools taught genetics in Year 1 (n = 4), others in Year 2 (n = 2), and 4 schools provided no information on genetics. All schools appeared to teach anatomy, but some taught it in Year 1, others continued it into Year 2, and pharmacology was similar (some taught it in Year 1, others in Year 2). Laboratory sessions varied from 70 hours to 7 hours (and four schools did not provide this information). All of these nursing schools have had their curriculum approved by Nursing Council of New Zealand.

Some nursing schools had common first year science courses – that is, the nurses sat alongside other students (science, medical, pharmacology, etc.) and the nursing school itself therefore may not have managed the content of those courses. Some of the rationalisations for changes to the science courses that were provided by the nursing schools included: student feedback indicating that the courses were challenging to students, that the courses were no longer being taught by scientist but by nurses, reduction in laboratory hours (review of time allocations), preparation for nurse practitioner roles and a movement away from medical model of delivery.

In summary, the depth and breadth of science required to support nursing practice does not appear to be well articulated, resulting in diversity in how nursing schools interpret and develop the science curriculum. There appears to still be a view by the curriculum designers in New Zealand nursing schools that the issues that exist with nursing students learning science (previously referred to as the "bioscience issue" – see Chapter Two) are related to scientists (as opposed to nurses) teaching science to nurses and the 'medical model' approach. These changes examined through nursing schools' curricula show changes to topics, changes to laboratory hours, changes to who teaches, changes to delivery models (simulations). In general, most nursing schools taught approximately 100 hours of science content. As a possible comparison, the Taranaki Polytechnic taught 170 hours of contact hours for science in 2003 (Taranaki Polytechnic, 2003) which, if this was indicative of the history of other nursing degrees, may indicate a continuous decline in hours allocated to science in the nursing degree.

5.2.6 National Science Curricula and Entry Criteria

A comparison of science content of the various nursing schools in New Zealand shows that changes to the science curriculum occurs in many schools (Table 5.3). As there is not much guidance from the Nursing Council as to what breadth and depth of content is required in nursing science education, nursing schools determine curriculum through interpreting broad policy from the Council and combining this with stakeholder input, hence it is subject to variety in content between nursing schools. There is also variation in who teaches it (e.g., a nurse or a scientist – see Table 5.3) and how it is taught and in entry criteria.

By 2006, the Nursing Council of New Zealand had changed the entry to nursing degrees from requiring 42 credits at Level 3 to specifying that all applicants required the New Zealand University Entrance Standard (set by the New Zealand Vice-Chancellors Committee which dictates the amount of credits required to matriculate at university in New Zealand) to enter a nursing degree (Vice-Chancellors Committee, 2010). However, this only dictates the number and level of credits required, not the subjects required – these are set by individual educational providers. Some nursing schools started to state that science courses at senior high school were required to enter nursing. Auckland University specified that nurses require 16 credits in NCEA Level 3 from *one* of biology, chemistry or physics with those with merit and excellence will earn more ‘points’ towards gaining entry to the competitive first year, which is a common Health Science year (Auckland University, 2010). Auckland University of Technology required for entry to nursing 14 credits at Level 3 in *one* of biology, chemistry, physics or mathematics at Level 3 (Auckland University of Technology, 2010). Otago Polytechnic specifies 14 credits in *either* biology or chemistry (not physics) at Level 3 (Otago Polytechnic, 2010) and the Christchurch Polytechnic Institute of Technology accepts 14 credits in biology, physical education or chemistry at Level 3 (Christchurch Polytechnic, 2010). The Southland Institute of Technology requires 14 credits Level 3 or higher in science related subjects (Southland Institute of Technology, 2010).

The distinction between these schools is that the University of Auckland and Auckland University of Technology specifies the number of credits required in one of the subjects, whereas the other institutes allow the specified credits to accumulate from all the accepted subjects (biology, chemistry etc.). Some schools do not specify any science credits or courses required for entry (e.g., Unitec, Massey University, Northtec) and those that do, tend to require Level 2 (i.e., Manukau Institute of Technology, Waikato Institute of Technology, Western Institute of Technology at Taranaki, Otago Polytechnic) (Massey University, 2010; Manukau Institute of Technology, 2010; Northtec, 2010; Southland Institute of Technology, 2010; Otago Polytechnic, 2010; Waikato Institute of Technology, 2010;Western Institute of Technology at Taranaki, 2010; Unitec, 2010).

A detailed analysis of the teaching material provided for a university post-graduate applied science for registered nurses paper (distance on-line course) showed that there were many content similarities to the undergraduate nursing science courses (Auckland University, 2006). For example, the recommended textbook is the same as used in most of the undergraduate nursing science schools. Although the course material contained scientific terminology that the nurse studying must engage with such as ATP, acidosis, pH, ions, and molecular formulae, it also contained simple descriptions and diagrams of many of simple concepts such as diffusion, osmosis and pH. Many of the objectives appear very similar to expected undergraduate science outcomes, for example, the objectives under microbiology include the ‘review’ of major classes of microbes, differences between viruses and bacteria, differences between gram positive and gram negative, use of antibiotics and resistance to antibiotics (Auckland University, 2006a). Interestingly, the notes within the coursework contained some alternative conceptions to accepted scientific views such as reference to how bacteria are “able to learn novel ways to overcome the antibiotic” (the word “learn” seems inappropriate), and discussion on how viruses do not “have a full set of DNA” (whereas many viruses do not have any DNA, and if it did, what is considered to be a “full set of DNA”) (Auckland University, 2006a, p. 2). The document also stated that viruses enter other cells to hence avoid being exposed to antibiotics (viruses are not susceptible to antibiotics at all) and that “antibiotics destroy the cell walls” of bacteria, suggesting that this is the mode of action for all antibiotics (Auckland University, 2006b, p. 2) seemingly unaware of the other modes of action such as on genetic material or other cellular components). Although this paper was a post-graduate nursing science paper it was not taught by a scientist, but by a nurse (Auckland University, 2009) who had an undergraduate degree in science (physiology and biochemistry), and so possibly was not able to identify the alternative conceptions in microbiology. It could be, however, that the intention was to simplify the information for the nurse consumer, however, they appear to have been simplified to the point of inaccuracy. The content of the postgraduate paper appears to be reinforcing or reviewing content taught by most undergraduate nursing schools, which suggests that a nurse in clinical practice may be able to integrate and use the knowledge better than an undergraduate (the assumption being that the nurse has forgotten all the undergraduate science). This may be due to the experienced nurse being able to apply context and relevance due to their own clinical practice, in comparison to undergraduate provision, where the nurse has no clinical experience that might make the science knowledge relevant.

In essence, the depth and breadth of content in the postgraduate (masters) applied science paper appears to not be significantly more in depth than the undergraduate nursing programmes (at least in relation to microbiology). This could be due to the course designer placing less importance on this subject than say physiology, or it could suggest that nurses do not retain their undergraduate science knowledge and the information in the postgraduate course appears to be new.

5.2.7 Summary

Although formal science knowledge may not appear to be required for 'hands-on' practice or the provision of nursing care (other than for observation of change using basic physiology), it appears implicit in the ability to make clinical decisions (which registered nurses are required to do). It is not established if the differences in the science prescription (in the form of education standards) from Nursing Council adequately reflect the differences in responsibility (as in the scopes of practice), nor does it articulate how the science influences or informs the different levels of practice.

As the depth and breadth of science knowledge required for clinical decision-making for a registered nurse is not known, curriculum topics are then established by education providers after consultation with the nursing workforce. The variety of curricula in New Zealand shows how varied this interpretation can be, with no common core clearly articulated, and that this content is subject to many revisions. All nursing programmes must meet the Nursing Council of New

Zealand standards for education of nurses to be approved and so this variety appears to be accepted by the Nursing Council. A historical analysis of the changes to nursing science curriculum in one nursing school in New Zealand charts a progressive reduction of science subject matter, depth of content, assessment requirements and teaching hours, and as all iterations were accepted and approved by the Nursing Council of New Zealand, this further indicates how the science required for nursing is ill defined. Comparison of 14 New Zealand nursing school's science courses shows diversity in depth and breadth as well as delivery of content, with some rationalisation for change indicating student difficulties and movement away from scientist-led and medical models of delivery. Analysis of postgraduate science papers shows similar content to undergraduate nursing science courses, however, experienced nurses report that these papers are useful in their clinical practice, indicating that clinical experience increases the relevance of the course content.

In summary, Nursing Council requires that nurse educational programmes must contain science knowledge, but the depth and breadth of this knowledge appears to be established by nursing schools, in collaboration with the local nursing workforce, and hence is subject to change and national variation.

5.3 Attitudes to using science in nursing clinical practice

For this study, 71 nurses were surveyed to attempt to establish nurses' attitudes to science, and self-efficacy to using science in nursing practice. The nurses surveyed were active in a variety of clinical practice areas, and had a variety of clinical and educational experiences. For a full description of the participants see Section 5.1.2. The survey tool had questions that related to nurses' attitudes towards the science education they had in nursing school, self-efficacy questions where nurses related their confidence levels to undertaking science laden tasks, as well as questions on how they felt that science informed their practice. The following sections present the findings of these questions.

5.3.1 Attitudes to Learning Science for Nursing

This section describes the findings for the questions that examined the nurses' attitudes to learning science for nursing. In general, just over half (51%) of the nurses indicated that they found their nursing science courses easy, and more than half (56%) indicated that the language and terminology of the courses were easy to learn (see Table 5.4). Almost half the respondents (43%) felt that the readings were easy and most felt that they did not worry more about science courses more than their other courses (55% of respondents). They also indicated overall that they didn't think there was too much material in their science courses (55%).

Table 5.4: Attitude towards learning science for nursing (n = 71)

SASE-for-Nursing Survey Question Topic	Mean*	Standard Deviation *	Proportion who agreed with statement (%)	Proportion who disagreed with statement (%)	Proportion who were not sure (%)
I found the science course(s) easy.	2.4	0.9	51	42	7
I worried more about science course than other nursing subjects.	2.6	0.8	42	55	3
I found that there was too much material to cover for the time allowed.	2.6	0.9	37	55	8
The readings required for science were easy.	2.5	0.8	53	50	7
I found that the language and terminology of the science courses were easy to learn.	2.4	0.8	56	38	6

*Key: 1 strongly agreed, 2 agreed, 3 disagreed, 4 strongly disagreed

The data represented in Table 5.4 indicates mean values that are centrally clustered (between 2 and 3, which are between agreement and disagreement) and standard deviations that suggest that few participants indicated extreme views, although all response options were represented in the data set (range between 1 and 4). There was a diversity of views presented, with every question eliciting both agreement and disagreement responses. To determine what patterns or relationships if any the various views (agreement or disagreement) may have with other data sets such as science background, or self-efficacy towards using science-in-practice scores, various correlation examinations were performed.

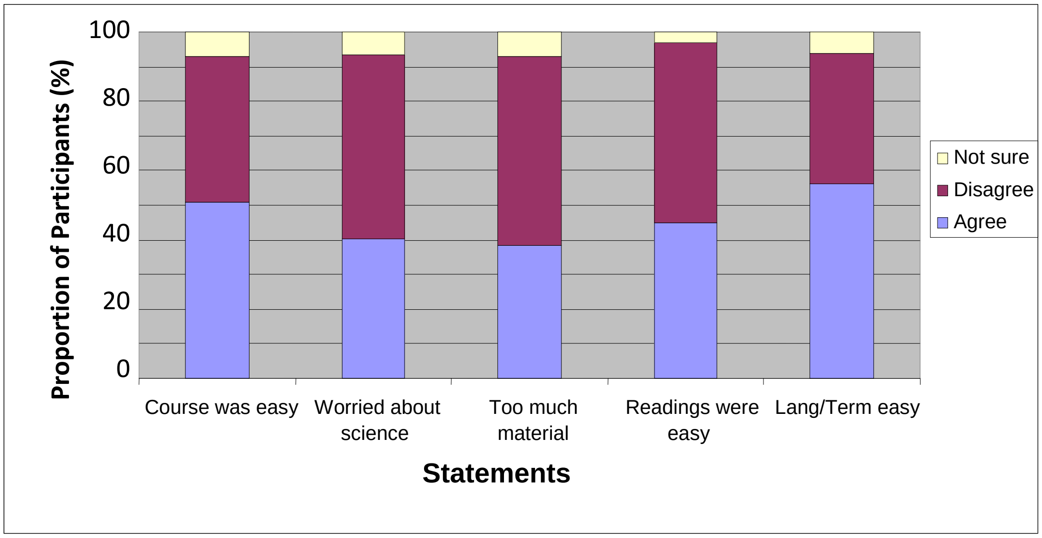


Figure 5.2: Perceptions of learning science for nursing (n = 71)

Aligning the participants' responses to the questions about learning nursing science in the *SASE-for-Nursing* survey with the nurses' highest secondary school science achievement shows that those with Level 3 science passes tended to agree that their science course(s) in their nursing training had been easy (67%), compared to those with no high school science passes where only 32% agreed that it had been easy (see Figure 5.3). The greater the level of science achievement at school seems to lead to a greater ease in learning nursing science.

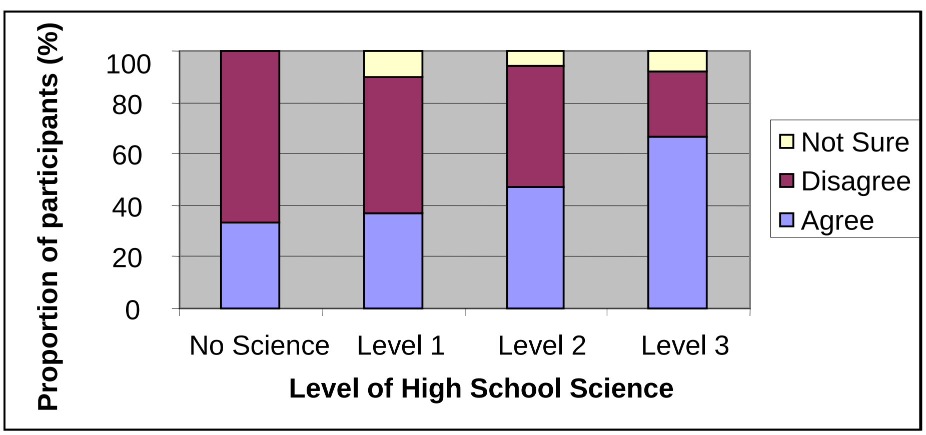


Figure 5.3: Survey participants who found the nursing science course(s) easy correlated with their high school science achievements (n=71)

Additionally, nurses who had no science passes tended to feel that the nursing science courses had too much material to cover in the time allowed (50%)

compared to 25% of those with Level 3 science passes from secondary school (see Figure 5.4).

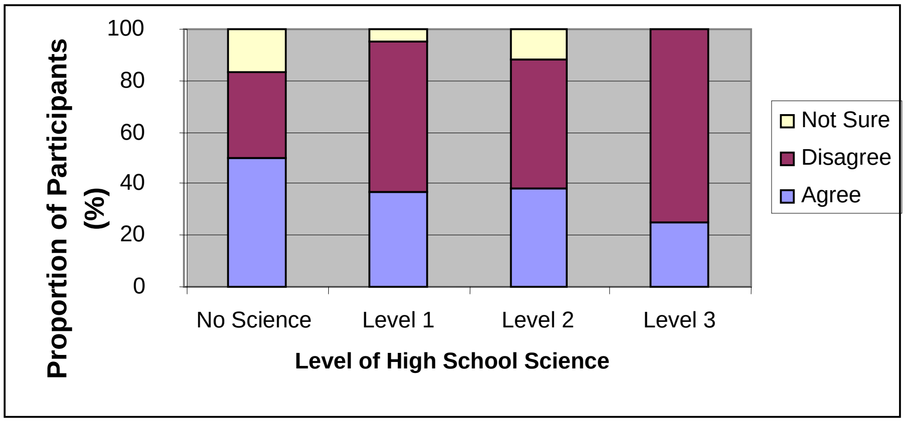


Figure 5.4: Participants who felt that there was too much material to cover in the nursing science course(s) correlated with their high school science achievements (n=71)

Nurses who had Level 3 science passes tended to agree (75%) that the readings that were required for the nursing science courses were easy, whereas fifty percent of those with no science passes at secondary school disagreed with the statement (see Figure 5.5). Those with Level 1 and 2 science backgrounds also tended to disagree with the statement.

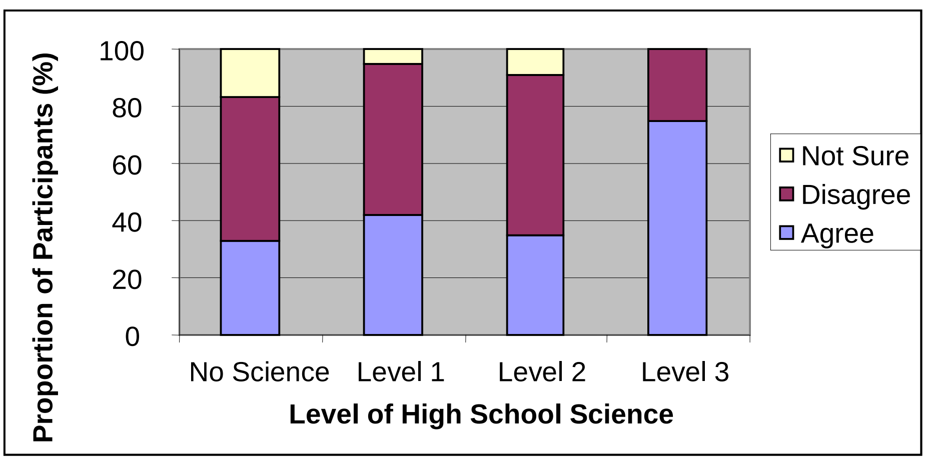


Figure 5.5: Survey participants who felt that the readings for the nursing science course(s) were easy correlated with their high school science achievements (n=71)

Likewise, nurses who had a higher level of science background tended to find that the language and terminology of the science courses were easy to learn (67%) compared to those with no science at any level (33%) (see Figure 5.6). Those nurses who ticked “not sure” tended to have trained between 10 and 45 years ago, possibly indicating that they could not remember that amount of detail, or possibly were not prepared to agree or disagree with the statement.

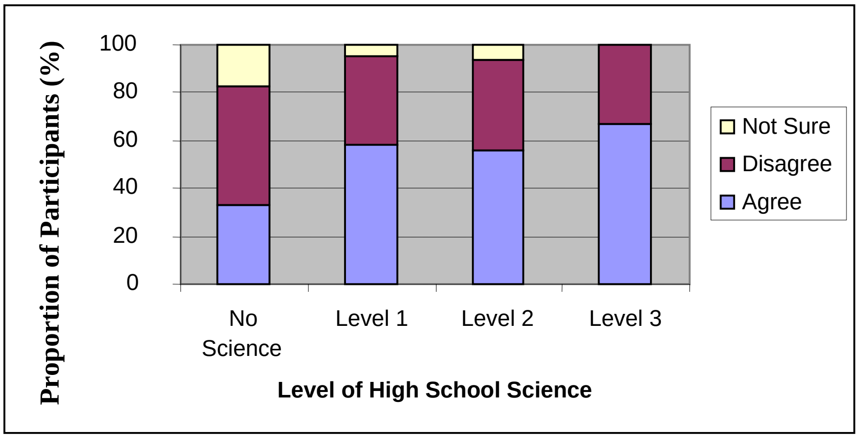


Figure 5.6: Survey participants that found the language and terminology of nursing science course(s) easy to learn correlated with their high school science achievements (n=71)

The literature suggested that nursing students tended to find their science courses difficult, experienced high levels of anxiety over the nursing science courses and that many are not convinced that the science was relevant to nursing (Caon & Treagust, 1993; Jordon, Davies & Green, 1999; McKee, 2002; Taylor, Small White, Hall & Fenwick, 1981). The relatively positive response from the nurse participants in this study therefore is unexpected. However, the literature tended to examine the attitudes of students to their science study and it could be that the nurses who participated in this study had a more positive outlook on their science courses, because they had achieved them (they graduated), or it could be that time spent in clinical practice altered their perspective, perhaps if they had been able to see more relevance of the science.

Those nurse participants who had been successful at high school Level 3 science (or equivalent) were more likely to report that the science courses they had studied were easy (67%), did not have too much material to cover in the time allowed (75%), found the readings for the nurse science course easy (75%), and found the language and terminology of the science courses easy to learn (67%). In essence, those students who had more science background at entry tended to find the nursing science courses manageable, or even easy.

5.3.2 Attitudes to Nursing Science Education

This section describes the findings that relate to nurses' attitudes towards nursing science education. Most participants' opinions are represented by unisex pseudonyms. Some nurses expressed their opinions on how science in nursing should be taught or what helped them during their studies. Some of these opinions were written in the survey under the free comment section, and others discussed their opinions during the interviews after observation.

One nurse expressed an opinion during interview (after observation) that science courses were placed in the nursing degree to cull out students, and that "other things are suffering because this was taught so in-depth" (*Pat*). *Pat* was a nurse who was a relatively new graduate and had only been in practice for a year or so, and had come to nursing as an older student (was between 30 and 39 years old) with a Level 1 secondary school science background.

Some nurses suggested that there was not enough linkage between the undergraduate science and nursing practice and suggested that nursing science needed to be taught with a mix of practical and theory learning. For example *Alice* said "It wasn't until after 5 years of practice that I started to understand the importance of science to my nursing practice". Some nurses felt that more practical work done in the laboratory during nursing training might have helped them prepare for the clinical environment. *Casey* explained during a follow-up interview, "I feel that the polytechnic was responsible for the high failure rate in the science classes as next to no experiments were provided … it is not the same as in a book. First time you see blood would be out of a patient – the first time I saw it was out of a bone sample … it was awful". Nurses discussed how the learning done in the laboratory could become clinically relevant. *Agatha* explained during her interview how the learning she did in a practical session helped her prepare for clinical practice, "You know if you have a green

Pseudomonas[5] – I may only see it once in my whole five years, but …. you retain that". Although not all the activities were enjoyed, some nurses reported that the sights and smells of the laboratory had helped them to retain the learning e.g. "We were told to take the intestines out in one piece … it stuck in my mind" (*Casey*). *Casey* expanded on this when discussing bacterial infection:

> Actually seeing it before your own eyes – you can be told until you are blue in your face that bacteria are spread by hand contact but you don't really know it until you can see it. [It] nails in the knowledge.

Who taught the science courses was important for some nurses, with *June* suggesting that the in-depth knowledge provided by scientists "put them in good stead" for later clinical practice. *Charlotte* added, "In my undergraduate degree we were taught A[natomy] and P[hysiology] and all other related science subjects by the same tutors teaching the medical students. This level of expectation I think is positive for nursing and nurses". However, others felt that science for nurses needed to be taught by nurses rather than "people outside of nursing", because it was felt that the science taught was often "not related to a nursing perspective" (*Pat*).

In summary, it appears as if nurses who were exposed to laboratory sessions found the learning experiences valuable, and they reported that they were able to apply it later on in practice, possibly due to the experience being memorable. There were a variety of opinions from nurses on who should teach science, with some stating that the science teachers had provided them with an in-depth background that they were able to draw upon later, and others discussed that the science needed to have more of a nursing focus. It is interesting to note that the nurse who felt that science was in the nursing curriculum to reduce numbers of students, had a limited background in science (before studying nursing) and felt that the science teacher had taught too in-depth and the science had not been relevant to nursing. This was in spite of her reporting that she had achieved very high grades in her nursing programmes, including science courses.

[5] *Pseudomonas* is a gram negative, clinically important bacteria

5.3.3 *Attitudes to Nursing Science in Practice*

In this section the findings that relate to nurses' attitudes to nursing science in practice are reported. Table 5.5 shows that nurse respondents were in general, positive about the material covered in their science course(s), and disagreed that it had been too in-depth for nursing (83%). The majority of nurses felt that science knowledge forms the foundation for nursing practice (82%) and that nurses required an in-depth knowledge of science (85%). Most nurses felt that they had enough science background to understand the science required in nursing currently (72%), but many felt that they would like to know more (63%). The majority of nurses also report that they found it easy to apply science to their practice (79%).

Table 5.5: Attitude towards Science in Nursing Practice

SASE-for-Nursing Survey Question Topic	Mean *	Standard Deviation *	Proportion who agreed with statement (%)	Proportion who disagreed with statement (%)	Proportion who were not sure (%)
The material covered in the science course(s) was too in-depth for nursing.	3.1	0.7	13	83	4
Science knowledge forms the foundation for nursing practice.	2.0	0.7	82	17	1
It is important for practicing nurses to have an in-depth knowledge of science.	1.9	0.7	85	15	0
My science background is good enough to understand the science needed in nursing now.	2.3	0.8	72	23	2
I would like to have a better knowledge of science than I have at the present.	2.3	0.6	63	34	3
I find it easy to apply science to my own nursing practice.	2.3	0.9	79	14	7
I used to have a better knowledge of science than I do now.	2.3	0.9	41	59	0

* Key: 1 strongly agreed, 2 agreed, 3 disagreed, 4 strongly disagreed, 5 not sure

The data represented in Table 5.5 shows mean values that are centrally clustered (mainly near 2). The standard deviations suggest that few participants indicated extreme views, although the questions about "science being the foundation for nursing practice", "important to have in-depth knowledge of science" and "I find it easy to apply science to my nursing practice" elicited no strong disagreement from any participant. There was a diversity of views presented, with every question eliciting both agreement and disagreement responses. To determine what patterns or relationships if any, the various views (agreement or disagreement) may have with other data sets (such as science background, clinical experience, self-efficacy towards using science-in-practice scores), various correlation examinations were performed.

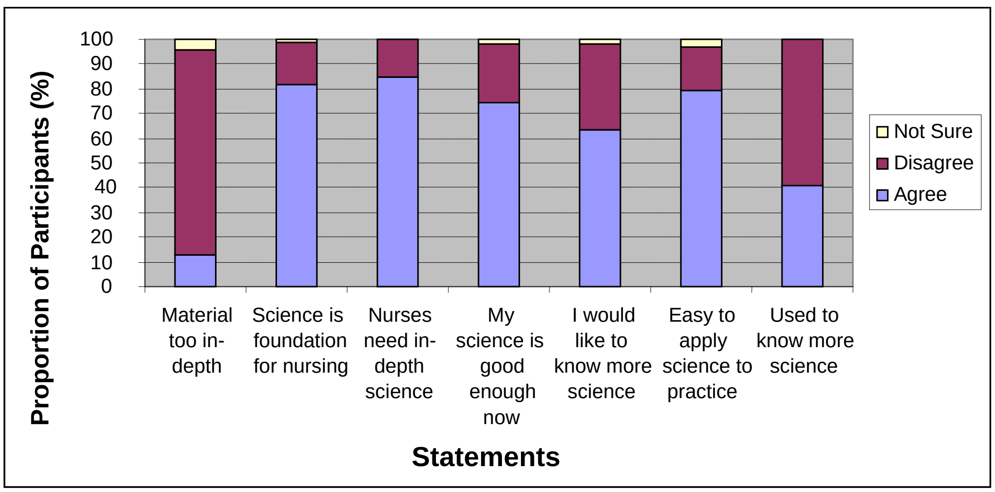


Figure 5.7: Attitudes towards nursing science course(s)

When aligned with high school science achievement, all respondents with Level 3 passes in science disagreed or strongly disagreed with the statement that the material covered in the science course(s) was too in-depth for nursing (see Figure 5.8). However, most nurses in practice, irrespective of science background felt that the courses were not too in-depth for nursing.

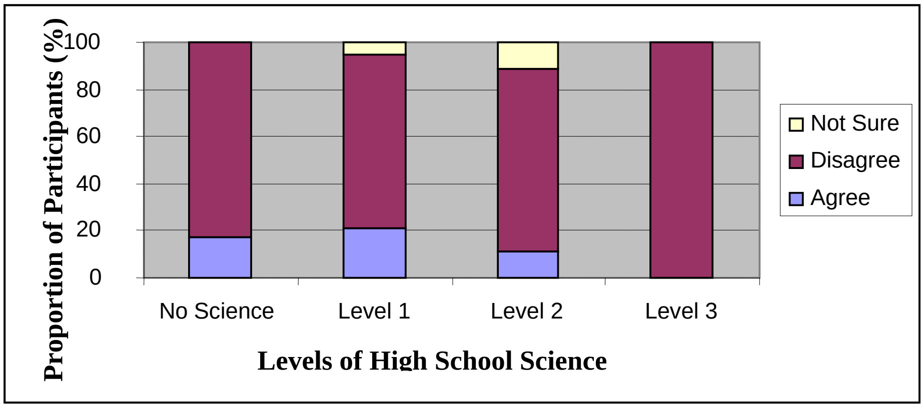


Figure 5.8: Survey participants that found that the material in the science course(s) was too in-depth for nursing (n=71)

When aligned with high school science achievement, nurses with Level 2 and Level 3 tended to agree or strongly agree with the statement that science knowledge forms the foundation for nursing practice (Figure 5.9). Whereas, most nurses with no science passes from high school tended to disagree with the statement (50%) or felt more 'unsure', compared to the other nurses (17%).

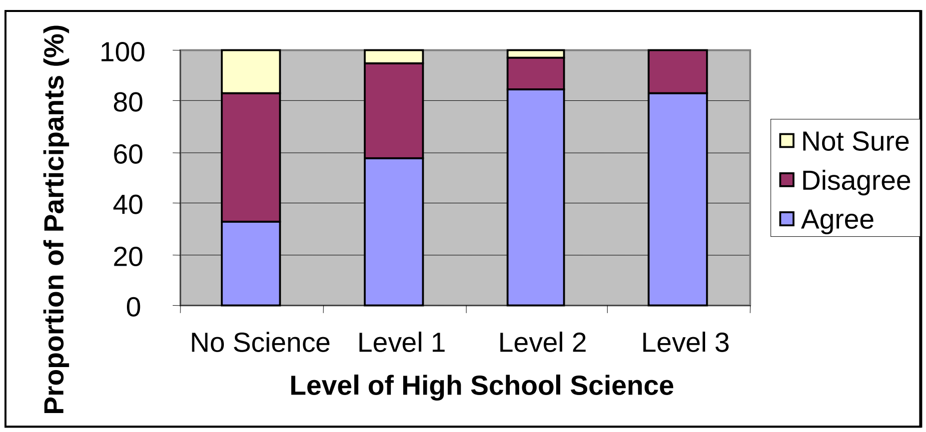


Figure 5.9: Survey participants that felt that science forms the basis of nursing practice (n = 71)

Alex was a nurse lecturer who was between 60 and 65 years old and had originally qualified an enrolled nurse and was quite open during interview about attitudes to the science required in nursing.

> I'll be quite honest. I would hate to be redoing my nursing training now as I don't think I could cope with the level of science

> knowledge that the students have to learn – I also acknowledge that the students have to have the knowledge. *(Alex)*

The literature suggested that some of the bioscience issues relate to undergraduate science courses being too in-depth or not relevant for nursing practice (Davies et al., 2000; Taylor et al., 1981; Thornton, 1997). The results of this study then are unexpected, as it reports that the majority of nurses surveyed felt that the science course(s) were not too in depth for nursing practice (83%), and that science does form the foundation for practice (82%). Most of these nurses also felt that nurses need in-depth science knowledge for nursing practice (85%). Seventy-nine percent of nurses also indicated that had they found it easy to apply science to their own practice.

It could be that the sample of nurse participants who responded to the survey had a more positive attitude to science than other nurses (who may have read the questions then decided not to respond), or it could be that as all the participants were nurses working in clinical practice, that they were able to see how science relates to practice, giving a different perspective than they may have held as a student. Most of the literature that attempts to examine the bioscience issue tends to have focused on nursing students rather than graduates.

5.3.4 Perceptions of Relevance of Science to Nursing

This section reports the nurse participants' perceptions of the relevance of science to nursing taken from interviews and observations. When asked to discuss what science knowledge, if any, the educators/lecturers considered to be the most relevant for student nurses to learn, the main response tended to indicate that, basic biology and chemistry were the most relevant to nursing, with physics probably being the less relevant. *Joanna*, who was a community nurse educator, replied, "Is it biology or is it chemistry? They are part and parcel, you can't go one without the other".

Most nurses felt that biology knowledge was needed down to the cellular level, with *Riley*, a relatively newly qualified nurse saying, "We had a science professor as our tutor so it was a very in-depth paper ... I think at a cellular level, and I believe this set me in good stead for my expert practice now". Whereas *Sheila* who was a nurse who had been a nursing lecturer, then had gone back to practice suggested that nurses are "Never going to talk about cells to a patient – if they want more detail you would refer them to a book, doctor, another source". Most nurses also discussed how basic knowledge of the human body was required. *Joanna*, for example, expressed concern at the lack of biological knowledge students seem to have when they come for clinical practice experience and said, "I am often gob-smacked by the lack of knowledge [of the human body]. Some students have no idea where the organs are placed inside the body".

As noted above, physics appeared to be considered to be the least relevant, but some educators felt it had a role to play, but at a basic level which can then be built up on in practice. As explained by *Alex* (a nurse lecturer), "Physics – pressures and things … that is more specialised knowledge – they only need a passing knowledge – they only need a passing understanding ... not in-depth". One educator who had responsibility for teaching science expressed ambivalence over physics and whether it was needed in the science curriculum. "You could argue that you need physics, but for me at the moment, it is not a priority … but that may reflect my own bias. I think because physics is not something I have done a great deal of … so I query that". Whereas some nurses in practice were able to see direct relevance to physics in practice such as *Agatha* who was a highly regarded nursing expert who specialised in supporting the elderly to maintain independence in their own homes. She also had studied sub-degree level science before becoming a nurse. She suggested that physics was directly helpful in her work as the knowledge of mechanics in terms of lifting patients and helping them to mobilise:

> If you go into a client's home and you are thinking about how they can mobilize, aren't you thinking about physics, how are they maintaining their balance, where their point of balance is, how they work their walking stick.

Another nurse who worked in a similar field (aged support) said something similar. She stated that when she entered a patient's home, she looks for ways she can support the patient to reduce the likelihood of falls, and this required analysing points of balance and environmental risks, as well as identifying where to install hand-rails, so the patient can support their own weight. Both this nurse and *Agatha* work independently in the community and have to rely on their own judgement for the assessment of risks.

Nurse educators interviewed during the course of this study agreed that nursing will need more science knowledge due to changes in the health sector with a need for an advanced nursing role (due to predicted shortage of doctors), and that will have impact for nurses' decision-making and specialised practice. They also suggested that advances in knowledge and technology will continue to impact on nursing knowledge. Nurse lecturers although they tended to agree with the forecast and an increased demand on science knowledge in the nursing role, they implied that the science knowledge would come after specialisation. *Daisy* indicated that nurses will continue to only need "Some basic understanding". *Alex* suggested that they will need "At least what they have now, maybe marginally more, not less, but I don't know how they would fit it in", suggesting that the curriculum is overcrowded.

Some nurses felt that science had limited application to nursing practice and that some nurses were over-inflating their role, hence their need for science knowledge, as explained by *Alex* who was a nurse lecturer, "Some nurses would like to see themselves as 'super doctors' without having to do the six years of medical school. Some nurses have an over inflated worth of the value of nurses". *Daisy*, a nurse lecturer who specialised in community nursing, felt that students needed only to have an awareness and appreciation of scientific knowledge at registered nurse level. She suggested that "you don't want to switch people off by intimidating them with science". She also described her perspective indicating that science has a limited place in the world of nursing:

> They need to know its relevance and its limitations [science] – more they need to have an understanding or be able to critique the value of different sources of knowledge… you don't have to cite verbatim back scientific facts and figures … there is a lot of political issues that underpin [science] – who funded the research?

> Anatomy and physiology doesn't affect your daily decision-making - it isn't our jobs to find out what the issue is. It would be dangerous for nurses to think that they can do this. Some postgraduate papers are heavily scientific to the point of not being useful to the nurse. *(Daisy)*

Many nurses commented on the value of their postgraduate applied science papers such as *Laura*, an experienced acute care nurse, "I have done science post-grad so probably find science/ pathophys[iology] a bit easier than some nurses." She went on, however, to state that the science she did in her postgraduate study was similar to what she had studied at undergraduate level and similar to science expected at senior high school. This was also suggested by *June* and *Joanna*; "My son did seventh form chemistry [i.e., Year 13, or Level 3] and that was the stuff that I did, but postgraduately. It was most helpful [the postgraduate paper] certainly the biochemistry stuff".

> It was all the same stuff I had already learned years ago but you forget. Having been a nurse for few years, doing all that again in such depth was fantastic as it really linked in what you were seeing with the science ... You would be dangerous if you didn't understand. *(June)*

Alex (nurse lecturer) also felt that science was relevant for nurses after graduation, when they had chosen their area of specialty practice and stated that, "[You use science] to a point ... develops when you specialise". This was supported by nurses in practice such as *Pat* who suggested that the science nursing curriculum was too full to learn everything, "There is so much in nursing and you really have to pick what is that basic understanding and later, they can build on it with their applied science". Lecturer *Daisy* suggested that specialisation in practice is probably where science becomes more relevant (as opposed to undergraduate education).

> Within nursing, if someone has an interest and aptitude in that area, they will go and develop… As soon as they complete their degree they will be expected to choose their clinical path and some of those

> will need higher levels of science … I think that nurse practitioners would need a high level of science. (*Daisy)*

Other nurses reported that nurses didn't need in-depth science knowledge from their education, because they were able to pick it up in the clinical setting. *Donna*, for example, was a nurse who had been in practice many decades and who had started off as an enrolled nurse, reported that, "Knowing what happens in the physiology of the patient does help, but I am trying to get my head around that – the longer you are in the job the more you pick up". Some nurses such as *Louise*, discussed how they felt that their science knowledge at graduation was so inadequate, that they had to learn a lot of the science and details required to understand what was going on with the patient from various doctors, while working in clinical practice. *Donna* suggested indicated a similar experience and describes:

> [I knew] very little science – I knew nothing about oncology when I got here, knew nothing about chemotherapy, we have all just picked it up. Patients don't want scientific – you say things like chemotherapy kills off your infection fighting cells and then you are at risk of infection but I picked all of that up from here [practice setting] really.

Others suggested that nursing is so busy and more task-orientated than science-orientated, suggesting that science has limited impact to nursing. *Kelsey*, a nurse in practice, reflected on this saying, "I wonder if nursing has become so task-orientated that the science in nursing is overlooked and nursing knowledge is indeed the way of doing nursing as a practical skill". *Kim* discussed how she felt about practice being so busy, "Sometimes I think nurses are a 'jack of all trades' and master of nothing". Other nurses suggested that nurses can choose to be busy, and do tasks, or they can choose to practice in ways which are more challenging, and less task-orientated. *June*, for example, operates an independent practice and suggested that some nurses like to do a task, then move on to the next one. She says that "Following protocols is not good enough, that is task nursing". Whereas *Sam* suggested that nurses should "Follow the guidelines – you should be safe, rather than thinking, so if there is an issue, we are not liable".

Other nurses in practice suggest that nursing practice does require science-based knowledge. *Lindsay*, a nurse in practice reported, that in her opinion, nurses have to be more responsible for their actions, “Nursing is becoming more science-based in the clinical setting. It is important to be able to understand the whys of treatment, not just the ‘doctor said so’ mentality”. Some felt that without science knowledge, you may not be safe in nursing practice: “Need to understand what you are doing – dangerous if don’t” (*June*). *Tracey* (nurse in practice) felt similar, as suggested by her statement, “It is really great to know the sciences behind it but it was never really stressed that those things are really important. You have someone’s life in your hands, if you miss an observation, that person could die”. As nursing assessment requires decision-making, then understanding what is happening with the patient is important as suggested by *June,* “If you don’t understand, you make wrong choices”.

For many nurses, science is important for communication with doctors, other health professionals and with patients. *Carol,* for example, felt that the ability to translate information into layman terms implies in-depth understanding of the issues and that this is part of caring. *June* also raised this point stating that:

> Caring etc. is absolutely necessary, but there will come a point where you wouldn’t be able to help if you didn’t know science. You have to explain what is going on – it is very caring that you take the time and explain, people respond to it – it is respectful. There is so much information on the internet – if nurses do not understand, consumers will understand more than they will.

June also discussed how she felt that some nurses tend to refer patients on to other health professionals too quickly, “Referring the patient on to a G[eneral] P[ractitioner] is less effective – you could have done health assessment and passed the information on”. Other nurses seemed to rely on other professionals or colleagues to provide patient information and education. *Pat* discussed that if a patient needed to know more about what was in an injection that they were administering, “you would refer the patient to the G[eneral] P[ractitioner]”. *Casey* said, “I am confident about a few things, if I am not, I refer to the house surgeon". *Donna* also discussed how she would access information if she needed to, "we have a very good doctor on site that explains things". She also indicated that she often used a textbook and guidelines but admitted that she "struggles with some of the terminology". *Donna* also indicated that she can find decision-making responsibilities difficult and likes to use colleagues, "I have to make these decisions and took a long time to get used to that and I am still democratic in my decision making".

Jo explained how one of the patients had requested more information on their health condition. *Jo* took the time to search through a university library database for articles that related, and then highlighted the most applicable parts for the patient, taking the time to deliver and discuss them. Other nurses such as *Sam* and *Donna* preferred to use pamphlets and handouts written by others. *Trudy* said "Some patients, you know that are not going to cope with more information" and so also tended to use pamphlets as sources of education and information to the patient. *Daisy,* a nurse lecturer also suggested that nurses have to be weary of providing too in-depth information to a patient "don't want to switch people off by intimidating them with science". Interestingly, the nurses who tended to rely on the information of other 'authorities' (i.e., doctors, colleagues, guidelines, pamphlets, websites) and provided shallow information to patients, indicated less positive attitudes towards science's relevance to nursing in their surveys. They also worked in practice areas where they had access to other professionals. Whereas those nurses who tended to rely on more in-depth sources of information (i.e., databases, peer reviewed journals) where they had to critique, interpret and translate themselves, tended to work in practice areas where they were more autonomous and independent.

Julie, a nurse in community practice who tends to practice independently, suggested that to access funding and extra help to advocate for patient care, nurses have to "use proper terminology, as it helps the client". *Carol* also indicated that participating in a multi-team environment where the doctor/nurse relationship has credibility requires knowledge as the "Doctor has a greater knowledge but you can have a conversation about the parameters and why – very important".

> We are more of a team – it used to be doctor spoke and we were subservient but now they listen and I think they respect us because they realise that our knowledge is important. They want us to be fully aware nurses - why we are doing the treatment and what is happening. (*Carol*)

In general, there was diversity in the perspectives of the relevance of science to practice. Interestingly, the nurses who tended to have the most positive outlook to its relevance, tended to be those nurses in practice who worked more autonomously than other nursing colleagues. These nurses also tended to provide more in-depth information to their patients (as opposed to provision of pamphlets) and considered it as part of being respectful and caring. Whereas those with a less positive outlook to science's relevance in science tended to suggest that the provision of in-depth information to a patient was intimidating and unnecessary. Some of these nurses had postgraduate qualifications, some did not. Nurse lecturers tended to have a less positive perception of science's relevance to nursing, which is of interest as nurse lecturers would be more likely to have power and influence over changes to curriculum than nurses in practice may have. There is general agreement that the topics chemistry, basic physics and human biology (to the cellular level) appear to be important to nursing.

Many nurses discussed that nursing science was best learned when in practice. However, as nurses are now comprehensively trained (i.e., do not select a specialty) it is possible that a nurse may change areas of practice many times during their career. A nurse may become limited in their ability to practice in a variety of areas if they are not able to assimilate the required scientific knowledge of a new practice area. A fundamental science background must help support the workplace learning. Nurses indicated that sometimes their science knowledge at graduation had been so poor that they had to learn their science on the job. Interestingly, doctors (not other nurses) tended to be the source of more in-depth science information that helped them adapt to their new practice environment. It is possible that for these nurses, the relevance of the science knowledge was more visible in practice, and so was more easily retained or applied. This may be why the postgraduate nursing science courses were also considered valuable, even though there are indications to suggest that the content was similar to that taught in undergraduate nursing degrees. This could support the claim from literature that front-loading science knowledge in a nursing curriculum is wasteful (Eraut, Alderton, Boylan & Wraight, 1995).

Some nurses indicated that nursing practice was too task-orientated (protocol-driven) to be concerned with science and the busy-ness of the nursing role makes it difficult to be concerned with details. Those nurses who prefer to operate at a task-orientated level may not be working at a registered nurse level, where decision-making, being able to act as an informed patient advocate and communicate with other health professionals using appropriate language and terminology are all important.

5.3.5 Self-efficacy towards using Science Knowledge in Practice

When the *SASE-for-Nursing* survey was being developed (see Chapter Four), the self-efficacy towards using science in nursing practice questions were trialed. Trialists included those with a nursing background (n = 2), those with a science background (n = 2), those with no science or nursing background (n = 4) including an adult literacy expert. The trialists were subjected to interview to ascertain how they were discerning between values (within a continuum of 10 values). Subjects who participated in the trials were able to articulate why they felt confident when they selected a value near the 'very confident' end of the spectrum. They tended to explain that they felt very confident that they could do that particular task as they were familiar with it, and they also had confidence in their knowledge of the task or topic (see Figure 5.10). When they indicated that they were less confident, they explained that although they had done something similar before, therefore they were confident in their skill level, they were less confident in their knowledge of the task or topic. Those trialists who indicated low levels of confidence (towards the 'very unconfident' end of the spectrum) explained that they felt that they had no knowledge to know how to even start the task. Hence, it appears as if respondents choose the extreme ends of the continuum based on confidence or lack of confidence in their own skills and knowledge, whereas more central responses tend to indicate a confidence in their skills with less confidence in their knowledge behind the skill. It is possible then that the nurses who responded to the survey may have chosen responses at the extreme end of the continuum when they were confident (or not) in both their knowledge and their skill, and the mid-range responses related more to their confidence or familiarity with skill or protocols.

This next section reports the finding from the *SASE-for-Nursing* survey questions (see Appendix B). These respondents were asked to indicate how confident they felt if they had to perform some nursing tasks that were based loosely on chemistry/biochemistry in Questions 25 to 31. The nurses did not have to perform the tasks, just indicate how confident they would feel if they were to perform the task. Nurses who were confident tended to respond between 6 and 10 on the spectrum, with "10" being very confident (possibly indicating confidence in their knowledge basis and their skill level) and those who did not feel confident tended to respond between 1 and 5 on the spectrum, with "1" being very unconfident.

Very unconfident √ _ _ √ _ _ √ _ _ √ **Very** confident

Recipients articulated that a response at the extreme of the "very unconfident" end of the continuum relates to the recipient's lack of confidence in both the **knowledge** and the **skills** required to do the task "*I have no idea. Don't know anything about it*". (Trialist #5) "*Wouldn't even know where to start with that one".* *(Trialist #7)*	Recipients articulated that a response more in the middle of the continuum but near the "very unconfident" end relates to the recipients lack of confidence in mainly their **skills** required for doing the task. "*Not sure what this means. I probably could look it up if I had to*". (Trialist #4) "*I probably could do it if I had to, but I'd be rusty".* (Trialist #3)	Recipients articulated that a response more in the middle of the continuum but near the "very confident" end relates to the recipients confidence in mainly their **skills** required to do the task. "*I probably can do this, but I would have to look it up first*". (Trialist #5) "*It has been a while since I have had to do this sort of thing but I think I could do it."* *(Trialist #2)*	Recipients articulated that a response at the extreme of the "very confident" end of the continuum relates to the recipient's confidence in both the **knowledge** and the **skills** required to do the task. "*I am absolutely confident that I can do this task because I know all about nutrition and I know I could communicate this well*". (Trialist #7)

Figure 5.10: Description of responses from survey trialists for survey self-efficacy continuum questions

Nurses were in general, confident with their ability to calculate and convert calorific intakes (69%) but they appeared less confident in their ability to establish an appropriate diet (54%). Confidence in their ability to describe medication side-effects was relatively high (68%), but they appeared slightly less confident in their abilities to read biochemistry (60%). Nurses were less confident in their own abilities to explain the composition of different saline solutions (54%), and calculate drug dosages (59%). The majority of the nurses were not confident in their abilities to explain radioactive iodine with only 37% indicating some confidence.

Table 5.6: Registered nurses' self-efficacy scores for biochemistry based tasks

SASE-for-Nursing Survey Question Topic	Mean *	Standard Deviation *	Mode *	Proportion who felt confident in own abilities to do task (%)	Proportion who felt unconfident in own abilities to do task (%)
Q.25 Calorific conversion	7.0	3.2	10	69	31
Q.26 Diet recommendation	5.4	2.7	7	54	46
Q.27 Medication side-effects	6.8	2.3	9	68	32
Q.28 Read biochemical test	6.7	2.4	8	60	40
Q.29 Explain saline composition	7.3	2.3	8	54	46
Q.30 Drug calculation	8.9	1.9	10	59	41
Q.31Explain radioactive iodine	4.9	2.8	3	37	63

*Key: 1 very unconfident, 10 very confident (n = 71)

The data indicated in Table 5.6 shows the diversity in responses from the participants. The range for most of the questions was between 1 and 10, although some questions had no "very unconfident" responses (Q.27, 28 and 29). Nurses may have been indicating confidence in their knowledge and skill when they were responding near the extreme ends of the continuum, whereas those in the mid-range may have been indicating their confidence with their skill set. For example, with question 26 which related to diet, it is interesting to relate that nutrition is not necessarily part of the formal part of a nursing curriculum (see Appendix A), and so nurses could be indicating some confidence not in their knowledge, but in their ability to find out the information, and complete the task (skill). The low mean for the question on radioactive iodine may also indicate that the nurse may not have confidence in understanding information about the topic, and so that may compromise their confidence in carrying out the task (resulting in lower self-efficacy scores).

Questions 32 to 37 had a microbiological nursing task focus and nurses indicated high levels of confidence to question 32 which related to aseptic swab taking with all respondents indicating that they felt confident (see Table 5.7). A further 89% indicated confidence in wound dressing and they also felt confident in their abilities to ensure that they did not introduce opportunistic normal flora to immunocompromised patients (89%). They had high levels of self-efficacy about their abilities to explain why antibiotics do not work for viruses (87%) and they also felt capable in describing the differences between specified bacteria with 72% indicating confidence. However, they were less confident in their abilities to explain about antibiotic resistance (46%).

Table 5.7: Registered nurses' self-efficacy scores for microbiology based tasks

SASE-for-Nursing Survey Question Topic	Mean *	Standard Deviation *	Mode *	Proportion who felt confident in own abilities to do task (%)	Proportion who felt unconfident in own abilities to do task (%)
Q.32 Aseptically swab wound	9.5	0.9	10	100	0
Q.33 Aseptically dress wound	8.2	2.3	10	89	11
Q.34 Ensure no cross infection	8.0	1.8	10	89	11
Q.35 Explain antibiotics/viruses	8.2	2.0	10	87	13
Q.36 Describe bacterial difference	7.4	2.4	10	72	28
Q.37 Explain antibiotic resistance	7.5	2.2	10	46	56

*Key: 1 very unconfident, 10 very confident (n = 71)

The data indicated in Table 5.7 shows the diversity in responses from the participants. The range for most of the questions was between 1 and 10, although some questions had no "very unconfident" responses (Q.32, 34, 35 and 36). Nurses may have been indicating confidence in their knowledge and skill when they were responding near the extreme ends of the continuum (such as for question 32 relating to asepsis), whereas those in the mid-range may have been indicating their confidence with their skill set, or familiarity with protocol or task. The responses to questions 36 and 37 (bacteria related) may indicate the nurses confidence in finding information and explaning/describing it (skill) rather than their knowledge of the subject.

Questions 38 to 44 had a nursing task focus based loosely on cell biology (see Table 5.8). Seventy-five percent of nurses felt confident in their abilities to describe the differences between vaccination and immunisation and 69% felt that they could explain how antibodies are produced. There was far less confidence in their abilities to describe genetic testing (51% unconfident). Sixty nine percent of nurses had low self-efficacy (felt unconfident) about their ability to discuss genetic risk but there was more confidence (85%) reported in their ability to discuss blood typing. Most nurses felt able to explain the difference between fever and allergy (90%). Growth and repair was a topic that only 56% of nurses felt confident about describing.

The data in Table 5.8 indicates the diversity of the participants responses to the survey questions. These means are mid-range, possibly indicating that the nurses had more confidence in their skills (finding information, explaining, describing) rather than in their knowledge. As these questions were loosely grouped on "cell biology", it appears as if there may be a skills/knowledge divide when it comes to cell biology knowledge.

Table 5.8: Registered nurses' self-efficacy scores for cell biology based tasks

SASE-for-Nursing Survey Question Topic	Mean *	Standard Deviation *	Mode *	Proportion who felt confident in own abilities to do task (%)	Proportion who felt unconfident in own abilities to do task (%)
Q.38 Describe vaccination	7.4	2.4	9	75	25
Q.39 Explain antibodies	6.8	2.5	9	69	31
Q.40 Describe genetic testing	4.4	2.8	1	49	51
Q.41 Explain genetic risks	4.1	2.8	1	31	69
Q.42 Discuss blood typing	7.8	2.5	7	85	15
Q.43 Explain allergy or infection	6.4	1.9	10	90	10
Q.44 Describe growth and repair	6.3	2.3	4	56	44

*Key: 1 very unconfident; 10 very confident (n = 71)

Calculating the average self-efficacy scores across all respondents and all questions, the mean for the scores for self-efficacy towards using-science-in-nursing practice was 7 which were more towards the "very confident" side than the "very unconfident" side. Across the three science categories of biochemistry, microbiology and cell biology, the average scores were 7, 8 and 6 respectively.

As all the nurses were in practice, the confidence reported towards the microbiological tasks may reflect their familiarity with the tasks presented. Literature reports that microbiology and asepsis tends to be ritualistic and routine suggesting a reliance on protocol-driven practice (Trnobranski, 1993) hence this confidence may not be influenced by knowledge of fundamental microbiology, but more on their familiarity with the protocols. Many nurses had low levels of self-efficacy towards the genetics tasks, and this is interesting because literature reports that many schools have not taught genetics, and there is great diversity in what is taught when it is taught (Nicol, 2002).

Aligning the self-efficacy scores with levels of secondary school science passes showed that the nurses who had achieved at Level 3 high school science tended to be slightly more confident in the cell biology tasks, whereas there is no distinction for the microbiological tasks (see Figure 5.11). Those with no science background before nursing training had less confidence in biochemistry compared to those with some science passes from high school.

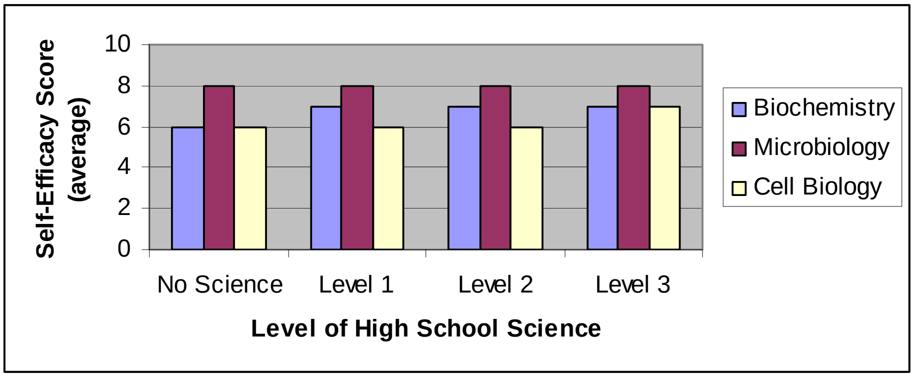


Figure 5.10: Average self-efficacy scores in each subgroup discipline (n=71)
Key: 1 very unconfident; 10 very confident

Some analysis was performed to investigate if there was any relationship between scores in self-efficacy with types of practice areas. While nurses had a variety of clinical experience from a variety of different areas, the analysis was done on areas of current practice - primary setting (n = 34), acute setting (n = 23), mental health (n = 5) and aged care setting (n = 5) with the remainder of nurses stating that their main area of practice was administration/education (n = 4), (and hence were not part of this analysis. It appears that nurses currently working in mental health indicated slightly less confidence in microbiological tasks than those nurses working in other areas but more confidence in tasks utilising biochemistry and cell biology (see Figure 5.12). Given that possibly the nurses in mental health are not so concerned with asepsis, but in fact may have more concern with biochemistry and cell biology (pharmacological management of mental illness etc.), then this may explain the variations in terms of self-efficacy towards science based tasks. That is, microbiological tasks may not be routine for them.

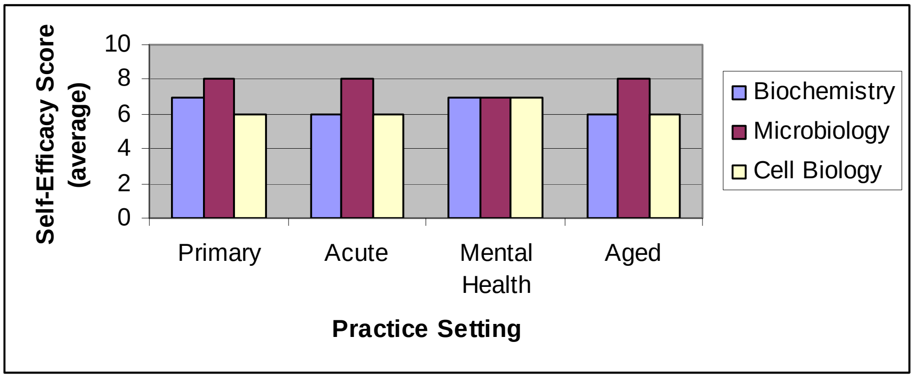


Figure 5.11: Average self-efficacy scores grouped according to practice setting (n = 71) Key: 1 very unconfident; 10 very confident

Some analysis was performed to relate scores in self-efficacy with practice experience to see if length of practice influenced self-efficacy scores. It was found that those currently working in mental health had the highest number of years of practice experience (mean of 23 years from 5 participants), followed by those in primary health (mean of 16 years from 34 participants), an average of 8 years (from 5 pariticipants) for aged care, and an average of 15 years practice for those currently working in the acute environment (n = 23). Hence, it seems unlikely that for this sample, length of clinical practice had influence on the self-efficacy scores. For example, those who indicated that they were currently in mental health areas of practice tended to have lower confidence in their own ability to do the microbiology based tasks, yet they had the highest mean of clinical practice years (23 years). Also, the nurses with the lowest mean for clinical practice (8 years) did not have a self-efficacy score profile (as a group, see Table 5.12) that was any different from the nurses in acute practice where there was a mean of 15 years of clinical practice. Likewise, nurses working in acute care had a similar mean of clinical experience (16 years) as the primary care nurses, but had different self-efficacy score profiles.

5.3.6 Summary of Attitudes and Self-efficacy towards Sciences

In general, the nurse participants were positive about their nursing science course(s), with most of them indicating that they had found their science courses easy, and that the readings, language and terminology of the course(s) had been easy to learn (see Table 5.4). Most participants also reported that they had not worried more about science courses than their other courses. This is in contrast to the literature which had examined attitudes of student nurses who tended to find that their nursing courses difficult and they had worried more about the science courses than their other nursing courses (see Chapter Two). The majority of the nurses were also positive about science's relevance to nursing, reporting that they considered that the science course(s) had not been too in-depth for nursing practice, that science does forms the foundation for practice, and that nurses need in-depth science knowledge for nursing. Most nurses also reported that they found it easy to apply their science to their own practice.

Those nurse participants who had been successful at high school Level 3 science were more likely to report that their nursing science courses had not been too difficult. However, those nurses who entered nursing school or training without any science background tended to have experienced more difficulty with the science courses they took during their training. It could be that the sample of nurse participants who responded to the survey had a more positive attitude to science than other nurses (who may have read the questions then decided not to respond), or it could be that as all the participants were working in clinical practice, they were able to see its relevance and have a different perspective than that of a student. Most of the literature that attempts to examine the bioscience issue tends to have focused on nursing students.

Nurse lecturers tended to have a less positive perception of science's relevance to nursing which is of interest as nurse lecturers would be more likely to have power and influence over changes to curriculum than nurses in practice may have. There is general agreement that chemistry, basic physics and human biology (to the cellular level) are all important to nursing. It appears as if nurses who were exposed to laboratory sessions found the learning experiences valuable, and they reported that the learning was able to be retained and applied in practice. It is interesting to note that the nurse who had a less positive attitude to science (in terms of its relevance to nursing and in their attitude to learning science) indicated that a nurse was more appropriate to teach nursing science (than a science tutor). Other nurses who preferred to use information supplied by 'authorities' such as doctors, guidelines and other colleagues also indicated that patients do not like to be provided with too much information and tended to suggest that patients were intimidated by scientific knowledge. This was in contrast to other nurses who were working in autonomous and independent practice situations who discussed how their in-depth teaching by their nursing science teacher had prepared them well for practice. These nurses also tended to suggest that supporting patients by being able to access in-depth information was respectful and part of caring and these nurses did not seem to rely on information from other colleagues, but appeared to be more self-reliant (in terms of being scientifically literate such as being able to access, critique, and interpret scientific information).

Many nurses discussed that nursing science was best learned in practice. Doctors (not other nurses) tended to be the source of more in-depth science information in the practice environment. It is possible that the practice setting made the science knowledge more relevant as it was directly applicable to their work. This may also explain why the postgraduate nursing science courses were considered valuable, even though the content appeared similar to that which is taught in undergraduate nursing degrees, possible indicating that science taught in the first year of the nursing degree (front-loading) is not easily retained.

Nurses who had a secondary school background in science (that is, they passed Level 3 or equivalent science courses), tended to have had less difficulties with nursing learning science than those with no or less science background. They also appeared to have a more positive attitude to science's relevance to nursing, than those with less (Level 1 or 2) or no background. There appears to be no relationship with the length of clinical experience, but there may be a link with areas or types of clinical practice.

Nurses that choose mid-range levels of confidence in the self-efficacy questions may be indicating their confidence towards application of a skill, or their abilities to do a task which might be considered routine, familiar or protocol-driven in their area of clinical practice. Whereas those who indicated high levels of confidence in their own abilities to use science in their practice appear to be indicating confidence in both their knowledge of the science behind the task, as well as application of the task itself. In general, the biochemistry grouped tasks showed a skill/knowledge divide indicating with few nurses indicating confidence in both their knowledge of the science behind the task, and their skills in carrying out the task (see Table 5.7). The microbiological tasks indicated high levels of confidence, possibly due to the tasks being very protocol-controlled and familiar within nursing (see Table 5.8), except for those engaged in mental health practice, where aseptic practice is not necessarily routine. The cell biology tasks appear to also indicate a skill/knowledge divide as means were clustered in the mid-range area for those questions (see Table 5.9).

5.4 Chapter Summary

The nurses who participated in this research had a wide variety of practice experience and were relatively representative of the New Zealand nursing workforce. The sample of nurses observed was similar to the surveyed population in that most nurses studied had Level 1 or 2 high school science course passes, but the observed population had less numbers of nurses with Level 3 science background than the survey population did. There were also more nurses who had no science background (or high school science passes) in the observed population (24%) than in the survey population (8%).

Nursing Council documents show that science knowledge is required in nursing education but the depth of breadth is not evident, and so curriculum design in nursing schools is subject to variation across the country. Curriculum design is reliant on feedback from the nursing workforce which may not be able to articulate the depth and breadth of science required for clinical practice. Curriculum design may be influenced by personal beliefs and attitudes towards science in nursing by those individuals who hold power and influence. The science curriculum is therefore subject to change and variation as the foundational knowledge that informs nursing and how it informs nursing, is not established.

Those nurses with some background in science (as indicated by high school passes at senior high school) appear to have more positive attitudes towards the importance and relevance of science in nursing compared to other nurses, and in general, had not found their nursing course(s) difficult. Nurses with positive attitudes towards science were more likely to access sources of in-depth information and appeared to be more self-reliant (in terms of engaging with scientific information) in practice. Nurse lecturers appeared to be less positive in their attitudes towards science's relevance or importance in nursing compared to their colleagues in practice (nurse educators).

While the sample size is low it appears that confidence in performing science-based nursing tasks may be influenced by a nurse's practice experience. For example, nurses in mental health may not normally be overly concerned about microbiological issues and so they may have lost some confidence in their ability to perform some tasks (or lost confidence in their ability to perform a skill), in comparison to other nurses who may have asepsis as a constant concern. The tasks that related to biochemistry and cell biology indicated more of a knowledge/skill divide than that for microbiological related tasks, which possibly suggests that nurses may have confidence in their skills (such as finding out information, explaining, or describing to a patient), but may not have as much confidence in their knowledge of the topic, as indicated by a mid-range response in the self-efficacy scores. When the self-efficacy score was near the unconfident end of the continuum, the nurse may be indicating a lack of confidence in their own knowledge base which may impact on their ability to perform the task (i.e., explain to a patient).

Confidence in performing these science-based nursing tasks do not appear to be linked with the length of time the nurse has been in practice. While the sample size is low it does appear that confidence in performing science based nursing tasks may be influenced by a the nurse having a senior high school (Level 3) background in science. This may be due to the nurse having a more positive attitude to science and so being more comfortable with their knowledge base with which to tackle the tasks.

CHAPTER SIX
FINDINGS - APPLICATION OF SCIENCE IN NURSING PRACTICE

Overview of the Chapter

This chapter begins with a description of nursing practice that occurred in the nursing clinical environment. It then addresses the types of scientific information that were used by nurses in their clinical practice. This information was taken from the nurse observation phase of the study, together with the follow-up interview statements which were examined and categorised into topics. Topic statements were then categorising according to depth of knowledge. A comparison of the nurses' depth of topic knowledge with the nurses' self-efficacy towards using science-in-practice scores was also performed and is then described.

6.1 Science Used in Registered Nurse's Clinical Practice

Registered nurses are required to undertake nursing assessment and make decisions about patient care. Nurses were observed in practice to ascertain if science knowledge contributed to their decision-making and their practice.

6.1.1 Registered Nurses' Clinical Practice

In any clinical environment, registered nurses tend to perform assessment, prepare and carry out procedures or tasks, and provide health promotion and education to patients/clients/service users. Nurses might not conduct all of these duties for any one patient or situation or in this order. Jarvis (2000) suggests that the assessment phase of nursing practice may be shared with other health professionals – such as taking the patient's history and physical examination which may be shared with doctors or specialists, but the focus of the assessment tends to be different. A medical doctor evaluates the cause of disease whereas the nursing assessment tends to assess the whole person. The doctor may listen to a patient's breathing (say, asthma) to prescribe a medication which may assist the patient, whereas the nurse listens to the patient's breathing to monitor the response to the treatment, and provide support measures and education. The assessment part of practice varies depending on what type of clinical environment the nurse is engaged in, and this usually involves communication with the patient, and the collection of data (patient's history, analysis of medical record/tests). Objective and subjective data are both documented. A nurse will usually make a decision on what to do next based on the information gathered, such as performing a procedure like removing a dressing or taking blood pressure. If the nurse performs a procedure, then there could be a phase of preparation that includes preparing the clinical area or materials. Sometimes a nurse may be instructed to perform a task or procedure by another health professional. The actual undertaking of the procedure would then follow – this may involve a physical examination, taking vital signs, dressing wounds, vaccination, administering medications and so on (either decided by the nurse or by another health professional). The nurse might then provide more information to the patient (health promotion or education), or refer the patient to another service provider if required (specialist, dietician, nurse specialist, etc.).

The following sections examine what science was being used by the registered nurses during their clinical practice.

6.1.2 The Types of Knowledge used by Registered Nurses

During the observation phase of this study, the practice of nurses was recorded via field notes, and nurses subsequently participated in in-depth interviews to ascertain the science knowledge behind the observed activities. Questions posed during the open ended interviews were guided by the observations of the nurse's practice, as indicated in the field notes. This usually took the form of 'set' questions to establish the depth of information that the participant was using. The 'set' questions started with re-stating the action that was observed so the participant could confirm or verify the action that was observed. This usually was usually followed up with "why" or "what" questions – that is; Why did you ask/do (action/task); What were you looking for? What does this mean? For example, if a nurse prepared a patient's arm for an injection using alcohol wipes, the questions used to explore the nurse's knowledge and how it influenced the action were; "With patient X, did you give him an injection into his upper arm?" The response will verify or correct the observation. Questions that ascertained the knowledge base that was informing the action included: "When you were preparing patient X for that injection, you wiped the injection site with an alcohol wipe, why was that?" Here the response may contain some rationale for the action that may have some science in it. The questioning then continued to delve deeper into the context, to attempt to uncover how much science the nurse was using to support the nursing action. For instance, using the above example, if the nurse's response related to the alcohol sterilising the skin in the area before the injection is given, the subsequent questions would be asked relating to why the nurse felt it was important to do this, what are the risks from not doing this, what are the type of microbes you wish to remove from the arm and why; how does alcohol do this; and continuing the line of investigation until there are no further responses. The same observed action also could ellicit a line of questions that relates to the injection site, or the type of medication being administered, and so on. Due to the open ended, unstructured nature of the interviews, a variety of topics that involved the use of science were discussed, and captured as data, and these were placed into categories or topics (see Tables 6.1 & 6.2). Table 6.1 presents the categories of science-related topics with the number of statements made by the nurses that were coded into the category, the rationale for categories and an example statement. Table 6.2 contains categories that are not science-related, for example, statements that related to nursing activities such as bed making or behavioural management were put into a category called *Nursing*. The *Education* category contained statements that were the nurses' opinions of nursing education and *Politics* was another non-science related category that contained statements that related to nurses' opinions on their work conditions or other related topics.

As can be seen in Table 6.1, the most common discussion topic related to human biology – normally referred to as anatomy and physiology. Other topics such as cell biology and pathophysiology were included under the category of *Human Biology* for the purposes of this study, with no further distinction being made. Nurses often discussed various aspects of their work which highlighted the *Relevance* of science to their practice, and this category was the second most common topic. *Microbiology* was the next most common discussion point – some topics that related to immunity were categorised under *Microbiology* (not *Human Biology*) if, for example, they were related to vaccine production or efficacy. *Monitoring and Recording* was a category related to discussions about documentation or observation. Other less frequently mentioned topic categories were *Chemistry, Information Skills, Physics, Pharmacology* and *Laboratory Tests.*

Table 6.1: Categories of Science-Related Topics that Arose from Statements during Observation/Interviews with the Registered Nurses about their Clinical Practice

Category	*n*	*Rationale for category*	*Example statement*
Chemistry	14	Discussion statements that focused on molecular aspects that require some chemistry knowledge.	"Electrolytes – charged chemicals, molecular structure is probably too much" *Agatha*
Decision making	5	Statements that highlighted how nurses were using science knowledge to inform their decision making.	"Chest pain dull or sharp – cardiac or respiratory – if sharp I look at respiratory way, if it was dull, head off to cardiac" *Sam*
Human Biology	181	Statements that related to the anatomy and physiology of the human body including biochemistry, cell biology and patho-physiology.	"The veins are now breaking down – blockage in leg" *Julie*
Information Skills	43	Discussions on how nurses access information and perspectives on information sources.	"Googling is a starting point but you have to critique it" *Agatha*
Microbiology	156	Statements that were about microorganisms, asepsis or the production of vaccines	"*E.coli* means nothing much to me" *Carol*
Monitoring and Recording	84	Discussions that related to documentation or observation	"Our role is to monitor, note and discuss making sure that the doctors is aware of what is happening that there is a change" *Carol*
Pharmacology	63	The focus of the comments was about medicines or administration of medicine.	"Recommend that she carries on with the same dose as it is not harmful" *June*
Physics	4	Comments that showed that the nurse had some understanding of some physics concepts.	"I don't move watches – but I make sure there is no metal to metal" *Sam*
Relevance	168	Statements that highlighted science's relevance to the nurse's practice.	"Science gives you confidence because you understand things" *Drew*
Laboratory Tests	24	Discussion focused on laboratory testing or the interpretation of tests.	"Had to learn about blood tests on the job." *Pat*

Table 6.2: Categories of Non Science-Related Topics that Arose from Statements during Observation/Interviews with the Registered Nurses about their Clinical Practice

Category	n	Rationale for category	Example statement
Education	69	Opinions or perspectives on nursing education including science and clinical experiences	"I can't just absorb from a book" *Lauren*
Nursing	70	Comments that related to keeping the patient comfortable such as bed making or aspects of behavioural management.	"I change my voice to try and get it more relaxed and slower" *Sam*
Politics	17	Employment conditions, or issues relating to the nursing workplace or nursing in general.	"I am concerned that some nurses wish to have all the rights of our medical colleagues, without the responsibility" *Casey*

When the non-science related discussion points were removed, the remaining topics (*Chemistry, Human Biology, Information Skills, Microbiology, Monitoring and Recording, Pharmacology, Laboratory Tests,* and *Physics*) made up the topics that were the most relevant to science curricula.

As this thesis is concerned with the use of science-related knowledge in nursing clinical practice, the following section discusses how observations and statements which emerged from the data were grouped into the science topic categories (*Chemistry, Human Biology, Information Skills, Microbiology, Monitoring and Recording,Pharmacology, Laboratory Tests,* and *Physics*).

6.1.3 Categorising of Science Knowledge used in Practice

As suggested above, the *Human Biology* category was something of a catch-all section for anything related to structure and function of the human body, irrespective of whether it was macro-biology (e.g., names of muscles, or organ functions) or micro-biology (e.g., cells, tissues and biochemistry of molecules). For example, the *Human Biology* category contained statements related to structures in the body such as "safe sites to inject are the leg or upper quadrant or deltoid" (*June*) which could be classified as anatomy, but for the purposes of this study, was classified as *Human Biology* without making any further distinctions. Other statements such as "use saline as it is compatible with intracellular fluid"

(*Charlotte*) might be considered to be cell biology, and “Vitamin B12 aids in the production of blood cells” (*Charlotte*), coud be seen as physiology, nutrition or even pathophysiology (here the context was about vitamin B12 deficiency), yet they were all classifed as simply *Human Biology*. Further categorising into distinct topics such as physiology, biochemistry or nutrition was deemed impractical. Statements such as “diet is important, we recommend that the patient goes back to check their ketone levels as they might be getting breakdown of muscle” (*Jordan*) is *Human Biology*, and to classify it further, as being physiology, biochemistry, nutrition or even pathophysiology was not considered meaningful. The large category of *Human Biology* was the most pragmatic approach to categorising statements that related to human form and function. It also highlighted how integrated the knowledge was in practice, whereas in formal nursing curricula, one knowledge area is often artificially separated from another usually in the form of topics, courses or modules.

Categorising statements as microbiology (the study of bacteria and viruses, etc.) and immunology, was challenging with the obvious connection to the human body. As a consequence, any statement that related to how the body reacted to the prescence of microbes was categorised as *Human Biology*, whereas any statement that tended to focus on the microbe or use of the microbe to aid immunity (such as vaccines), was classified as *Microbiology*. This section also contained statements on hygiene and infection control (including statements related to supporting healing) such as “dressing activates under water releasing silver onto the wound bed … good antibacterial, lays antibacterial properties in wound bed but also prepares for healing” (*June*).

Pharmacology was categorised by topic statements that clearly related to medicines – either the act of administration, “standard recommended dosage is two puffs” (*June*), interactions between medicines, or even the mode of action, “pain relief goes through the liver” (*June*). Although there is also a clear link with physiology, the focus was the medication and knowledge of the drug and its effects in the body. *Chemistry* and *Physics* however, tended to be identified through specific statements such as “need to know how the [dressing] product works – it’s a chemical reaction” (*June*) and “jewelry can cause an electrical arc”

(*Taylor*). *Chemistry* in this case was clearly more classical chemistry, although the link with what the dressing product was doing in the wound could be microbiological (infection control). However, the focus of the nurse's statement was on the chemicals and their interaction with each other when active.

Some statements were clearly identifiable as focusing on *Laboratory Tests*; such as "some tests are time sensitive and you have to send the patient to the lab as they need to be processed with time frames, such as calcium" (*June*); while others were about interpreting laboratory tests; "Full blood count will give haemaglobin level – if it is low you need to transfuse them so that is what I would look for" (*Taylor*). These statement types constituted the category of *Laboratory Tests*.

Monitoring and Recording was a category that contained statements that were about measurement of data such as blood pressure, weight or lung capacity, and also clear, concise documentation and recording of that data to enable monitoring of a patient. Many statements related clearly to the importance of watching for changes by establishing base line measurements, and to the proper documentation of data: "If you haven't written it down, it didn't happen" (*June*). Whereas the category *Information Skills* contained discussion points that related to how nurses tended to get their information, or their perspectives on various sources of information. Protocols and guidelines for practice were often discussed with various perspectives such as; "Guidelines are good but I like to know why did they make those decisions and where did they get the information from" (*Jordan*) to: "Guidelines and protocols for the regional service – everything is in there and that is what we go by" (*Donna*). There were discussions showing an awareness of information types and what it needs to go through in order to be rigorous, with comments such as; "Randomised controlled trials – they have done the hard yards and condensed it into an easy to read formula that I can say I base my practice on" (*Sam*). Within nursing, there is a general understanding that practice needs to be based on evidence, however, sources of information that are commonly used by nurses included the Internet, Google and Wikipedia, as well as other colleagues; "If I don't know, I always touch base with colleagues or other agencies" (*Julie*). Another frequently used source of information in practice was textbooks, although many nurses discussed how they were too busy to look information up. Other nurses felt that looking things up was part of their professional responsibility, irrespective of their workload. A more available and instant source of information tended to be posters – many contained considerable amounts of scientific information that nurses relied on to inform their decisions and education of patients: "This poster on the wall about colds, tonsils … Anatomical poster of the head/throat … I use it a lot [in winter]" (*June*).

As seen above in Table 6.1, *Relevance* of science to nursing also featured strongly in the nurses' discourse of their practice and findings related to this area are presented next.

6.1.4 Relevance of Science to Nursing Practice

Statements that tended to indicate the *Relevance* of science knowledge to nursing practice were grouped together. This included statements on topics that were considered by some participants to be not relevant to nursing practice, but may have been covered in formal nursing science courses such as; "Krebs cycle, atoms, covalent bonds". *Pat* felt that these topics were irrelevant to practice and topics that were considered to be more relevant to nursing were also included, such as reading blood tests.

It also contained statements that shed light on nursing's use of science, such as the following:

> Came out thinking [after graduation] that "oh my god I know nothing". Tasks are tasks, anybody can give an injection and dress a wound – so many different products out there, you couldn't know all about them anyway. Stuff and science – the 'ooh, that is why that happens', that is why these levels are out and this person is experiencing this. [Nursing education] needs more science that applies to nursing. *(Julie)*

There were various statements that suggested that, depending on the area of practice, the science knowledge gained from education or previous clinical experience may be forgotten. For example *Sam* said, "pathophys[iology] is very interesting but you tend to forget the details if you are not using it … not necessary to learn 100 conditions, every ward that you are in, main job is assessment". There were other comments that related to nurses not being able to know everything. Some nurses indicated that their in-depth education helped even if they had not retained all the details, "Forgot the underlying knowledge but if you teach the underlying knowledge behind it as it makes people more aware of the principles". Their science knowledge appears to have helped inform them of what the possibilities of an abnormal observation could be, even if they were not completely familiar with the issue, condition, or disease state. *Sam* discussed how nurses "Learn the bottom layers, forgotten we ever learned them, but I know somehow that it is right, but if you were to ask me how I wouldn't be able to articulate it", implying that the knowledge or information was familiar, but not necessarily available for recall. This may suggest that there are multiple layers to the nurses' knowledge – in-depth and wide breadth of teaching may increase the nurse's confidence to be able to re-engage with the knowledge and information when they have to, with a small snippet of information being retained.

Some comments also highlighted how science knowledge used in nursing practice may go unrecognised, such as:

> Lot of it is unscientific; a lot of it is going on your feelings. An evasive feeling that something is not correct – subconscious, an intuitive thing – can take 20 minutes of discussion [with patient and colleagues] to try and figure out what is going on. (*Casey)*

In this context, the nurse was discussing how they have to keep one step ahead, trying to conduct risk assessments on what might happen next, or what to watch for, as they are observing and monitoring for change. Yet, it was described as "unscientific". While there is no doubt that there is intuitive skill in observation, in theory this would be enhanced by knowing what possibly could go wrong, and so knowing what to look for. This nurse suggested that this was initiated by a "feeling" but it could be argued that this may have been initiated by skilled observation due to knowing possible risks and how they may manifest. The act of decisively trying to establish what was happening could be deductive based on observed data, which is clearly a scientific process (but not the exclusive domain of science).

Some comments related to how important it was to ensure that a nurse knew what they were talking about for example, *June* said “We make decisions in this role … legally you need to know what you are talking about to make those decisions and explain your actions”. Nurses also discussed how their nursing practice altered once they had more science knowledge. For example, *Sam* stated that “Working in ED [emergency department] I knew what to do to fix people but it was not until I was teaching that I realized what was happening – it didn’t change my treatment, it just helped me educate people”. Nurses suggested that the science knowledge reinforced their practice by reassuring them that they were doing the right things and gave them the confidence so that they could adapt their practice if needed.

> [Science] informed my practice with wound management. I knew what to do but it has made me a lot more aware – I have changed the products that we use here. I developed access to more handouts – and was able to explain to a patient. (*Sam*)

Some nurses in the study had initially qualified as enrolled nurses and felt that their activities then may have been task-orientated only, and that they were oblivious to risk; as one said; “We thought we were delivering safe nursing care, then I started to get knowledge behind what I was doing and I realized …. we were just doing as we were instructed to do and as we have always done, with no understanding” (*Alex*). Other nurses who started their nursing career as an enrolled nurse made similar comments regarding their decision making abilities once they became registered nurses.

> Didn’t change my practice [becoming a registered nurse] - as an enrolled nurse I would discuss with others – now as a registered nurse suddenly I have to make these decisions and it took a long time to get used to that and I am still democratic in my decision making”. *(Donna)*

A category called *Decision making* was also established and contained statements that showed how the science knowledge was used to make decisions. Nurses discussed how nursing had changed, for example, “In the old system you were expected to notice things, but not make any decisions based on it … Wouldn’t say it is the case in 2009 – lot more is expected … autonomous decision making" (*June)*. This autonomous decision making usually related to nursing assessment. Nurses suggested that the more assessments they do, the easier it is to help the doctor diagnose and as one said, "When people come in you exclude different things. To look at something, could lead somewhere else, and if you don't ask the questions you don't find out" (*Carol*). The nursing assessment is not to achieve a diagnosis, but to try and pre-empt risks and make decisions about the best care that would be required for the patient. *Casey* explained the decision-making process, "What is the likely path for this pathway – look outside the box". Sam gave an example of how the process of decision-making worked:

> Chest pain dull or sharp – cardiac or respiratory – if sharp I look at respiratory way, if it was dull, head off to cardiac – I'm assuming that it was respiratory so asked respiratory based questions like, is it worse when you cough or deep breathe. "Are you coughing?" If she said not I would have been asking more about radiation, shortness of breath, the cardiac way – where am I heading with this lady to keep her safe? (*Sam*)

These categories make up the topics that were extracted from the statements taken from nurses in practice, after observed actions. When the non-science related topics were removed, (that is, *Education, Nursing* and *Politics)*, the remaining topics (*Chemistry, Decision-making, Human Biology, Information Skills, Pharmacology, Microbiology, Monitoring and Recording, Laboratory Tests* and *Physics*) made up the topics that were considered the most relevant to science curricula.

In summary, observation studies of nurses in practice resulted in interviews where nurses discussed their knowledge behind their nursing practice. The statements that were taken from the interviews were analysed, grouped and categorised into non-science related statements or opinions, or science-related discussions. A total of 931 statements were categorised. The science-related statements were further grouped into categories that related to science tasks or activities and science topics. Further analysis of the science related topics that would be relevant to a nursing science curriculum are discussed next.

6.2 Depth and Breadth of Science Curriculum Topics

The science knowledge behind the observed practice of the nurses in the clinical area was also grouped according to perceptions of the depth of the knowledge being articulated (see Table 6.3). That is, after coding the statements into the categories above, the statements were further coded by using a scale of 0 to 3 which related to the perceived depth of articulated knowledge. These designations of depth relate to whether articulation of the science knowledge that underpins the observed action was either *absent* (participant appeared to follow learned protocols or procedures with no articulated idea of significance or relevance and so science knowledge appeared to not be utilised) which were coded as 0; or appeared to be based on *shallow* knowledge only (nurse could appreciate that a concept or concepts were relevant but could not articulate details) which was coded as 1; or if the science knowledge appeared to be *deep* (i.e., the nurse could articulate the relationship between the action and the science) was coded as 2: if a participant was extending the knowledge relationship between the action and the science further, or demonstrated a global understanding of various concepts, then this was coded at the *deepest* level of 3 (see Table 6.3). This coding system is referred to as the 'scale of depth'.

An example of an action codified as 0 was when *Lee* was taking a patient's blood pressure. The nurse lifted the patient's clothes before securing the cuff. At interview, the nurse was asked why she did this and she was unable to explain other than she was taught to do it that way. An example of an action codified at 1 was when *June* was taking blood from a patient for a routine test. The nurse knew that this patient had high levels of anxiety about having blood drawn and so she chose a vein and did the procedure quickly.

Table 6.3: Description of Scale of Depth of Coding Applied to Observation/Interview Statements

Code	Description	Comment	Example
0	Participant appeared to follow learned protocols or procedures with no indication that science knowledge was being utilised.	Articulated knowledge behind task is absent or at a very basic level. **Knowledge is shallow.**	"Taught to do it that way. Don't know the reason why." *Lee*
1	Participant could appreciate that a science concept or concepts were relevant but could not articulate details.	Some evidence of a scientific concept is understood but no relationship between facts or ideas are evident. **Knowledge is shallow.**	"Don't need to remember names of veins. If you need to tell someone else, can look it up." *June*
2	Participant could articulate the relationship between the action and the science.	Connections are made between science facts and ideas but meta-connections, details or significance is missing. **Knowledge is deep.**	"Some people with congestive heart failure the pump is not getting it back, so [fluid] accumulates lower" *Sam*
3	Participant was able to extend the knowledge relationship between the action and the science further, or demonstrate a global understanding of various concepts.	Appreciation of other connections not only with given context and concept. Appreciation of significance of science concept, facts and ideas and their relationship with the whole. **Knowledge is deep.**	"I try and relate it so if you don't have enough of this, then this is not going to happen – like potassium and sodium pump - actin in the muscle, synapses, the brain" *Agatha*

At the interview, the nurse was asked if she knew the name of the vein that she withdrew blood from, and her response was that she did not, but if she had to, she could look it up. She indicated that although the knowledge was not at instant recall, she would have no problem with the terminology of an anatomy book as she was somewhat familiar with the anatomy of the circulatory system. An example of an action coded at 2 was when *Sam* was conducting an electrocardiograph on an elderly patient. As the nurse was applying the electrodes to the lower extremities, the nurse noted that there was some swelling around the ankles. When questioned during the interview what was the significance of that clinical manifestation (swelling), the nurse was able to explain that it was indicative of congestive heart failure due to the pump (heart) not working efficiently and so swelling may occur in the lower extremities. The nurse went on to say that the condition was already diagnosed so it was not their job to do anything further about it.

An example of an action coded as 3, was when *Agatha* was discussing how important she felt it was to know in-depth scientific details, and how they can support nursing practice. For example, she said that many nurses consider that knowledge of the sodium/potassium pump is too in-depth for nursing, however, she was able to articulate connections with other facts or ideas such as actin in the muscle, synapses in the brain, which she then related to nursing practice such as knowing to talk slowly to a patient who had an issue that affected synaptic function. This nurse was able to think globally and connect one scientific concept or fact with other facts and ideas, extending the information into nursing practice such as, “slow down when you talk”.

6.2.1 Depth and Breadth of Chemistry Topics

This section presents an analysis relating to the depth and breadth of statements made that were coded as *Chemistry*. There were few statements (n = 13) that clearly had a chemistry context and were categorised as such and this category constituted less than 3% of categorised topic statements. For example, when *Taylor* put on purple nitrile gloves and used a sterile gauze pad to change an intravenous (IV) line for a patient, in the follow up interview, the question was asked “What was the significance of the purple gloves?” The response related to the colour not being especially significant, except for that everyone used the purple coloured nitrile gloves in this area, due to the types of cytotoxic medication that was being used. The use of the sterile gauze was also to ensure that, when changing the IV bag, any drops were absorbed onto the gauze and so could not be transferred to others by the glove. Discussion continued showing that the nurse was aware that the cytotoxic medications were a danger to the nurse and that the nitrile gloves and use of the gauze (as well as other protective gear such as wearing gowns) were protecting the nurse. The nurse went on to say how they had been trained how to clean up any spills if the IV bags were to rupture. The spill-kit was shown and the comment was made that the chemicals used “can give off gas”, and so the nurse’s main role in a clean up was to contain the chemicals and “protect yourself and others around you”. *Taylor* could not articulate what the chemicals were or the reaction, just that there was one, and that it was potentially harmful. This was coded as 1 in terms of depth.

Of the 14 chemistry-related statements, none were coded on the depth scale as 0 or 3, and most were coded at 1 (n = 10). That is, the statement showed that the nurse was aware of the science, but did not articulate the details or demonstrated only a shallow knowledge of science, for example, “I tried to remember the simple sugar formula but couldn’t” (*Agatha*). The remaining statements (n = 4) in the *Chemistry* category were coded as 2, as they showed that the nurse was familiar with the concepts and was able to discuss various aspects in some depth, for example, “Children need more dextrose than adults … There were a lot of studies about giving normal saline. You need to know what are colloids, what are the crystalloids” (*Carol*). *Carol* here was preparing an IV bag for a patient and this led to discussion about how to mix up the medication, and if she knew what diluent to use. She was discussing the various diluents and IV solutions that are used and how sometimes it is at a doctor’s preference, which may sometimes contradict with what may be considered best practice.

To establish the breadth of topics required under *Chemistry*, the statements taken from the follow up interviews (initiated by observed actions in clinical practice) were examined to provide a list of topics that nurses appear to require for practice. For example, knowledge of the terminology of chemistry – words such as colloids, crystalloids, saline, dextrose, potassium, sodium, sodium chloride, electrolytes, molecular formula, chemical reactions, nitrogen and pH were used by the nurses. There was also an awareness of chemical activity (i.e., that chemical reactions occur) and the potential risks of handling chemicals (e.g., cytotoxins and liquid nitrogen).

Further analysis of the chemistry-related data was undertaken to compare the depth of apparent use of chemistry knowledge by the individual nurse participants with their espoused self-efficacy towards using science-in-practice as recorded in their survey responses (see Chapter Five). All the nurses who participated in the observation phase had also participated in the *SASE-for-Nursing* survey. The average (mean) of self-efficacy towards using-science-in-practice scores for those nurses who made the chemistry-related statements that were coded as 1 was 6.90 (1 being very unconfident, 10 being very confident) (see Table 6.4). Nurses who made the statements that were coded as 2 had an average self-efficacy towards using science-in-practice score of 7.00.

Table 6.4: Depth of Statements Categorized as *Chemistry* Compared to Self-Efficacy towards using Science-in-Practice Scores

Number of Statements in category (n = 14)	**Scale of Depth**		**Average self-efficacy score**
10	Shallow	0	6.90
		1	
4	Deep	2	7.00
		3	

Key: 1 very unconfident, 10 very confident (self-efficacy scores)

This indicates that on average (for this sample), nurses who were slightly more confident in their use of science in practice, were more likely to use (or articulate) in-depth chemistry in their practice. However, the sample size was too small to establish if there was any statistical significance or correlation.

The nurses appeared to function as registered nurses without using a detailed knowledge of chemistry – more an awareness of it with the most in-depth statements demonstrating some familiarity with terminology and the basic concepts of chemistry.

6.2.2 Depth and Breadth of Human Biology Topics

This section presents analysis of statements relating to the depth and breadth of statements that were coded as *Human Biology.* As suggested earlier, the *Human Biology* category contains statements that were about the human body. These statements included anatomy, physiology, pathophysiology and cell biology and may have concerned the various systems of the body. The statements were often so integrated across areas that further classification was not considered of value. Out of 181 statements categorised as *Human Biology*, 17 (9%) were coded as having no depth (0), such as taking blood pressure and lifting up the patient's sleeves: "Taught to do it that way, do not know the reason why" (*Lee*). Forty-nine statements (27%) were coded as 1. These statements typically suggested that the nurse had some understanding of the science behind their activities. For example, when *June* removed blood from a patient's veins she did not know the name of the vein she was accessing but knew how to find it out if she had to, as she said "Don't need to remember the names of the veins … just where they are" (*June*). Fifty-nine percent (n = 107) of statements under *Human Biology* were coded as 2 against the scale of depth as nurses were able to articulate some science behind their practice such as when *Sam* noticed that her patient had swollen ankles. She said, "Some people with congestive heart failure – the pump is not getting it back so [fluid] accumulates lower" (*Sam*). Statements coded at 3 (n = 8, 4%) showed some detailed knowledge or understanding of other implications. For example, *Drew* discussed how sometimes nurses are at a disadvantage when reading patient notes if you do not have detailed knowledge of terminology and an ability to connect that information and make it relevant to nursing practice:

> A person may not be able to use parts of their body or it affects their speech. Yes, to scientific names of the parts of the brain - when you read documentation it says CAA (Cerebral Amyloid Angiopathy) or TIA (Transient Ischemic Attack) – doesn't tell you how they are affected, you find that out for yourself … help straight away and medication might reduce the severity. (*Drew)*

To establish the breadth of topics required under *Human Biology*, the statements taken from the follow-up interviews (initiated by observed actions in clinical practice) were examined to provide a list of topics that nurses appear to require for practice. The majority of statements related to nurses demonstrating that they needed to have a thorough overall understanding of how the body works and a good basic knowledge of anatomy (without necessarily being able to recite verbatim various scientific names).

Further analysis of the human biology-related data was undertaken to compare the depth of apparent use of human biology knowledge by the individual nurse participants with their espoused self-efficacy towards using-science-in-practice as recorded in their survey response. The mean self-efficacy towards using science-in-practice score for those individual nurses who made the statements that were coded as 0 or 1 and hence were shallow statements (n = 66) was 6.73 (10 being very confident, 1 being very unconfident) (see Table 6.5). This combined group which contained all *shallow* statements (coded as 0 or 1) consisted of 37% of all statements categorised as *Human Biology*.

The combined group which contained all statements codified as 2 or 3 (n = 115) which were *deep* statements, constituted 63% of all statements categorized as *Human Biology* and had a combined average self-efficacy towards-using-science-in-practice score of 6.71. The number of statements that were coded at 3, the deepest level, was only 4% and the self-efficacy score for these statements averaged 7.50, indicating that nurses who were articulating, recognizing and using in-depth *Human Biology* knowledge appeared to have higher self-efficacy towards using science-in-practice scores.

There appears to a positive correlation between the depth of knowledge articulated and average self-efficacy towards using science-in-practice scores, with a Pearson coefficient (Cohen, 1988) of 0.59. While this could be interpreted as an indication of a weak relationship between being able to explain science and having confidence in their own ability to use science, it does not confirm any relationship or suggest any predictive one (that is, it does not suggest that those who have low self-efficacy towards using science-in-practice scores will articulate shallow science knowledge and those with high self-efficacy towards using science-in-practice scores participants will articulate deep levels of science knowledge). In the context of this study, it implies that there appears to be a slight linear relationship between the data that relates to the scale of depth, and the data that relates to self-efficacy scores. There may be an actual relationship, but this is simply suggesting that as one set of values appears to increase (x value), so does the corresponding y value as if on a scatter-plot diagram. This does not imply any statistical significance between the two sets of values.

Table 6.5: Depth of Statements Categorized as *Human Biology* Compared to Self-Efficacy towards using Science-in-Practice Scores

Number of Statements in category (n = 181)		**Scale of depth of knowledge**		**Average self-efficacy score (combined)**
66	17	Shallow	0	6.73
	49		1	
115	107	Deep	2	6.71
	8		3	

Key: 1 very unconfident, 10 very confident (self-efficacy scores)

What is of interest is that *Human Biology* is a topic that is taught in all nursing schools (usually described as Anatomy and Physiology), and is usually taught using a systems based approach (that is, each organ system is taught in isolation to the others). Whereas in reality, analysis of the statements that were categorised as *Human Biology* indicated that the knowledge required for nursing is not based on systems, but is far more integrated. It is possible therefore that those nurses with higher levels of self-efficacy towards using-science-in-practice may have been more able to recognise, use or articulate that integration (as suggested by in-depth statements that showed connections to other facts and global understanding). Although *Human Biology* was not a specific topic in the self-efficacy questions, some of the questions, if they are analysed in a similar way to the statements from the observation studies, could be categorised as human biology type topics (nutrition, immunology, genetics, allergies, blood typing, growth and repair). An analysis was then performed on the survey participant data and for those questions that could be categorised as human biology (such as questions 25, 26, 40, 41, 42 and 44). The average self-efficacy score towards using science-in-practice (as taken from the *SASE-for-Nursing* survey) was 5.6, which is essentially neither confident nor not confident. The same analysis was performed only on the observation participants' self-efficacy scores taken from the *SASE-for-Nursing* survey (relating only to those questions which could be categorised as *Human Biology*) where the average was 6.2, which was similar to the larger survey population. It is interesting that in spite of *Human Biology* being one of the common topics in any science curriculum (that is, all nursing schools tend to teach it so all the nurses in practice must have passed it), the participants' average self-efficacy towards using science-in-practice scores for the questions that could be considered to be *Human Biology* were not near the very confident end of the continuum. This suggests that being successful at formal nursing science courses does not necessarily boost confidence in a nurse's ability to use knowledge of human biology in their practice. This may also reflect the diversity of the category as genetics and nutrition for example, are topics that are not necessarily covered in all curricula (see Appendix A), hence some of the tasks may have been unfamiliar to the nurse.

6.2.3 Depth and Breadth of Microbiology Topics

This section presents analysis of statements relating to the depth and breadth of statements made that were coded as *Microbiology*. Out of 156 microbiology-related statements, eleven percent of statements (n = 17) were coded as 0 as they indicated that the nurse was simply following protocols or procedures such as wearing gloves when a protocol required it, without espoused knowledge of why that would be required. For instance, when *Charlotte* was questioned during the follow-up interview why she put on gloves before administering eye drops for a patient, she answered that it was to "protect the patient from my rings and fingernails", which was a comment made by many nurses in regard to using gloves. The nurse may have had more knowledge about the use of gloves than she articulated in this instance as in this situation, the nurse was more concerned about the contact with the eye and the risk of doing physical damage to the patient as well as splashing the eye drops on herself, as opposed to microbiological concerns about asepsis, so the comments may simply reflect that focus. However, awareness of microbiology (including the risk that the nurse could cause an infection in the patient from her own normal flora) appeared to be absent from her response, so that statement was coded as 0. Statements that were coded as 1 constituted 40% of the *Microbiology* category (n = 62) and showed that the nurses had some understanding of the science behind actions. For example, when *Charlotte* attended a patient who had a wound, she discussed the sterile wound pack and the different coloured sterile forceps that come enclosed in it. In this context she was able to discuss how she used one set of forceps for taking the dirty material off (old dressings, etc.) and the other for the clean material (putting on the new dressing). She discussed how this technique was part of her training. This could have been coded as 0 as it is following learned protocol, however, she was able to adapt the practice somewhat as she was working within the patient's own home, and discussed how she attempted to do that, showing some awareness of microbiology and asepsis. However, both statements and actions (gloves and wound dressing) reflected relatively shallow knowledge and reliance on protocols/training.

More in-depth comments that were coded as 2 (n = 64 or 41%) suggested that the nurse had some knowledge of the interrelationship between actions such as vaccinations or injections and immunity. For example, one nurse said, "Look at the injections already had – any allergic response is usually second, not first … system is primed and so may respond to next injection" (*June*). In this context *June* was explaining why she was asking a patient about how many injections of a particular type the patient had already had. She was aware that subsequent injections brought an increased likelihood that the immune system may react more quickly raising the risk of an allergic reaction. Once she ascertained from the patient that it was in fact the patient's fourth injection with no history of reaction, she was able to make a decision. Statements coded as 3 (n = 13, 8%) tended to demonstrate a more global understanding of the science knowledge such as when *Agatha* was discussing the importance of knowing about clinically important microorganisms, and how they can be identified. This conversation was particularly insightful, as most nurses exhibited a limited understanding of the microbiology of wounds. However, *Agatha* could relate the clinical manifestations in the wound (going green) with possible microbial pathogens. She was also aware that methicillin resistant *Staphylococcus aureus* (MRSA)[6] for example, is a resistant form of *Staphylococcus aureus,* which is part of normal flora and present on healthy people:

[6] *Staphylococcus aureus* is a gram positive bacterium that exists on human skin. It can cause disease.

> You need to know that if something is going green, it is a *Pseudomonas*[7]. MRSA is another good example, what are the risks, people don't understand that you have *Staph[lococcus]* anyway and it is a usual thing. It is rife in the community. (*Agatha*)

There were many examples during the observations of nursing practice in this study where the observed practice appeared to be guided by an uncertain understanding of microbiology (such as infection control). There were situations where nurses made a risk analysis (wearing gloves or not, using sterile products or not, using aseptic technique or not, washing hands or not) where the knowledge of microbiology the nurse had appeared to be confused. For example, when giving injections there was huge variety in techniques observed. Some would use an alcohol wipe on the intended injection site, such as *Drew* stating that it was to "remove skin bugs so that they don't move down into the muscle" but it was also observed that many would feel the site again with their bare fingers just before injecting. When asked, the nurses tended to comment that it was difficult to find the correct site with gloves on. However, the gloves they indicated that they would use were not sterile, implying a lack of understanding about how to maintain sterilely at the injection site, or even if it was important to do this. In these situations, it appears as if the nurses tended to think about the patient's skin being covered in microbes, and considered how to protect themselves (possibly explaining the comment about gloves – more to protect themselves rather than maintain a sterile injection site) but seemed to be unaware of the potential risk that their flora may have to the patient. There were many different views expressed about the use of alcohol to prepare an injection site or even if it was best practice, with many nurses advocating that it was not necessary and in fact, caused irritation and discomfort for the patient. One nurse, *Lee,* suggested that the alcohol wipes were to remove sugar from the patient's fingers (before administering a blood glucose check).

There was also considerable variety observed in wound care along with understanding of how to maintain asepsis in various environments. *Sal* indicated that the policies for wound care alter about every three weeks and it is based on

[7] *Pseudomonas* is a gram negative bacterium that does not normally form part of normal skin flora but can cause disease.

information mainly from Australia. *Sal* explains, “A lot of variances in practice and difference of opinion which can be conflicted by medical staff. A lot of it is personal preference or experience and history”. There appeared to be confusion as to whether to swab wounds or not. Some nurses were adamant that you should, others were adamant that it was not necessary, as all wounds were dirty. *Sal* and *Lisa* both indicated that there were conflicting research reports as to effectiveness of swabbing, but they were able to indicate the limitations of the different reports. Both of these nurses appeared to have critiqued the original sources of the information, whereas other nurses appeared to have adhered uncritically to preferences.

Some nurses discussed procedures which were quite complicated and “old school” (*Sam*). These included the maintenance of clean and dirty zones while performing a procedure. Sam described these as not allowing the “dirty” activity and the “clean” activity to cross paths – for example, using one hand to do the “dirty” work such as removing bandages and the other hand to do the “clean” work. A mantra of “clean to dirty” was also used, such as when using a sterile swab to clean a wound (clean) – once the swab was in contact with the wound, it was then considered to be dirty, and hence could not pass back over the “clean” zone (i.e., the space between the dressing pack and the wound). *Sam* explained that some nurses feel that if the zones crossed path or the wrong hand were used, the procedure is considered to be contaminated or was subjected to cross infection.

Casey indicated that nurses practicing in mental health will readily transfer a mentally ill patient to a medical ward if they develop an infectious disease, “If temp goes over 39.5 degrees, we say that’s enough, you are going to be transferred. It’s not our specialty – when people get to that stage, they need people with that specialty”. *Casey* also suggests that during any infectious disease outbreak the mental health ward can be difficult to control, as the patients are not bed-ridden and may be difficult to influence and indicated that they normally do not have to worry as much about asepsis as other nurses are the patients may be physically fit and well.

Various opinions on wounds also existed and there were many examples where nurses such as *June* and *Chris* referred during observations to wounds as "being dirty and full of microbes from the skin", suggesting that their cleaning and aseptic technique would not contribute to the healing of the wound other than by removing debris to allow the wound to heal. There were contrasting opinions such as "most wounds are infected by *Staph[ylococcus*] or some other skin flora anyway" with others explaining that the purpose of a dressing was to provide a damp environment for healing (to try and recreate conditions that would exist under the skin, such as moisture, pH etc). In contrast, *Stacey* suggested that most wounds are infected by *Pseudomonas* bacteria mostly because wounds are kept too moist.

Even in areas as fundamental as hand washing, some nurses had ideas that were not scientifically-based. For example, one nurse said, "Important thing is to wash and dry – moisture attracts everything from the air and it sticks" (*Jay*). In this regard, it was observed that many of the nurses in this study did not use best practice for hand washing. *Drew*, when asked about hand washing, said that in some areas, "there is not so much hand-washing between patients … some areas don't have hand basins so I forget to use the hand sanitizer". However, this nurse did discuss that they knew when it is important to wash hands thoroughly and this is to do with how ill the patient was. During the entire observation phase the average time taken to wash hands (across all participants) was only 3 seconds (not including the time taken to dry). One nurse did not use any soap. The majority of nurses, however, used non-sterile gloves (changing them often) or used hand sanitizers. When asked what types of microorganisms the hand sanitizers were effective against or how they worked as a mode of action (they all contained approximately 70% ethyl alcohol – an effective antimicrobial solution), no nurse could offer an explanation. However *Tracey* did say that many antimicrobial solutions needed time to work, and that it was common for nurses to wipe them straight off (this discussion was in relation to cleaning benches).

Topics taken from the statements categorized as *Microbiology* that could constitute the breadth of subjects required for nursing practice included: control of microbes, knowledge of medically important microbes, and the relationship between normal flora, health and disease, as well as aseptic technique. Most nurses were aware of the concept that microbes can be potentially harmful to themselves (via body fluids), but most appeared to be unaware of the relationship between their own body flora to a patient or to others.

Further analysis of the microbiology-related data was undertaken to compare the depth of apparent use of microbiology knowledge by the individual nurse participants with their espoused self-efficacy towards using science-in-practice as recorded in their survey responses. The average self-efficacy towards using science-in-practice scores of the combined individuals who made 0 and 1 (shallow) statements, and those that made 2 and 3 (deep) statements showed that those nurses who were more confident in their use of science-in-practice tended to recognise, use or articulate more integrated microbiology knowledge in their nursing practice (see Table 6.6). That is, those who espoused a higher self-efficacy score tended to explain their practice with more in-depth explanations. There appears to be a positive correlation between the depth of knowledge articulated and average self-efficacy towards using-science-in-practice scores with a Pearson coefficient (Cohen, 1988) of 0.66.

Table 6.6: Depth of Statements Categorized as *Microbiology* Compared to Self-Efficacy towards using Science-in-Practice Scores

Number of Statements in category (n = 156)		**Scale of depth of knowledge**		**Average self-efficacy score (combined)**
79	17	Shallow	0	6.49
	62		1	
77	64	Deep	2	7.32
	13		3	

Key: 1 very unconfident, 10 very confident (self-efficacy scores)

This indicates that for this sample, there is a relationship between nurses who are able to articulate in-depth microbiological knowledge and their self-efficacy towards using science-in-practice scores.

Microbiology is an important part of science knowledge that affects and contributes to a nurse’s clinical practice; however, some aspects of it appear to be misunderstood or misinterpreted. Although microbiology is taught in most nursing schools, it is subject to variety in terms of content and detail. Also microbiological skill such as using aseptic technique seems to be missing from formal nursing science curricula, even though it is a significant part of nursing practice.

6.2.4 Depth and Breadth of Pharmacology Topics

This section presents an analysis relating to the depth and breadth of statements made that were coded as *Pharmacology.* Six statements (out of 66 or 9%) were coded as 0 as the science knowledge behind the action was not articulated, such as when *Donna* stated that a discussion about medication was just to keep the patient talking and busy, and was “of no note to me at all”. Statements coded as 1 (n = 11 or 17%) showed that the nurse had a basic awareness of pharmacology, as *Sam* said, “I asked about his weight to prepare in case the doctor wishes to give medications” (*Sam*). More in-depth statements were coded as 2 (n = 40 or 62%) indicating that the nurse had some knowledge of pharmacology such as side-effects or risks. For example, *Casey* said: “About a third of our patients have drug disorders or addictions” and went on to explain that to be effective in nursing practice, the nurse had to have an understanding how medications and other drugs may interact, and how they may affect the patient.

The most in-depth statements were coded as 3 (n = 8, 12%) when they indicated a global understanding of interrelated concepts, illustrated when one nurse said, “this is usually an antipsychotic drug but it is not found to be good as antipsychotic … But has good anti-anxiety properties, which is most likely why it was prescribed in this case” (*Casey*). Even though this nurse was not able to prescribe drugs, *Casey* was able to exhibit an understanding of the mode of action and different uses of medication to manage conditions.

The breadth of topics discussed under the category of *Pharmacology* included: responsibilities under the *Medicines Act,* (1981) different preferences and techniques for administration of injections, interactions between medications, long action and short action medication administration including variances on administration (such as pill crushing), modes of action on the body, safe use of and preparation of drugs (including diluents, mixing, etc.). Use of mathematics such as in drug calculations and estimation of measure was a skill that was also required, with *Casey* discussing how a drug had been incorrectly charted as 1 gram, which would have required 20 bottles or 1000 pills, and nurses had apparently read the order and assumed the doctor had meant 1 milligram. Yet the order itself had not been corrected or questioned.

During the observations of practice, a nurse meticulously measured out liquid medication without apparent knowledge of the meniscus or how to read the volume accurately, and also seemed to be unaware if it was crucial for this particular medication or condition to measure accurately or precisely. Another nurse was told to prepare intravenous antibiotics and did so before weighing the patient. After preparing the drug, the patient was weighed and found to be heavier than estimated, yet the nurse continued administering the medication and stated that it did not matter, and that it was close enough. Another nurse was very busy on a drugs round and had some patients who were unable to manage the medication in pill form. Lauren used a mortar and pestle and crushed the pills for administration by spoon to the patient. During the follow-up interview, *Lauren* was able to discuss how some drugs cannot be crushed and that some have an enteric coating which crushing would compromise. However, *Lauren* used the same mortar and pestle to crush all the drugs, with occasionally using a tissue to wipe out some drug dust/debris. Examination of the equipment, however, showed that there were many scratches where there could be carry-over of drugs.

Many nurses discussed how concerned they were about the administration of drugs and their responsibilities under the *Medicines Act* (1981). Some nurses such as *Sam* said they were very reluctant to take on responsibilities (even refusing to dispense paracetamol without doctor supervision) which appeared to be a deliberate act to remove them-selves from responsibility under the *Medicines Act* (1981). *Casey* said that it was a nuisance not being able to administer common medications (such a paracetamol, ibuprofen or Ventolin for asthma for example) without a doctor's approval, but stated that it "would only take one [nurse] who may not ask if the patient has asthma and gives ibuprofen" to place a patient at risk. *Casey* suggests that "some nurse wish to have all the rights of our medical colleagues, without the responsibility". Whereas other nurses such as *Trudy* staff a prescription phone where the patient phones up to get a prescription renewed. *Trudy* and her team look up the patient's record, ask questions, and if it is straight forward case, they authorise a renewal of the prescription and conduct six-monthly vital sign checks. The doctors in this practice simply check the details off a clipboard that the nurse has prepared. *Trudy* says “Not sure if the doctor realises that we do all this, but nothing has gone awry. We do too much really, made a rod for our own back.”

Some nurses were in sole charge (no doctor) and had no choice but to take on the responsibility of administering medicines. Many commented that they felt unprepared for such responsibility, for example, “It scares me – would I know if I was giving something prescribed wrong?” (*Drew*).

Further analysis of the pharmacology-related data was undertaken to compare the depth of apparent use of pharmacology knowledge by the individual nurse participants with their espoused self-efficacy towards using science-in-practice as recorded by their survey responses. Overall, there appears to be a positive correlation between the depth of knowledge articulated and average self-efficacy towards using science-in-practice scores with a Pearson coefficient of 0.60.

Table 6.7: Depth of Statements Categorized as *Pharmacology* Compared to Self-Efficacy towards using Science-in-Practice Scores

Number of Statements in category (n = 65)		**Scale of depth of knowledge**		**Average self-efficacy score (combined)**
17	6	Shallow	0	6.52
	11		1	
48	40	Deep	2	6.57
	8		3	

Key: 1 very unconfident, 10 very confident (self-efficacy scores)

These results indicate that in general (for this sample), nurses who were slightly more confident in their use of science in practice were slightly more likely to recognise, use, or be able to articulate more in-depth and integrated pharmacology in their practice.

Pharmacology is a topic that all nursing schools reviewed in this study addressed in their curricula, and the average score for the pharmacological type questions (question 27 and 30) for the survey participants was 8, which is quite high and indicates that nurses were in general, confident in those tasks. These tasks related to drug calculations and describing side-effects to a patient and many nurses may have felt quite familiar with these tasks, which may explain why there were high levels of confidence. Nurses take their responsibilities under the *Medicines Act*

(1981) very seriously, and it is a source of concern for many. In spite of pharmacology being represented in all nursing schools curricula, the mathematical skill that is associated with being able to perform drug calculations appears to be assumed, or is often a hidden part of the pharmacology curriculum.

6.2.5 Depth and Breadth of Physics Topics

This section presents an analysis relating to the depth and breadth of statements made that were coded as *Physics*. Only four statements were categorized as relating to *Physics;* three were coded as 1, and one was coded as 2 due to the depth of knowledge shown. Statements that were coded as 1 were comments that demonstrated some knowledge of physics, such as a nurse checking for jewellery on a patient before surgery because it "can cause an electrical arc" (*Taylor*). In this instance, *Taylor* was using a written check sheet and asking a patient a variety of questions before they went into the operating theatre. One of the questions related to asking the patient if they were wearing any jewellery. When asked during interview why this was, the nurse was able to explain that some procedures used to stop bleeding during surgery can cause an electrical arc, and *Taylor* was aware that metal items (such as jewellery) might then cause an issue for the patient. The more in-depth statement (coded as 2) related to a nurse assessing a client's need for home help relating to mobilisation, balance, point of balance and walking aids. *Agatha* has to assess if clients can manage some kind of independent living in their own homes and as such is often looking for ways to support them, which includes aids to help with mobilisation and also with stopping falls in the home (such as lever points in the bathroom). She suggests that to do that, a nurse requires an understanding of basic physics. During an interview with *Jaqueline* (a nurse educator), she discussed how much physics knowledge is involved in understanding and using ventilators, but advised that that would be taught when the nurse specialised in their practice. A discussion with *Alex* (nurse lecturer) also reinforced that although some nurses do concern themselves with blood gases and Boyle's law, that would be only in specialty areas and that there would be training provided, so nursing undergraduate education needs only provide nurses with a basic understanding, enough for the nurse to build upon when in practice.

Physics topics in used in clinical nursing practice therefore seemed to include concepts of basic electricity and mechanics/machines, including lever points and points of balance, and also basic knowledge of pressure and flow.

Further analysis of the physics-related data was undertaken to compare the depth of apparent use of physics knowledge by the individual nurse participants with their espoused self-efficacy towards using science-in-practice as recorded in their survey responses. The average self-efficacy scores for the statements coded as 1 compared to the statement codified as 2 shows an increased confidence across all the categories of self-efficacy towards using science-in-practice (see Table 6.8). Overall, the results indicate that in general (for this very small sample), nurses who were slightly more confident in their use of science in practice were more likely to recognise, or use or articulate more integrated or in-depth physics in their practice. The number of statements was too low to perform a correlation study or draw any conclusions.

Table 6.8: Depth of Statements Categorized as *Physics* Compared to Self-Efficacy towards using Science-in-Practice Scores

Number of Statements in category (n = 4)		**Scale of depth of knowledge**		**Average self-efficacy score (combined)**
3	0	Shallow	0	6.67
	3		1	
1	1	Deep	2	8.00
	0		3	

Key: 1 very unconfident, 10 very confident (self-efficacy scores)

Physics appears to be complimentary to nursing practice by supporting the nurse's basic understanding of the physical world and its interaction with and affect on, the human body. Very few nursing schools appear to teach physics concepts, which means nurses have to either learn the context in practice, or rely on their secondary school exposure.

6.2.6 Summary

Nursing practice (in the context of this study) appears to be supported by scientific knowledge and skills. To establish the breadth and depth of topics, the data that was extracted from the clinical observations were analysed and categorised into topics, some of which were non-science related, and others were science related. In order to identify the topics (breadth) that would be appropriate for an undergraduate nursing science course, the categories that related to science topics such as *Chemistry, Pharmacology, Human Biology, Physics and Microbiology* were further analysed. The statements within each category were further grouped according to the scale of depth (see Table 6.3).

In terms of *Chemistry*, nurses appear to function at the registered nurse level without recognising, or using a detailed in-depth knowledge of chemistry. Nurses reported needing to have an awareness of chemical concepts and a familiarity with the language and terminology of chemistry. They also described needing to have familiarity with matter composition (atom, molecules, periodic table of elements, ionic compounds, states of matter) and basic knowledge of chemical reactions and properties (pH, alkalinity, acidity, electrolytes).

Physics also appears to be complementary to nursing practice, that is, it supports the nurse's basic understanding of the physical world, and its interaction with, and affect on, the human body. Topic breadth for *Physics* used in clinical practice therefore seemed to include concepts of basic electricity and mechanics/machines, including lever points and points of balance, and also knowledge of pressure and flow.

Human Biology appears to be used in clinical practice in a very integrated way. The topic of *Human Biology* consists of many subtopics – including nutrition, cell biology, anatomy, physiology, genetics and biochemistry and they all play a role in the human body. The nurse appears to require a global, integrated knowledge of how the human body works, and this seems to be central to nursing practice. Being familiar with the terminology and language of *Human Biology* so that a nurse can access more in-depth information if required, appears to be an advantage in terms of communicating with other health professionals as well as providing care for the patient. A nurse cannot know (rote learn) everything that they may encounter in practice, but it does appear important that the nurse should be able to recognise patterns that may help them manage risks. There seems to be a relationship between a nurses' self-efficacy belief towards using science-in-practice, and their ability to articulate in-depth knowledge of *Human Biology* that informed their practice.

Microbiology is an important part of nursing science knowledge that affects and contributes to a nurse's clinical practice. Microbiological skill such as using aseptic technique seems to be missing from formal nursing science curricula, even though it is a large, critical part of nursing practice for most practice areas (mental health being the possible exception). The applied, practical side of microbiology (infection control) seems to be of great value to nursing. Topics taken from the statements categorized as *Microbiology* that could constitute the breadth of subjects required for nursing practice included: control of microbes, knowledge of medically important microbes, and the relationship between normal flora, health and disease, as well as aseptic technique. Most nurses were aware of the concept that microbes can be potentially harmful to themselves (via body fluids), but most appeared to be unaware of the relationship between their own body flora to a patient or to others. Knowledge of microbiology alongside being able to perform microbiological skills would contribute to the nurse's ability to manage risks in the clinical environment. Nurses who had higher self-efficacy scores towards using science-in-practice were more likely to be able to explain the microbiological science behind their nursing practice.

In terms of *Pharmacology*, nurses reported taking their responsibilities under the *Medicines Act* (1981) very seriously, and it was a source of concern for many. Basic mathematical skill is also required to support nursing pharmacological practice, although this is not explicitly represented in many nursing curricula. Nurses appear to be relatively confident in their abilities to calculate drug dosages and explain side-effects to patients, although that could be due to familiarisation with the tasks, and a reliance on protocol, rather than having an in-depth knowledge behind them that can support their risk management. This could be why although they appeared to be confident (as indicated by their self-efficacy scores), they still voiced concern over their responsibilities for administering medications.

There appears to be a link between nurses' confidence in performing science based nursing tasks and being able to apply (or at least, articulate) in-depth science to their practice. During the *SASE-for-Nursing* survey trials, participants discussed how they tended to choose the mid-range marks in the continuum for the self-efficacy questions (range of 10 values) when they were confident in their skill level to perform the task, and their tendency to choose the extreme ends related to their confidence in their knowledge of the topic behind the task as well as their skill (application). Nurses who perform nursing tasks based on science routinely, may choose self-efficacy confidence values in the higher mid-range area (indicating confidence with their ability to perform the skill), but nurses who appeared to have in-depth knowledge tended to select values closer to the "very confident" end of the spectrum.

6.3 Depth and Breadth of Science Related Topics

Some of the statements that the nurses made when being interviewed after their practice was observed were placed in science-related categories that did not align to the majority of the curriculum topics represented in nursing science curricula (see Chapter Five). These are now discussed in this part of the chapter and include *Information*, *Monitoring and Recording* and *Laboratory Tests.* Although the *Laboratory Tests* category contains knowledge (of biochemical parameters for example), it is not a topic that was a part of nursing schools' science curricula reviewed in this study and the interpretation of results appears to be considered more of a skill that tends to be developed in the workplace, rather than a theory topic.

During the nurse educator interviews, nursing lecturers and clinical educators were asked what science skills, if any, they considered the most relevant for student nurses to learn. Many interviewees asked to be prompted as they appeared uncertain as to what science skills could be, and so they were shown a prompt sheet that contained a list: analytical thinking, aseptic technique, calibration of equipment, calculations, evaluation of evidence, evaluation of information, handling of biohazards, handling of chemicals/gases, interpretation of data, pattern recognition, swab taking, take samples for analysis, terms and vocabulary (see Appendix E). Once prompted, they all confirmed that in their opinion, aseptic technique, handling biohazards, calculations, analytical evaluation of evidence, were important. *Dorothy* said that she considered that the skills on the prompt list were part of nursing, not necessarily science - but agreed that nurses needed to have them no matter which domain of knowledge they fell under. She said, "It is interesting that there is pattern recognition – it is important but I probably wouldn't have put it under science." Nurse lecturer *Alex* suggested that skills such as pattern recognition cannot be taught and that "analytical thinking is not specifically science", but also agreed that all the skills listed were required for nursing.

Alex went on to explain that skills develop as you practice and specialise, going on to say that nurses would be unlikely to handle chemicals or gases other than handle oxygen cylinders and then just to turn them off and on. Whereas some of the educators in clinical practice talked about using liquid nitrogen and oxygen cylinders and *Emily* said that if you didn't know how to handle them properly, "you could be putting other people at risk as well as yourself". *Joanna* stated, "Handling of chemicals and gases – definitely. We have some nasty things here and we need an understanding on how to deal with these things. What happens if you mix chlorine bleach with citric acid? We keep them separate for that reason".

Some nurse educators felt that calibration of equipment was a skill that was important for nurses, but others felt that it was not part of a nursing role. For example, *Alex* a nurse lecturer stated, "Calibration of equipment – no, they are not electronic electricians", but did agree that nurses had to know that equipment needed calibrating. Most nurses observed in practice seemed aware of the need for calibration for accuracy of their equipment and hence data. Often in the larger medical practice or service area, such duties were contracted out; however one nurse observed did have to calibrate the equipment in the area that she worked. *Joanna* suggested that calibrating or adjusting equipment is a skill of modern life and that everyone has to adjust their television, video and computer - meaning that they could be taught such skills in the workplace readily.

Daisy, a nurse lecturer, suggested that nurses have a limited scope to evaluate evidence due to limitations on their time, and she felt that they needed to rely on others doing their job properly (health professionals who write the practice guidelines) to inform nursing practice. She suggested that nurses need to "go to those journals, like Cochrane review … so you know that other people have analysed stuff, people who have credibility. They [nurses] haven't got the time or energy themselves." *Bethany* suggested that nurses cannot rely on a doctor, and must be able to say that they think something is wrong – nurses have to "put together the jigsaw". *Daisy* did state that being able to translate information and make it relevant to patients was a skill that was required for a nurse, and *Emily* commented that scientific measurement is important, but referred to it as pharmacology, "we need to know what is a microgram, what is a gram … acidity, alkalinity."

In fact, there were a few incidences where conventional names for topics were not used by nurses in the same way that scientists or science teachers may use them. For instance, *Dorothy* talked of the "physical sciences like anatomy and physiology" whereas normal scientific convention would say that the physical sciences were physics and chemistry. The distinction for nurses is to determine things that are physical in the body from things that are spiritual or emotional. When nurses discussed mathematics, they tended to be discussing arithmetic such as drug calculations and inter-conversions of units, not algebra or calculus such as used in pharmokinetics or pharmodynamics.

Supporting science skills (analytical thinking, calibration of equipment, evaluation of evidence and information, interpretation of data, pattern recognition, taking samples for analysis, handling biohazards and aseptic technique) are not represented in traditional curricula (or in Nursing Council requirements for education). Nurse educators and lecturers tended to agree that science skills would support nursing practice, but were divided as to if they should be part of undergraduate nursing curricula. In general, nursing lecturers tended to feel that although the discussed skills were important, they did not necessarily need to be taught, and articulated the reasons why not, which included, "They don't need to do it", "they are too busy" (*Daisy*) or "it would be taught in practice" (*Alex*). It could be that the nurse lecturers felt that science skills were not significant to require being in curricula. Whereas the clinical nurse educators tended to feel that the science skills would be used in practice, and it is possible that they expect new graduates to have these skills at employment (as opposed to having to learn on the job), as they did not state that it was dependent on placement or experience, instead confirming that they were required for practice.

This is interesting because the literature suggested that the theory-practice gap could be due to a misalignment between what nursing schools teach, and what the nursing workplace needs (Eraut, Alderton, Boylan & Wraight, 1995; Jordan, 1994). Nursing lecturers tend to hold the balance of power in terms of curriculum design, and as most nurses did not easily identify what science skills were it is possible that during the curriculum design and approval process, these skills may not be made explicit in the nursing curriculum. These skills that could be important to nursing as evidenced by the observation and interview studies are discussed next.

6.3.1 Depth and Breadth of Information skills

This section presents an analysis relating to the depth and breadth of statements made that were coded as *Information Skills.* The category *Information Skills* contained discussion points that related to how nurses tended to get their information, or their perspectives on information sources. This included statements which indicated an awareness of information types and evidence-based practice.

Out of 43 statements about *Information Skills,* there were no statements coded as 0, however, 42% of statements (n = 18) were coded as 1 as they showed some knowledge that their activity had a scientific basis to it. For example, Casey said, "Quantitative information was difficult to get to terms with – like interpreting lab tests. I need the guides". Statements at this shallow level include statements that indicated that the nurses found information from web sources such as Google or other colleagues. Statements that were coded as 2 (50%, n = 21), tended to show more understanding of what constitutes appropriate information for clinical decision-making, for example, "Guidelines are good but I like to know why did they make those decisions and where they got the information from" (*Jordan*).

Pat indicated that although a lot of information in her workplace was mostly of a quantitative nature (instructions, research, textbooks, and graphs) she felt that she didn't need to know the statistical basis of how they were constructed. "Bell curves and skewing … waste of time. No one gets anything out of it." Other nurses indicated that quantitative information challenged them (in terms of their ability to interpret the information) but appreciated that the majority of the information in the health care environment is quantitative. For example, *Taylor* said, “I like charts and tables because you can see what the normal is, I need the guides as my understanding of that is pretty limited, it is full on.”

Topics that appear to relate to this category included: sources of reliable information, how to source reliable information, understanding the process that information goes through to become reliable, critical reading skills, quantitative analysis skills, reading graphs, charts and tables.

Further analysis of the *Information Skills* statements was undertaken to compare the depth of the apparent use of information skills by the individual nurse participants with their espoused self-efficacy towards using science-in-practice as recorded in their survey responses. The self-efficacy towards using science-in-practice score for the statements coded as 1, was 6.28 (see Table 6.9). Nurses who appeared to have a more in-depth understanding of the types of information tended to provide statements such as “randomized controlled trials – they have done the hard yards and condensed it into an easy to read formula that I can say I base my practice on” (*Sam*). *Sam* also referred to peer-reviewed articles and databases and discussed how they questioned the information and critiqued it. For statements that were coded 2 and 3 (n = 25, 58%), the average self-efficacy towards using science-in-practice score for these statements was 7.12. Overall, the results may indicate that on average (for this small sample), nurses who were more confident in their use of science in practice were more likely to use (or articulate) more in-depth understanding of *Information* sources in their practice, and but there appears to be a weak mathematical correlation (Pearson’s coefficient of 0.52) between self-efficacy scores and espoused understanding on information skills.

Table 6.9: Depth of Statements Categorized as *Information* Compared to Self-Efficacy towards using Science-in-Practice Scores

Number of Statements in category (n = 43)		**Scale of depth of knowledge**		**Average self-efficacy score (combined)**
18	0	Shallow	0	6.28
	18		1	
25	21	Deep	2	7.12
	4		3	

Key: 1 very unconfident, 10 very confident (self-efficacy scores)

Nursing care is supposed to be evidence-based practice, however, many nurses state that they rely on being informed on what is best practice (by guidelines or other nurses) rather than critique information themselves or try to establish best practice on their own. Nurses in practice appear to be the consumers of research and information from the scientific arena, more than contributors. There were a few examples where nurses had innovated practice, such as but the effect was localized, and it was not disseminated. *Sal* for example overturned a procedure that was driven by doctors after investigating the matter further and discussing with a doctor in Australia. *Sal* said, “It worked as well as the [old procedure], but the [old procedure] was using more oxygen as the patient was struggling to maintain their temperature. Not sure if they still do it.” She indicated that the new procedure had not been written up for publication. *Sam* indicated that there was an easy home treatment for a certain common condition that worked well (according to *Sam)* which provided relief to the patient, but they were unable to advise the patient of this home treatment as it had not been published, and hence was not be considered to be “evidenced”. This statement indicates perhaps that nurses in practice may not know how to support a new procedure or nursing task/treatment with evidence that may be publishable, possibly due to a reliance on the “others” who appear to be authorities.

Information Skills is not represented in any of the science nursing curricula analysed. However, it is possible that other aspects of the degree do include this topic as nursing tend to contain a course on research skills. Interestingly, literature suggests that nurses tend to sit more comfortably with social science research (Davies, Murphy & Jordan, 2000; Thornton, 1997), and if this bias continues in undergraduate nursing research papers, it is possible that nurses are ill-equipped to establish what scientific evidence would be necessary to base their practice on (i.e. due to lack of exposure to quantitative analysis).

6.3.2 Depth and Breadth of Monitoring and Recording Skills

This section presents an analysis relating to the depth and breadth of statements made that were coded as *Monitoring and Recording.* Out of 84 statements coded in this category, 8 were coded as 0 (10%), and tended to be actions or statements where the nurse was simply documenting data (like blood pressure readings), making no judgment if the reading was appropriate or not. Many nurses, when observed, measured the patients' vital signs, and simply documented the results in the computer system. When this practice was discussed at the follow-up interviews with the nurses, it was often stated by the nurse that they did notice whether it was low/high, as that was the doctor's role and that the patient was seeing the doctor. *Lee* noted that a patient's blood pressure had been higher than it had been before and said, "It can be an emotional response to coming here … patient is seeing the doctor afterwards". Some nurses stated that they would point out any abnormalities to the doctor, while others would not but they would record the measurement. *Darryl* said that if the doctor doesn't look at the number documented when they hand the patient over, then "we point it out if it is excessively high".

June said that one of the ways a nurse can create a respectful working environment with the doctor is to be as professional as possible when documenting information. This included using the proper terminology. She said that sharing information with doctors is important and creates respect for the nurses by "being open, showing sound knowledge and presenting the information in clear, concise, to the point, talk the same language. That involved us training and learning how to do that".

Lee was a nurse who had to use a computer system to document the patient's consultation and there were fields in the programme that related to objective and subjective information. When questioned, *Lee* was unable to articulate any differences, and commented that it had been confusing, saying that different doctors required different types of information, "I find it difficult to know which is subjective and which is objective".

Some nurses admitted that they struggled with using computers. One computer system had guidelines and prompts for each question that they needed to ask of the client and when the computer did not work in the client's home, the nurse *Drew* found that she had not gathered the correct data on the home visit. The computer system appeared to manage the risk in consultation in that it highlighted or red flagged areas of concern for the nurse to follow up, but the nurse was not confident in using it. *Jackie* however had made a conscious decision to not take the computer into the consultation (home visit) as it was felt that it made the nurse focus on the computer and not the patient, "I don't enjoy using computers and feel selfconscious when I take them into people's homes".

Statements categorised in *Monitoring and Recording* which were coded as 1 (n = 28, 33%) tended to be those that showed that the nurse had an awareness of the data that was being recorded, either to set baselines to monitor for change. *Carol* says that "people may have elevated blood pressure due to white coat syndrome but if they have no other symptoms … go back and check it" (*Carol*) ("White coat syndrome" refers to patients being nervous at seeing the doctor and so may have elevated blood pressure). Statements coded as 2 (n = 43, 51%) showed the nurses' understanding of monitoring and recording was relatively detailed "need to monitor peak flow – hard to ascertain how ill he is without baseline - 140 is not good and 220 after nebuliser is an improvement but I don't know if that is near his capacity" (*June*). There were 5 statements (6%) which were coded as 3 due to the nurse showing how interrelated monitoring and recording can be, for example;

> History is seventy percent of what we do – take that story … could be allergic rhinitis, a cold, sore throat, does he normally have asthma … was it caused by the fire extinguisher? You do three peak flows, look at the baseline, and examine throat, lymph nodes, tonsils (*June).*

The main topics that emerged under this category related to: measurement, accuracy (including calibration and using same equipment for measurement), the importance of establishing baseline and norms for individuals, as well as the recording of objective/subjective data that can inform clinical decision making, either by the nurse or another health practitioner, which may also involve the use of databases or computer systems.

Further analysis of the monitoring and recording-related data was undertaken to compare the depth of apparent use of *Monitoring and Recording* by the individual nurse participants with their espoused self-efficacy towards using science-in-practice as recorded in their survey responses (see Table 6.10). The average self-efficacy towards using science-in-practice scores showed that the more confident the self-efficacy score, the more in-depth the statement. The mathematical correlation for this showed a strong positive relationship (Pearson's correlation of 0.99). Overall, the results may indicate that on average (for this sample), nurses who were more confident in their use of science in practice were more likely to use (or articulate) more in-depth understanding of *Monitoring and Recording* in their practice.

Table 6.10: Depth of Statements Categorized as *Monitoring and Recording* Compared to Self-Efficacy towards using Science-in-Practice Scores

<table>
<tr><th colspan="2">Number of Statements in category (n = 84)</th><th colspan="2">Scale of depth of knowledge</th><th>Average self-efficacy score (combined)</th></tr>
<tr><td rowspan="2">36</td><td>8</td><td rowspan="2">Shallow</td><td>0</td><td rowspan="2">6.33</td></tr>
<tr><td>28</td><td>1</td></tr>
<tr><td rowspan="2">48</td><td>43</td><td rowspan="2">Deep</td><td>2</td><td rowspan="2">7.02</td></tr>
<tr><td>5</td><td>3</td></tr>
</table>

Key: 1 very unconfident, 10 very confident (self-efficacy scores)

Monitoring and Recording information is a significant part of nursing practice, yet there was no evidence reviewed in this study to suggest that it was formally taught or recognised in any nursing science undergraduate curriculum.

6.3.3 Depth and Breadth of Laboratory Test Topics

This section presents an analysis relating to the depth and breadth of statements made that were coded as *Laboratory Tests*. Statements that were categorised as *Laboratory Tests* were further classified according to depth. Out of 24 statements coded in this category, there were three statements (13%) coded as 0. They related to nurses' procedural understanding of laboratory testing, such as when *June* was explaining how she was preparing to take a blood test, "You put the sample in the right tube or they won't process it and the sample is wasted". Some 13 statements (54%), related to the nurse showing some underlying science knowledge, such as stating that some of those tubes had "enzymes" in them, so you had to use the correct colour tube, and these statements were coded as 1. More in-depth statements that were coded as 2 (n = 6, 25%) suggested that the nurse had a more in-depth knowledge of the results from laboratory tests, as *Tracey* explained: "Won't give chemo[therapy] unless haem[aglobin] over 100 and platelets over 100…" Statements coded as 3 (n = 2, 13%) tended to be comments that showed that the nurse had a global understanding of the implications of results, for example:

> Take the urine creatinine ratio – body filters out creatinine from kidneys, and we look at what is in the blood …. High blood creatinine then it is not being filtered through … with diabetes, the blood vessels become fragile and blood filters through. (*Lee*)

The types of content that appears to be required under this topic category includes: common tests – reagents, protocols (time or temperature sensitivity), sampling, normal range, and interpretation of laboratory data.

Further analysis of the laboratory test-related data was undertaken to compare the depth of apparent use of knowledge related to laboratory tests by the individual nurse participants, with their espoused self-efficacy towards using science-in-practice as recorded in their survey response. The average self-efficacy towards using science-in-practice scores showed that the more confident the self-efficacy score, the more in-depth the statement (see Table 6.11). Overall, the results may indicate that on average (for this small sample), nurses who were slightly more confident in their use of science in practice may be more likely to use (or articulate) more in-depth understanding of *Laboratory Tests* in their practice, although both the sample size and the difference in the self-efficacy scores are both too small to realistically state that there is any clear correlation.

Table 6.11: Depth of Statements Categorized as *Laboratory Tests* Compared to Self-Efficacy towards using Science-in-Practice Scores

Number of Statements in category (n = 24)		**Scale of depth of knowledge**		**Average self-efficacy score (combined)**
16	3	Shallow	0	6.31
	13		1	
8	6	Deep	2	6.87
	2		3	

Key: 1 very unconfident, 10 very confident (self-efficacy scores)

Few nursing curricula which were subject to review during this study had *Laboratory Tests* as a discrete subject or an intended, formal part of the curriculum. Yet it is a significant part of a nurse's practice and many, felt unprepared to interpret them. As *Pat* explains, "A lot of the job is interpreting blood tests, wouldn't have had a clue based on my nursing training … best we had was telling if it was within normal or not."

6.3.4 Summary

Nurses educators and lecturers were in agreement that skills that are common to science such as: analytical thinking, calibration of equipment, evaluation of evidence and information, interpretation of data, pattern recognition, taking samples for analysis, handling biohazards and aseptic technique, were also important for nursing. However, some nurse lecturers tended to suggest that these skills may not need to be formally taught. Clinical nurse educators however, were able to provide examples of where the 'science skills' would support nurse practice and so this implies that they should be explicitly part of the curriculum.

To establish the breadth and depth of the science related topics, the data that was extracted from the clinical observations were analysed and categorised into topics. In order to identify the topics (breadth) that would be appropriate for an undergraduate nursing science course, the categories that related to science related topics such as *Information Skills, Monitoring and Recording* and *Laboratory Tests* were further analysed. The statements within each category were further grouped according to their depth (see Table 6.3).

Topics that appear to relate to the *Information Skills* category included: sources of reliable information, how to source reliable information, understanding the process that information goes through to become reliable, critical reading skills, quantitative analysis skills, reading graphs, charts and tables. Nursing care is supposed to be based on evidence-based practice, however, many nurses state that they rely on being informed on what is best practice (by guidelines or other nurses) rather than critique information themselves or try to establish best practice on their own. Nurses in practice appear to be the consumers of research and information more than contributors. *Information Skills* is not explicitly represented in any of the science nursing curricula analysed.

The main topics that emerged under the category *Monitoring and Recording* related to: measurement, accuracy (including calibration and using same equipment for measurement), the importance of establishing baseline and norms for individuals, as well as the recording of objective/subjective data that can inform clinical decision making, either by the nurse or another health practitioner, which may also involve the use of databases or computer systems. Monitoring and Recording information is a significant part of nursing practice yet there was no evidence reviewed in this study to suggest that it was formally taught or recognised in any nursing science undergraduate curriculum.

Few nursing curricula which were subjected to review during this study had *Laboratory Tests* as a discrete subject or an intended, formal part of the curriculum. The type of content that appears to be required under this topic category includes: common tests – reagents, protocols (time or temperature sensitivity), sampling, normal range, and interpretation of laboratory data. Laboratory Tests are also a significant part of nursing practice, and although tests results usually come with normal values and abnormal values 'red flagged' so theoretically, nurses do not need to interpret them, many none the less described how unprepared they felt for this aspect of their nursing practice.

Comparisons of all the science topics and science-related activities or skills and self-efficacy towards using science-in-practice data indicates that nurses who were more confident in using science-in-practice were more likely to apply or articulate more in-depth science knowledge. It could be argued that a nurse may have a high self-efficacy towards using science-in-practice score due to their own motivation in and attitude towards science and so might also have confidence in using scientific skills such as monitoring and recording and using of information as they are fundamental scientific practical skills. Activities that use the scientific skills described in this section were observed frequently in practice, yet they do not form part of the traditional nursing science curriculum.

6.4 Science Self-Efficacy Scores compared to Depth of All Science Statements

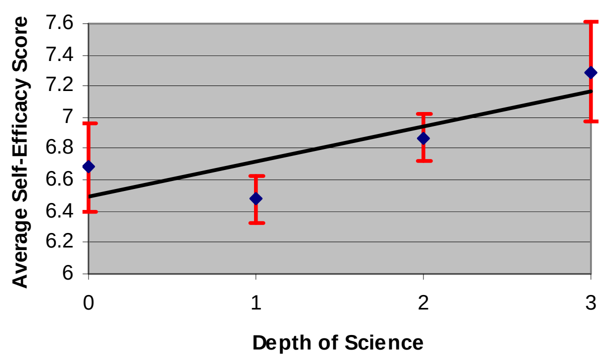
Futher analysis of the coded statements taken from the science curriculum topics and science related skills and compared to the participants self-efficacy scores was undertaken to compare the depth of science articulation by individual nurse participants with their espoused self-efficacy towards using science-in-practice as recorded from their survey responses (see Table 6.12).

Table 6.12: Depth of Statements Categorized as *Science or Science Related Skill* Compared to Self-Efficacy towards using Science-in-Practice Scores

Number of Statements in category (n = 572)		**Scale of depth of knowledge**		**Average self-efficacy score (combined)**
245	51	Shallow	0	6.68
	194		1	6.48
327	286	Deep	2	6.87
	41		3	7.29

Key: 1 very unconfident, 10 very confident (self-efficacy scores)

The average self-efficacy towards using science-in-practice scores showed that the higher the self-efficacy score, the more likely it was that the nurse participant articulated in-depth statements across all science curriculum topics and related skills. The mathematical correlation for this analysis showed a strong positive relationship (Pearson's coefficient of 0.83) (see Figure 6.1).



Key: Red Bars indicate 95% confidence intervals

Figure 6.10: Average Self-Efficacy Scores versus Depth of Science Statements for All Science Topics and Science Related Skills

Overall, the results may indicate that on average (for this sample of 17 nurses), nurses who were more confident in their use of science in practice were more likely to use (or articulate) more in-depth understanding of *Science* and *Science Related Skills* in their practice. Interestingly, if the Pearson's Coefficient is calculated for those statements coded as 1, 2 and 3 only (not the 0 statements), the coefficient is 0.99 (a very strong linear relationship).

6.5 Chapter Summary

Observation studies of nurses in practice resulted in interviews where nurses discussed their knowledge behind their nursing practice. The statements that were taken from the interviews were analysed, grouped and categorised into non-science related statements or opinions, or science-related discussions. A total of 931 statements were categorised. The science-related statements were further grouped into categories that related to science tasks or activities and science topics.

When the non-science related discussion points were removed (such as *Nursing*, *Education* and *Politics*), the remaining topics (*Chemistry, Human Biology, Information Skills, Microbiology, Monitoring and Recording, Pharmacology, Laboratory Tests, Chemistry* and *Physics*) made up the topics that were the most relevant to science curricula.

The science knowledge behind the observed practice of the nurses in the clinical area was also coded according to perceptions of the depth of knowledge being articulated by the nurse. That is, after coding the statements into the categories above, the statements were further coded by using a scale of 0 to 3 which relates to the perceived depth of articulated knowledge (see Table 6.3).

Analysis of the findings indicates that nursing practice (in the context of this study) appears to be supported by the following scientific knowledge and skills:

- *Chemistry* - nurses need to have an awareness of chemical concepts and a familiarity with the language and terminology of chemistry.

- *Physics* appears to support the nurse's basic understanding of the physical world, and its interaction with, and affect on, the human body.

- *Human Biology* appears to be used in clinical practice in a very integrated way. The nurse requires a global, integrated knowledge of how the human body works, and this seems to be central to nursing practice. Being familiar with the terminology and language of *Human Biology* so that a nurse can access more in-depth information if required, appears to be an advantage for communicating with other health professionals as well as providing care for the patient

- Microbiology is an important part of nursing science knowledge that contributes to a nurse's clinical practice. Knowledge of microbiology as well as being able to perform microbiological skills would contribute to the nurse's ability to manage microbiological risks in the clinical environment. Most nurses were aware of the concept that microbes can be potentially harmful to themselves (via body fluids), but most appeared to be unaware of the relationship between their own body flora to a patient or to others.

- In terms of *Pharmacology*, nurses take their responsibilities under the *Medicines Act* (1981) very seriously, and it is a source of concern for many. Nurses appear to be relatively confident in their abilities to calculate drug dosages and explain side-effects to patients, although that could be due to familiarisation with tasks, and a reliance on protocol rather than having an in-depth knowledge behind them that can support their risk management.

- Nurses educators and lecturers were in agreement that skills that are common to science such as: analytical thinking, calibration of equipment, evaluation of evidence and information, interpretation of data, pattern recognition, taking samples for analysis, handling biohazards and aseptic technique, are also important for nursing.

- Nurses in practice appear to be the consumers of research and information more than contributors. Although nursing practice should be based on evidence many nurses state that they rely on being informed on what is best practice (by authorities) rather than critique information themselves or try to establish best practice on their own. *Information Skills* are not represented in any of the science nursing curricula analysed.

- *Monitoring and Recording* information is a significant part of nursing practice yet there was no evidence reviewed in this study to suggest that it was formally taught or recognised in any nursing science undergraduate curriculum.

- *Laboratory Tests* are a significant part of nursing practice, and many nurses described how unprepared they felt for this aspect of their nursing practice. Few nursing curricula which were subjected to review during this study had *Laboratory Tests* as a discrete subject or an intended, formal part of the curriculum

There appears to be a link between nurses' confidence in performing science based nursing tasks and being able to apply (or at least, articulate) in-depth science to their practice, at least for the sample size studied. This implies that a nurse, who has more confidence in using science in their nursing practice, is more likely to be able to articulate in-depth science as an explanation for their actions. As this relationship appears to be linear (but various topic sample sizes were too small for mathematical correlation studies), then it makes sense that the opposite relationship may exist. That is, nurses who have low confidence in using science in their practice are less likely to be able to articulate the science behind the nursing actions.

The implications and conclusions for these findings from this chapter and previous chapters will be discussed in the next chapter.

CHAPTER SEVEN
DISCUSSION AND CONCLUSIONS

Overview of the Chapter

This chapter begins with discussion of the findings of this study in regards to the research questions. Firstly, a discussion on the role of science in nursing practice is presented, followed by a discussion of the ways in which registered nurses reported using science in their clinical practice. A discussion on what is the role of science education and educators then follows. The chapter draws conclusions from this discussion of findings and seeks to identify an undergraduate nursing science curriculum for the New Zealand context. The thesis is completed with recommendations, and opportunities for further research.

The overarching research question for this thesis is "What is the role of science in nursing practice?" This question has been further unpacked and developed into sub-questions that framed the investigation, such as establishing if science is required for clinical practice, and if it is, in what ways do registered nurses use science in their clinical practice? To answer these questions, an extensive analysis of documents that govern nursing practice and education was undertaken as well as interviews with nurse educators and lecturers. The nursing practice of registered nurses was observed and the participants were involved in follow-up interviews. Registered nurses also participated in a comprehensive survey.

7.1 What is the Role of Science in Nursing Practice?

7.1.1 Is Science Required for Clinical Practice?

Nursing practice and the education of nurses is controlled by the Nursing Council of New Zealand. The Council sets and monitors the various standards relating to nursing practice, including educational standards for nursing schools. According to the Nursing Council of New Zealand's competencies and scopes of practice documents, science is required for the education and practice of nurse assistants/enrolled nurses (NCNZ, 2005b, 2007c & 2010a), registered nurses (NCNZ, 2005a & 2007b) and nurse practitioners (NCNZ, 2008c). Although Nursing Council documents state that science is required to be taught in nursing schools, they do not provide guidance as to what depth or breadth of science content is required. This means that nursing schools independently interpret the education standards, and this has lead to variety in content and in complexity in nursing science courses across New Zealand nursing schools.

At all levels of nursing practice Nursing Council documents assert that nurses are required to observe changes in the patient. Observation studies undertaken in the clinical environment indicated that the nurse must not only know how to perform nursing skills or procedures (such as taking vital signs), but also be able to record and monitor the data. Nurses in clinical practice were observed to require some understanding of risk patterns and analyses (such as pattern recognition from physiologically based data) and an understanding of possible scenarios that might follow (human physiology) in order to keep the patient safe and comfortable. To monitor and report the information taken from the nursing observation, nurses in practice were seen to require knowledge about the nature of data (objective and subjective) as well as knowledge on the nature of measurement (such as establishment of baselines, defining 'normal' measures, accuracy versus precision, and calibration of instruments or tools) as well as be able to use skills such as reading and filling out forms, charts or graphs, and use computer databases. Interviews with nurse educators and lecturers confirm that the skills used in pattern recognition, measurement, monitoring and recording are all important skills for nursing, as is knowledge of human biology.

Decision-making and Risk Analysis

The Nursing Council documents further indicate that registered nurses are responsible for decision-making in nursing practice (as opposed to nurse assistants or enrolled nurses) (NCNZ 2007b & 2008b). According to the literature, clinical decision-making can be intuitive which tend to be based on experience, or deductive which tends to be based on knowledge (Benner, 1982; Hamm, 1988; Luker, Hogg, Austin, Ferguson & Smith, 1998; Radwin, 1995, 1999). Data taken from the observation and interview studies indicate that the nurse needs to have enough science knowledge to be able to perform risk analyses and this requires the nurse to have some understanding of the nature of the risk that the patient may be faced with, including enough knowledge of human physiology to be able to conceive possible outcomes. *Sam* and *Casey* for example discussed how they focused on what tshey needed to do to keep the patient safe, which was based on their knowledge of the most likely pathways that the patient's situation could take. Literature suggests that nursing is a very socially-orientated career, with clinical decisions often being verbally narrated and based on prior experiences and observations (Radwin, 1995). The nurses that were observed in clinical practice who did tend to engage in collaborative decision-making (involving other colleagues) were more likely to articulate shallow levels of science knowledge as explanation for clinical actions in the interview situation. These nurses tended to have a reliance on 'authorities' such as other health professionals, protocols or guidance documents as sources of information. Other nurses who were observed to be engaged in independent and autonomous practice tended to rely more on their own knowledge and skill (as opposed to relying on colleagues), to make risk assessments in their practice environment. These nurses were also more able to articulate in-depth knowledge of science to explain their nursing actions or decisions and were observed to access scientific information from various sources (i.e., textbooks, journals, posters, tables, charts, databases, journals, etc.).

At its most basic level, nursing requires science knowledge and skill to monitor a patient, and record data. At the registered nurse level, nursing requires science knowledge and skill to support clinical decision-making by informing risk analyses. Although nurses' decision-making can be experiential and intuitive, nurses who were engaged in independent practice tended to draw upon sources of objective, scientific information to support their nursing actions.

Education and Advocacy

Competent nurses are expected to support the patient by providing patient education, and by acting as an advocate (NCNZ, 2007b). Observed nurses in practice who had a positive attitude towards science in nursing (as indicated by the survey data) were more likely to engage with in-depth information (i.e., peer-reviewed articles) and then translate the information for the patient. Whereas other nurses who had less positive attitudes towards science's in nursing tended to prefer to use shallow sources of information for education of the patient (such as providing a pamphlet that was written by 'authorities') and indicated during interviews that scientific information can be intimidating for patients. This could be a projection of the nurse's attitude towards science knowledge or a reflection on the nurses' own ability to engage with scientific information, and hence understand and translate it into layman's terms. It may be that if a nurse can practice with relatively superficial science knowledge, then they may perceive that the average patient only requires superficial information. If a patient required more depth, many nurses referred the patient to another professional. Some nurses appear to make judgment on how in-depth the information provided to the patient needs to be, based on their own understanding of science.

Some nurses who were able to articulate in-depth science detail behind their nursing practice during interview suggested that today's patients have access to enormous amounts of information (via the internet). *June* suggested that this information can confuse or even frighten them. She suggested that the detailed explanation (or translation) that the nurse could provide supported the patient, and that it was respectful and caring to do so. Some nurses indicated that they engaged with information from peer-reviewed articles as sources of information, and then translated the information to educate a patient. In particular, those nurses who were more likely to see science's relevance appeared to be more willing to engage with science-based material. The New Zealand Nursing Workforce Strategy (2006) suggests that the consumer (patient/client) of the future will have higher expectations and be more informed than they have been previously (Future Workforce, 2006). This suggests that a nurse's ability to engage with scientific information and translate it into layman's terms will be required more in the future workplace. Nurses who were observed engaging with in-depth information needed science knowledge (content, terminology, understanding of relevance) and skill (sourcing and critiquing of information) in order to translate the information to the patient.

Competent nurses must be effective communicators with both clients/patients, and also with other health professionals (NCNZ, 2007b). Nurses in practice indicated that being able to communicate with doctors and other health professional colleagues by using the appropriate scientific terminology increased their professional credibility in practice. There is also evidence taken from observation and interviews that suggests that a nurse's ability to support and advocate for a patient may be impaired if the nurse cannot communicate using appropriate scientific and medical terminology, especially for nurses who tend to work more in isolation from other colleagues, or in autonomous practice situations.

Perceptions of Relevance

Literature suggests that one of the issues that contributes to nursing students' experiencing difficulties when learning nursing science is their perception of science's relevance to nursing (Caon & Treagust, 1993; Jordon, Davies & Green, 1999; Kinsella, Williams & Green, 1999; McKee, 2002; Neyle & West, 1991; Taylor, Small White, Hall & Fenwick, 1981; Thornton, 1997; Wilkes, & Batts, 1996). However, in this study, the majority of nurses in practice who participated felt that science knowledge was the foundation for nursing practice, and that nurses required an in-depth knowledge of science. Although this is in contrast to the literature, most of the reported literature studies involved nursing students, and not nurses engaged in clinical practice. The exposure to clinical practice may have enabled explicit linking of science knowledge to practice which suggests that nurses in practice may be more likely to see the relevance of science to nursing.

The nurses who had a less positive attitude towards science's importance in nursing, and tended to articulate more shallow science knowledge as explanations for their practice, were more likely to work in the acute/hospital practice setting where they functioned as part of a large health care team alongside pharmacists, medics, surgeons, dieticians, anaesthesiologists, and so on. It is possible that in this environment, the science knowledge of others is readily available to the nurse, which may allow nurses to focus more on 'nursing' or patient-care, or the completion of tasks. This may reinforce perceptions of irrelevance which could lead to devaluation of the contribution that science makes to nursing. Literature indicates that knowledge is distributed over the entire social system, rather than just being held by individual participants (Salomon & Perkins, 1998) which suggests that if science's contribution to clinical practice is unrecognised, nurses may place less importance on its value.

Observation of practice indicates that even the most basic of nursing observations (such as documentation and monitoring of vital signs) requires knowledge of physiology, skills of recording and documentation, interpretation of data, and the performance of risk analyses. Interview data suggests that some of these skill sets may be considered by nurses to be part of nursing (i.e., observation of patterns, monitoring, and recording of data, interpretation and analysis of data sets) and not necessarily considered to be part of a scientific process. These skills do not appear to be explicitly articulated in the nursing curriculum documents reviewed in this study and so their relevance to practice may be unrecognised. Knowledge that is not shared by the social group or community is less likely to be maintained or considered to be authentic or valid (Vygotsky, 1978).

The nurses who were less confident in their abilities to use science-in-practice (as indicated by their self-efficacy towards using science-in-practice scores in the *SASE-for-Nursing* survey) were less likely to be able to provide detailed science explanations for their nursing practice. As the registered nurse programme of study is a degree that has almost half of its three years of study occur in the practice setting by way of clinical placement (NCNZ, 2005a), it is likely that students may be mentored in practice (preceptored) by nurses who may not be able to articulate or explain the science behind nursing actions, and this may further contribute to science being devalued as its contribution being unrecognised.

<u>Devaluation of Science in Nursing</u>

In all phases of this research, participants acknowledged that nursing practice required science knowledge, although the perceptions of what type of science and how important it was for practice, varied. It might have been expected that nurse educators (specialty nurses in practice who provide education to other registered nurses) from one type of practice setting would hold similar views about the relevance of science as nurse lecturers (nurses who teach in nursing educational institutes) who specialised in the same practice area, but this did not appear to be the case. In fact, nurse lecturers tended to have more in common (in terms of their opinions of what topics or skills were relevant to nursing) with other nurse lecturers from different specialty areas, rather than with nurse educators from practice. Conversely, nurse educators tended to have more opinions in common (regarding what topics or skills were most relevant to nursing) with each other, irrespective of specialty area, compared to nurse lecturers who specialised in the similar area of nursing practice. It is possible that these types of gaps in perceptions contribute to the devaluation of nursing science during the curriculum development process as lecturers may not share the same perceptions of the use of science knowledge, as those colleagues in practice. Some literature suggests that gaps between theory and practice may be due to nurse lecturers placing more value on the academic nature of nursing than their practice colleagues (Eraut, Alderton, Boylan & Wraight, 1995; Fulbrook, Rolfe, Albrarran & Boxall, 2000; Jordan, 1994; Smeby & Vagan, 2008), and this may also contribute to the devaluation of science in nursing. There is also evidence to suggest that nurses do not always share the same language of science and this may further hide the science that may exist within nursing.

Curriculum Changes

A thorough document analysis of the changes to one school's science curriculum over a period of 25 years indicates a decline in the depth and breadth (or complexity) of science content. The curriculum development processes would have been initiated by the academics in the educational setting, and ultimately approved by the Nursing Council of New Zealand (NCNZ, 2005a). As curriculum design is subject to influence by those who hold power (Keogh, Watson & Dick, 2007; Pardue, 2006; Trnobranski, 1997) in this case, nursing specialists, the science curriculum may have been susceptible to significant change, more so than other aspects of the nursing curriculum. Within a nursing school, science academic staff are unlikely to be in positions of power due to the Nursing Council requirements for nursing programmes to be managed by nurses (NCNZ, 2005a). Some of the changes that were evident in the case-study of this particular school's curriculum appeared to be based on weak rationale (i.e., a new staff member who was a nurse with some science in her undergraduate courses was to make the science more nursing focused – yet there was no evidence that that this would achieve positive outcomes), yet the changes were accepted and approved. Without knowledge of how science informs nursing practice (as its contribution may be unrecognised or devalued), and with those in power possibly holding perceptions that science is not relevant for nursing, reductions in content and complexity of the science curriculum would result, unless science had powerful champions.

When reviewing the changes to some New Zealand nursing schools' science curricula between the years of 2006 and 2009, the rationalisation for change as reported by the schools tended to indicate that nursing students were continuing to find the science courses difficult, with some champions attributing the cause of this difficulty to who teaches science (scientists or nurses) and how it is taught (medical model or a more holistic model). Changes to the science nursing curriculum included decreasing hours in the laboratory, removing some content topics (i.e. immunology, pathophysiology), moving content from Year One to Year Two or vice-versa, repackaging of content into courses and these all appeared to have been justified or rationalised based on perceptions for which no clear evidence appeared to have been presented. Without clear guidance on what is required to inform nursing practice, changes to curriculum will continue.

Learning Science in Practice

The undergraduate nurse's education needs to prepare the graduate nurse not only for the workforce, but also for opportunities for specialisation in their practice area (such as becoming a nurse practitioner) (NCNZ, 2008c). Interview and observation data indicates that science learning continues in practice after graduation (both formally and informally), and such learning appeared to be of great value to the nurse. The close links with clinical practice may enable science content or knowledge to be more easily assimilated (compared to undergraduate nursing courses), possibly due to explicit relevance. In fact, the type of clinical practice experience seems to influence a nurse's self-efficacy towards using science-in-practice more than the years of experience that they may have. This may be due to the nurse gaining confidence in their abilities to perform science-based tasks that may be routine, familiar or protocol-driven in the particular clinical area. Nurses observed in practice who were able to apply or articulate in-depth science as explanation for nursing actions tended to have higher levels of self-efficacy towards using science-in-practice. If the nurse maintained high levels of knowledge this may then provide them with an element of confidence towards performing any science-based task. That is, nurses who have confidence in their abilities to use science knowledge may be more likely to be able to perform science-based nursing skills. Whereas those nurses who were more protocol-driven may be confident in their ability to carry out tasks due to familiarity, not knowledge – hence be dependent on their practice experience.

According to future workforce projections, the New Zealand health system will require nurses to provide more care in the community setting, and nurses may be required to become more autonomous in their decision-making (Cook, 2009; Future Workforce, 2006; Key, 2010). This means that nurses may have to make clinical decisions in isolation, possibly without readily available backup by other health professionals. Under these circumstances, the nurse will need to draw on as much knowledge and information as possible. Literature suggests that professionals should be functioning at the 'contextual' knowing stage of intellectual development where all sources of evidence (which would include science) are used in the decision-making process (Felder & Brent, 2004). Nurses observed who were operating as independent, autonomous professionals in the community drew heavily on their science knowledge, and placed great value on it. Nurses who appeared to be more comfortable with task-based nursing and relied on authorities or protocol-driven practice would be functioning at the transitional or independent knowing stage of intellectual development (Felder & Brent, 2004), which is probably insufficient for a registered nurse who holds responsibility for clinical decision-making, and would be insufficient for nurses in independent practice.

In summary, there is evidence from the international literature, Nursing Council of New Zealand requirements, curriculum documents, interviews with nurse educators and nurse lecturers, observations and interviews with, and a survey of, registered nurses, that indicates that science is required for nursing practice. Science is utilised at the most basic level of nursing practice, which includes monitoring of a patient's condition, recording and documentation of data, and analysis of patterns to enable risk assessment. It is utilised at the registered nurse level and informs decision-making and risk analyses. Nurses work in a variety of different practice areas and some of those areas have access to other health professionals or nursing experts (such as nurse educators and specialty nurses) and may rely on authorities (guidelines, protocols) for practice, which may mean that the nurse does not maintain their own in-depth science knowledge. This may have contributed to aspects of nursing science being unrecognised or devalued as often the basic nursing practice requirements (monitoring, recording, documenting, analysis of patterns, risk assessment) tend to be considered by some to be part of nursing, not necessarily part of science. It is also clear that nurses tend to continue to learn whilst in practice, and hence the nurse also needs to be provided with a comprehensive education that enables later specialisation.

7.1.2 What Ways, if Any, Do Registered Nurses use Science in Their Clinical Practice?

Basic Nursing Practice

At the most basic level, nurses were observed to use scientific skills such as monitoring and recording, (patient history, vital signs, objective and subjective information), and risk assessment (observation for physiological changes that might suggest that the patient's condition is altering or deteriorating). Nurses in practice were observed to need to: know how and what to measure in terms of objective data; know the importance of accurate recording and documenting; and be aware of what the possible scenarios are (in terms of assessment of risk). Nurses were also observed to use science to support and inform the patient through providing education and by acting as an advocate (NCNZ, 2007b). Nurses in practice report that a nurse must also be able to communicate with other professionals in a credible manner using correct terminology.

Task-orientated Nursing Practice

In some areas of practice, this study found that many nurses rely on authorities as a source of information. Nurses discussed the different levels of nursing practice such as task-nursing where the nurse provides a service (e.g., changes a wound dressing) and does so in an efficient, but friendly, empathetic manner, whereas others report being more proactive in their nursing assessment. The nurses who felt that nursing should not be task-orientated said that they investigated and researched information in their own time, and indicated that nursing practice continues out of hours. However, task-orientated nurses suggested that there is no time allowance for their own investigation and information seeking and that their jobs are confined by parameters of time, which suggests that often the nursing role has to become task specific. The observation, survey and interview data shows that these nurses tended to be less confident in their ability to use science-in-practice and less able to articulate the science behind their actions. They were probably more comfortable with a role that allows them to provide a service to the community, within safe guidelines and policies as perhaps they were not confident that their science could inform their decision-making autonomously in practice. However, registered nurses are required under their scope of practice (NCNZ, 2005a) to be responsible for decision-making and for nursing assessments and interventions. Task-orientated nurses therefore are probably not functioning at registered nurse level, although this level of practice may be appropriate for nurse assistants or enrolled nurses.

Decision-making in Nursing Practice

Registered nurses are required to make decisions about patient care and literature shows that expert decision making is based on knowledge, and on intuitive pattern recognition based on experience (Radwin, 1995). However, in situations that are atypical, or where the nurse has no experience, expert nurses need to use deductive reasoning in their decision-making, which is based on information and knowledge (Luker, Hogg, Austin, Ferguson, & Smith, 1998). Many nurses in practice appear to be functioning at an 'absolute' or 'transitional' knowing stage of intellectual development (Felder & Brent, 2004) where knowledge is often rote learned, passive, and often based on procedure. Such nurses appear to base judgments on intuition and personal feelings. This was evidenced by explanations of nursing actions during interviews that were shallow and tended to be based on learned protocols where the science was either unrecognised or not able to be easily articulated. Some nurses also talked about "feelings" in terms of making judgments or risk analysis (i.e., intuitive or nonscientific assessment).

Many other nurses were seen functioning at 'independent' knowing stage where knowledge could be articulated, and actions explained or rationalised, but authorities (such as guidelines or publications written by others or government departments) were still relied upon. Many nurses tended to rely on caring, empathy and understanding of the position of others as a basis for making judgments. It could be argued that this is the core of nursing – empathy, understanding of another's position or situation, and hence nursing assessment and decision-making should be heavily influenced by these. Nurses who were able to articulate in-depth science knowledge and showed a wide understanding of issues were probably working at a 'contextual' knowing stage of intellectual development (Felder & Brent, 2004). These nurses were often operating in independent practice, where they utilised science information to support their decision-making.

Science based Innovation of Nursing Practice

There were many incidences during the observation phase of this study where there were potential research opportunities for nurses to develop further understanding of a practice or adapt/innovate a nursing action, that were clearly within the domain of nursing (as opposed to medicine or pharmacy for instance) but firmly based in science. Literature indicates that nursing practice is still mostly experiential, and not research-based (Camiah, 1998; Fulbrook, Rolfe, Albarran & Boxall, 2000). There appeared to be a reluctance of nurses in practice to consider engaging in research processes that could improve the understanding of some practices – this may be due to time parameters (task-orientated nursing), perceptions of roles, or due to lack of confidence in their science knowledge or processes. There were many incidences where nurses did not know if there were risks to some of their practices, or if there were other ways to practice. Occasionally a nurse had been innovative in their practice, such as when *Sal* established a new way to manage patient fever. As the innovations had not been tested through research, the nurses were not prepared to advocate for a change, as they were aware that practice needed to be evidence-based, and this suggested a formal process of testing. Instead, the bulk of nursing innovation is done by others – and managed by people who write guidelines based on published literature. Nurses in practice appear to consume research based on science, rather than produce it.

Confidence in Using Science in Practice

Nurses in practice appeared to be more confident (as indicated by their self-efficacy scores) in using science knowledge in practice, and had a more positive attitude towards science, when they had an extensive background in science from secondary school. The higher the level of science studied, the more confident the nurse appeared to be in applying in-depth science knowledge to practice.

Confidence in performing the science-based nursing task does not appear to be linked with the length of time the nurse has been in practice, at least not in this study. Nurses who were successful at senior secondary school also tended to have a more positive outlook on the importance of science to nursing practice, and tended to have had less difficulties and anxieties with studying the undergraduate nursing science courses. As these nurses had a more positive outlook on the contribution that science makes to nursing this may have influenced their confidence levels. It is also possible that those who had success at senior secondary school science had a fuller scientific background than those who only studied during their nursing training or education. These nurses may have felt that they had fewer gaps in their knowledge or were more confidently able to update their knowledge accordingly and plug any gaps through their own study. Literature indicated that success in senior secondary school biology was linked to success in the nursing science courses (Andrews, 1998; Davies, Murphy & Jordan, 2000; Jordan, Davies & Green, 1999; Van Rooyen, Dixon, Dixon, & Wells, 2006; Wharrad, Allcock & Chapple, 1994). More likely however, secondary school science contributed to the successful student's confidence in engaging with scientific materials or tasks. It could be argued that self-efficacy towards science was already high in those students who chose to study senior secondary school science. As not all students who might be attracted to nursing as a career, and might make excellent nurses, will have met with success in secondary school science, this has implications for entry into nursing programmes.

Science Used in Practice

The science observed as being used in practice did not align well with the New Zealand undergraduate nursing curricula reviewed in this study. In particular, science skills tended to not be explicit in the curriculum documents (although could have been part of the hidden curriculum or detailed within nursing courses) but were a significant part of the observed practice of registered nurses. These skills included: monitoring and recording, laboratory testing, analytical thinking, aseptic technique, measurement, calibration of equipment, calculations, evaluation of evidence and information, handling biohazards, handling chemicals/gases, interpretation of data, pattern recognition, taking samples for analysis, and using scientific terms and vocabulary. There is evidence taken from interviews that nurses and scientists did not always use the same language or share common definitions when discussing science. These deviations from common understanding have the potential to confuse a student.

Some science topics that were clearly represented in the nursing curricula were observed in practice including anatomy, physiology, microbiology and pharmacology. The anatomy and physiology topics, however, were entirely integrated in practice with no real demarcation of subject matter. For this reason, the 'anatomy and physiology' topic was labelled *Human Biology* during the analysis of statements made by nurses about their work, and consisted of a variety of topics including nutrition, biochemistry, genetics, cell biology and all aspects of form or function that related to the human body. There was an apparent correlation between nurses who succeeded at senior secondary school science and their ability to articulate in-depth human biology explanations of their nursing actions. *Human Biology* is a topic that is taught in all nursing schools (usually described as Anatomy and Physiology), and is usually taught using a systems based approach (that is, each organ system is taught in isolation to the others). Whereas in reality, analysis of the statements that were categorised as *Human Biology* indicated that the knowledge required for nursing is not based on systems, but is far more integrated. It is possible therefore that those nurses with higher levels of self-efficacy towards using-science-in-practice may have been more able to recognise, use or articulate that integration (as suggested by in-depth statements that showed connections to other scientific concepts). *Pharmacology* was a topic that nurses in practice expressed concern over, in particular, their responsibilities for administering medication. *Pharmacology* also showed an apparent correlation between the ability to articulate more in-depth explanations of the science behind nursing actions and senior high school science success. It would be likely that no student would have studied pharmacology at secondary school, so it is not necessarily familiarity with subject matter that appears to influence confidence, but it may be influenced by confidence in scientific skills that could underpin the knowledge, such as mathematics and chemistry.

The demarcation of anatomy, physiology and pathophysiology that normally occurs in the nursing curricula does not align with how the knowledge is used in practice. Nurses do not separate the normal from the abnormal, but consider the whole. Nurses do have to monitor change and as such, establish what is ‘normal’ for this person (taking into account physiological changes that occur across the lifespan) and the situation that is occurring, but it is an integrated process. Nurses in practice during observation and interview discussed how a nurse cannot know everything, and that they need to build on their knowledge in the practice setting. This suggests that the nursing science curricula needs to provide nurses with skills to ensure that they can access, understand, critique and process information on the various conditions and issues that they will encounter, rather than rote learn conditions. It is not possible to cover all potential conditions of people in the undergraduate nursing degree. Hence, nurses need to have a thorough understanding of human biology, in a very integrated manner, and be able to understand and interpret the detail as required.

Microbiology activity that was observed in practice tended to be surrounded by the most confusion, whereas the *SASE-for-Nursing* indicated high levels of confidence in the microbiology related tasks. As asepsis and management of cross-infection is a constant concern in most healthcare environments, it could be that the nurses surveyed were confident in their ability to perform nursing tasks that were likely to be based on guidelines and protocols. Trnobranski (1993) suggests that aseptic technique is a procedure that many nurses have relied on as a ‘ritualistic routine’ rather than the application of the fundamental principles of microbiology. Nurses may be reporting their considered abilities in adherence to protocols and guidelines, and may not have high levels of knowledge guiding their practice, which may account for the confusion. Some aspects of practice that related to microbiology were quite contentious, such as wound swabbing. Some nurses may not be able to make judgement on the research as to which is the more effective guide, protocol or research outcome. When self-efficacy towards performing nursing tasks based on microbiology scores were analysed against the different types of practice areas, it was found that those currently working in mental health were less confident in their microbiology based tasks. Nurses observed working in mental health indicated that they had limited confidence in their abilities to manage infectious diseases as the patients were usually physically well, and so asepsis was not such a concern for them. This suggests that confidence in performing tasks is maintained in the practice area possibly due to the task, guideline or protocol being socially mediated (accepted as normal) by the practice environment.

The other science-related topics that were observed in nursing practice included *Chemistry* and *Physics*. While all nurse educators and lecturers agreed that *Chemistry* was required for nursing, most were ambivalent about physics. Nurses who tended to be able to articulate in-depth science concepts behind their practice tended to recognise the value in physics and suggested that it provided a basic understanding of the physical world, that some nurses were able to put to advantage (i.e., mechanics of lifting). Nurses interviewed indicated that a basic understanding of chemistry was necessary and this was supported by observation of practice where an awareness of basic chemistry would be an advantage.

Nurses discussed during interviews that they could not remember everything that they learned in their pre-registration education/training. Once nurses finished their qualification, nurses report that much of that knowledge is not retained (including science and pathophysiology). The way nurses appear to use science knowledge in practice could be conceptualised by the proposed "Iceberg" model of science knowledge (see Figure 7.1). That is, some science knowledge may be retained, used and maintained, and is therefore subject to instant recall and accessibility (the visible part of the iceberg). This knowledge is probably related to the area of practice that the nurse is in (used and maintained), and the rest (submerged part of the iceberg), underpins it. The various complexities and depths of that knowledge are conceptually larger than the shallow or surface knowledge. Nurses did discuss that the in-depth knowledge can be reactivated when needed. Some nurses suggested that being exposed to in-depth information during their training or education (even if the knowledge was not retained) provided them with confidence that when they need to engage with the in-depth scientific detail, they can make sense of it, and it was somewhat familiar.

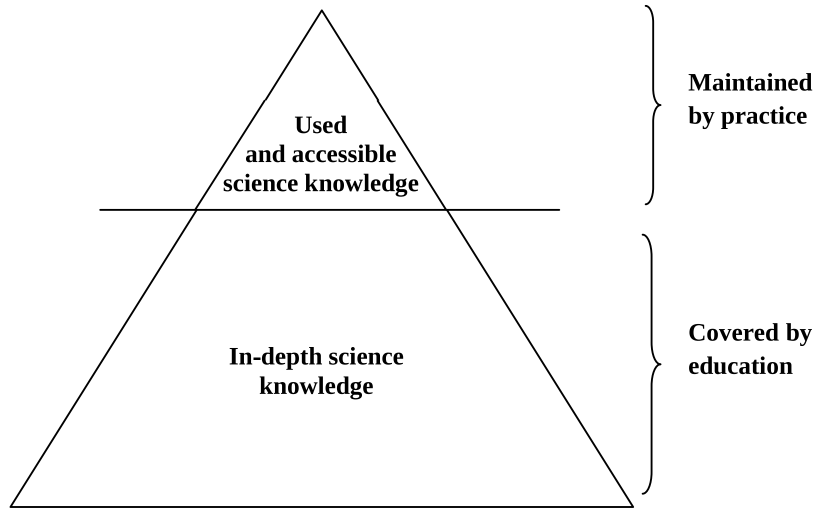


Figure 7.1: Iceberg model of nurses' science knowledge

In summary, many of the observed science topics used in practice did not align well with undergraduate nursing curricula from New Zealand nursing schools although one new curriculum from Institute D (Table 5.3) appeared to be the most closely aligned. Interestingly, this institute is one of the few nursing-education institutes to have an active science department (that is, offered science programmes of study, and was separate from the nursing department) and hence the curriculum design process may have had effective science champions. Nurses who had experienced academic success in the final year of senior secondary school science (Level 3 or Year 13) tended to be more likely to articulate in-depth scientific statements when explaining their nursing actions, compared to those without any senior science background. It could be that these nurses had more positive attitudes to science which contributes to their learning and confidence, or it may be that they encountered fewer difficulties with their nursing science courses. It seems likely that, as there appear to be significant gaps in the undergraduate nursing curricula as they align with nursing practice, those nurses with some science background or confidence in their abilities to engage with scientific information and tasks are more able to 'plug' those gaps in knowledge and skills themselves, especially as they appeared to be more likely to find science relevant to nursing. This thesis identifies those aspects of science topics and skills that support registered nurses' in their clinical practice and these should become part of nursing undergraduate curriculum.

7.2 Role of Science Education and Educators in Nursing

Having established that science is required for nursing practice, and an understanding of how science knowledge is used in clinical practice has been reached, then the focus can fall on the examination of the role of science and science educators in nursing education. The depth and breadth of science that is required to support patient observation, competent practice and clinical decision-making is discussed, followed by discussion on what science educators could do to establish an appropriate curriculum and pedagogy to enable nurses to be able to confidently use science knowledge and skills when in clinical practice.

7.2.1 What is the Role of Science Education in Nursing Education?

Once it is understood how science informs nursing practice (see section 7.1) then the role of science education in nursing education becomes more clarified. Preparing nurses who can act as patient advocates, educators and perform risk analysis in their nursing practice requires nurses who can engage with scientific information. Hence, the role of science education is to increase the confidence of the student nurse in their abilities to engage with science (increase their self-efficacy towards using science-in-practice). Creating an educational curriculum that positively increases nurses' attitudes and self-efficacy towards using and learning science for the future nursing workplace is critical.

<u>Attitudes towards Science</u>

Nursing workforce statistics indicate that the majority of nurses are female (NCNZ, 2002) and this was also the case for this study. Therefore, it would be expected that the majority of students attracted to nursing are female. Literature suggests that students who may be attracted to nursing may find it difficult to consider themselves capable of doing science, may have negative attitudes towards science and mathematics, or may feel that science had no relevance to careers that relate to helping people (Cobern, 1993; Jones, Howe & Rua, 2000; Larcombe & Dick, 2003; Lumb & Strube, 1993; Strube, 1991). Nurses in practice were found to be divided with regard to their perceptions or attitudes towards science in nursing. If the types of people who are attracted to nursing perceive that nursing is fundamentally about caring for people, they may enter nursing with a history of having avoided science-based subjects. Science is a subject that some students who are considering becoming nurses may not have had success in before, and they may have difficulty visualising themselves as being successful in science tasks. In this study, eighty-three percent of the participants held secondary school science passes of Level 2 or less with 10% of these having experienced no successes in science from school in any level. It has also been suggested that student attitude-towards-science, is not easily changed and that may explain the link between nurses with no or little science background who tended to indicate a less positive attitude towards science. Confidence in their own abilities in science appears to be predictive for science outcomes in females, more so than males (DeBacker & Nelson, 1999; Schibeci, 1989) suggesting that if a female student lacks confidence in their abilities to do science, then they are more likely to have poor educational outcomes in science. In other words, many students who enter nursing may encounter difficulties with their science courses as they may fail to see the relevance of the learning, they may lack confidence in their abilities to engage with the material, and their attitudes and opinions may be difficult to change. This study indicates that nurses' who experienced difficulties in learning science, tended to be less positive towards their science and applied shallow levels of science in their practice. This in turn may have an impact on their perception of science's relevance in nursing practice.

Self-efficacy towards Using and Learning Science

Confidence in being able to perform science-based nursing tasks in practice appears to be linked to success in the final year of senior school science according to the survey data in this study. This is similar to some reports in the literature where it was discussed that senior secondary school science success (equivalent to Year 13) is predictive of success in nursing science (Jordan et al., 1999; Wharrad, Allcock & Chapple, 1994). In this work, nurses who were successful at senior secondary school science also appear to have a more positive attitude towards science in nursing practice. Literature indicates that decision-making needs to draw upon all sources of evidence and knowledge when issues are not routine or are atypical (Benner, 1982; Luker et al., 1998), and since the case has been made that science is required for nursing, then it stands to reason that a nurse who is confident in using science knowledge is more likely to access and use scientific knowledge when the situation requires it. It is therefore beneficial to nursing that nursing education produces graduates who are able to integrate science knowledge into their decision-making and nursing practice.

Nurses that participated in the *SASE-for-Nursing* survey who had high levels of self-efficacy towards using science-in-practice tended to be able to apply or articulate in-depth science behind their nursing practice during observation of clinical practice. Although there appears to be a link with senior secondary science success (Year 13 in particular), it could be that those students who engaged with senior secondary science courses did so because they had a motivation, an interest or confidence in science type subjects. The success in Year 13 science may simply be a symptom of those students who have high self-efficacy towards science. However, literature suggests that self-efficacy towards particular actions can be increased by various methods which can enhance motivation and achievement, such as: mastery and vicarious experience, social persuasion and by students reaching an understanding of cause and effect on themselves (such as being tired from study) (Bandura, 1995). Hence, some students may have engaged and been successful in Year 13 science, which in turn increased their self-efficacy towards doing science by the manner in which they were taught, or the supports they were given when they were studying. Nurses discussed during interviews how some of the vicarious, active experiences that they encountered during the nursing science laboratory sessions helped them remember scientific concepts, and possibly contributed to their attitudes towards relevance of science in nursing. Increasing personal self-efficacy towards-using-science via social persuasion and the provision of active experiences that support mastery via appropriate goal setting could support a positive change in attitude and increase self-confidence when engaging in science activity for female students. There is some evidence to suggest that students who do well in the nursing science courses will continue to do well in the other nursing related courses (Alexander & Brophy, 1997; Bryd, Garza & Nieswiadomy, 1999; Blackman, 2001; McKee, 2002; Van Rooyen, Dixon, Dixon, & Wells, 2006).

This suggests that some nursing students who may exhibit low self-efficacy towards-using-science may benefit from a pre-nursing programme that is aimed towards novice and unconfident science learners. Literature suggests that novice learners (where they are not familiar with the content) need well-structured and skill-based learning environments that allow introductory knowledge acquisition using guided examples and activities (Jonassen, Mayes & McAlesse, 1993; Vygotsky, 1978). Front-loading of in-depth science content does not appear to be useful in the context of producing registered nurses, but has its place perhaps in pre-nursing programmes in terms of increasing familiarity, science-based skills, and confidence towards engaging in science material. It has also been suggested that in order for learner-centred science instruction to be effective (which is most likely to occur in the clinical setting), students require a high level of scientific vocabulary and content knowledge, and this is commonly achieved by teacher-centred methods (Von Secker & Lissitz, 1999).

Nurses engaged in science learning (formal or informal) in the clinical environment report during interviews that they found the science learning of great value, even if it was similar in content to that which was taught in undergraduate nursing science courses. The linkage that the nurse was able to make with clinical practice was probably more immediate and explicit, and so the information and knowledge had more value than the learning that may have occurred in formal undergraduate education due its isolation from clinical practice. Literature suggests that advanced learners may already be familiar with science content especially the language and terminology (Jonassen, Mayes & McAlesse, 1993), and so the learning environment can move towards a less structured domain based on acquiring more in-depth or advanced knowledge, which could be complementary to and integrated within nursing, not separated and front-loaded. An appropriate model for this type of learning acquisition according to Jonassen et al. (1993) would be case-studies, and the coaching and use of the apprenticeship model of delivery.

As nursing degrees contain clinical placement opportunities, the explicit linkage of science content from case-studies and their own practice experience will enhance the nursing students' concepts of relevance. Literature reports that teachers in the clinical practice area may not have sufficient science background or bioscience knowledge to facilitate application of science knowledge in the clinical setting (Friedel & Treagust; 2005; Morrison-Griffiths, Snowden &

Pirmohamed, 2002), and so educational institutes would need to ensure that the reflection of science/practice links are made explicit in the curriculum. This study found that some of the nurses, who articulated shallow science knowledge as explanation of their nursing actions, also reported that they did act as preceptors to nursing students. It is likely then that such nurses would have difficulty explaining the science behind nursing to students, contributing to its devaluation and perception of lack of relevance.

Jonassen, Mayes and McAlesse (1993) suggest that expert learners (i.e., those that have understanding of content and context) can handle more problem-based learning where knowledge is interconnected. These types of learning opportunities can provide experience and decision-making opportunities. The science learning opportunities need to be made explicit within the clinical context and be guided or facilitated by science educators who can help to navigate the content and terminology (Mayer, 2004). Those students who hold a belief that science is not a static subject, and it is instead dynamic (where ideas change and develop) were found to be more likely to be able to use their scientific knowledge in an integrated manner (Songer & Linn, 2006). This suggests that any learning experience must also attempt to focus on the nature of science, not just content. Nurses who have confidence in engaging with scientific based material are more likely to be able to contribute to innovating practice and may be more adaptable in the future nursing workplace.

Future Nursing Workplace

If the nursing workplace of the future continues the trend of the last few decades, then there will be more decentralisation of health-care away from large, regional hospitals to community-based care (Barr & McConkey, 2007; Burton & Stewart, 2003; Dawson, 1998; Future Workforce, 2006; Gottlieb, 1998; Key, 2010; Kutlenios, 1998; KMPG Report, 2001; Longley et al., 2007; Maradiegue, 2008; Taunton, 2010; Wilkes & Batts, 1991; Williams, 1998; Wilson, 1999). Scientific and technological advances will continue to impact on health-care, and these will have an influence on the ways that nurses practice and the knowledge base that they would utilise. Nurse educators interviewed during the course of this study agreed that nurses will need more science knowledge due to changes in the health sector requiring a more advanced nursing role (due to shortage of doctors), and they noted the impact that will have for nurses' decision-making and specialised practice. Nurse lecturers tended to indicate that nursing will not need less levels of science but did not tend to forecast an increased demand on science education for nursing, suggesting instead that it would come after specialisation.

Nursing needs graduates who are able to function at the 'independent' or 'contextual' stage of intellectual development and hence they need to be educated to know how to think, critique, analyse and make decisions (Felder & Brent, 2004). Any education programme needs to be structured to enable students to achieve the independent, or preferentially, the contextual stage of intellectual development and literature suggests that active learning experiences that are authentic (relevant) and delivered in an integrated manner, can assist in raising intellectual development of students (Ackerman, 1996; Brown, Collins & Duguid, 1989; Duffy & Jonassen,1992; Ernst & Colthorpe, 2007). Nursing in practice, as observed in practice, is not delineated and demarcated into topics and as such, the current practice of delineating nursing science courses into separate topics (as indicated by the review of New Zealand science curriculum documents) may not be the ideal educational practice for nursing science. There is opposition to the concept of integrating science into nursing subjects as some literature reports that there is a risk that nurses could pass courses without science knowledge (as it is integrated and possibly hidden), which may lead to unsafe practices in the workplace (Morrison-Griffiths et al., 2002) and could further devalue the contribution science makes to nursing practice. Using different methods of summative assessment than those that are currently used (such as using standard-based achievement methodology instead of competency or achievement-based methodology) could minimise the risk that any students pass nursing but have not met a required standard of science knowledge. That is, science aspects (including learning outcomes and summative assessment requirements) will have to be explicit.

7.2.2 What is the Role of Science Educators in Nursing Education?

If the role of science education in nursing education is to increase the students self-efficacy towards using science-in-practice and so to positively influence their roles as patient advocates, educators and risk assessors, then teaching methodologies will have to adjust accordingly, which has impact on the role of the science educator.

<u>Increasing Confidence</u>

Nurses interviewed and surveyed were quite divided on their perceptions of learning science for nursing. While literature indicated that many nursing students found nursing science difficult, too in-depth, and irrelevant for nursing (Jordan et al., 1999; Taylor et al., 1981; Thornton, 1997), about half the nurses in practice reported that they had not found the nursing science courses too difficult, nor did the courses cause them much anxiety. While the above literature tended to examine the attitudes of students, the nurses who participated in this study were nurses in practice who had been successful in their science courses and this may have contributed to the positive attitude. To increase a learner's confidence, literature suggest that educators need to use active and positive interactive teaching methodologies that are subjected to social validation and are designed to develop motivation and confidence (Bandura, 1995; Gist, 1989; Kavanagh & Bower, 1985; Litt, 1988). It is suggested that this can be done by regular opportunities for mastery within an achievable level that challenges the learner, but does not de-motivate them (Mayer, 2004). To lift the intellectual development of nursing students to prepare them for professional practice and decision-making, literature suggests that educators need to provide authentic and contextual learning experiences that focus on the science behind the nursing but in a scaffolded, guided manner leading gradually to intellectual independence (Jonassen et al., 1993). Laboratory work appears to provide some relevance and vicarious experiences to nursing students with some nurses from this study reporting how memorable these experiences had been for them. A laboratory session, if well planned (Tobias, 1990) and contextual to nursing, can assist students with active learning experiences, and social-validation of knowledge (Azer & Eizenberg, 2007; Becu-Robinault, 2002; Beney & Séré, 2002 Davies, Murphy & Jordan, 2000; Forester, Thomas & McWhorter, 2004; Granger &

Calleson, 2007; Guillon & Séré, 2002; Larcombe & Dick, 2003). Science skills, and integration of science knowledge can be modelled in the laboratory under the context of nursing, and this will increase the perception of relevance. Literature suggests that science educators are well placed to support nursing education by using their skills in the laboratory (Larcombe & Dick, 2003; Davies et al., 2000).

Delivery Methods

Much of the criticism that exists in the literature about the 'bioscience issue' is a perception held by many, that the nursing science teacher teaches in a manner that is non-contextual and too in-depth for nursing (Taylor et al., 1981; Trnobranski, 1996; Thornton, 1997; Wharrad et al., 1994). Analysis of the documents that explained the rationalisations for change to the science curriculum at some nursing schools' in New Zealand, suggest that this is still a widely held perception in New Zealand. Nurses who were interviewed had quite varied opinions on who should teach nursing science. Those that tended to have a more shallow understanding of the science behind their practice tended to indicate that science teachers were not the preferred teacher for nursing science due to the teaching being too in-depth and irrelevant. Those that tended to exhibit a more in-depth knowledge of science tended to indicate that the science teacher had equipped them well for practice.

Nursing requires nurses to work with professional teams (NCNZ, 2007b) and there is opportunity within nursing education to role model this. Science educators should work within the professional team of nurses ensuring that contexts are authentic, and definitions and descriptions are shared and integrated or complementary to nursing. As nursing lecturers tended to have a less positive attitude towards science in nursing than nurses in practice (as indicated by interviews), there may be some reluctance on behalf of nursing academics to work closely with scientists. As literature indicated that nursing lecturers may have lower self-efficacy towards science than students do (Friedel & Treagust, 2005), it may be that nursing lecturers may lack confidence to work with science tutors and co-teach.

Science that is used as observed in clinical practice is not fragmented, and therefore should not be taught in a fragmented, unrelated way. Using case-studies or guided learning activities based within a nursing context (Jonassen, Mayes & McAlesse, 1993; Mayer, 2004; Srinivasan, Wilkes, Stevenson, Nguyen & Slavin, 2007; Theyβen, Schumacher & von Aufschnaiter, 2002) can support the nurse to integrate science as part of their professional tool kit, but care has to be taken to ensure that the science knowledge is explicit and recognised. Those nurses who were able to articulate detailed science behind their clinical practice were observed to integrate science knowledge into their decision-making and nursing actions. This supports the modern nursing philosophies that nursing should be holistic (Jordan et al., 1999; Wynne, Brand & Smith, 1997), which should include maintaining a thorough understanding of the human body.

As registered nursing practice appears to use science in decision-making, risk assessment, advocacy, medication administration, education and nursing skills, the acronym of which is DRAMES, this could provide a framework for nursing science education and assessment.

7.3 Conclusions and Recommendations

This chapter has been focused on discussing the findings of this research and has been framed by the research question that guided this study: "What is the role of science in nursing practice?"

This question was underpinned by the following questions which were discussed earlier in this chapter:

- Is science required for clinical practice?
- In what ways, if any, do registered nurses use science in their clinical practice?
- What is the role of science education in nursing education?
- What is the role of science educators in nursing education?

The research goals for this inquiry were to:

1. Establish the most appropriate aspects of undergraduate nursing science curricula that might contribute to safe and informed practice as a registered nurse.

2. Establish if nurses with high science self-efficacy are more likely to use science in their clinical practice.

3. Understand the political nature of the undergraduate nursing degree and the various tensions and pressures that affect curriculum development as it relates to science content and delivery.

This study has found that science is required for clinical nursing practice, as shown by curriculum documents, interviews with nurse educators, surveys of practicing registered nurses, observations and follow-up interviews of nursing practice.

The lack of guidance on the depth and breadth of science required to inform nursing practice has led to variations in the science being taught in the different nursing schools, and gaps in the science knowledge that contributes to nursing practice. As the Nursing Council of New Zealand has responsibility for monitoring and approving nursing education, it should prescribe more effective guidelines for nursing science education based on the outcomes of this thesis.

<u>Recommendation One</u>: That the Nursing Council of New Zealand prescribes in detail the science required to inform registered nurses clinical practice as recommended in this thesis, as guidance for nursing school curricula.

Nurses who had passed Year 13 secondary school science were more likely to have found studying nursing science courses easy, and have a positive attitude towards using science in practice. Nurses who tended to have a positive attitude towards science were more likely to apply and use in-depth science knowledge in their nursing practice and be able to practice in areas where their decision-making is independent and autonomous. Nurses who tended to have a less positive attitude towards science, tended to have difficulty studying science courses as a student, and were more likely to apply shallow science in their nursing practice.

Students who met with success at final year senior secondary school science appear to be more likely to be able to use science knowledge to inform their decision-making.

Recommendation Two: That nursing schools set their entry criteria to include a requirement for prospective nursing students to have Level 3 (Year 13) NCEA or equivalent passes in at least one science subject.

Self-efficacy towards using science-in-practice appears to influence a nurses' ability to be able to apply science knowledge in the clinical practice setting. Those students who do not have high levels of self-efficacy towards using science (or who do not have senior secondary school science passes) should engage in a pre-nursing course that is designed to increase motivation and confidence in engaging with scientific information. Not all prospective nurses who enter nursing school who could potentially become effective nurses will have met with success in secondary school science**.** Setting the entry criteria that requires Level 3 science passes will impact on the numbers of students directly accepted into nursing degrees, and hence it is important to be able to provide educational opportunities that enable pre-nursing students to gain science knowledge and increase their confidence in, and motivation for science.

Recommendation Three: That prospective nursing students who do not have Level 3 (Year 13) NCEA passes or equivalent in at least one science subject are required to enter a pre-nursing science course.

This study has found that nursing lecturers are likely to hold less positive attitudes of science's relevance to nursing practice than nurses in practice. Aspects of science's contribution to nursing are unrecognised by nurses in practice and nurse educators/lecturers. The curriculum design processes within nursing schools may contribute to the devaluation of science in nursing as science may not have champions to negotiate changes to curricula. Science is required for nursing practice, and science educators can support nursing to "own" nursing science and support its impact on clinical practice working within a multidisciplinary team. Nurse/Scientist teams need to facilitate reflection on critical incidences that occur in practice setting (as well as using case-studies and problem-based learning approaches) that focus on the science behind the practice, to ensure that science's relevance and role in nursing is emphasised.

Recommendation Four: It is recommended that science educators be given opportunities to support student learning in practice, either while the student is in the clinical environment or afterwards, in terms of reflection on critical incidences to enhance the recognition of science in nursing.

Nursing science educators would benefit from a specialised course of training that focuses on teaching science to reluctant learners, and is based on social-cultural views of learning where teaching opportunities are authentic and based on nursing practice. These nursing science educators need to hold postgraduate qualifications in science (as opposed to nursing) as required by legislation (as nursing is a degree) and be able to act as nursing science champions.

Recommendation Five: That a post-graduate "Nursing Science Educator" qualification or course be designed that focuses on assisting nursing science educators to engage reluctant learners and provide authentic teaching opportunities.

Nursing science educators often operate in isolation and may lack support within their educational practice. A network that could provide opportunities for professional development and support would be beneficial for these educators.

Recommendation Six: It is recommended that a network or association of nursing science educators be established to foster growth and discussion on nursing science, and to provide collegial support and advocacy for science/nursing educator teams in nursing programmes.

Nursing students need to be regarded as novice science learners until they have gained mastery of science content and terminology. Guided learning using scaffolding approaches incorporating active learning opportunities such as laboratory sessions moving towards problem-based learning will facilitate science learning and prepare nurses for using science in nursing practice. Socio-cultural views of learning suggest that teaching and learning should be authentic to the community of practice. Case-studies should show various conditions and situations of altered health status presented in routine and uncomplicated contexts, demonstrating knowledge of patient including age continuums, and patient circumstance. Problem-based studies should include various conditions and situations of altered health status presented in non-routine and uncomplicated (moving towards more complexity) demonstrating knowledge of patient including age continuums and patient circumstance.

Recommendation Seven: It is recommended that science education for nursing students uses a scaffolding approach starting from guided case studies moving towards problem based learning where the focus and assessment emphasis is on the process, not the product.

Science is required for clinical practice. This study has found that the scientific skills used in pattern recognition, information searching, measurement, monitoring and recording are all important skills for nursing. Nursing requires science knowledge and skills to monitor a patient, and record data. At a registered nurse level, nursing requires science knowledge and skill to support clinical decision-making by informing risk analyses. Although nurses' decision-making can be experiential and intuitive, nurses who were engaged in independent practice tend to draw more upon sources of objective, scientific information to support their decisions. Nurses who were more confident with using science were more likely to use in-depth science knowledge to support patient education and be an effective advocate.

Nursing science needs to be integrated as part of nursing and not separate from it. Additionally, traditional nursing curricula have discrete packages of science content that are delivered and assessed at designated levels, whereas science used in nursing is integrated throughout a nurse's practice. Nurses use science throughout practice, from observation, to decision-making in routine, uncomplicated situations through to decision-making in non-routine, complicated situations, as outlined as in Table 7.1. While summative assessment should be integrated, it should be standard- based (achievement for knowledge and competency for skills) ensuring that the science is not hidden or unrecognised, and that students reach a standard of science that is safe for clinical practice.

Recommendation Eight: It is therefore recommended that the following framework be considered for undergraduate nursing science education and that nursing science is integrated but made explicit within nursing education and summative assessment.

Depth and Breadth of Nursing Science Topics

Nursing practice (as observed in practice and confirmed in interviews) is supported by scientific knowledge and skills in the following areas:

- *Chemistry* - nurses need to have an awareness of chemical concepts and a familiarity with the language and terminology of chemistry. For example: colloids, crystalloids, saline, dextrose, potassium, sodium, sodium chloride, electrolytes, molecular formula, chemical reactions, nitrogen and pH were used by the nurses. There was also an awareness of chemical activity (i.e., that chemical reactions occur) and the potential risks of handling chemicals (e.g., cytotoxins and liquid nitrogen).

- *Physics* supports the nurse's basic understanding of the physical world, and its interaction with, and affect on, the human body. Physics topics used in clinical nursing practice therefore seemed to include concepts of basic electricity and mechanics/machines, including lever points and points of balance, and also basic knowledge of pressure and flow.

- *Human Biology* needs to be used in clinical practice in a very integrated way. The nurse requires an integrated knowledge of how the human body works, and this seems to be central to nursing practice. Being familiar with the terminology and language of *Human Biology* so that a nurse can access more in-depth information if required, is an advantage for communicating with other health professionals as well as providing care for the patient.

- *Microbiology* is an important part of nursing science knowledge that affects and contributes to a nurse's clinical practice. Knowledge of microbiology as well as being able to perform microbiological skills would contribute to the nurse's ability to manage microbiological risks in the clinical environment. Topics included: control of microbes, knowledge of medically important microbes, and the relationship between normal flora, health and disease, as well as aseptic technique.

- *Pharmacology* needs to clearly address nurse responsibilities under the Medicines Act (1981), as it is a source of concern for many for practicing nurses. The topics to be addressed should include: responsibilities under the Medicines Act, (1981), different preferences and techniques for administration of injections, interactions between medications, long action and short action medication administration including variances on administration (such as pill crushing), modes of action on the body, safe use of and preparation of drugs (including diluents, mixing, etc.). Use of mathematics such as in drug calculations and measurement was a skill that was also required.

- Science-based skills that are also important for nurses to learn are: analytical thinking, calibration of equipment, evaluation of evidence and information, interpretation of data, pattern recognition, taking samples for analysis, handling biohazards and aseptic technique, are also important for nursing.

- *Information* topics that should be taught to nurses include: sources of reliable information, how to source reliable information, understanding the process that information goes through to become reliable, critical reading skills, quantitative analysis skills, reading graphs, charts and tables and scientific literacy.

- *Monitoring and Recording* topics that should be taught to nurses include: measurement, accuracy (including calibration and using same equipment for measurement), the importance of establishing baseline and norms for individuals, as well as the recording of objective/subjective data that can inform clinical decision-making, either by the nurse or another health practitioner, which may also involve the use of databases or computer systems.

- *Laboratory Tests* topics that should be taught to nurses include: common tests – reagents, protocols (time or temperature sensitivity), sampling, normal range, and interpretation of laboratory data.

This consideration of science-based topics for nursing students, together with the earlier recommendations around curriculum structure and delivery, leads to the following suggested approaches to nursing science for a range of learners. It should be noted that this curriculum recommendation should not be considered to be definitive. It is considered that science education should be integrated across all years of nursing education and not front loaded.

Table 7.1: Possible Undergraduate Nursing Science Approaches

Novice Learners (Unfamiliar with science content)	**Advanced Learners** (Familiar with science content)	**Expert Learner**
Learning Focus: Well structured domains Skill based Terminology and science literacy Monitoring and Recording Confidence Motivation Information	**Learning Focus:** Ill-Structured domains Knowledge-based Decision-making Risk Assessment Medication Education Science Skill	**Learning Focus:** Interconnected knowledge Decision-making Risk Assessment Advocacy Medication Education Science Skill
Learning Outcome: Describe science aspects that support nursing observations across the lifespan Discuss the science that supports physical examination and head to toe assessment Discuss the science that supports infection control in nursing	**Learning Outcome:** Explain science content that informs clinical decision making in a variety of routine and uncomplicated case-studies or situations Explain the science content that informs clinical decision making in a variety of non-routine and uncomplicated case-studies or situations	**Learning Outcome:** Explain the in-depth science content that informs clinical decision making in a variety of non-routine and complicated situations

Teaching model:	Teaching model:	Teaching model:
Engagement Guided examples Active teaching methods Scaffolding, mastery, vicarious Social mediated	Apprenticeship Coaching Active teaching methods Social mediated Contextual Case-studies	Experience Decision-making Problem-based studies

7.4 Opportunities for Further Research

Most of the recommendations in this chapter can be further developed into research investigations or interventions that examine the effectiveness of each recommendation as a strategy. For instance, an investigation of the effectiveness of a pre-nursing science course whose purpose is to increase confidence and motivation in science would be valuable. If the recommended entry criterion is set, a project investigating the effectiveness of this strategy and its effect on pass rates, student anxiety and effectiveness of the science course(s) could be investigated, and this to would also be valuable. As nurses in practice appeared to have valued their post-graduate exposure to formalised nursing courses, the development of post-graduate nursing science courses for nurses in practice should be considered to be a compulsory part of graduate study programmes. However this was not made a recommendation as this is beyond the scope of this research which was focused on undergraduate degrees that lead to registration.

Curriculum design can be fraught with power conflicts and subject to personal influences and perceptions. Science therefore can be at a disadvantage in the curriculum development process if it does not have champions who value its contribution to nursing. The normal process of curriculum design is to consider the product (the graduate) and then to compile packages of learning that will be assessed in a manner that provides evidence that the product has met the standard (passed courses that are represented by learning outcomes, graduate outcomes, competencies). This curriculum is subject to consultation and verification by the clinical community. As there is evidence to suggest that science's contribution to nursing is unrecognised, alterations to the science curriculum that may disadvantage nursing may occur. The process undertaken in this thesis (that is, observing practice to provide evidence of science behind nursing actions) may be developed further to become a curriculum design process. It is possible that this research process may be useful for subject areas other than nursing where one particular area of knowledge or discipline is marginalised, and may be at risk of being unrecognised. An opportunity for further research then is to develop and trial the process outlined in this thesis (Objective Observation of Practice) as an alternative to current curriculum design processes. The curriculum topics outlined in this study should not be considered definitive, but a starting point and more research should be undertaken to continue to build a fuller picture of how science informs nursing practice.

Connection with clinical practice is also required for the development of the science educator who has responsibility for the teaching and learning for nursing science. Having the science educator enhance learning that occurs in practice (either by direct supervision or by reflections on critical incidences), needs to be investigated to examine if it enhances the ability of the student nurse to use science in practice and see if it highlights the value of nursing science, resulting in peer validation and nurses owning their nursing science knowledge**.** An opportunity for further research then is to develop intervention strategies where science educators provide support to students in clinical practice and evaluating if these are effective.

This thesis presents recommendations that would significantly change the way nursing science is taught in undergraduate nursing degrees, and any recommendation could be investigated to see if it was an effective strategy – that is, if the science curriculum that was developed as a result of implementing these recommendations was appropriate for undergraduate nursing in New Zealand resulted in positive outcomes for patients.

7.4.1 Limitations of Study

As the process of coding statements made by the nurses whose practice was observed was a subjective decision, and due to the nature of the methodology (intense observation and follow-up interview), the participants of this study may have had more knowledge than they articulated at the time of observation. In particular this may be true for those statements coded 0 (indicating that the participant had no science knowledge informing the practice). It could be that as the observation was during the nurse's daily duty, the nurse may have responded with a 0 level statement without much considered thought. It is possible that if the nurse was questioned further, they might have been able to articulate further knowledge behind the practice.

The findings described in this thesis have established a theme that for most topic categories, the in-depth science statements (as designated against the scale of depth, Table 6.3) were made by nurses who tended to have more confidence in using their science-in-nursing-practice (compared to those nurses who made shallow statements as explanation for their practice actions). Extrapolating further, if nurses who had more confidence in using science in their nursing practice also had a more positive attitude towards science (and the learning of science), then it stands to reason that may have confidence in articulating their science in the interview situation, resulting in statements showing deep or integrated knowledge. These are possible limitations of the methodologies used in this study, along with small sample sizes which limited the mathematical correlation studies and representativeness of the sample population.

Also, as the nurses who participated in the survey would have become aware that the focus of the study was on science (due to the nature of the questions), the study methodology may have inadvertently selected participants for the observation studies due to their motivation or interest in science. This may have overrepresented the number of nurses who had high self-efficacy toward using science-in-practice and who had positive attitudes towards science.

Other limitations are due to the nature of the observation studies where participants may have engaged in activities that were not part of their normal practice, simply because they were being observed. Within this study, the observations were for many hours and within a busy practice area, and the nurses appeared to be relaxed and comfortable, however, it is possible that some nurses did carry out nursing actions in ways that were not part of their normal practice.

The ability of the researcher to observe and identify actions of significance in nursing practice could also be considered a limitation of this study. That is, not all actions of significance may have been identified or recognised, or the researcher may have had a bias towards a particular outcome, or type of action. That is, some actions may have been identified when they were not in fact significant, whereas others that may have been considered by others to be significant may not have been identified.

Another limitation of this study was that due to the small sample size (17 nurses in the observation studies) the findings of the science behind the nursing practice should not be considered complete and so the results should be considered to be an indicative and not a definitive study on what nursing schools should teach in their nursing curricula.

This study has concluded that science is required for nursing practice but has not attempted to provide evidence that nurses who were able to articulate in-depth science as explanation for their clinical practice were, in fact, good nurses whose practice resulted in improved patient outcomes. It also does not imply that nurses who do not apply in-depth science in their practice were poor nurses.

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Appendix A: Nursing school Curriculum 2006 -2009

Course/Learning Objectives	Comments
Institute A 2006 Science is taught with all the students from the Medical and Health science Faculty Year two and three of the programme are integrated and science is again taught by scientists from the faculty 2009 – no information provided about any changes to these courses	Laboratory sessions are held every two weeks for 3hrs Lecturers with PhD's in their topics (Science components are taught by Scientists).
Institute B 2006 **BN141 Health Sciences One** **Unit 1** Students will acquire knowledge of the basic concepts of microbiology, chemistry, biochemistry and physics and their relationship to the human body, providing a sound theoretical foundation for nursing practice. **Unit 2** Students will demonstrate knowledge of basic concepts of anatomy and physiology related to the human body providing a sound theoretical foundation for nursing. **Unit 3** Students will acquire knowledge and understanding of 'over the counter' medications (i.e. those preparations available for purchase without prescription) as a recognised component of people's health care, and develop a fundamental, understanding of Pharmacology and methods of drug administration. **Year Two** **BN242 Health Sciences** Students will further develop their knowledge base established in Health Sciences I. Understanding of selected aspects of Anatomy, Physiology, Microbiology and Biochemistry will be gained to provide a sound theoretical basis for safe nursing practice. **BN242 Altered Health** The focus of this paper is on developing the student knowledge and understanding of altered bodily functioning and medications commonly prescribe to treat the person. This will assist in safe and appropriate assessment, planning and evaluation of client care. Unit 1 – Pathophysiology Unit 2 – Pharmacology 2009 - *The structure and delivery of the Health Sciences remains fundamentally the same as reported in 2006, apart from the usual content fine-tuning to reflect current health issues (H1N1, new HIV, etc.).*	"There is growing evidence (through formal and informal feedback) that many students continue to find the Health Sciences very challenging and would value both an increased time allocation and a longer time frame for the assimilation and contextualisation of these subjects. We are currently preparing for a general curriculum review, where such issues can be discussed. We view this as a key series of "hands-on" experiences that provide valuable pathways for making sense of the accompanying health science theory – a view strongly supported by student feedback". *Course Coordinator*
Institute C 2006 **Level 5 Human structure and function.** This is a paper that is the level 5 paper for all the Bachelor of	**2006:** Taught by science lecturer.

Course/Learning Objectives	Comments
Health Science degrees. Changed to **Human Anatomy & Physiology 1** 15 credits (150 hours) in 2009 **Level 6 Human Bio Science.** Changed to **Human Anatomy & Physiology 11** 15 credits (150 hours) **Pathophysiology** Physiological adaptation	**2009:** Taught by nursing lecturers.
Institute D 2006 **Year 1 (Level 5)** **SP140:** Human Biology 1: cell structure and function, Introduction to Microbiology; Tissues, Digestion, Absorption, Metabolism, Nutrition **SP141:** Human Biology 2: skin, cardiovascular, respiratory, Nervous intro, Musculoskeletal, urinary, reproductive, intro genetics. 10 credits, 34 hrs lectures **Year 2 (Level 6)** **SP241:** Human Biology for Nursing Practice. Taught as two parallel lecture series, one focusing on Anatomy and physiology and the other Pharmacology (2 hrs per teaching week), with a. Topics- A&P strand covers Neurology, Endocrinology, senses, lymphatics and immunity, Introduction to pathophysiology (cancer, genetics of disease); Pharmacology strand covers basic pharmacology, pharmacokinetics, pharmacodynamics, pharmacology and special groups (very young, aged, pregnant); autonomic drugs, antibiotics and applied microbiology, principles of chemotherapy. **Year 3 (Level 7)** **SP341:** Human Biology for Nursing Practice 2. Each topic module covers system pathophysiology followed by relevant pharmacology/ treatment of common selected conditions. 2009 **BN503 Bioscience for health professionals I** 15 credits (60 hours taught) Explain the basic concepts of the sciences relating to the human body and its physiological systems. Identify normal human physiological function, its variability and the significance of practical observation, measurement and data collection. Explain basic cell and tissue structure and function. Explain how body systems contribute to homeostasis. Investigate the relevance of microbiology and explain the interaction of micro-organisms within the human body. CONTENT: Introduction to biological science and genetics; Cell biology/cellular mechanisms: Microbiology and infection control: Introduction to specified body systems: Breasts and reproductive, Musculoskeletal, Urinary, Endocrine. **BN504 Bioscience for health professionals II** 15 credits Explain how the function of selected organ systems is related to their structure. Link the control of micro-organisms with the structure and function of the digestive system. Describe the relationship between nutrition and health. CONTENT: Normal structure and function of the following body system; Cardiovascular system; Respiratory system; Gastro-intestinal system, including nutrition; Skin; Neurological system	**2006:** SP140: 26 hrs lab taught over semester 1 (1x 2 hr science lab per student each teaching week). SP141: 24 hrs labs taught over sem 2 (1x 2 hr science lab per student each teaching week). SP241: supporting 1 hr tutorial or science lab each teaching week SP140: 26 hrs lab taught over semester 1 (1x 2 hr science lab per student each teaching week). **2009:** Laboratory dissection, computer based interactive atlas for histology and gross anatomy; haematocrit. Laboratory dissections in physiology lab. 60 hours taught 40 hours taught

Course/Learning Objectives	Comments
BN603 Nursing science and practice I 15 credits Competently undertake health histories and physical examination skills related to specific body systems. Explain pathophysiology related to specific body systems. Describe genetic/hereditary/familial issues related to specific body systems. Explain the principles of drug action and metabolism related to specific body systems. CONTENT: Anatomy, physiology, and pathophysiology of selected body systems which may include endocrine, cardiovascular, peripheral-vascular, lymphatic, respiratory, neurological and skin; Principles of pharmacology; Introduction to health assessment and physical examination skills, using a holistic framework across the lifespan; Integration of health assessment findings using a problem-solving focus; General nursing survey, care planning, and documentation; Communication and interpersonal skills related to assessment.	
Institute E This institute had embarked on developing a whole new curriculum with one of the rationales for change being due to changes in nursing such as the development of nurse practitioner roles where it required a change towards a more scientific orientation in undergraduate programmes. **Year 1: Bioscience for Nurses (semester 1)** 15 credits **Semester 2: Anatomy and Physiology** 15 credits Science is integrated across degree of Nursing for following semesters.	**Taught by Scientists – Masters Degrees** 48 hours taught **2006:** 16 hours labs 48 hours taught **2006:** 12 hours labs Taught by Scientists – Masters Degrees and PhD **2009:** 12 hours labs **2009:** 12 hours labs
Institute F 2006 **Year 1** Basic chemistry, biochemistry, Microbiology, A + P of all body system **Year 2** Pathophysiology of all body systems, Nutrition, Immunology, Pain, stress, Pharmacology	11 labs: 2-hr lab sessions with first years in science and 3 x 2-hr sessions in second year Staff: Nurse x 1, scientist x 4
Institute G 2006 **Anatomy and Physiology** Introduction to the human body, Tissue level of organisation, Integumentary system, Skeletal system, Muscular system, Cardiovascular system Heart Blood vessels and haemodynamics Blood, Lymphatic system, Nervous system, tissue , Central nervous system, Peripheral nervous system, Autonomic nervous system, Special senses, Endocrine system, Digestive system, Respiratory system, Urinary system. **Bioscience** Principles of chemistry and biochemistry, Major nutritional	80 hours taught laboratory sessions – 3 hours 90 hours taught No laboratory sessions

Course/Learning Objectives	Comments
categories and their functions, Properties of food groups and other nutritional elements, Cell processes of metabolism relating to nutrition, Nutrition in relation to normal body function, Cellular level of organisation, Mitosis as a mechanism for growth and cellular repair, Meiosis as a mechanism for sexual reproduction, Principles of genetics, Defining antigen, Non-specific body defenses and clotting pathways, Differentiating between specific and non-specific body defenses, Cell mediated immunity, Differentiating between natural and artificially acquired immunity, Active and passive immunity and their relationship, Vaccine production and the cold chain, Defining microbiology and the different characteristics of micro-organisms, Host versus parasite interactions, Relevance of microbiology to health professionals, Defining pathogens, Common pathogens, Understanding diagnostic laboratory tests, Reservoirs of infection, Strategies to control micro-organisms, Fluid, electrolyte and acid base balance 2009 **Anatomy and Physiology** 15 credits Removal of blood and lymphatic system and addition of Reproductive System. Same content. **Bioscience** 15 credits Same content as 2006**.** *Since 2006 the science courses have been reviewed and recombined in 2008 to be a 30 credit one semester course to align with Fundamentals of nursing. Student feedback was that the course was too intense. It was reformatted back to 2 x 15 credit courses for 2009.*	50 hours taught 10 hours laboratory sessions 50 hours taught 10 hours laboratory sessions
Institute H **In year 1, A and P.** Cell, tissue, organs, systems; Chemistry- atom, chemical bonds and reactions, acids and bases, proteins, carbohydrates and fats; Physics - pressure (negative, positive, hydrostatic), gas laws, flow rate, laminar and turbulent flow.; Microbiology - bacteria, rikettsiae, fungi, protozoa, viruses, and parasites; Microbial growth, sterilisation and disinfection; Chain of infection, inflammatory response; Systems - integumentary, lymph and immune, blood, cardiovascular, respiratory, musculo-skeletal, nervous, special senses, endocrine, digestive, renal, reproductive; Electricity, magnetism, waves **In year 2, pathophysiology and physical assessment** Pathophysiology re gaseous exchange and transport - blood, cardiovascular, respiration, shock; Pathophysiology re fluid and electrolyte balance - kidney, endocrine; Pathophysiology re cell growth and proliferation; Pathophysiology re metabolism; Pharmacology - pharmacokinetics, pharmacotherapeutics, pharmacodynamics, and toxicology	Nurse with a special interest in science and microbiology, and the other is a non-nurse, with a science background. We also have other 2 lecturers, teaching pathophysiology and physical assessment, both nurses, one with a BSc and the other with a PG Cert in Critical Care. 46 hours in science lab
Institute I **214101 Human Bioscience:** Normal Body Function, covers anatomy and physiology and concepts such as aging and homeostasis	2 hour lab 13 weeks 2 hour lab 13 weeks

Course/Learning Objectives	Comments
214102 Applied Sciences for Health Professionals, microbiology, nutrition and biochemistry **214201 Human Bioscience:** Impaired Body Function, pathophysiology related to body systems from different science perspectives i.e. anatomy/physiology/ microbiology/ biochemistry **214202 Pharmacology:** 2009 – no information provided	2x 2 hour labs Qualifications vary from masters to PhD in a science related discipline such as for example biochemistry, microbiology
Institute J **Year 1**: covers organisation, chemistry, cells, tissues, integ mx-skeletal, cardiovascular/respiratory & the 2nd paper (year 1) covers the other systems including microbiology & immunology. Pathophysiology in **year 3**	Students are also taken to the science labs for dissections/ wet labs etc, (approx 8 hours / paper) Science qualifications and co-teach these papers with another lecturer with a nursing degree & post-grad science
Institute K 2009- just released new curriculum **Bioscience** 15 credits Demonstrate the application of knowledge from the biosciences when assessing individual's homeostatic status; Demonstrate a sound understanding of the principles of anatomy and physiology; Describe how the integrated functioning of body systems from cellular to tissue to system level; Use scientific concepts and vocabulary appropriately when functioning as a students nurse. Content includes discussion of: Consideration of the cellular basis for the physiology and anatomy of humans; How this cellular basis specialises to form tissues and systems; Where these tissues are located (anatomy) and their specific functions(physiology)in the role of maintaining equilibrium (homeostasis) within the body; How this knowledge relates to the nursing process **Pharmacology** 10 credits Pharmacological terminology relevant to nursing practice; Mechanisms by which drugs exert their pharmacological actions; Absorption, distribution, metabolism and excretion of drugs.; Adverse effects of drug therapy and outline their physiological basis; Interactions that may occur between concurrently administered drugs; Influences on the effectiveness of drug therapy such as age, gender, co-morbidity and genetics **Pathopysiology** 15 credits Describe how pathophysiological processes may disrupt or alter body function including the implications for the person concerned; explain how physiological compensatory mechanisms may or may not assist in restoration to homeostasis;	70 hours 50 taught 80 hours

Course/Learning Objectives	Comments
identify the clinical manifestations of major disease processes and explain the underlying physiological and/or anatomical alterations and be able to relate these to nursing practice; demonstrate knowledge of pharmacological principles and the application of these to the various body systems; understand genetic influences on health and how these may interact with environmental and lifestyle factors to cause disease; understand diagnostic techniques in relation to specific pathological conditions commonly encountered in nursing practice. Content includes: general introduction to key concepts that may be encountered across a variety of clinical settings and pathological states; The pathophysiology of multiple body systems will be studied, including an exploration of some aspects of their clinical management. Body systems and topics studied include: central and peripheral nervous systems; respiratory system; neurology; cardiovascular system; gastro-intestinal system; pregnancy; endocrine system; reproductive system; renal system; musculoskeletal system; integumentary system; haematology; immune system; infectious disorders. Content will also include investigation of selected drug classes used to treat or manage clinical conditions including their cellular and systemic effects.	
Institute L <u>2006</u> **Human Biological Science I** Structural organisation and homeostatic mechanisms of the body; Cellular structure and function; Basic chemistry and biochemistry;The tissue and integumentary system ; The nervous system and special senses ; Biology of micro-organisms: life-cycles and transmission **Human Biological Science 2** The musculo-skeletal system; The cardiovascular system ; Infection and the immune system; Anti-microbial treatment The respiratory system **Human Biological Science 3 (level 6)** The urinary system; The endocrine system; Fluid and electrolyte balance; The gastrointestinal system; Reproductive systems Genetics; Foetal development and physiology of pregnancy <u>2009</u> *Follows same outline. Changes in staff – movement away from "medical model" to more explicit relevance to nursing practice and follow on courses such as pharmacology and pathophysiology. Great emphasis placed on microbiology to ensure safety in clinical setting.*	**2006**: Including 6 hours in lab **2006:** Including 9 hours in the lab **2006:** Nursing undergraduate qualifications, with additional undergraduate study in bioscience, chemistry, and post graduate qualification in nursing **2009:** Courses now on-line. Interactive experiences as well as "hands-on" laboratory experience. **2009:** Bachelors degree in Science Masters in Developmental Physiology, RN, Midwife
Institute M **BN111** Describe the anatomy and physiology of the human body through the study of cells, tissues and organ systems; Explain the concept of homeostasis and describe how a range of homeostatic mechanisms maintain balance within the body ;	Lecturer has a PhD, one has a masters in science and one has a diploma in physiotherapy before becoming a teacher

Course/Learning Objectives	Comments
Describe the molecular basis of life in order to understand the physiology function, nutrition and health status; Begin to integrate knowledge of anatomy and physiology with nursing practice. **BN113** Describe the anatomy and physiology of the human body through the study of cells, tissues and organ systems; Describe how a range of homeostatic mechanisms maintain balance within the body; Describe the molecular basis of life in order to understand physiological function, nutrition and health status; Demonstrate understanding of the principles of microbiology and immunology; Integrate knowledge of anatomy, physiology, microbiology and immunology with nursing practice **BN211** Use knowledge of normal physiology to explain pathophysiological changes; Demonstrate understanding of the pathophysiological changes which occur during trauma and disease; Describe the physiological responses of the body to these disturbances which may result in a return to normal functioning; Demonstrate understanding of the principles behind preventative, diagnostic and medical interventions. Demonstrate understanding of the rationale behind nursing interventions and their effectiveness in restoring or minimising damage to normal body function; Use current research findings in relation to pathophysiology and nursing interventions to guide nursing practice. Explain the application of microbiological principles to nursing practice; Explain the application of immunological principles to immunological conditions commonly encountered in nursing practice; Demonstrate understanding of the principles of pharmokinetics, pharmogenetics, pharmodynamics, drug interactions and drug safety and awareness	
Institute N <u>2006</u> **Level 5 Human structure and function.** This is a paper that is the level 5 paper for all the Bachelor of Health Science degrees. **Level 6 Human Bio Science** **Pathophysiology** Physiological adaptation <u>2009</u> Changed to **Human Anatomy & Physiology I** 15 credits Changed to **Human Anatomy & Physiology II** 15 credits **Pathophysiology** Physiological adaptation	**2006:** Taught by science lecturer**.** **2009:** Taught by nursing lecturers. **2006:** labs (5 hours) **2009:** 1x 2 hr science lab per student each teaching week. **2009:** 3 labs (5 hours) One 2 hour lecture x 8 weeks + online tutorials + 6x 2hr tutorials per semester

Appendix B: Science attitude and Self-efficacy (SASE) for nursing survey

Registered Nurse Survey 2009

INSTRUCTIONS:

Please answer the following questions by ticking, crossing or writing in the most appropriate answer box. This survey should take about 10 minutes. Please put the survey in the freepost envelope provided and post in the mail by 25 September 2009.

Demographic Information

1. Please specify your age range (in years):

20 – 29 ☐ 30 – 39 ☐ 40 – 49 ☐ 50 – 59 ☐ 60 plus ☐

2. Indicate your gender:

Female ☐ Male ☐

3. What ethnic group do you identify the most strongly with?

Māori ☐ Pacific Islander ☐ NZ European or European ☐ Asian ☐ Other ☐

Qualifications

4. What qualification did you gain initially to become a **registered** nurse?

Hospital Qualification ☐ Diploma ☐ Degree ☐

5. What year did you become a registered nurse? ☐

6. What is your scope of practice? E.g. RGON, Comp ☐

7. What qualifications have you obtained since becoming registered?
Please write the qualification in the box below indicating any subjects or majors if appropriate.

☐

8. What is the highest level of **secondary school science** subjects that **you studied**? (Please tick).
(NOTE: Science can include physics, biology, chemistry or general science).

- Fifth form level or NCEA Level 1 (Year 11) or equivalent ☐
- Sixth form level or NCEA Level 2 (Year 12) or equivalent ☐
- Bursary level or NCEA Level 3 (Year 13) or equivalent ☐
- Other: Please state ______________________

9. Which science subjects did you **pass** at this level?

Biology ☐ Chemistry ☐ Physics ☐ General Science ☐

The following questions relate to **science*** subjects that you studied at **nursing school**. Please indicate with a tick in the corresponding box if you agree or disagree with the statement.

*(Note: * Science subjects may have been called Science for Nurses, Anatomy and Physiology, Microbiology, Biochemistry, Bioscience or similar, or may have been integrated into nursing subjects).*

Learning nursing science

	Strongly agree	Agree	Disagree	Strongly disagree	Not sure
10. I found the science course(s) easy.	☐	☐	☐	☐	☐
11. I worried more about science courses than other nursing subjects.	☐	☐	☐	☐	☐
12. I found that there was too much material to cover for the time allowed.	☐	☐	☐	☐	☐
13. The readings required for science were easy.	☐	☐	☐	☐	☐
14. I found that the language and terminology of the science courses were easy to learn.	☐	☐	☐	☐	☐

Science in nursing practice

As a registered nurse in clinical practice, please indicate with a tick in the corresponding box if you agree or disagree with the following statements.

Statement	Strongly agree	Agree	Disagree	Strongly disagree	Not sure
15. The material covered in the science course(s) was too in-depth for nursing.	☐	☐	☐	☐	☐
16. Science knowledge forms the foundation for nursing practice.	☐	☐	☐	☐	☐
17. It is important for practicing nurses to have an in-depth knowledge of science.	☐	☐	☐	☐	☐
18. My science background is good enough to understand the science needed in nursing now.	☐	☐	☐	☐	☐
19. I would like to have better knowledge of science than I have at the present.	☐	☐	☐	☐	☐
20. I find it easy to apply science to my own nursing practice.	☐	☐	☐	☐	☐
21. I used to have a better knowledge of science than I do now.	☐	☐	☐	☐	☐

22. What is your main area of current clinical practice?

Primary Health ☐ Aged care ☐ Mental Health ☐ Hospital or Acute ☐ Admin Education ☐

23. What is your area of specialty or where do you have the most experience?

☐

24. How many years have you been in clinical practice? ☐

Using science in nursing practice

In the following questions please indicate how **confident** you feel in your ability to perform the following tasks. **You do not have to perform the task**. Please answer honestly - there are no right or wrong answers.

Place a tick on one of the dashes. **Ticking √ on the dashed line** near the "very confident" side suggests that you believe that you could perform the task well. Ticking near the "very unconfident" side indicates that you believe that you could not perform the task well.

25. Convert Mary's dietary intake of 2500 cal to kilojoules given that one calorie = 4.185 kJ.	Very confident	_ _ _ _ _ _ _ _ _ _ _	Very unconfident
26. Provide appropriate diet recommendations to a pregnant, female adolescent who is vegetarian, and has food allergies.	Very confident	_ _ _ _ _ _ _ _ _ _ _	Very unconfident
27. Describe possible side-effects of a new medication to a patient who is already taking multiple medications for underlying health conditions.	Very confident	_ _ _ _ _ _ _ _ _ _ _	Very unconfident
28. Read biochemical laboratory test results, and explain what the results mean to the patient.	Very confident	_ _ _ _ _ _ _ _ _ _ _	Very unconfident
29. Explain the difference in composition of normal saline, and dextrose saline.	Very confident	_ _ _ _ _ _ _ _ _ _ _	Very unconfident
30. You have a 50 kg patient who requires a drug dose of 3 mg/kg of body weight. The ampoules contain 300 mg of the drug. Calculate the volume of the drug that you would require for the patient.	Very confident	_ _ _ _ _ _ _ _ _ _ _	Very unconfident
31. Explain to a patient what radioactive iodine is.	Very confident	_ _ _ _ _ _ _ _ _ _ _	Very unconfident
32. Aseptically take a swab from a wound for laboratory analysis to determine the infectious agent.	Very confident	_ _ _ _ _ _ _ _ _ _ _	Very unconfident
33. Aseptically dress a wound using a sterile dressing pack in a patient's own home where 20 cats also live.	Very confident	_ _ _ _ _ _ _ _ _ _ _	Very unconfident

34. Ensure that you do not introduce opportunistic normal flora to an immuno-compromised patient. | Very confident _ _ _ _ _ _ _ _ _ _ _ Very unconfident

35. Explain to a patient who has a severe bout of influenza why antibiotics will not work as a treatment. | Very confident _ _ _ _ _ _ _ _ _ _ _ Very unconfident

36. Describe what the differences between *Staphylococcus aureus* and MRSA are. | Very confident _ _ _ _ _ _ _ _ _ _ _ Very unconfident

37. Explain how bacteria become resistant to antibiotics. | Very confident _ _ _ _ _ _ _ _ _ _ _ Very unconfident

38. Describe the difference between vaccination and immunisation. | Very confident _ _ _ _ _ _ _ _ _ _ _ Very unconfident

39. Explain how antibodies are produced, and how they provide protection. | Very confident _ _ _ _ _ _ _ _ _ _ _ Very unconfident

40. Describe how genetic testing is undertaken, and what the results may mean for a family. | Very confident _ _ _ _ _ _ _ _ _ _ _ Very unconfident

41. Explain to a male client the likelihood of an autosomal recessive genetic mutation being transferred to his children. | Very confident _ _ _ _ _ _ _ _ _ _ _ Very unconfident

42. Discuss the significance of blood typing with regard to transfusions. | Very confident _ _ _ _ _ _ _ _ _ _ _ Very unconfident

43. Explain the difference between an allergy (e.g., hay- fever) and an upper respiratory infection (e.g., a cold). | Very confident _ _ _ _ _ _ _ _ _ _ _ Very unconfident

44. Describe the biological mechanisms of growth and repair in the human body. | Very confident _ _ _ _ _ _ _ _ _ _ _ Very unconfident

45. Please feel free to comment on any aspect of your science education that was especially memorable or meaningful that you feel helped your nursing practice (attach extra paper if required).

Thank you for participating in this survey. Please post in the envelope provided along with permissions letter.

Appendix C: Letters to survey participants

Dear Nurse Manager/Educator

I would like to invite you to participate in a research project as part of my PhD in education with the Centre for Science & Technology Education Research at the University of Waikato, Hamilton, New Zealand.

I would like to investigate the relationship between science undergraduate nursing curricula and its relevance to nursing practice. I hope my findings will inform the development of nursing education curricula.

If you would like to contribute to this study, I would like to conduct a short interview with you (no more than 20 minutes duration) at a time and place of mutual agreement. I would like to audiotape this interview to allow me to keep a record of our conversation. I will provide you with a transcription of the interview in order that you can amend anything that you said, should you feel you wish to. If you are willing to participate, please provide your contact details (see attached) and return in the envelope provided.

Your responses will be treated as confidential and there will be no record made of your identity in the interview transcriptions. All findings and reports will also be written in a manner that no participants can be identified. Pseudonyms will be used when reporting data gathered from any participant. Data collected from you may be used in writing my thesis, publications or in presentations. I will make sure that I store all the information I gather from you securely. You can withdraw from involvement in the research at any time. This will mean that no further information will be gathered from you for the project, and I will return any interview data to you where possible.

If you have any questions about the research, please feel free to contact me at the address given below. If I cannot clarify the question/issue please contact my thesis supervisor, Dr Chris Eames at the University of Waikato (email: c.eames@waikato.ac.nz, Tel: 07 838 4357).

Thank you for helping me with this research.

Yours faithfully

Christine D. Fenton

New Plymouth contact details:

mfenton@clear.net.nz;

Interview consent form – Nurse Manager/Educator

I have read the attached letter of information.

I understand that:

1. My participation in the project is voluntary.
2. I have the right to withdraw from the research at any time.
3. Data may be collected from me in the ways specified in the accompanying letter. This data will be kept confidential and securely stored.
4. Data obtained during the research project will be used for the purpose of writing my thesis, publishing papers and making presentations. This data will be reported without use of my name.

I can direct any questions to Christine Fenton (email:mfenton@clear.net.nz

Tel: xxx).

For any unresolved issues I can contact thesis supervisor, Dr Chris Eames at the University of Waikato (email: c.eames@waikato.ac.nz Tel: 07 838 4357).

I give consent to be involved in the observations under the conditions set out above.

Name: ____

Signed:____

Please return to Christine Fenton in the freepost envelope provided.

The University of Waikato
Te Whare Wānanga o Waikato

Dear Registered Nurse

I would like to invite you to participate in a research project as part of my PhD in education with the Centre for Science & Technology Education Research at the University of Waikato, Hamilton, New Zealand.

I would like to investigate the relationship between what you learnt in your undergraduate nursing education and your clinical practice. I hope my findings will inform the development of nursing education curricula. If you would like to contribute to this study, I would like to invite you to participate in the first phase of the research by completing the attached survey. The survey should take no more than 15 minutes to complete and then return using the envelope provided.

Your responses to the survey will be treated as confidential and there will be no record made of your identity in any reporting of the findings. Pseudonyms will be used when reporting data gathered from any participant. You have the right to decline to participate and will also have the right to withdraw your survey data up to one week after I receive it from you.

The second phase of the research is for me to observe nursing practice and I invite you to indicate your willingness to participate in this phase also by completing your contact details on the attached sheet and returning it with the survey in the envelope provided. Completing the survey does not oblige you to participate in this next phase of observations.

These observations of your nursing work would be conducted at your convenience at your place of work and may vary in length (half days or whole days in duration). This would occur on 1 to 3 occasions depending on your approval and that of your manager. Short interviews with you will also be conducted (no more than 15 minutes duration) at times and places of mutual agreement to check my observations with you. I would like to audiotape these follow up interviews to allow me to keep a record of our conversations. I will provide you with a summary of each interview so that you can amend anything that you said, should you feel you wish to. I will take steps to gain approval for my observations of your work from your manager and will follow any necessary ethical procedures in your place of work to ensure patient confidentiality and safety.

Data collected from you may be used in writing my thesis, publications or in presentations. I will not use your name, the names of your workplace or any patient you are working with. I will make sure that I store all the information I gather securely. You can withdraw from involvement in the research at any time. This will mean that no further information will be gathered from you for the project, and I will return any observational and interview data to you where possible.

If you have any questions or issues about the research, please feel free to contact me at the address given below. If I cannot clarify the question/issue please contact my thesis supervisor, Dr Chris Eames at the University of Waikato, (email address: c.eames@waikato.ac.nz Telephone: 07 838 4357).

Thank you for helping me with this research.

Yours faithfully

Christine D. Fenton

New Plymouth contact details: mfenton@clear.net.nz

Observation and interview consent form – Registered nurse

I have read the attached letter of information.

I understand that:

1. My participation in the project is voluntary.
2. I have the right to withdraw from the research at any time.
3. Ethical approval will be gained from my manager before conducting any observations or interviews for this project.
4. Data may be collected from me in the ways specified in the accompanying letter. This data will be kept confidential and securely stored.
5. Data obtained during the research project will be used for the purpose of writing my thesis, publishing papers and making presentations. This data will be reported without use of my name, the name of my workplace, or any patient I am working with.

I can direct any questions to Christine Fenton (email: mfenton@clear.net.nz Tel: xxx).

For any unresolved issues I can contact the thesis supervisor, Dr Chris Eames at the University of Waikato (email: c.eames@waikato.ac.nz Tel: 07 838 4357).

I give consent to be involved in the observations under the conditions set out above.

Name: ____

Signed: ____

Email address: ____

Phone: ________________________

Date: ________________________

My manager for gaining approval for my involvement in the observation phase is:

Name: ____

Work address: ____

Phone: ________________________

Please return to Christine Fenton in the freepost envelope provided, along with the survey if you have completed that.

Dear Ms [insert name]

I am writing to you to request your approval to conduct nursing education research in your place of work. This research will include observations of nurses' practice and will be focused on how nurses have translated their learning into their practice as a registered nurse. I am investigating the relationship between undergraduate nursing curricula and its relevance to nursing practice as part of my PhD in education with the Centre for Science & Technology Education Research at the University of Waikato, Hamilton, New Zealand. I hope my findings will inform the development of nursing education curricula.

The first phase of my research required registered nurses to complete a survey. The survey should have taken no more than 15 minutes to complete and then return using the envelope provided. All findings and reports will be written in a manner that no participants or their workplace(s) can be identified. Completing the survey did not oblige the participants to be part of the next phase of the research.

The second phase of the research is for me to observe nursing practice. Your staff member [insert name] has indicated a willingness to participate in this phase. I have informed her that this phase requires the approval of their manager or supervisor.

These observations of nursing work would be conducted at the participant's convenience at their place of work and may vary in length (half days or whole days in duration). This would occur on 1 to 3 occasions depending on your approval and that of your staff member. Short interviews will also be conducted (no more than 15 minutes duration) at times and places of mutual agreement to check the observation details.

I will follow any necessary ethical procedures in your place of work to ensure patient confidentiality and safety. All findings and reports will be written in a manner that no participants can be identified. Pseudonyms will be used when reporting data gathered from any participant. Data collected will be used in my thesis, publications or in presentations. I will make sure that I store all the information I gather securely and participants can withdraw from involvement in the research at any time.

If you have any questions about the research, please feel free to contact me at the address given below. If I cannot clarify the question/issue please contact my thesis supervisor, Dr Chris Eames at the University of Waikato (email: c.eames@waikato.ac.nz, Tel: 07 838 4357).

If you are able to approve the registered nurse(s) who have indicated that they are willing to participate in the observation phase of the research, please complete your details in the attached sheet, and post in the freepost envelope provided.

Thank you for helping me with this research.

Yours faithfully

Christine D. Fenton

New Plymouth contact details:

mfenton@clear.net.nz;

Manager/Supervisor Approval

I have read the attached letter of information.

I understand that:

I can direct any questions to Christine Fenton (email: mfenton@clear.net.nz Tel: xxx).

For any unresolved issues I can contact the thesis supervisor, Dr Chris Eames at the University of Waikato (email: c.eames@waikato.ac.nz Tel: 07 838 4357).

I give consent for the following nurses to be involved in the observations and interviews under the conditions set out in the "Observation and Interview Consent Form – Registered Nurse". I am the direct manager or supervisor of these nurses.

Proposed participants:

Name: ____

Work address: ____

Signed: ____

Email address: ____

Phone: ______________________

Date: ______________________

Please return to Christine Fenton (XXX, or mfenton@clear.net.nz)

Appendix D: Nursing Skills Aligned with Science Content

NURSING SKILLS	POSSIBLE BIOSCIENCE LINK
HEAD TO TOE ASSESSMENT	
Communication	
Skills Communication • Paraphrasing • Reflection • Clarifying • Focusing • Active listening • Use of silence De-escalation **Physical examination** Observation • Facial expression, symmetry and behaviour • Level of awareness • Speech pattern age appropriate • Hygiene, grooming • Posture and motor activity • Mental State exam (MSE) **Decision-making** Knowledge of patient including norms for age continuum and patient's circumstance	Neurology Developmental psychology Central nervous system anatomy and physiology Age appropriateness physiology Infection Neurological and psychological disorders (patho-physiology) Integumentary system Muscle system Skeletal system Micobiology
Connective Tissue	
Physical examination Cranium/scalp • Inspect and palpate for symmetry, shape, masses, tenderness • Hair – inspect for texture • Neck and trachea – symmetry Skin • Inspect for lesions, scars, moles, colour, temperature • Assess skin turgor Musco-skeletal • Palpate joints (shoulder, elbow, wrist, knee and ankle) for tenderness, swelling, masses, nodules, temperature • Test limb strength for range of movement • Inspect and palpate spine for structural changes • Observe mobility and gait, use of aids Ears • Inspect and palpate external ear structures (auricle, tragus and mastoid) for masses, lesions and tenderness • Inspect ear canal for discharge, colour, Swelling Nose • Inspect for symmetry, tenderness, Patency	Anatomy and physiology of integumentary system, Muscle system Skeletal system Sensory system Pathophysiology / disorders Genetics Cell division Mitosis Infection, immunity Osmosis Tissue fluids Endocrine system (thyroid etc) Lymphatic system Life span appropriateness

Decision-making Knowledge of patient including norms for age continuum and patient's circumstance	
Nervous System (Central CNS) (Peripheral - PNS)	
Vital signs Pain assessment – PAIN or PQRST PCA (Patient controlled analgesia) **Physical Exam** • Glasgow Coma Scale • Neurological observation • Alert, verbal, pain, unconscious (AVPU) • Assess Motor function – muscle strength, gait and balance • Sensory – differentiate sharp and dull sensations distally • Eye examination – symmetry, alignment, strabismus, dryness, tears, ectropion, Entropion • Inspect conjunctiva, sclera and cornea • Light reflex (PERLA) • Assess visual/hearing acuity **Skills** Spinal care – injury Epidural care Pressure areas Cerebral vascular accident (CVA) cares and positional **Decision-making** Knowledge of patient including norms for age continuum and patient's circumstance	Nervous system anatomy and physiology CNS and PNS Integument Neurophysiology Action potentials Electrolyte imbalance Na K pump Na, Cl – ion channels/gates Secondary messengers – cAMP Enzymes – cascades Endorphins, encepahlins, dynorphins Blockers GABA Neurotransmittors Chemical mediators Histamine Prostaglandins Enzymes Pharmacokinetics – absorption, distribution, metabolism, excretion Bioavailability Synapse Lock and key theory Inflammation – infection Cell death Behavioural responses Vascular system Fluid compartments (osmosis, muscular system, blood, lymph)
Chest, lungs and Heart	
Cardiovascular (CVS)	
Vital signs Pulse – Quality and rhythm Blood pressure ECG - electrocardiograph **Physical examination** • Auscultate and record apical heartbeat • Inspect distal extremities for colour, pigmentation, texture, clubbing of fingers • Palpate distal extremities for temperature, oedema, capillary refill time • Palpate radial and pedal pulses bilaterally • Visual assessment of jugular vein or distension **Skills** IV site assessment Removal IV cannula CPR	Anatomy and physiology of cardiovascular system Cardiac cycle – diastole, systole Cardiac output, vessel capacity, intravascular vol Heart pump action Fluid flow and pressure physics Resistance and volume Myocardial cells Impulse propagation (excitory activity) Nervous system Neurotransmitters – receptors choligenic sites Acetylcholine Pressure – hydrostatic, osmotic (oncotic) Pressure – diastolic, systolic Laws of osmosis Tissue fluids Plasma proteins (liver physiology) Lymphatic drainage Cell death Composition of blood Smooth muscle Skeletal muscle Lungs – thoracic pressure

Crash trolley Blood transfusion assessment **Decision-making** Knowledge of patient including norms for age continuum and patient's circumstance	Capillary exchange Anatomy CVS barorecptors Heart anatomy – physiology Na, K pump Electrolyte imbalance Fluid balance – skin, kidneys, gut Renin/Angiotensin/aldosterone ADH Endocrine – noradrenaline and adrenaline, thyroid hormones Exogenous chemicals (diet, drugs, caffeine) Blood/lymph/extracellular fluid Respiratory system – thoracic pressure Metabolism – lactic acid Infection Behavioural responses Immunity – antigenic determinants Blood type
Respiration	
Vital signs Respiration rate – depth, rate and rhythm Oxygen Saturation Peak flow **Physical exam** Chest – inspect for symmetry, shape, note lesions, masses, tenderness • Visual assessment of inspiratory/expiratory effort • Palpate posterior chest bilaterally – thoracic expansions, vibrations • Auscultate lungs bilaterally – anterior, posterior and lateral • Chest pain • Dyspnoea • Pallor • Diaphoresis • Cough • Fatigue • Symmetry of chest **Skills** Oral suctioning Chest drain cares Collection sputum specimen Pre-op spirometry **Decision-making** Knowledge of patient including norms for age continuum and patient's circumstance	Anatomy and physiology of respiratory system and cardiovascular system Acid-base (protons) buffering CNS Diffusion Partial pressures Sigmoid curve – saturation levels Haemoglobin (Hb)-O_2 disassociation Hb-CO_2 Enzymes – carbonic anhydrase Thyroid Hormone Oxygen CO_2 Bicarbonate ion Anatomy Surface area - lungs Buffers Blood composition Haemopoiesis Bone marrow Electrolytes Nutrients/metabolism/wasteproducts (cells) Osmosis/ osmotic pressure Mitosis rates Nutrition Haematocrit Fluid balance Cell death Plasma proteins Body fluid compartments Haemoglobin – structure – saturation – sites Hb-CO affinity Protein structure/composition Cellular metabolism Drug induced respiratory depression Infection (respiratory) CNS damage Behavioural responses

<table>
<tr><td colspan="2">Abdomen</td></tr>
<tr><td colspan="2">Gastrointestinal System</td></tr>
<tr><td>Vital Signs
Blood Glucose Levels (BGL)

Physical examination
• Enquire about elimination pattern - bladder and bowel, frequency, continence, constipation
• Enquire about fluid intake
• Inspect for contour, lesions, scars, bruising, swelling
• Enquire about nausea, vomiting
• Auscultate abdomen for 4 quadrants for bowel sounds
• Palpate over all 4 quadrants for tender-ness, masses, guarding or rigidity.

Decision-making
Knowledge of patient including norms for age continuum and patient’s circumstance</td><td>Endocrine system
Nutrition – food groups, carbohydrates
Energy derivation
Weight
metabolism
Blood
Feedback system
Central nervous system
Cellular metabolism – catabolism, anabolism
Genetics
Mutations/ disorders
Bilirubin breakdown
Fibre
Urinary system anatomy and physiology
Normal Flora
Mechanism of pathogens
Anatomy and physiology of gastrointestinal system and excretory system
Mitosis – healing and repair
Infection and immunity
Central nervous system
Age appropriateness – development
Caloric intake
Calibration of blood glucose metre</td></tr>
<tr><td colspan="2">Reproduction System</td></tr>
<tr><td>Physical examination
• Enquire menstrual cycle – bleeding, discharge, menopause
• Discomfort, swelling, genitalia
• Pregnancy
• Prostate

Decision-making
Knowledge of patient including norms for age continuum and patient’s circumstance</td><td>Female and Male reproductive system anatomy and physiology
Normal Flora
Infection/immunity
Cell division/mitosis
Meiosis
Genetics
Infectious diseases
Routes of infection
Transmission
Stem cells
Genetic screening</td></tr>
<tr><td colspan="2">Vital Signs</td></tr>
<tr><td>Temperature

NOTE:
Pulse rate, blood pressure and ECG – see cardiovascular system
Respiration rate, peak flow and oxygen saturation – see respiratory system
Pain – see central nervous system
BGL – see nutrition

Decision-making</td><td>Metabolism of nutrient
body temp regulation
Feedback systems
Endocrine
Anatomy and physiology of integumentary system
Respiratory system anatomy (nasal etc)
CVS – vasoconstriction, vasodilation
CNS
Hypothalamus
Physics – evaporation, radiation, convention, conduction, perspiration, excretion
Immune system
Microbiology – pyrogenic determinants
Fever mechanisms
Drug induced – skeletal muscle (mitochondria)
Surface area/volume ratio
Behavioural responses
Protein structure/denaturation</td></tr>
</table>

Knowledge of patient including norms for age continuum and patient's circumstance	
NURSING CARE	
Infection Control	
Standard precautions	Normal flora Routes of infection Transmission Microbiology Host versus pathogen Pathogenicity and virulence
Opening sterile supplies	Asepsis Sterility
Use of gloves, mask, gown – donning, wearing, disposal	Routes of infection Transferance (cross infection) Aerosols
Infectious waste disposal	Decontamination Routes of infection Growth requirements Biofilms
Swabs/samples	Swabbing Gram staining Cell wall Normal Flora Commensals Opportunistic pathogens Antibiotic resistances Environmental pressure Bacterial mutation Anatomy of area to be swabbed Transport of sample/swab Biochemical testing Monoclonal antibodies
Barrier nursing	Routes of infection Pathogens
Transmission based precautions	Routes of infection Major pathogens
Maintaining clean equipment and work area	Sanitation Infection control Control of microbial growth Fomites Antiseptics, disinfectants
Wound care • Measure depth and size • Exudate colour and amount • Appearance – colour, slough moisture • Pain • Undermining • Re-evaluate • Edge – colour, moisture and temp	Integumentary system Central nervous system Nutritional status Immunity Healing – mitosis Infection – microbiology Normal Flora Opportunistic pathogens Routes of infection
Documentation	
Documentation of assessment • Patient name • Date, time • Signature and status • Subjective data from patient • Objective data (communication, vital signs)	Objective data Subjective data

Admission process and documentation Discharge processes and documentation Pre-op assessment form	Provision of education/advice due to knowledge of condition and circumstances
Report writing	Correct terminology
Patient history – risk factors	Lifestyle risks Genetics Medication Allergies – immune system
Provision of education/nursing care/advice due to knowledge of condition and circumstance Treatment plans • Relapse prevention plan • Wellness recovery action plan (WRAP) • Nursing care plans	Knowledge of patient's condition and circumstances Pathophysiology/disorders Research/information literacy Critical consumer of evidence based practice
Observation chart recording	Reading charts and tables Arithmetic graduations Logarithmic progressions Multivariate charts Units baseline measures Scales Percentages Ratios
Medication	
Oral	Absorption Fillers GIT Nutrition Pharmokinetics Interference
Topical	Integumentary system Absorption Pharmokinetics
Subcutaneous • Injection angle • Manipulation of skin • Injection speed • Site landmarked	Integumentary system Fluid balance Age continuum Absorption Anatomy
Intramuscular • Injection angle • Manipulation of skin • Injection speed • Site landmarked	Skeletal system – anatomy Fluid balance Nutrition Absorption
Inhalers, nebuliser	Air flow physics Age related physiology Lung anatomy
Intravenous priming line flow rate IV	Flow rate calculations Vascular tissue Skin Infection control – microbiology Opportunistic pathogen Routes of infection Normal flora Physics – gravity flow Cardiovascular system
Changing bag	Infection control Biohazard
Rectal, Vaginal, Nasal	Anatomy, absorption, dosage
Medication chart signing	Documentation
Eye and ear drops	Anatomy, absorption, dosage

History of allergies	Immune system response Antigenic determinants Antibodies White blood cells
Knowledge of patient's condition and situation • Contraindications • Knowledge of drug	Knowledge of drug types and mechanisms Half lifes/dosages
7 rights	Documentation, checking
Vaccinations	Passive, active immunity Adjuvant Immune response Antigenic determinant Cold chain Antibody production

Note: Comprised from – Nursing School praxis course outlines, assessments and Course Descriptors, NCNZ competencies for Registered nurse, Nursing demonstration skill topics, staff meeting documents, text books (Bergquist & Pogosian, 2000; Burton & Englekirk, 1996; Coleman & Huskey, 1993; Crisp & Taylor, 2001; Farrell, 2005; Jarvis, 2000; Lehne, 2001; Ochs, 2001; Marieb, 2001; Morello, Mizer, Wilson and Granato, 1994; Thibodeau, & Patton, 2007; Watson, 1999; Walsh, 2002), nursing and science experts.

Appendix E: Nurse Educator Interview and Prompt Sheets

Nurse Educators Interview Protocol

INTRODUCTION

Thank you for agreeing to allow me to interview you today. To help me document your responses, are you happy for me to record your answers to my questions on this digital recorder?

This interview should take no more than 20 minutes of your time.

Demographic Information

1. What is your age range (in years):

   PROMPTS: 20 – 29, 30 – 39, 40 – 49, 50 – 59, 60 plus

2. Indicate gender

3. What ethnic group do you identify the most strongly with?

   PROMPTS: Māori, Pacific People, NZ European, European, Asian, Other [If other, specify]

Nursing Career

4. How long have you been teaching nurses?

5. What is your area of teaching for nurses? Which particular subjects?

6. Do you have a particular area of specialty? Is this based on your clinical experience?

7. How long were you in clinical practice? In what areas?

IS SCIENCE REQUIRED FOR CLINICAL PRACTICE?

Nursing Education

8. What do you think that students in a comprehensive nursing programme need to learn?

9. How would these topics [from question 8] support a comprehensive nurse's clinical practice?

10. What science knowledge if any, do you consider the most relevant for student nurses in a comprehensive nursing programme to learn?

PROMPT: Anatomy, biochemistry, cell biology, chemistry, genetics, immunology, mathematics, microbiology, nutrition, pathophysiology, pharmacology, physics, physiology, scientific method/process

11. What science skills if any, do you consider the most relevant for student nurses to learn?

PROMPT: analytical thinking, aseptic technique, calibration of equipment, calculations, evaluation of evidence, evaluation of information, handling of biohazards, handling of chemicals/gases, interpretation of data, pattern recognition, swab taking, take samples for analysis, terms and vocabulary.

12. Do you think it is important for student nurses to achieve a high [detailed, in-depth] level of science knowledge and skills in order to practice? Why/why not?

13. Do you think nurses use science knowledge and skills in their day-to-day practice? How?

14. Do you think that science knowledge enhances nurses' clinical decision making? Can you explain?

15. Do you think that nurses of the future will need more science knowledge or less? Why is this?

16. Do you think that nurses of the future will need more science skills or less? Why is this?