A Study of the Relationships Between Student Nurse Characteristics and Calculation Ability

By

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Abstract

Studies suggest that many nursing students are deficient in the skills necessary to calculate drug dosages accurately and therefore their ability to administer medications safely becomes questionable. Students are admitted to nursing programs after having met specific admission criteria which are intended to identify applicants with the greatest potential to succeed. However, research that addresses the relationships between admission criteria and calculation ability of nursing students is limited. Therefore, the purpose of this study was to examine the relationships between demographic characteristics and admission criteria of the University of Manitoba Baccalaureate Program in Nursing and calculation ability of nursing students. The theoretical framework used to guide this study was provided by Higgs (1984). A descriptive correlational design was used to examine the relationships among variables. The sample consisted of 33 second-year nursing students attending the Baccalaureate in Nursing Program in 1995-1996. Data were collected by using a Demographic and Academic Status Questionnaire and Mathematics and Drug Calculation Test. Although no significant correlations were found between demographic characteristics and Calculation scores, statistically significant relationships were found between students' pre-nursing Mathematics grades and GPA and Calculation scores. Knowledge gained from this study may be useful to admission committees and faculty working with students who are having difficulty in the drug calculation and practice component of nursing programs.

Chapter One: Introduction

1.0 Background to the Study

"Nurses have an ethical and legal responsibility for the safe administration of medications" (Chenger, Conklin, Hirst, Reimer, & Watson, 1988, p.17). However, compared with physicians and pharmacists, nurses who administer medications have been found to commit the greatest percentage of medication errors in the clinical setting (Allan & Barker, 1990; Becker, Johnson, & Longe, 1978; Bolan, Laurie, & Broome, 1986; Edgar, Lee, & Cousins, 1994; Hassall & Daniels, 1983; Taylor & Gaucher, 1986). Others add that dosage calculation errors by practising nurses are one of the most common causes of medication errors in the clinical setting (Calliari, 1995; Graham & McMahon, 1989; Long & Johnson, 1981; McGovern, 1986). Although accurate calculation of medication dosages is an integral part of safe nursing practice, it has been found repeatedly that nurses have demonstrated difficulty with this skill (Allan & Barker, 1990; Barker & McConnell, 1962; Bayne & Bindler, 1988; Bindler & Bayne, 1991; Bliss - Holtz, 1994; Calliari, 1995; Conklin, MacFarland, Kinnie-Steeves, & Chenger, 1990; Girotti, Garrick, Tierney, Chesnick, & Brown, 1987; Graham & McMahon, 1989; Laverty, 1989; Perlstein, Callison, White, Barnes, & Edwards, 1979; Segatore, Miller, & Webber, 1994; Worrell & Hodson, 1989).

In a study conducted by Perlstein, Callison, White, Barnes, and Edwards (1979), it was found that miscalculation of drug dosages committed by registered nurses caring for infants in an intensive care unit occurred at a rate of one in twelve written calculations. Barker and McConnell (1962) noted that nurses rated as excellent practitioners made drug calculation errors at a rate of one in thirteen without being aware of their errors. More recently, Bayne and Bindler (1988) report that only 54% of nurses they studied attained 80% or more on a medication calculation test. In a later study they found that 43.6% of nurses tested scored lower than 70% (Bindler & Bayne, 1991). Bliss - Holtz (1994) suggests nurses in her study demonstrated difficulty with the most basic arithmetic operations in that 34.7% of the sample attained 90% or better with the use of a calculator while only 21.7% scored 90% or better without the aid of a calculator.

Is there a relationship between performance on calculation tests and subsequent medication errors by practising nurses? Some researchers report that scores on medication calculation tests are not good indicators of which nurses are most likely to commit medication errors (Anrig, Daly, Futrell, Robinson, Rubin, & Weiss, 1987; Conti & Beare, 1988; Howards, 1987; Sullivan & Clarkson, 1982). However, findings contrary to these have also been documented (Calliari, 1995), leading to an unclear view of the relationship between calculation testing and actual performance in the area of drug administration.

When investigating nurses with varying lengths of nursing experience, Conti and Beare (1988) found that calculation test scores did not vary as a function of different lengths of nursing experience and that there was no significant association between the performance on a mathematics/drug calculation test and subsequent incidents of medication errors of wrong dosage. Yet, Calliari (1995) found that nurses who failed a medication calculation test during orientation were more likely to make medication errors when followed over a three year period, than nurses who had passed the medication test. Therefore, further research in this area would be helpful in clarifying the value of using written calculation test scores to predict performance in the clinical setting. Although examining the relationship just described is not within the scope of this study, it is helpful to have an understanding of the work in this area so that recommendations arising from this study may be placed into a broader practical context for nursing practice.

It is assumed that nurses acquire the knowledge and skills necessary to perform drug calculations correctly in their basic nursing education program (Calliari, 1995; Chenger, Conklin, Hirst, Reimer, & Watson, 1988; Worrell & Hodson, 1989). However, this assumption becomes questionable in view of the findings related to the inadequate calculation ability and commission of medication errors by practising nurses. That is, it is possible that nurses who are unable to demonstrate the fundamental competency of drug dosage calculation completed their basic nursing program without having mastered this vital skill. Furthermore, if practising nurses have difficulty performing math calculations, nursing students may also find such exercises difficult.

Between 1979 and 1982, Bindler and Bayne (1984) tested over 700 baccalaureate nursing students and report that 38% failed to achieve the 70% pass grade on a seventh-grade mathematics proficiency test. Similarly, Blais and Bath (1992) found that of 66 nursing students, only 7% obtained a passing score of 90% on a medication dosage calculation exam. Several other studies also suggest that many nursing students are deficient in the skills necessary to calculate drug dosages accurately (Chenger, Conklin, Hirst, Reimer, & Watson, 1988; Gillham & Chu, 1995; McCann-Flynn & Moore, 1990; Ptaszynski & Silver, 1981; Segatore, Edge, & Miller, 1993; Worrell & Hodson, 1989).

It is believed widely that American students entering nursing programs possess weak mathematical skills upon admission (Blais & Bath, 1992; McCann-Flynn & Moore, 1990; Ptaszynski & Silver, 1981; Segatore, Edge, & Miller, 1993; Timpke & Janney, 1981; Worrell & Hodson, 1989). Declining national Scholastic Aptitude Test (SAT) math scores (Calliari, 1995), declining American College Test (ACT) math scores (Munday & Hoyt, 1965), lower enrollments in non-required high school and college math courses (Sherman & Fennema, 1977), and parental satisfaction with relatively low mathematics achievement in high school (Stevenson, Chen, & Lee, 1993) over the past three decades have been cited as contributing to reduced levels of math preparedness of students entering American nursing programs.

In Canada, the perception that high schools were promoting more marginal students than previously was examined by the Newfoundland Task Force on

Mathematics and Science Education in the late 1980's (Crocker, 1989). This task group documented high failure rates in entry-level university mathematics courses and found that pass rates in mathematics had fallen from 75% in the early 1980's to less than 50% in 1987. They concluded that many students, therefore, were entering university with inflated marks and an innocent, but false, sense of security about their mathematics competencies.

In 1992, the Economic Council of Canada reported that 36% of Canadian high school graduates could not perform simple numerical operations needed to meet everyday demands. They also documented that over 44% of persons between 16 and 24 years of age who had completed at least nine years of schooling were considered functionally innumerate (Economic Council of Canada, 1992). Just recently, phase one results of the Third International Mathematics and Science Study were released (Beller & Gafni, 1996). Beginning in 1991, this study surveyed approximately 150,000 grades seven and eight students representing more than 40 countries across the world. Although Canadian students were reported to have scored "above average", that is, 4% higher than the international mean in mathematics, the average score in this subject was only 59%. Unfortunately, Manitoba did not produce a large enough sample to enter into the inter-provincial comparisons and therefore it is difficult to determine how Manitoba students performed in relation to the rest of Canada. It is possible the Canadian students may now be in a position to complete their high school education and graduate

(1991 - 1996; grade 7 to grade 12). However, it is not known how much better prepared they have become over the past four to five years. Therefore, as Segatore, Edge, and Miller (1993) point out, faculty who expect provincial high school graduates to have an acceptable level of mathematical proficiency, "as successful completion of high school mathematics prerequisites supposedly means, may be woefully misguided" (p. 162).

1.1 Statement of the Problem

A subject of interest to nurse educators is student academic and clinical success. A multitude of student nurse characteristics have been studied in an attempt to find some relationship with success in nursing education programs. Generally, nonacademic characteristics such as age, marital status, and learning style have been found to correlate significantly with success measures (Nortridge, Mayeux, Anderson, & Bell, 1992; Oliver, 1985; Safian-Rush & Belock, 1988; Yess, 1980). Significant relationships between success and academic characteristics such as high school English, Mathematics, and Science grades, and pre-nursing university grade point average, have also been reported (Felts, 1986; Oliver, 1985; Weinstein, Brown, & Wahlstrom, 1980; Yess, 1980; Wold & Worth, 1990). While many studies suggest that a relationship exists between several student nurse characteristics and success in a nursing program, there is a paucity of research which addresses the link between these characteristics and calculation competency as a component of success in nursing education.

Students are admitted to nursing programs after having met specific admission criteria which are intended to identify applicants with the greatest potential to succeed. The research examining the association between particular admission criteria and overall achievement and success in nursing education is abundant (Aldag & Rose, 1983; Alichnie & Bellucci, 1981; Allen, Higgs, & Holloway, 1988; Baker, 1975; Burgess & Duffy, 1969; Chacko & Huba, 1991; Clemence & Brink, 1978; Munday & Hoyt, 1965; Payne & Duffy, 1986; Poorman & Martin, 1991; Richards, 1977; Safian-Rush & Belock, 1988). However, studies addressing the relationships between admission criteria and calculation ability of nursing students as a component of nursing practice are limited (Chenger, Conklin, Hirst, Reimer, & Watson, 1988; Dexter & Applegate, 1980; McCann-Flynn & Moore, 1990; Segatore, Edge, & Miller, 1993).

Predictors of nursing students' math performance as an area of study has limited representation in the literature. Dexter and Applegate (1980) found an inverse relationship between age of nursing students and math test grades, suggesting that older students tended to possess weaker calculation skills than their younger classmates. McCann-Flynn and Moore's research (1990), however, did not support this finding.

Another study reports that academic achievement in high school is predictive of mathematical performance in nursing school (Chenger, Conklin, Hirst, Reimer, & Watson, 1988). Segatore, Edge, and Miller (1993) correlated seven separate characteristics, including age, sex, and high school average, with drug calculation scores and found no significant associations. Overall, the work in this area is limited and offers inconclusive results.

The ability to calculate and administer medications safely is a fundamental nursing responsibility which nursing students should master prior to graduation in order to practise safely. Nursing students who do not demonstrate these skills often find themselves in jeopardy at some point in their program. Faculty often expend substantial effort tutoring and supervising students having difficulty; the result is either successful remediation or eventual withdrawal of the student from the program. In some cases, however, students will progress through the program and graduate with deficient calculation skills that have been inadequately addressed for a variety of reasons. These graduates, therefore, go on to practise nursing at a greater risk of committing medication errors which can cause varying degrees of harm to the patients in their care.

An understanding of the relationships between admission criteria and the ability of nursing students to perform drug calculation skills correctly would be helpful. This information could be used by nursing programs in setting valid admission standards that would predict success in this component of the nursing program. Applicants could be selected with these criteria in mind, and early detection of students likely to experience difficulty could be made. Time, effort, and financial costs to students and nursing programs could be spared if such problems could be managed early in the educational process.

Despite declining applications to nursing programs (Gothler & Rosenfeld, 1986; Griffiths, Bevil, O'Connor, & Wieland, 1995; Redman & Pillar, 1986), the profession needs to remain committed to accepting and graduating only those students who are the best qualified and capable of fulfilling the demanding and expanding responsibilities of the nurse. Therefore, identifying factors that predict which nursing students are most likely to have difficulty mastering the skill of medication calculations becomes an important endeavour.

1.2 Purpose of the Study

The purpose of this descriptive correlational study was to examine the admission criteria of the University of Manitoba (U of M) Baccalaureate in Nursing Program and selected demographic factors in relation to the calculation abilities of nursing students enrolled in this program. The intent was to identify which academic and nonacademic factors may be used to determine which nursing students are more likely to have difficulty demonstrating mathematics and drug dosage calculation competencies.

1.3 Research Questions

The research questions guiding this study were:

1. What is the relationship between demographic characteristics (site, age, marital status, years since high school graduation, location of high school attendance, type of student, previous education, and attainment of other

mathematics-related courses) and calculation ability of second year baccalaureate nursing students?

2. What is the relationship between academic status, related to the admission criteria of the University of Manitoba Baccalaureate in Nursing Program (pre-entrance Mathematics grade, pre-entrance Science grade, pre-entrance English grade, and university grade point average), and calculation ability of second year baccalaureate nursing students?

1.4 Definition of Terms

Definitions for the following terms as identified in the research questions appear in Appendix A:

1. **Site of Nursing Program Attendance**
2. **Age**
3. **Marital Status**
4. **Number of Years Since High School Graduation**
5. **Location of High School Attendance**
6. **Type of Student**
7. **Previous Education**
8. **Attainment of Other Mathematics-Related Courses**
9. **Pre-entrance Mathematics Grade**
10. **Pre-entrance English Grade**
11. **Pre-entrance Science Grade**

12. University Grade Point Average

13. Calculation Ability

14. Baccalaureate Nursing Students

1.5 Conceptual Framework

The Model for the Study of Prediction of Success in Nursing Education and Nursing Practice (Model) (Higgs, 1984) and a review of the literature provided the framework for selecting the variables examined in this study. The Model provides direction for evaluating factors which exist prior to nursing, within the nursing curriculum, and during transition into practice. The Higgs Model was first developed and used in the early 1970's when the Intercollegiate Centre for Nursing Education (ICNE) undertook an evaluation of its admission policies and procedures. The purpose of the evaluation was to identify the predictiveness of the existing admission criteria at that time and make recommendations for future change. In 1984, Higgs refined, applied in a research study, and published the Model as it had evolved over the previous decade. It is in this printing that the Model is explained and the intent for its use in guiding future research is proposed. Since this time, the Model has been used as a guiding framework for studies related to predicting student nurse progress and success in undergraduate nursing programs (Allen, Higgs, & Holloway, 1988; Brennan, Best, & Small, 1996).

Variables in the Model are categorized as pre-nursing major, nursing major, and post-graduation, to establish a succession of events. Both academic and nonacademic variables are considered within the three categories. Prenursing major variables encompass those factors which are considered during the admission process to a nursing program and may include the following five areas: (a) intellectual ability/aptitude, (b) scholastic performance, (c) demographic, (d) personal/personality, and (e) sociological - situational/interactional. Nursing major variables are those factors measured at different points throughout the nursing program that identify the degree of success demonstrated by the student nurse. These variables are organized into the following five areas: (a) progression - completion/attrition, (b) level of achievement, (c) performance/clinical behaviours, (d) NLN exam scores, and (e) organizational variables. Post-graduation variables are measured after completion of a nursing program and involve measures of success in terms of: (a) career performance/advancement/satisfaction, (b) aptitude test scores, (c) scholastic progression, (d) state board test scores, and (e) organizational variables in the workplace.

From the vast selection of variables identified in the Model, Higgs (1984) encourages investigators to select the categories and variables of interest to them. Future studies have the flexibility to explore the existence of various relationships within the Model and describe the findings within the context of previous research. Each investigator's use of the Model is therefore presumed to be unique, yet contributory to the overall understanding of predictors and measures of success in nursing education and practice (Higgs, 1984).

The Model by Higgs (1984) was helpful for this study. The demographic factors and admission criteria currently used by the University of Manitoba Baccalaureate in Nursing Program, as predictor variables, fit conceptually within the prenursing major category of the Model in the scholastic performance and demographic areas. Although the caculation ability of nursing students was admittedly a narrow measure of success, this criterion or outcome variable was conceptualized within the nursing major category as a clinical performance behaviour or component of achievement in general. Therefore, the dimensions of the Model that guided this study were the prenursing major and nursing major categories and the accompanying supportive research in these areas. The remaining variables and post-graduation category of the Model were not examined.

Since the variables under investigation in this study were only a small part of the what the Model describes, the conclusions arising from this study were limited. Another consideration was the difference in operational definitions for the variables used in this study in comparison to those outlined in the Model (Higgs, 1984). However, the investigator believed the use of particular definitions was appropriate in order to make the findings of this study relevant to the nursing program in which the students were enrolled.

1.6 Summary of Chapter

Research addressing the relationships between academic and nonacademic criteria, typically used as admission criteria, and calculation abilities of nursing students is strikingly lacking in the literature. Findings related to the predictive power of admission criteria are inconclusive and based on research with significant methodological limitations which will be elaborated upon in the following chapter.

Finding consistency and congruency in the literature is a difficult task. While it is clear that many student nurses do not possess the calculation skills necessary to practice safely, it is not so clear how to discriminate which students are likely to succeed or fail in this area of competence before difficulties arise. Admissions committees have the responsibility to select students with the greatest potential to excel in nursing, of which calculating and administering drugs safely is a critical component. Faculty members and students would also benefit from the knowledge gained by examining predictors of this vital skill. The detection of students likely to experience difficulty could be made early and the appropriate remediation could be put in place to assist those at risk for academic or clinical jeopardy.

Chapter Two: Review of the Literature

2.0 Introduction

An important component of safe administration of medication in the clinical area is the ability to calculate drug dosages accurately. Therefore, it is important to identify factors that predict the calculation ability of nursing students. Students who cannot demonstrate calculation competency should be identified early in the nursing program so they may be assisted to develop this critical skill.

A review of the literature reveals that studies have been conducted over the last three decades in areas that are pertinent to the research questions identified for this study. This literature review addresses the major areas of study: (a) calculation skills, (b) predictors of success, (c) factors influencing calculation ability, and (d) predictors of nursing students' mathematics performance. Studies done in the disciplines of Education and Psychology have examined factors influencing the development of mathematical skills of students and, therefore, provide insight into how student nurses may develop these same skills. Drug calculation skills of pharmacists and predictors of success in the allied health professions and in medicine also have been explored. Therefore, selective research from the areas of Psychology, Education, Medicine, Pharmacy, and Allied Health literature, in addition to Nursing, are included in order to provide support for this study.

2.1 Calculation Skills

Studies that have examined calculation abilities have primarily addressed the frequency and nature of calculation errors made by nurses and student nurses (Bindler & Bayne, 1984; Blais & Bath, 1992; Chenger, Conklin, Hirst, Reimer, & Watson, 1988; Segatore, Edge, & Miller, 1993; Worrell & Hodson, 1989). While these investigations contribute to the understanding of calculation abilities of nurses and student nurses, methodological aspects of these studies vary widely. Therefore, an analysis of the similarities and differences of the methods used will provide the framework for the review of work in this area.

Diversity in instrument designs and their implementation in various studies are noteworthy. The use of different acceptable passing grade levels leads to different interpretations of success in mathematics and drug calculation skills (Bindler & Bayne, 1984; Chenger et al., 1988; Segatore et al., 1993). Some instruments tested basic mathematical skills (Bindler & Bayne, 1984; Chenger et al., 1988; Ptaszynski & Silver, 1981), while others tested more advanced drug calculation abilities (Bindler & Bayne, 1984; Blais & Bath, 1992; Segatore et al., 1993). The number of items on the mathematical and drug calculation tests were not consistent and therefore the ability to compare competencies based on greater or fewer test items becomes complicated (Blais & Bath, 1992; Segatore, Edge, & Miller, 1993). Tests were administered over varying lengths of time and so it is difficult to compare the students' scores within the context of time pressure to complete the test (Bindler & Bayne, 1984; Segatore, Edge, & Miller, 1993).

Small convenience samples were used in the majority of the studies (Blais &

Bath, 1992; Segatore, Edge, & Miller, 1993; Timpke & Janney, 1981), limiting the strength of the statistical procedures and particularly the ability to detect small significant differences in the scores of the sample groups. Convenience samples, although appropriate for these types of descriptive investigations, contribute to the inability to generalize the findings to populations beyond the scope of samples used in the studies. The heterogeneous nature of the different samples (i.e., diploma, baccalaureate, associate degree, sophomore, first year, and exiting nursing students), makes it difficult to compare findings and identify patterns in competency levels (Bindler & Bayne, 1984; Chenger, Conklin, Hirst, Reimer, & Watson, 1988; Worrell & Hodson, 1989). However, these differences may be viewed as a strength, in that similar findings resulted across diverse groups, lending support to the belief that inadequate calculation skills of nurses and student nurses are a multidimensional problem.

Generally speaking, the statistical procedures and descriptive research designs employed in the following studies are relatively similar and appropriate for the type of investigations conducted (Brink & Wood, 1989). However, inconsistencies and limitations in specific aspects of the designs used make generalization of the findings difficult. Despite some of these difficulties, valuable information can be gleaned from the following studies in order to provide a foundation of understanding in the area of calculation abilities of nurses and student nurses.

Calculation Skills of Nurses.

Although accurate calculation of medication dosages is an integral part of safe nursing practice, it has been found repeatedly that nurses have demonstrated difficulty with this skill. In a study conducted by Perlstein, Callison, White, Barnes, and Edwards (1979), it was found that miscalculation of drug dosages committed by Registered Nurses caring for infants in a neonatal intensive unit occurred at a rate of one in twelve written calculations. These potential errors would have resulted in doses ten times greater or lesser than the prescribed dose in 56% of their errors.

Barker and McConnell (1962) noted that nurses rated as excellent practitioners made drug calculation errors at a rate of one in thirteen without being aware of their errors. A study conducted in a Canadian Intensive Care Unit showed that drug dosage errors by nurses accounted for 12.7% of the total number of errors reported (Girotti, Garrick, Tierney, Chesnick, & Brown, 1987). In this study, however, the method of chart review utilized to gather data on drug errors could be considered unreliable since it was possible that nurses may have calculated and administered the wrong dosage of drug, yet have recorded the drug as being given according to the physician's order. Several other studies have shown that dosage calculation errors by nurses are one of the most common causes of medication errors in the clinical setting (Allan & Barker, 1990; Calliari, 1995; Conklin, MacFarland, Kinnie-Steeves, & Chenger, 1990; Graham & McMahon, 1989; Long & Johnson, 1981; McGovern, 1986; Segatore, Miller, & Webber, 1994; Worrell & Hodson, 1989).

More recently, the work by Bindler and Bayne (1984; 1991; Bayne & Bindler, 1988) has contributed significantly to the understanding of the issue surrounding inadequate calculation skills of practising nurses. Since 1979 these investigators have studied the calculation skills of student and practising nurses and have found that both groups possess weak mathematical and drug calculation abilities. In Bayne and Bindler's (1988) study of practising nurses, a convenience sample of 62 nurses was tested. It was found that only 35% attained a score of 90% or better on a medication calculation exam.

In a later study, a convenience sample of 110 Registered Nurses from four western U.S. states were tested (Bindler & Bayne, 1991). Only 19% of the nurses were able to achieve the 90% mastery level in drug computation. Overall, 43.6% of the nurses in this study scored lower than 70%. Although the group of consecutive studies by Bindler and Bayne have limitations in generalizability due to relatively small convenience samples, they are useful in showing that different groups of nurses have demonstrated weak drug calculation skills over a period of time. One may assume that if experienced nurses have difficulty performing math calculations, students may also find such exercises difficult.

It is not surprising that nurses are responsible for the greatest percentage of drug errors since nurses administer the vast majority of medications (Conklin, MacFarland, Kinnie-Steeves, & Chenger, 1990; Segatore, Miller, & Webber, 1994). Next in frequency to nurses, physicians and pharmacists are also often responsible for the administration and dispensing of medications to patients. An understanding of the calculation abilities of these professional groups is helpful in terms of understanding the prevalence of errors committed by nurses in contrast to other groups. A review of the medical literature did not uncover any literature describing the mathematical abilities of physicians or the degree to which physicians commit calculation-based medication errors.

However, a review of the pharmacy literature revealed that medication errors based on incorrect dosage calculations (although at a much lower incidence than by nurses), have been committed by pharmacists (Becker, Johnson, & Longe, 1978; Hassall & Daniels, 1983; Hoffman, Bartt, & Berlin, 1984; Mayo, Kitchens, & Reese, 1975; Taylor & Gaucher, 1986). "Medication errors are typically viewed as being related to drug administration, whereas dispensing errors are mistakes made by pharmacy staff when distributing medications to nursing units or directly to patients in an ambulatory-care pharmacy" (Allan & Barker, 1990, p.558). Bolan, Laurie, and Broome (1986) reported that a pharmacist made a calculation error when preparing rifampin suspension (anti-tuberculosis agent which causes body fluids to turn orange); the result was that 19 children had one or more adverse effects, including red-man syndrome.

Clearly, the calculation skills of nurses have been studied the most widely in this area. When compared to other professional groups, such as pharmacists, the greater degree of responsibility for the safe administration of medications on the part of the nurse is highlighted.

Calculation Skills of Nursing Students.

(a) Passing Level

It has been found widely that students in nursing programs possess weak basic mathematical skills and may also be deficient in more complex conceptual skills related to mathematical concepts (Bindler & Bayne, 1984; Blais & Bath, 1992; Chenger, Conklin, Hirst, Reimer, & Watson, 1988; Segatore, Edge, & Miller, 1993). Studies that examined the calculation skills of nursing students have primarily addressed the rates of failure to achieve a passing grade on a mathematical or drug calculation test and the nature of calculation errors made by distinct student nurse groups (Blais & Bath, 1992; Segatore, Edge, & Miller, 1993).

The majority of studies used a passing grade of 85% or above, presumably based on the assumption that the skills being tested were basic in nature (Bindler & Bayne, 1984), and that it was necessary to demand a high passing score given the severity of potential consequences of inaccurate calculations in an actual situation (Perlstein, Callison, White, Barnes, & Edwards, 1979). Making comparisons in achievement levels is difficult, however, because passing grades across studies varied between 70% (Bindler & Bayne, 1984) and 90% (Blais & Bath, 1992; Chenger, Conklin, Hirst, Reimer, & Watson, 1988). Despite the incongruencies in passing grades, it was noted in several studies that between 38% (Bindler & Bayne, 1984) and 93% (Blais & Bath, 1992) of the students tested were unable to achieve a passing grade. Undoubtedly, differences in the percentage of students able to pass were related to the passing grade.

(b) Test Content

Mishel (1989) suggests that the type of question on an instrument or test is important in understanding what is being measured. When testing calculation skills, it is important to have an understanding of what skills are being evaluated in order to make fair judgements about competency. Some studies have used tests which have examined advanced, problem-oriented drug calculation skills, while others have designed instruments which test only fundamental mathematical operations (Blais & Bath, 1992; Ptaszynski & Silver, 1981; Segatore, Edge, & Miller, 1993). Both approaches to testing nursing students' calculation competencies are valid since they are skills that are closely related in the actual practice of calculating drug dosages.

In studies that used tests to examine advanced, problem-oriented drug calculation skills, calculation errors were often classified as mathematical, measurement, or conceptual in nature (Blais & Bath, 1992; Segatore, Edge, & Miller, 1993). Mathematical errors were those that resulted from the inability to apply the rules of addition, subtraction, multiplication, division, and manipulation of decimals and fractions. Measurement errors comprised those operations which required metric conversions. Conceptual errors were classified as those which resulted from the incorrect set up of calculation formulas and use of the wrong form of drug, for instance, using millilitres versus milligrams.

Descriptive statistics showed that conceptual errors occurred the most frequently on tests that examined advanced drug dosage calculations (Blais & Bath, 1992; Segatore, Edge, & Miller, 1993). Knowing the type of error committed most frequently is helpful because many calculations that students and nurses perform in the clinical area require complex problem solving abilities.

In a study of 145 exiting senior nursing students, it was found that 43% were unable to achieve a passing grade of 90% on a calculation test which was designed to examine problem-solving abilities of students about to graduate (Chenger, Conklin, Hirst, Reimer, & Watson, 1988). A review of the calculation test revealed that there were 15 fewer problem-solving questions than non-problem solving questions. It was likely that the unbalanced structure of the test did not allow students a fair opportunity to demonstrate their problem-solving skills. The content validity of the instrument used in this study, therefore, was less than adequate to measure the intended skills under investigation (Nunnally, 1978).

It becomes apparent that when testing particular skills of student nurse groups, the content validity of the items on the tool one uses must be established prior to its implementation. Equally important is the understanding that, when comparing passing and failing rates of student groups, one must know exactly which skills have been tested.

Fundamental mathematical skills of nursing students have been studied by several investigators (Bindler & Bayne, 1984; Chenger, Conklin, Hirst, Reimer, & Watson, 1988; Ptaszynski & Silver, 1981). These studies have contributed significantly to enhancing the current knowledge in the area of mathematical skills of nursing students. Prior to conducting their studies with practising nurses (Bayne & Bindler, 1988; Bindler & Bayne, 1991), Bindler and Bayne (1984) studied a total of 741 junior level nursing students attending the Intercollegiate Centre for Nursing Education in Spokane, Washington. Data collection took place between 1979 and 1982. In 1979 to 1980, five samples were tested, ranging in size from 60 to 117 students per sample. It was found that within this total group of 459 students, 18.3% were unable to achieve a passing grade of 70%. In 1981 through 1982, the remaining 282 students were tested in three samples ranging in size from 82 to 101 students. Within this latter group of 282 students, 33.7% of the students were unable to achieve a passing grade of 80% on a mathematical test (Bindler & Bayne, 1984).

These findings are significant to the extent that several samples of students at the same level of a nursing program were tested over a three year period, and consistently demonstrated the inability to achieve a passing grade on a test that examined basic mathematical skills. The ongoing work by Bindler and Bayne is particularly helpful because it shows that the issue of inadequate calculation abilities of student nurses and nurses not only dates back several years, but that the concern still exists today (Bindler & Bayne, 1991). The evolution of their work over time is also important because with each study, more knowledge is gained in understanding the dimensions and magnitude of the problem with calculation abilities of students and nurses.

In a study conducted by Chenger, Conklin, Hirst, Reimer, and Watson (1988), 210 entering junior nursing students were tested for their basic mathematical abilities. From this group, 61% of the students were unable to achieve the passing grade of 90%. Comparisons between this study and the previous one by Bindler and Bayne (1984) are difficult, however, because of the large difference in passing grades. Nonetheless, both studies contribute to the understanding of the inadequate mathematical skills of nursing students by their use of relatively large samples of students who were at the same level in a nursing program.

In a unique study by Worrell and Hodson (1989), 223 nursing programs across the United States were surveyed with regard to faculty knowledge of student nurse deficiencies in basic mathematical concepts required to calculate drug dosages. Faculties from the programs completed a Posology Data Form designed to collect data that would identify student nurse mathematical abilities. The authors (Worrell & Hodson, 1989) reported that 83% of the programs which participated in the study stated that 31% or more of their students were deficient in basic mathematical skills. Limitations to this study (Worrell & Hodson, 1989) are noted. Details were not provided as to how student nurse deficiencies in mathematics were determined by these faculty members. It is not clear if objective or subjective data were used to report competency rates. Therefore, it can be argued that the method used to collect information about students' performance in this study is questionable.

(c) Test Items

The number of items on the test also impacts on the students' potential to demonstrate competency. That is, the greater the number of questions, the more opportunity there is for students to demonstrate their knowledge and skill. Additionally, providing more questions on a test results in a smaller value for each question in relation to the total number of possible correct answers, so that an individual error does not carry as much weight as an error committed on a test with fewer questions.

While the majority of studies do not report the number of questions included on the mathematical or drug calculation tests used to test student nurses' skills (Bindler & Bayne, 1984; Chenger et al., 1988; Ptaszynski & Silver, 1981; Timpke & Janney, 1981), this information would be helpful in determining the potential for students to achieve passing grades in terms of the number of errors allowed. Blais and Bath (1992) and Segatore, Edge, and Miller (1993) report the use of twenty and ten test questions respectively. Nunnally (1978) states that the more items used in an instrument, the less chance there is for measurement error. It is suggested that 30 dichotomous items are usually required to obtain an internal consistency reliability of .80. Fewer multipoint items are required to achieve the same level of reliability

(Nunnally, 1978).

Items on a mathematical test can be dichotomous (answer given is correct or incorrect) or multipoint, as in the case of multiple-choice questions. Therefore, one could estimate that a multiple-choice mathematical test should consist of about 20 to 30 items, while a test requiring the student to provide the correct answer should contain 30 or more items. It would appear then, that the use of ten and twenty items (Blais & Bath, 1992; Segatore, Edge, & Miller, 1993) could be considered insufficient to achieve an acceptable degree of internal reliability. Combining this information with the fact that passing grades in these studies were 90% and 85%, one would be challenged to make comparative statements about the findings from these studies. Clearly, these limitations make the findings from these studies less useful.

Instrumentation Issues.

(a) Reliability and Validity

When using mathematical and drug calculation tests to measure a characteristic such as computational skills of nursing students, it is important to use instruments that are reliable. That is, one must have confidence that the variance in scores on an instrument is a measure of differences between subjects rather than as a result of error in the measurement of the characteristic (Isaac & Michael, 1974). The issue of instrument reliability requires discussion when one sees the diversity in maturity and structure of the mathematical and calculation tests implemented in different studies (Blais & Bath, 1992; Chenger, Conklin, Hirst, Reimer, & Watson, 1988; Fulton & O'Neill, 1989; Segatore, Edge, & Miller, 1993; Worrell & Hodson, 1989).

In every study, the tests used to measure mathematical or drug calculation skills of students were developed by the investigators at the time of the study (Bath & Blais, 1993; Bindler & Bayne, 1984; Blais & Bath, 1992; Chenger et al., 1988; McCann-Flynn & Moore, 1990; Segatore, Edge, & Miller, 1993; Worrell & Hodson, 1989). Instruments that are "immature", or have had limited use, should demonstrate a reliability coefficient of at least 0.70, while "mature" instruments, that have had repeated use, should achieve a reliability of at least 0.80 (Nunnally, 1978).

Since most tools in the above studies are immature, the reliability coefficients reported (Bath & Blais, 1993; Bayne & Bindler, 1988; Blais & Bath, 1992; Chenger et al., 1988; McCann-Flynn & Moore, 1990), ranging from 0.82 to 0.92, suggest these tools can be considered reliable measures of the computational skills of nursing students. One weakness among these studies, however, is the finding that every study used a different tool. Therefore, the ability to develop a mature measurement tool over time to enhance repeatability is limited.

It would have been helpful to find a tool that had been used in several studies in order to obtain some measure of standardization in testing. A major flaw of some studies was noted in that the reliability values for the instruments used in testing nursing students were not reported (Bindler & Bayne, 1984; Fulton & O'Neill, 1989;

Segatore, Edge, & Miller, 1993; Worrell & Hodson, 1989). Therefore, one should be cautious in concluding that the scores on these tests were an accurate reflection of variance between students rather than a result of random error in measurement.

Another factor to consider when determining the value of an instrument is whether measures have been taken to ensure content validity. Content validity refers to an estimation of the adequacy with which the items on a tool accurately measure the attribute it is intended to measure (Carmines & Zeller, 1979; Nunnally, 1978). There are acceptable techniques one can use to achieve content validity of an instrument. One strategy is the use of content experts to evaluate the content of the items for relevancy and fairness (Lynn, 1986). Pretesting an instrument with subjects who are asked to make suggestions for tool improvement is also effective (Fox & Ventura, 1983; Wolf, Putnam, James, & Stiles, 1978).

Some investigators have used the strategies of pilot testing their instrument (Bayne & Bindler, 1988; Bindler & Bayne, 1984; McCann-Flynn & Moore, 1990), and enlisting the review of items by faculty members and mathematical content experts (Bath & Blais, 1993; Blais & Bath, 1992; Chenger et al., 1988; McCann-Flynn & Moore, 1990). Therefore, one can be more confident that the instruments used by these investigators were able to measure the characteristic of mathematics or drug calculation skills of nursing students in a valid manner.

Instruments have been developed by selecting test items from a workbook (Segatore, Edge, & Miller, 1993) or nursing and pharmacology textbooks (Bayne &

Bindler, 1988; McCann-Flynn & Moore, 1990). A "standard mathematics test used routinely" in a particular program had also been administered (Fulton & O'Neill, 1989), yet there were no details describing to what "standard" the authors referred. Chenger, Conklin, Hirst, Reimer, and Watson (1988) developed their calculation test by comparing items to the instrument developed by Bindler and Bindler (1984). In these studies, less popular and acceptable steps were used to ensure that the items on the tests were valid measures of drug calculation skills (Lynn, 1986). Therefore, it is difficult to know how useful these tests actually were in measuring the attribute they were intended to measure.

It should be noted, however, that some of these investigators used a combination of acceptable and not acceptable techniques to establish content validity (Bayne & Bindler, 1988; Chenger et al., 1988; McCann-Flynn & Moore, 1990) Therefore, these tests could be considered somewhat more valid and accurate in describing the calculation skills of nursing students and nurses than those tests not subjected to the same rigor in ensuring validity.

(b) Timing

In actual nursing practice, the calculation of drug dosages is often done unde the pressure of time constraints. Therefore, it is important to explore how studies have addressed the issue of imposing time limits on the completion of test writing. The concept of time pressure becomes more complicated when one takes into consideration the number and level of complexity of test items. Although no supporting evidence could be found, it is the writer's experience that an average of one and one-half to two minutes should be allowed for each question. In other words, a student writing a test consisting of 20 questions should be allowed between thirty and forty minutes to write the test. This guideline changes when the questions vary in type and level of complexity, making it difficult to determine how long one should be allowed to write the test.

Bindler and Bayne (1984) allowed nursing students two hours to write their basic mathematics test, although the number of questions on the test was not reported. Segatore, Edge, and Miller (1993) originally allowed their students twenty minutes to write a ten item drug dosage exam, but extended the time by fifteen minutes when the students were unable to complete the test in the allotted twenty minutes. Blais and Bath (1992) did not impose a time limit for their students writing a twenty item drug dosage exam.

Other studies that examined the calculation skills of nursing students did not address the issue of imposing time limits on test writing (Chenger, Conklin, Hirst, Reimer, & Watson, 1988; Ptaszynski & Silver, 1981; Timpke & Janney, 1981; Worrell & Hodson, 1989). Clearly, there is a lack of standardization in the implementation of calculation tests among these studies.

Sample Issues.

The studies addressing the calculation skills of student nurses used descriptive designs. The descriptive design is appropriate when the intent is to describe the characteristics of a population as it exists naturally, without the manipulation of variables (Brink & Wood, 1989). One of the most important techniques to improve external validity in descriptive designs is to use randomly selected, representative samples of sufficient size (Wood & Brink, 1989). The determination of an adequate sample size for a study is not an easy task. Brink and Wood (1989) state that descriptive designs which use systematic and probability sampling should attempt to obtain 10% of the total available population. However, population parameters are often not available and probability sampling cannot be used. It is suggested (Buckwalter & Maas, 1989; Polit & Hungler, 1991) that in studies without probability samples, the desired sample size is dependent upon the number and type of variables under study. Buckwalter and Maas (1989) state that twenty to thirty subjects per subdivision of the data (or each cell of a factorial design) are recommended, with a minimum being ten per group.

Descriptive designs that do not use a probability sample from a well-defined population, and do not involve a number of variables, pose a special challenge to the researcher in determining a sufficient sample size. Most of the research in this area of study falls into this category. In order to examine the adequacy of the samples used in these studies, samples of at least 75 subjects will be considered "sufficient" for the purposes of these descriptive studies (J. Sloan, personal communication, January 25, 1995). Therefore, when reviewing the literature in this area of study, an important aspect to consider is the size and type of samples used to determine the calculation abilities of nursing students.

Small sample sizes of nursing students, including sizes of 66 (Blais & Bath, 1992), 44 (Segatore, Edge, & Miller, 1993), and 28 (Timpke & Janney, 1981), have been reported. In one study, the actual sample size was not reported at all (Ptaszynski & Silver, 1981). Although conclusions have been drawn by the investigators of these studies, it is possible that the data generated from these small samples would be insufficient for meaningful statistical analysis. Also, the findings from these studies should not be generalized to students beyond the samples since one cannot be sure that these samples were representative of a larger population.

Other studies have used larger samples and therefore are more helpful in being able to suggest that the findings are representative of their sample population. Chenger, Conklin, Hirst, Reimer, and Watson (1988) studied 210 entering juniors and a separate 145 exiting senior students in relation to mathematical and drug calculation skills. Although the sample sizes in this study appear more reasonable, the method by which the samples were obtained should be questioned.

Chenger, Conklin, Hirst, Reimer, and Watson (1988) acknowledged the element of self-selection bias in these samples since students were asked to participate in the study at the same time the mathematics and drug test was placed in front of them. The relationship of the investigators to the students was also unclear and an element of coercion to participate may have been a factor. Additionally, test scores could have been influenced by this approach since some students may have found this situation anxiety-provoking. The integrity of this study is therefore undermined by these factors.

Between 1979 and 1982, Bindler and Bayne (1984) tested a total of 741 baccalaureate nursing students. In 1979 to 1980, five samples were tested (n=459), ranging in size from 60 to 117 students per sample. In 1981 through 1982, the remaining 282 students were tested in three samples, ranging in size from 82 to 101 students. From these eight composite samples, only one sample comprised 60 subjects, while the rest were greater than 82 nursing students. Therefore, these samples could be considered sufficient in size. Also, due to the testing of a large number of similar students over a period of time, one can be more confident that the overall findings have emerged from a representative sample.

Worrell and Hodson (1989) surveyed 221 baccalaureate, associate degree, and diploma nursing programs in the United States regarding the calculation skills of nursing students. Their sample was obtained by using a randomized proportional sampling approach in which states were proportionally selected based on the respective number of nursing programs. They then randomly selected programs from within the states. Of the sample, 72 programs were baccalaureate, 95 were associate degree, and 54 were diploma based. It is important to note that the sample in this study (Worrell & Hodson, 1989) was number of programs, rather than a defined number of nursing students who attended these programs. It is unclear how many students would have been involved if they had been the source of the data. While one may presume a large number of students would be involved in the 223 nursing programs surveyed, it is difficult to make comparisons between this study and others due to differences in sampling design.

With the exception of the study by Worrell and Hodson (1989), the majority of the studies in this study area used a convenience type of sampling plan. Because probability sampling is often difficult, the use of convenience samples for descriptive investigations is common in nursing research (Polit & Hungler, 1991). When using a convenience sample approach, it is important to make the sample as homogeneous as possible in order to reduce the risk of bias. One can define the population in a way that variation resulting from extraneous variables is reduced (Polit & Hungler, 1991). By doing this, one enhances the amount of control of intervening influences, but the ability to generalize findings beyond the scope of the samples used in the study is limited.

Samples used in the studies cited previously could be considered relatively homogeneous in nature. That is, the nursing students comprising a particular sample would all be from the same program or same class (baccalaureate versus associate degree, and junior versus sophomore, for example). However, previous education, age, attitude, and so on, could be considered as other unmeasured factors that would have the potential to make a sample quite heterogeneous. Therefore, it is not clear how the convenience samples used in these studies should be described, and how far one should generalize the findings to "like" populations.

The heterogeneous nature of the different samples used in the different studies (diploma, baccalaureate, associate degree, sophomore, first year, exiting nursing students) makes it difficult to compare findings and identify patterns in calculation competency levels of nursing students. However, these differences are interesting to note since similar findings arose from a number of studies that used diverse groups. This itself is a pattern that lends support to the assumption that nursing students lack basic mathematical and drug calculation skills, regardless of the type of nursing program.

Calculation Skills: Summary.

The preceding review provides valuable insight into the nature of research on mathematical and drug dosage calculation skills of nursing students. The work by Bindler and Bayne (1984), over the span of several years, was particulary useful due to the use of adequate samples sizes and consistent findings over time. Furthermore, the understanding gained from the review of this literature is useful to this study because it highlights the significance of the problem and provides direction to the writer in terms of research design. Methodological aspects of the studies were examined, revealing that many studies were limited in their ability to ensure reliability of the testing procedures and determination of competency. The ability to generalize findings was also lacking because of small convenience samples used by a number of researchers. Keeping in mind the limitations identified, further research in this area of study would be helpful.

An abundance of research has examined predictors of overall success in a nursing program. A review of the literature in this area is useful because the studies provide direction in terms of research design and analysis. This literature is also helpful since it reveals that a multitude of student nurse factors, both academic and nonacademic, have been examined in relationship to success in a nursing program.

It may be assumed that if particular student nurse characteristics are found to correlate significantly with academic achievement, then perhaps similar relationships exist between these variables and calculation competency, as one component of achievement in nursing education. Therefore, a review of the literature demonstrating the most relevance to this study, in terms of student nurse factors and success criteria, will be presented in the following section.

2.2 Predictors of Success

It is apparent that nurse educators have been attempting to predict success in nursing education for many years, as evidenced by the literature which spans three decades (Aldag & Rose, 1983; Alichnie & Bellucci, 1981; Backman & Steindler, 1971; Clemence & Brink, 1978; Mueller & Lyman, 1969; Munday & Hoyt, 1965; Payne & Duffy, 1986; Poorman & Martin, 1991; Wold & Worth, 1990). Most of the studies were based on baccalaureate programs, many on associate degree programs, and few on diploma nursing programs situated in the United States. Only three studies used a Canadian sample (Brennan, Best, & Small, 1996; Jacono, Keehn, & Corrigan, 1987; Weinstein, Brown, & Wahlstrom, 1979, 1980). The abundance of research in this area has examined a multitude of predictor variables in relation to academic achievement in nursing programs and success on licensure examinations.

Before discussing the research examining predictors of success, a note regarding the literature using licensure examination success as a dependent variable will provide some clarification for the following review. Only the literature that has addressed the relationships between prenursing predictor variables and achievement in a nursing program will be addressed, for two reasons. First, studies using nursing licensure examination success as a dependent variable (namely, State Board Examinations and the NCLEX-RN) (Aldag & Rose, 1983; Crane, Wright, & Michael, 1987; Glick, McClelland, & Yang, 1986; Jenks, Selekman, Bross, & Paquet, 1989; Krupa, Quick, & Whitley, 1988; McKinney, Small, O'Dell, & Coonrod, 1988; Miller, Feldhusen, & Asher, 1968; Payne & Duffy, 1986; Perez, 1977; Reed & Feldhusen, 1972; Whitley & Chadwick, 1986; Woodham & Taube, 1986), use a criterion variable that is content and theory based (medical, surgical) rather than practically and conceptually based (psychomotor skill, drug calculation skill). Therefore, placing the findings from these studies into a meaningful context for this study is difficult.

Second, it has been suggested the fit between achievement predictor variables and success appears to be a function of time (Higgs, 1984). That is, as time between the predictor variables and criterion variable lengthens, the degree of predictiveness decreases (Owen & Feldhausen, 1970). Based on this finding, it could be assumed that prenursing variables are better predictors of achievement in subsequent nursing course work than of success on licensure examinations after graduation; and, nursing coursework is a better predictor of success on licensure examinations than is high school achievement. Therefore, studies that consider the connection between admission criteria and achievement in a nursing program are more helpful and relevant to this study (Alichnie & Bellucci, 1981; Backman & Steindler, 1971; Clemence & Brink, 1978; Felts, 1986; Jones, 1975; Oliver, 1985; Richards, 1977; Safian-Rush & Belock, 1988; Wold & Worth, 1990).

Psychometric Tests.

Psychometric tests as predictor variables were used extensively in the literature regarding success in nursing education. The Scholastic Aptitude Test (SAT) and the American College Testing Program (ACT) were the two tests used most frequently. Although the SAT and ACT have been widely studied, there is a diversity of results and considerable difference in opinion regarding the validity of these tests as predictors of success.

The SAT is primarily used to test verbal and mathematical reasoning ability of nursing students who have previously studied at a variety of educational institutions (Gardner, 1988). Several studies have found SAT verbal scores to be a better predictor of success than SAT math scores (Kissinger & Munjas, 1982; McKinney, Small, O'Dell, & Coonrod, 1988; Miller, Feldhusen, & Asher, 1968; Payne & Duffy, 1986; Reed & Feldhusen, 1972; Wold & Worth, 1990; Woodham & Taube, 1986). In contrast, others have found SAT math scores to be more predictive than SAT verbal scores (Alichnie & Bellucci, 1981; Yess, 1980). Poorman and Martin (1991) determined that SAT total scores were moderately positively correlated with NCLEX results (0.30, $p<.05$), while Whitley and Chadwick (1986) showed that students from one class who failed the NCLEX had demonstrated significantly lower SAT verbal and math scores on admission than their successful counterparts.

The ACT is comprised of sections that test English, mathematics, social studies, and natural sciences content that has been previously studied in educational settings (Geisinger, 1984). Several investigators suggest that ACT scores are predictive in determining a student's potential to succeed in an associate degree program (Aldag & Rose, 1983; Boyle, 1986; Felts, 1986; Munday & Hoyt, 1965; Sharp, 1984; Wittmeyer, Camiscioni, & Purdy, 1971; Yang, Glick, & McClelland, 1987).

Wittmeyer, Camiscioni, and Purdy (1971) found that ACT math scores were the best predictors of successful completion in a baccalaureate nursing program. Others (Yang, Glick, & McClelland, 1987) have determined that ACT social science subscores correlated the highest with scores on the NCLEX (0.48, $p<.05$). Perez (1977) provides similar findings and speculates that reading ability tested in the ACT social science component may be the determining factor in success as opposed to particular knowledge of content. When ACT comprehensive scores were combined with Chemistry grade point average (GPA), high school rank (HSR), and pre-nursing GPA measures for 210 baccalaureate nursing students, it was determined that these predictor variables (in order) accounted for the greatest variance on NCLEX scores (Yang, Glick, & McClelland, 1987).

The concern expressed in the literature about the usefulness of the SAT and ACT as valid predictors of success requires discussion. While support for almost every aspect of the SAT or ACT as predictors is noted, the role of SAT math and verbal scores remains unclear. Grover (1981) adds, when SAT or ACT scores are added to high school transcript measures, there is little increase in predictive ability (0.08). Therefore, the usefulness in implementing these tests as separate admission criteria is questionable.

Although the SAT and ACT are the most common tools used to determine one's aptitude for success in higher education, there is a lack of consensus in the psychology community about what these tools actually measure (Jensen, 1980; Sternberg, 1985). Jensen (1980) suggests these tests measure intelligence, but fails to offer an operational definition of this concept. Sternberg (1985) argues that the SAT and ACT do not measure intelligence, but rather the context, experience, and components of intelligence as a broad construct that is influenced by ones' immediate environment. Sternberg (1985) adds that how one performs on these psychometric measures is dependent upon how well the individual has adapted to the context of the testing situation, and that scores obtained at one time may not be a true reflection of that person's actual ability. Concerns and arguments about the influences of age (Brody & Brody, 1976; Eysenck & Kamin, 1981), speed and experience with test-writing (Grover, 1981; Jensen, 1981; Sternberg, 1985), and stress (Jensen, 1980; Sternberg, 1985), add to the confusion about the validity of using the SAT and ACT as predictors of academic success.

Concern over how the results of these tests are used has also been expressed (Estes, 1981; Jensen, 1980). Using an applicant's scores on the SAT or ACT as the sole determinant for admission has been criticized as a strategy that should be avoided. Since these scores measure only one aspect of an applicant's potential, and often add little to the variance in overall achievement when combined with other predictor variables, SAT and ACT scores should not be considered the most reliable and valid measure of potential success (Jensen, 1980; Estes, 1981). It has even been recommended that these scores not be used as admission criteria, because they have the potential to restrict and eliminate applicants that may in fact be good candidates for success in nursing programs (Brody & Brody, 1976; Wigdor & Garner, 1982).

In addition to the writer's choice not to elaborate on the literature that uses licensure examinations as the sole dependent variable, it was also decided that there be no further discussion of the relationship between SAT and ACT scores and achievement in nursing programs due to the concerns just expressed. Other reasons for excluding this perspective in the subsequent review include the considerations that SAT and ACT measures are not part of the Canadian context, and that psychometric testing does not take place in the nursing program under investigation for this study.

Predictor Variables.

The literature abounds with achievement prediction studies that explore the relationships between a host of admission criteria and academic success in nursing programs (Allen, Higgs, & Holloway, 1988; Alichnie & Bellucci, 1981; Baker, 1975; Brennan, Best, & Small, 1996; Burgess & Duffy, 1969; Clemence & Brink, 1978; Hutcheson, Garland, & Lowe, 1979; Jones, 1975; Richards, 1977; Safian-Rush & Belock, 1988; Weinstein, Brown, & Wahlstrom, 1980). In these studies and others, academic success was generally defined as either nursing grade point average (Aldag & Rose, 1983; Allen, Higgs, & Holloway, 1988; Brennan, Best, & Small, 1996; Felts, 1986; Oliver, 1985; Wold & Worth, 1990; Yess, 1980), nursing course grades (Chacko & Huba, 1991), or completion of part or all of the nursing program (Aldag & Rose, 1983; Allen, Higgs, & Holloway, 1988; Hayes, 1981; Oliver, 1985; Safian-Rush & Belock, 1988; Weinstein, Brown, & Wahlstrom, 1980). These measures are related more directly to the content and practice experiences provided within the nursing program than is the content tested on a licensure examination such as the NCLEX . Therefore, using these criterion measures of success is helpful because nursing grades and completion of nursing programs occur as a result of theory and clinical practice achievement. Presumably, calculation ability and safe drug administration would be an inherent component of overall achievement for student nurses.

The nursing literature addresses academic and nonacademic variables when studying predictors of success. The strength of traditional cognitive and academic achievement predictors, such as high school grades, college GPA's, and prerequisite course grades, is generally supported in the literature (Alichnie & Bellucci, 1981; Backman & Steindler, 1971; Clemence & Brink, 1978; Chacko & Huba, 1991; Felts, 1986; Hayes, 1981; Oliver, 1985; Reed & Feldhusen, 1972; Seither, 1980; Weinstein, Brown, & Wahlstrom, 1980). In contrast, the use of noncognitive variables such as age, marital status, gender, and previous nursing experience to predict success, has produced inconclusive results (Aldag & Rose, 1983; Allen, Higgs, & Holloway, 1988; Bailey, 1988; Baker, 1975; Felts, 1986; Higgs, 1984; Montgomery & Palmer, 1976; Oliver, 1985; Richards, 1977; Safian-Rush & Belock, 1988; Yess, 1980).

(a) Academic Predictors

Early predictive studies have shown that pre-nursing grade point average and high school standing were found to be the strongest predictor variables of success in nursing programs (Backman & Steindler, 1971; Burgess & Duffey, 1969; Burgess, Duffey, & Temple, 1972; Clemence & Brink, 1978; Whittmeyer, Camiscioni, & Purdy, 1971; Reed & Feldhusen, 1972). More specifically, high school science grades have also been found to correlate significantly with success criteria (Clemence & Brink, 1978; Montgomery & Palmer, 1976). Hayes (1981) determined that academic variables were the most powerful predictors of academic success as they accounted for 62 percent of the criterion variance when studying graduates and non-graduates of a university nursing program.

More recently, high school rank ($r=.44$, $p<.01$) and high school GPA ($r=.28$, $p<.05$) have been suggested as reasonable predictors of nursing GPA when studying freshmen college (Alichnie & Bellucci, 1981) and associate degree (Oliver, 1985) nursing students. By using multiple regression analysis, Dyer (1987) suggested that overall, high school achievement accounted for at best, seven percent of the criterion variance. Seither (1980) studied 108 baccalaureate students and determined that, when combined with cumulative GPA, high school rank was the best predictor of nursing GPA ($F=124.9$, $p <.0001$).

Pre-nursing cumulative GPA, or GPA calculated on previous non-nursing course work, showed a significant relationship with nursing GPA ($r=.23$, $p.000$; $r=.48$, $p<.01$) when the achievement of baccalaureate students was examined (Allen, Higgs, & Holloway, 1988; Wold & Worth, 1990). Prerequisite GPA (Allen, Higgs, & Holloway, 1988; Hayes, 1981) and non-nursing support course grades (Felts, 1986), contributed to significant differences in nursing GPA ($r=.53$, $p.0000$; $F=141.24$, $p<.001$) and somewhat less strongly to successful completion or noncompletion of the nursing program ($F=5.7$, $p<.05$). Higgs (1984), in a study of 507 freshmen nursing students (drawn from three samples of 164, 166, and 177), found that prerequisite GPA was predictive of nursing GPA ($r=.40$-$.46$), clinical GPA ($r=.38$-$.47$), and science GPA ($r=.32$-$.40$) at a $p<.05$. More recently, in a Canadian study conducted in Newfoundland (Brennan, Best, & Small, 1996), similar results, with regard to pre-nursing GPA and Year One nursing GPA, were reported for a sample of 89 baccalaureate nursing students. Overall, high school rank and pre-nursing GPA have demonstrated the greatest consistency in predicting later achievement in nursing programs.

Support for the pre-professional GPA as a useful predictor variable of success in nursing is obtained by reviewing studies found in the allied health literature. Studies have shown that the GPA is the best predictor of academic success for students attending programs in physical therapy (Balogun, 1988), medical record technology (Slovensky, 1986), dietetics (Pope & Gines, 1986; Hanson & Fruin, 1984), and baccalaureate allied health (Schimpfhauser & Broser, 1976).

Others have posited that GPA is unrelated to performance in the disciplines of physical therapy (Levine, Knecht, & Eisen, 1986) and occupational therapy (Posthumas & Sommerfreund, 1985). Dietrich and Crowley (1982) studied 453 allied health programs throughout the United States, including programs in medical records administration, medical technology, physical therapy, occupational therapy, dental hygiene, and respiratory technology. They found no conclusive relationships between academic records, interviews, pre-admission testing, or demographic variables and success in these programs. As well, Hedl (1987) found no correlation between GPA and successful completion of a baccalaureate allied health program.

Limitations in this literature were identified. Small sample sizes such as 42

(Balogun, 1988) and 78 (Posthumas & Sommerfreund, 1985) are noted and different types of programs of varying lengths and grade requirements make comparisons difficult. The content of courses in these programs is not described and therefore the relevance to nursing content is called into question.

The role of the GPA and A-level course grades in predicting success in medical school has been investigated (Jones & Thomae-Forgues, 1984; Montague & Odds, 1990; Sarnacki, 1982). As found in the nursing and allied health literature, GPA is reported as being one of the best predictors of academic success in medical school (Jones & Thomae-Forgues, 1984). Montague & Odds (1990), in a study of 266 medical students in the UK, determined that there was a correlation between performance in various stages of a medical program and performance in A-level chemistry and biology, but not mathematics, physics or general studies. The findings discussed in the allied health and medical literature demonstrate support for the serious consideration of pre-professional GPA and particular support course grades as reasonable admission criteria and predictors of achievement.

Other academic variables typically considered during the admission process include high school or post-secondary science, English, and mathematics grades. Science courses, such as microbiology (Felts, 1986) and biology (Brennan, Best, & Small, 1996; Oliver, 1985; Seither, 1980), have demonstrated strong predictive ability when assessing the GPA of nursing students in associate and baccalaureate degree programs ($F=74.52$, $p<.001$; $r=.51$, $p<.01$; $r=.32$, $p<.05$; $F=216.4$, $p<.0001$). Average high school science grades were shown to be related to whether students dropped out (r=.42-.45, p<.01) or successfully completed the program (F=19.38, p<.01) (Alichnie & Bellucci, 1981; Weinstein, Brown, & Wahlstrom, 1980). However, other studies could not find a relationship between general science (Allen, Higgs, & Holloway, 1988; Wold & Worth, 1990) or chemistry grades (Hayes, 1981) and achievement or successful completion of a program.

Studies that have examined the predictive ability of English scores have shown that high school English and tests of vocabulary (Wold & Worth, 1990), reading, and language skills (Chacko & Huba, 1991), correlate significantly with successful program completion, nursing grades, and nursing GPA (Brennan, Best, & Small, 1996; Oliver, 1985; Weinstein, Brown, & Wahlstrom, 1980). In contrast, other studies did not discover such relationships (Hayes, 1981; Yess, 1980).

The findings related to the predictive ability of pre-admission mathematics grades are more inconclusive. Alichnie and Bellucci (1981) and Brennan, Best, and Small (1996) found that high school math was related to nursing GPA (r=.48, p<.01; r=.48, p<.01), and Weinstein, Brown, & Wahlstrom (1980) determined that math test scores achieved prior to admission were the third best predictor of successful program completion (F=7.57, p<.01), following grades achieved in science (F=19.38) and English (F=14.89). When combined with students' GPA and psychology grades, math grades became predictive of successful completion (F=8.9, p<.05) and could explain 50 percent of the variance between graduates and nongraduates (Hayes, 1981). In contrast, however, others report that mathematics scores as an admission criteria do not predict differences in rates of program completion (Oliver, 1985) or nursing grades (Chacko & Huba, 1991; Yess, 1980).

The best academic predictor variables of success are clearly high school standing and pre-nursing GPA. More caution is necessary, however, when deciding upon the predictive value of other typical academic variables such as science, English, and mathematics grades as independent measures. Many studies did not limit their investigation to academic predictor variables. Noncognitive or nonacademic predictors of success were also examined. A discussion of the influence of these predictor variables is helpful to this study because admission committees often take into consideration a wide range of variables in the decision to admit an applicant to a nursing program.

(b) Nonacademic Predictors

Predicting success in nursing programs involves the consideration of both academic and nonacademic variables. Nonacademic variables such as age, marital status, personality and maturity have shown predictive ability in earlier years (Baker, 1975; Jones, 1975; Montgomery & Palmer, 1976; Richards, 1977; Smith, 1968). Lavin (1965) asserts that variables in the noncognitive domain need to be taken more seriously and investigated as potential predictors since learning is a multisensory experience involving the total being of the learner. Nonacademic predictors have also included such measures as motivation and learning style

(Chacko & Huba, 1991; Hayes, 1981; Higgs, 1984; Nortridge, Mayeux, Anderson, & Bell, 1992; Talarczyk, 1989). More frequently, however, variables such as age, gender, marital status, and previous nursing experience have been examined for their predictive value (Aldag & Rose, 1983; Allen, Higgs, & Holloway, 1988; Bailey, 1988; Bueche, 1986; Oliver, 1985; Yess, 1980). Some authors have characterized the successful nursing student as older, mature, married, and having had prior college experience (Aldag & Rose, 1983; Oliver, 1985; McKinney, Small, O'Dell, & Coonrod, 1988).

The most commonly investigated nonacademic predictor variable in relation to success is age. While it has been found that age in general relates to achievement in nursing school ($r=.31$, $p<.05$) (Oliver, 1985), some have determined that older student nurses out-perform their younger peers ($x^2=35.22$, $p<.01$, $n=534$) (Aldag & Rose, 1983; see also, Bailey, 1988; Higgs, 1984; Safian-Rush & Belock, 1988). That is, increased age appears to be a positive influence in achieving success and successfully completing a nursing program. However, other investigators have not identified these same relationships (Allen, Higgs, & Holloway, 1988; Beuche, 1986; Felts, 1986; Weinstein, Brown, Wahlstrom, 1980; Yess, 1980).

Yess (1980) found that married and divorced student nurses achieved higher GPA's than single students ($R^2=.217$, $p<.05$, $n=75$). It was speculated that perhaps the marital relationship engenders a sense of responsibility and provides the motivation for earning good grades (Yess, 1980). However, marital status did not appear as a significant predictor variable in a study of 296 randomly selected baccalaureate nursing students (Allen, Higgs, & Holloway, 1988). Oliver (1985) also found no relationship between marital status and nursing GPA.

Gender is also often considered in prediction studies. In a study of 507 freshmen university students, female student nurses were found to achieve higher nursing theory and clinical GPA's than male students (Higgs, 1984). In contrast, gender has not shown predictive ability in relation to GPA or completion of a nursing program by others investigating this variable (Allen, Higgs, & Holloway, 1988; Oliver, 1985; Yess, 1980). Data on gender are often collected in studies, but deleted from the final analysis in many cases. Frequently, there is an insufficient number of male subjects to enter the data on gender into the statistical procedures. Therefore, the usefulness of gender as a predictor variable, in terms of statistical and practical importance, is debatable.

Findings related to the predictive ability of previous nursing experience are inconclusive. Oliver (1985) determined that Licensed Practical Nurse (LPN) status positively correlated with higher nursing GPA ($F=3.96$, $p<.05$) in an associate degree program ($n=67$). However, Yess (1980) found that LPNs achieved lower GPA's than students without previous nursing experience ($n=75$). Others found that LPN status made no difference in the achievement of nursing GPA or in completion of the program (Allen, Higgs, & Holloway, 1988; Felts, 1986).

It is often said that prior success is the best predictor of future success (Hayes, 1981; Talarczyk, 1989; Wold & Worth, 1990). Studies have shown that student nurses who have earned previous degrees or have attended university prior to entering nursing, perform better ($r=.57$ & $r=.26$, $p<.05$) than students without prior post-secondary experience (Allen, Higgs, & Holloway, 1988; Higgs, 1984; Oliver, 1985). Yet, in a study of 787 high school graduates ($n=555$) and transfer students who had previous university credits ($n=232$), Aldag and Rose (1983) found these two groups were equally successful in graduating from nursing programs.

Clearly, the predictive power of nonacademic variables is less convincing than that demonstrated by academic predictors. A review of the literature in this area demonstrates inconsistencies in the findings, making generalizations difficult. A brief discussion of the limitations inherent in some of these studies is helpful in explaining the confusion arising from the analysis of academic and nonacademic variables as predictors of success in nursing education.

Design Issues.

Most studies used an ex post facto design to review student records for academic and nonacademic data (Alichnie & Bellucci, 1981; Oliver, 1985; Weinstein, Brown, & Wahlstrom, 1980; Yess, 1980). Although appropriate for the research problems being investigated, this approach often resulted in a reduced sample size due to incomplete information found in the student records. The problem of missing data may be reduced by the use of prospective designs in which the researcher can plan for the type of information available in records. Reduced sample sizes also limited the ability to enter anticipated data into the statistical formulas and therefore reduced the power of the analysis carried out.

Sample sizes ranged from 34 (Safian-Rush & Belock, 1988) to 787 (Aldag & Rose, 1983). Most samples were convenience in nature (Alichnie & Bellucci, 1981; Felts, 1986; Higgs, 1984; Oliver, 1985; Seither, 1980; Wold & Worth, 1990; Yess, 1980). Few used a stratified random sampling approach (Allen, Higgs, & Holloway, 1988; Weinstein, Brown, & Wahlstrom, 1980). The studies based on a Canadian sample are minimal (Brennan, Best, & Small, 1996; Jacono, Keehn, & Corrigan, 1987; Weinstein, Brown, & Wahlstrom, 1980). The diversity of samples, number and type of variables studied as predictors, and the lack of consistent operational definitions for the independent and dependent variables (Higgs, 1984) across different types of nursing programs, makes it difficult to draw conclusions.

The lack of standardization in grading policies germane to the calculation of grades and GPAs among high schools, colleges, and universities raises the questio of uncontrolled variance (Friedemann & Valentine, 1988; Higgs, 1984; Munday & Hoyt, 1965). Similarly, differences in how high school transcript data and prior course work grades are collated (Wold & Worth, 1990) into admission criteria from applicants arriving from a variety of educational settings adds to the question of validity.

These studies employed both univariate (Pearson's r) and multivariate statistical procedures, such as stepwise multiple regression, to examine the relationships between individual and groups of predictor variables to the criterion measures. While helpful in prediction studies, multivariate analysis procedures require large random samples to be most effective. Small sample sizes of 34, 67, 75 and 95 respectively (Safian-Rush & Belock, 1988; Oliver, 1985; Yess, 1980; Chacko & Huba, 1991), in relation to the number of variables analyzed by the multiple regression method, renders the applicability of some of the findings questionable. Other investigators have attempted to identify predictor formulas to be considered during the admission process (Boyle, 1986; Miller, Feldhusen, & Asher, 1968; Reed & Feldhusen, 1972). However, these equations would be difficult to implement in practice since they were often lengthy (Hayes, 1981; Perez, 1977) and contained an assortment of variables that may or may not be applicable to a particular program.

Predictors of Success: Summary.

The lack of comparative and validation studies in this area has led to an abundance of research that is disconnected and inconclusive (Higgs, 1984). Higgs (1984) suggests that the confusion arising from such a haphazard approach to research can be reduced by following a systematic approach to variable identification and relationship testing, based on the needs of the researcher. The Model for the Study of Prediction of Success in Nursing Education and Nursing Practice (Higgs, 1984) offers a practical conceptual framework which encourages one to "tap into the model at various stages depending upon the purpose of the study and the problems under investigation" (p. 80). Today, this model remains helpful in guiding research owing to the continuing trend of disorganized and inconclusive work in this area.

Variables in the model (Higgs, 1984) have been categorized as pre-nursing major, nursing major, and post-graduation to establish a succession of events. Both academic and nonacademic variables are considered. Direction is provided in identifying variables previously investigated and the relationship between predictor and criterion variables in other studies. Using this model for the design and execution of further prediction studies would be a worthwhile and valuable endeavour in contributing to the current body of knowledge in this area of study.

2.3 Factors Influencing Calculation Ability

As the previous section demonstrates, many studies have examined the relationship between academic and nonacademic predictors of success in nursing education. However, when reviewing the literature related to predictors of mathematical ability of nursing students as a separate entity, one finds that research in this area is minimal. The psychology literature is helpful as it addresses the influence of mathematics anxiety on the calculation ability of students (Aiken, 1976; Betz, 1978; Fulkerson, Galassi, & Galassi, 1984; Hendel & Davis, 1978; Richardson & Suinn, 1972; Zeidner, 1991). The influence of math anxiety has been considered in some nursing literature, but not to a large extent (Bayne & Bindler, 1988; Fulton & O'Neill, 1989; Pozehl, 1996).

Calculation ability as a conceptual skill has been shown to be influenced by the individual learning styles of students (Bath & Blais, 1993; Bath, Chinn, & Knox, 1986; Grow & Johnson, 1983; Miller, 1986; Hodges, 1983; Midkiff & Thomasson, 1993). This perspective is described primarily in the education literature. Once again, only one nursing article on this subject was found (Bath & Blais, 1993).

The education and nursing literature have explored the issue of calculator use on the development and demonstration of calculation ability (Chenger, Conklin, Hirst, Reimer, & Watson, 1988; Hembree & Dessart, 1986; Koop, 1982; Shockley, McGurn, Gunning, Gravely, & Tillotson, 1989; Roberts, 1980; Szetela, 1982; Worrell & Hodson, 1989), as another influencing factor. However, there is a paucity of research, nursing and otherwise, which specifically addresses the link between academic and nonacademic variables and calculation competency of nursing students (McCann-Flynn & Moore, 1990).

Mathematics Anxiety.

The investigation of the relationship between math anxiety and math test performance is well documented (Aiken, 1976; Betz, 1978; Hendel & Davis, 1978; Morris, Kellaway, & Smith, 1978; Richardson & Suinn, 1972; Rounds & Hendel, 1980; Stodolsky, 1985). Burton and Russell (1979) suggest that a lack of a foundation in maths and low mathematics self-esteem reinforces math anxiety. Richardson and Suinn (1972) define math anxiety as "feelings of tension and anxiety that interfere with the manipulation of numbers and the solving of math problems in a wide variety of ordinary life and academic situations" (p. 551).

One of the most commonly used instruments in the literature designed to measure mathematics anxiety is the "Mathematics Anxiety Rating Scale" (MARS) developed by Richardson and Suinn (1972). The MARS is a 98-item, 5-point Likert-type instrument designed to assess math anxiety in a wide variety of ordinary-life and academic situations (Richardson & Suinn, 1972). Internal consistency and test-retest reliabilities have been reported at .97 and .85 ($p<.001$) respectively. It is considered the most widely used math anxiety measurement instrument with the greatest amount of psychometric, reliability, and validity data (Fulkerson, Galassi, & Galassi, 1984).

Another related variable of some significance is that of attitude toward mathematics. Eaton (1989) states, "many students, especially female students, have negative attitudes toward mathematics and little confidence in their ability to solve problems" (p. 342). Measures of attitudes toward mathematics have shown consistent relationships with tests of mathematics achievement and performance (Aiken, 1970, 1976). McCann-Flynn and Moore (1990) found mathematics attitude to be a significant predictor of math performance for 64 female junior students in a baccalaureate nursing program. Similarly, Bayne and Bindler (1988) found nurses who rated their own medication skills and overall comfort with medication calculation as below average tended to score lower on a calculation test than those who rated their skills as average or above average.

Timpke and Janney (1981) witnessed how their students often expressed feelings of frustration, anxiety and embarrassment about inadequate calculation abilities. It was estimated these feelings contributed to a 39% failure rate on drug dosage tests. After implementing a calculation computer program as an instructional strategy, they reported students experienced less anxiety and could progress satisfactorily at an individual pace. Subsequently, all students who used the computer program passed the mastery test on drug calculations the first time.

In a study involving 267 behavioral science students, 72 percent of whom were female, an inverse correlation between math anxiety and math performance ($r = -.49$, $p < .05$) was reported (Zeidner, 1991). This study was useful because it employed the largest sample size found in the literature and provided the greatest detail related to methodology, analysis, and theoretical explanation for the findings.

In contrast to the above studies, others have shown that a relationship between math anxiety and math performance does not exist (Fulkerson, Galassi, & Galassi, 1984; Fulton & O'Neill, 1989; Llabre & Suarez, 1985; Resnick, Viehe, & Siegel, 1982; Siegel, Galassi, & Ware, 1985). For example, Fulton and O'Neill (1989) studied 80 first year nursing students enrolled in a college nursing program in Ontario. Their results indicated there were no significant differences between groups examined for math anxiety levels and arithmetic test performance. While the relationship between math anxiety and math performance appears to have been a concern over several years, the relationship remains unclear.

In general, the studies in this area employed designs and methodological strategies that were appropriate for the research questions under investigation. Few limitations to these studies were noted. Some studies used small samples of 71 (Fulkerson, Galassi, & Galassi, 1984), 80 (Fulton & O'Neill, 1989), and 143 (Siegel, Galassi, & Ware, 1985), which, relative to the number of items analyzed by use of the MARS (Richardson & Suinn, 1972), could be considered insufficient to detect small significant differences.

Fulton and O'Neill (1989) postulated that the lack of significant differences between groups in terms of math anxiety and math performance could possibly be attributed to the use of the MARS (Richardson & Suinn, 1972) in their study and presumably by others (Fulkerson, Galassi, & Galassi, 1984; Siegel, Galassi, & Ware, 1985). They stated it was possible their sample, and others of this generation, were not as math anxious as their predecessors had been when this tool was developed; and therefore, the usefulness of this tool over time was questioned. Socialization changes over the past two decades and improved counselling facilities for students having difficulty with mathematics were identified as potential reasons why students did not display the same degree of math anxiety and subsequent difficulties in math performance. Nonetheless, few faults with these studies could be found, leaving the impression that the influence of math anxiety on math performance remains ambiguous.

Learning Styles.

It has been found that the majority of calculation errors made by students tend to be conceptually based (Blais & Bath, 1992; Segatore, Edge, & Miller, 1993). Inability to set up the problem correctly or not knowing in which form to administer the medication, are examples of conceptual errors. Researchers have suggested there are different styles to mathematics learning and subsequent performance. How an individual perceives, processes, and problem-solves a calculation situation appears to influence how an answer is generated (Bath, Chinn, & Knox, 1986; Grow & Johnson, 1983; Miller, 1986; Bath & Blais, 1993).

The role of learning styles in mathematics has been addressed as an area of consideration in the education and nursing literature (Bath & Blais, 1993; Hodges, 1983; Midkiff & Thomasson, 1993). Bath and Blais (1993) studied 66 first year nursing students who had completed course work involving calculation of drug dosage and medication administration skills. They used the Test of Cognitive Style in Mathematics (Bath, Chinn, & Knox, 1986) in conjunction with a drug dosage exam and found that students who were identified as "global, inductive, part-to-whole mental processors" were more likely to pass the drug dosage test than were the "analytical, deductive, whole-to-part problem solvers".

The results by Bath and Blais (1993) are in contrast to the view posed by Midkiff and Thomasson (1993). They suggest mathematical skills are primarily left-brain functions. Therefore, people who are left-brain learners, characterized as analytical and deductive thinkers, should perform better in math than those who are right-brain dominant and possess a global learning style. O'Neil (1990) agrees with

Bath and Blais's (1993) recommendation that instruction in mathematics should incorporate a mixture of learning style approaches in order to accommodate the individual styles of different students.

Much of what is presented in the literature regarding learning styles in mathematics was anecdotal and theoretical in nature. Related research-based information was minimal (Bath & Blais, 1993). Further empirical study in this area would be helpful.

Calculator Use.

There has been a long-standing debate in nursing education on whether or not students should use calculators on examinations to determine drug dosage calculation ability (Shockley, McGurn, Gunning, Graveley, & Tillotson, 1989). A review of the studies examining calculation abilities of students reveals that some programs have allowed the use of calculators (Segatore, Edge, & Miller, 1993), while others have not (Bindler & Bayne, 1984; Blais & Bath, 1992). Worrell and Hodson (1989) report that 81.3% of the programs they studied did not allow the use of calculators.

Several nursing authors have offered their opinions regarding the usefulness of calculators in testing. Dexter and Applegate (1980) asserted that "calculators are useless if one doesn't know how to set up the problem correctly" (p. 50). Murphy and Graveley (1990) add that, despite their virtual worthlessness if the user is unable to set up the problem, calculators should be available on every unit to verify manual calculations in order to reduce mistakes due to sloppiness and fatigue. This sentiment is shared by others who have stated if calculators were allowed during testing, educators would be better able to identify students who had conceptual difficulties, as errors due to carelessness or fatigue would be minimized (Chenger, Conklin, Hirst, Reimer, & Watson, 1988; Segatore, Edge, & Miller, 1993; Worrell & Hodson, 1989).

Shockley, McGurn, Gunning, Graveley, and Tillotson (1989) conducted a study of 166 undergraduate nursing students to determine the effect of calculator use on the arithmetic and conceptual skills associated with solving problems on a dosage calculation exam. They used an experimental repeated measures design in which students completed two parallel forms of a calculation exam, one form with a calculator and one form without. The results suggested calculator use was associated with improved arithmetic skills but diminished conceptual skill performance.

Independent of the calculator effect, pre-admission arithmetic ability of the students was acknowledged as a major factor underlying performance on the medication tests (Segatore et al., 1993). It was also reported (Segatore et al., 1993) the two tests required refinement to rule out differences in scores since an analysis of within subjects effects showed that one form was likely more difficult than the other form. Therefore, findings from this study should be considered with caution due to the limited reliability of the calculation tests.

Studies on the relationship between arithmetic and conceptual skills and the use of calculators were found almost exclusively in education journals, with only one study reported in the nursing literature (Shockley et al., 1989). Findings of the education studies were mixed. Szetela (1982) reports for students in Grades three to eight, calculators did not improve conceptual skills during problem-solving, but did help to avoid errors made as a result of basic computational weaknesses.

Following a study of 150 adult students enrolled in a college arithmetic course, Koop (1982) recommended calculators be allowed in adult classes requiring a math component. It was believed these adult learners had failed to retain the basic math skills learned earlier and that calculators would enhance basic skills performance and overall attitude toward mathematics. However, this study did not confirm the perspective that the use of calculators is also beneficial in increasing problem-solving skills (Hembree & Dessart, 1986).

Suydam (1982) carried out a review of 75 research studies concerned with the influence of calculators on basic and conceptual problem-solving skills in mathematics. Like other studies (Koop, 1982; Roberts, 1980; Szetela, 1982), results of this landmark review (Suydam, 1982) yielded few firm conclusions on the effects of calculator use in testing. That is, the majority of these studies reported the use of calculators led to mixed improvement in basic mathematics operations and no significant improvement in problem-solving or conceptual skills.

Most recently, a meta-analysis of the findings from 79 research reports was conducted by Hembree and Dessart (1986). The purpose of the analysis was to assess the effects of calculators on student achievement in mathematics for students in Grades K to 12. Studies selected for the review were subject to specific inclusion criteria which ensured consistency and adequacy of the methods used to study the issue of calculator use. The results indicated the use of calculators in testing produced much higher achievement scores than traditional paper-and-pencil efforts, both in basic operations and in conceptual problem-solving questions. This finding applied to all grades and ability levels.

Factors Influencing Calculation Ability: Summary.

Apart from the concerns noted in the study by Shockley, McGurn, Gunning, Graveley, and Tillotson (1989), no obvious methodological weaknesses of the literature reviewed in the previous section were found. The review of educational studies, and nursing literature to a lesser extent, would imply that while basic mathematical skills do not appear to be negatively influenced by calculator use, the relationship with conceptual skills remains unclear. Unfortunately, the question of whether calculators should be used, specifically in nursing education, continues to be unanswered.

It is not the intent of this study to focus on the issue of calculator use in math competency testing. However, a discussion of this literature is appropriate for this study for the following reason. It is assumed that calculators are used extensively in the primary and secondary school systems. Based on the research, it is conceivable that continued reliance on the use of calculators as a student moves through the school system may undermine the development of conceptual problem-solving skills and diminish the ability to perform basic numeracy operations due to a lack of practice. It is unclear to what degree mature learners, who have been away from the school system for several years, depend on the calculator. Nursing students who have grown accustomed to using a calculator may find themselves at a disadvantage when faced with having to demonstrate drug calculation ability without the aid of a calculator. These assumptions have significant implications for how nursing programs and researchers measure the competence of students, depending on whether calculators have been used or not.

It is also not the aim of this study to concentrate on the influences of math anxiety, learning styles, or the use of calculators in math competency testing. However, the inclusion of literature in these areas is significant to the discussion as it might help to explain potential sources of uncontrolled variance in math scores obtained during the course of this study. Having an understanding of these factors prior to design development also enables the researcher to consider ways to reduce error in instrumentation and testing, if at all possible.

2.4 Predictors of Nursing Students' Math Performance

Predictors of nursing students' mathematics performance as an area of study has limited representation in the nursing literature (Chenger, Conklin, Hirst, Reimer, & Watson, 1988; McCann-Flynn & Moore, 1990; Segatore, Edge, & Miller, 1993). The most widely studied area in mathematics achievement comes from the educational research in which investigators have examined gender differences in mathematics performance (Benbow & Stanley, 1982; Ethington & Wolfle, 1984; Fennema & Sherman, 1977; Sherman, 1979) and reasons for women's participation in mathematics learning (Armstrong & Price, 1982; Fennema, 1977).

Gender Differences.

The literature pertaining to gender differences favours the view that mathematics performance is found to vary as a function of sex, with men typically out-performing women (Fennema & Sherman, 1977). It has been suggested one reason women fall behind men in mathematics performance is women have traditionally avoided the study of mathematics (Armstrong & Price, 1982; Fennema, 1977). In order to explain why women avoided mathematics, Fennema (1977) reviewed the influence of numerous cognitive, social, educational, and cultural factors identified from previous studies. Although certain variables were identified as possible predictors of women's involvement, the results were often inconclusive due to small samples or because the examination of possible factors were inconsistent between studies. Armstrong and Price (1982) determined that attitudes, perceived usefulness of math, and expectations of parents, teachers, and peers emerged as predictors of why women tended not to engage in mathematics experiences as often as men.

Studies have also attempted to find other explanations for lower mathematics achievement by females. Sherman (1979) conducted a longitudinal study examining the predictive ability of cognitive and attitudinal variables for boys and girls from Grade nine to Grade twelve. She found that cognitive variables (aptitude and understanding) were more consistently predictive, although a negative attitude towards mathematics contributed significantly to lower math scores obtained by the girls. Sherman (1979) hypothesized that the "fear of success" phenomenon and sociocultural roles prescribed for females at that time likely played a part in the lack of requisite development for optimal mathematical learning.

In another longitudinal study of "Mathematically Precocious Youth", Benbow and Stanley (1982) established that gender differences in math achievement persisted over several years. More precisely, it was found that the abilities of males developed more rapidly than those of females, leading to male-favoured differences in mathematics participation and performance. However, few sex differences in attitudes and little relationship between attitudes and achievement were identified. Therefore, in contrast to other studies (Armstrong & Price, 1982; Ethington & Wolfle, 1984; Sherman, 1979), the lack of relationship between attitude and performance found by Benbow and Stanley (1982) could presumably be attributed to the more positive attitude toward math by both men and women in this sample.

Using data drawn from the "High School and Beyond" nationwide longitudinal study of high school sophomores and seniors ("National Opinion", 1980), Ethington and Wolfle (1984) examined the reasons men and women differ in mathematics achievement. After controlling for gender differences in cognitive abilities, background in math, and math interest or attitude, they determined that gender continues to have a significant effect on the math achievement of females. They suggested the greatest source of variance resulted from differences in the degree to which females were exposed to math by virtue of being enrolled in mathematics courses. Put simply, the more women participated in mathematics, the better they performed.

Results of the Third International Mathematics and Science Study (Beller & Gafni, 1996) are interesting to examine within this context. Commencing in 1991, a sample of over 150,000 students in grades seven and eight from over 40 countries were tested in the areas of mathematics and science. For Canadian students, it was found girls and boys performed equally "well" in mathematics and that both groups achieved an average of 59% in this subject. The authors (Beller & Gafni, 1996) highlight these findings represent a significant change from what has been reported over the past 20 years in terms of gender differences in mathematics achievement. It should be noted, however, these students are approximately four or five years from high school graduation and may take longer yet to enter university. Therefore, it will be interesting to watch whether the lack of gender difference in mathematics proficiency for this group will persist over the years, or if previous trends will emerge as these students move through the educational system.

The previous studies have identified several factors that describe why male-favoured, gender differences exist in the area of mathematics performance. Methodological strengths such as large sample sizes of 1788, 1996, and 13200 respectively (Armstrong & Price, 1982; Benbow & Stanley, 1982; Ethington & Wolfle, 1984), and the use of longitudinal designs employing multiple measures over time, enable one to have confidence in the findings generated by this body of research.

The literature related to gender differences was included in this review because it provides insight into possible factors why nursing students, who are primarily female, demonstrate difficulty with mathematics. Furthermore, an understanding of these factors may add a valuable perspective on the potential variance in scores, separate from that obtained as a result of the identified variables under investigation in this study.

However, gender as an independent variable, has limited value for this study. Nursing programs generally do not enroll sufficient male students to enter statistical data into the analysis to detect gender differences. This statement is supported by the decision of nursing studies which eliminated gender from the final analysis due to insufficient male subjects (Chenger, Conklin, Hirst, Reimer, & Watson, 1988; McCann-Flynn & Moore, 1990; Segatore, Edge, & Miller, 1993). It is interesting to note that despite this consequence, nursing studies continue to collect data on the variable of gender, which never reaches the analysis stage.

Academic and Nonacademic Predictors.

As mentioned, the amount of research addressing the links between academic and nonacademic variables and mathematical and drug calculation ability of student nurses is disappointing. Only four studies have examined these relationships (Chenger, Conklin, Hirst, Reimer, & Watson, 1988; Dexter & Applegate, 1980; McCann-Flynn & Moore, 1990; Segatore, Edge, & Miller, 1993). At best, the design details in these studies are sketchy, and the results are inconclusive.

(a) High School Average and GPA

High school average has been studied in relation to calculation ability. Although chi square analysis demonstrated that high school average correlated significantly with basic math scores in one study (n=355) (Chenger, Conklin, Hirst, Reimer, & Watson, 1988), it did not appear to have the same influence in another (Segatore, Edge, & Miller, 1993). Again, the latter study used a sample of 44, which may explain the inability to detect statistically significant differences.

Grade point average has been shown to predict achievement on a medication test in a study conducted by McCann-Flynn and Moore (1990). Using a sample of 64 students, the Pearson's correlation coefficient ($r=.453$, $p<.01$) and multiple regression analysis ($F=16.01$, $p<.01$) demonstrated the existence of a significant relationship between GPA and calculation ability. This is a useful finding because it is derived from a methodologically sound study and therefore offers support for including GPA in prediction studies concerned with the calculation skills of nursing students.

(b) Previous Mathematics Courses

Findings concerning the predictive ability of previous mathematics achievement are also unclear. Dexter and Applegate (1980) purport that high school algebra can predict basic math performance. However, it is difficult to put these findings in perspective since there was no information reported regarding the sample size or the methods used to measure the variables in this study.

The number of high school mathematics courses taken by nursing students did not appear to influence either basic math skills (Chenger, Conklin, Hirst, Reimer, & Watson, 1988) or medication calculation ability (McCann-Flynn & Moore, 1990). It is interesting to note these results are in contrast to the findings from the educational literature which suggests that greater mathematics exposure (taking more math courses) should improve mathematics performance (Ethington & Wolfle, 1984).

(c) Age

In an ex post facto correlational study of an unidentified number of nursing students, Dexter and Applegate (1980) found that an inverse relationship between age and basic mathematics performance existed. However, no statistical data were provided and details regarding the methodology and measurement used in this study were nonexistant. More recently, Kapborg (1995) reported an inverse relationship between age and mathematics scores for a sample of 975 Swedish nursing students. However, the absence of statistical data and the differences in basic education and nursing program designs between Sweden and North America, make it difficult to place Kapborg's (1995) findings in perspective. In contrast, McCann-Flynn and Moore (1990) found a significant positive relationship between age and scores on a medication test ($r=.36$, $p<.01$) for 64 baccalaureate nursing students. It is noted that these findings concur with those found in the literature describing increased age as a positive influence on achievement (Higgs, 1984; Oliver, 1985) in a nursing program.

Age was found to not influence basic mathematics and drug calculation skills for students in other studies using samples of 44 (Segatore, Edge, & Miller, 1993), and 355 nursing students (Chenger, Conklin, Hirst, Reimer, & Watson, 1988). However, these studies lacked detail with regard to methodology and measurement; therefore, comparisons between these and other studies are difficult. Overall, the predictive ability of age in relation to calculation ability remains ambiguous.

(d) Attitude Towards Mathematics

McCann-Flynn and Moore (1990) examined the predictive ability of mathematics attitude for drug calculation skills for female baccalaureate nursing students. Attitude was measured by using the Nurses' Math Attitude Questionnaire developed by Aiken and Dreger (1961). This is a 30-item, 7-point Likert-type scale that produced a reliability coefficient alpha of .95 for this sample of 64 students. Calculation ability was determined by a 20-item medication and intravenous test which achieved an alpha of .82. Multiple regression analysis revealed that math attitude created significant variance in test scores ($F=4.55$, $p<.01$).

Math attitude was also found to correlate positively with basic math skills for 355 students, although no statistical data to substantiate this claim were reported (Chenger, Conklin, Hirst, Reimer, & Watson, 1988). These results and the findings reported above, are in keeping with those suggested in the education literature regarding the relationship between math attitude and math performance (Armstrong & Price, 1982; Sherman, 1979). However, although mathematics attitude has shown the greatest consistency in predictive ability, attitude is not a variable that is usually considered during the admissions selection process.

(e) Other Nonacademic Predictors

The most helpful study found in the nursing literature regarding predictors of nursing students' mathematics performance was the one conducted by McCann-Flynn and Moore (1990). In addition to studying the variables of age, gender, math attitude, GPA, and number of math courses as reported above, the authors also examined the predictive ability of previous degrees and prior health care experience. Although it was found these two variables had contributed to overall GPA achievement in previous work (Allen, Higgs, & Holloway, 1988; Higgs, 1984; Oliver, 1985), McCann-Flynn and Moore (1990) did not find this same effect on medication test scores of nursing students. Therefore, conclusions regarding the significance of prior nursing experience and attainment of a previous degree in predicting calculation ability are difficult to make.

Overall, this study clearly reported the methods used to investigate the research questions which aimed to determine the relationships between these predictor variables and scores on a medication calculation test. No significant weaknesses of this study were found, except the sample size of 64 could be considered small in relation to the number of variables included in the investigation.

Predictors of Nursing Students' Math Performance: Summary.

Clearly, the literature addressing the relationships between typical academic and nonacademic admission criteria and calculation ability is limited. Adding to the deficit in this area is the use of small sample sizes like 44 (Segatore, Edge, & Miller, 1993) and 64 (McCann-Flynn & Moore, 1990) to examine a number of different variables. Also, these studies lack detail (Chenger, Conklin, Hirst, Reimer, & Watson, 1988; Dexter & Applegate, 1980; Segatore et al., 1993), making any judgements or generalizations unwise. Except for one study (McCann-Flynn & Moore, 1990), little direction in terms of variable definition or methodology is gained from this literature. Finally, the findings in this area of study continue to be murky, even after comparisons to other areas of study are made.

2.5 Chapter Summary

A review of the literature supports the view that nursing students possess weak mathematical and drug calculation skills. Concerns were raised regarding test construction and the reliability of instruments used to measure mathematical competency. It was also noted the use of small convenience samples limited the ability to generalize the findings beyond the parameters of the studies in this area.

An abundance of research on predictors of success in nursing programs was found in the nursing literature. However, numerous variables and inconclusive findings made a synthesis of this literature challenging. It was determined that, generally, cognitive or academic predictors, rather than non-cognitive variables, were more predictive of success. Analysis of the data in these studies was complex and the use of advanced statistical procedures for relatively small samples was questionable.

Those studying factors influencing calculation ability, such as math anxiety, learning styles, and calculator use, offered insight into possible sources of variance in math performance. The research in this area came primarily from the disciplines of education and psychology, with some from the nursing literature. Researchers demonstrated that while these factors may play a role in how students perform mathematically, the nature of this influence remains unclear.

In closing, and perhaps most noteworthy, research addressing the relationships between academic and nonacademic criteria and calculation abilities of nursing students was strikingly lacking in the literature. Findings related to the predictive power of typical admission criteria were inconclusive and were based on research with significant methodological limitations.

The task of identifying patterns in the literature is not easy. While it is clear that student nurses do not possess the calculation skills necessary to practise safely, it is not so clear how to predict which students are likely to succeed or fail in this area of competence. Admissions committees are charged with the duty to identify students with the greatest potential to excel in nursing. The ability to calculate drug dosages correctly is a critical component of overall success in nursing education and practice. Faculties and students would also benefit from the knowledge gained by examining predictors of calculation skill. The detection of students likely to experience difficulty could be made early and the appropriate remediation could be put in place to assist students at risk for academic or clinical jeopardy.

Chapter Three: Methodology

3.0 Research Design

This study was conducted using a non-experimental, descriptive correlational design. A correlational design was chosen for several reasons. First, in the correlational survey, two or more variables are measured as they exist in the population and their relationships are analyzed on the basis of a conceptual framework (Wood & Brink, 1989). Although correlational designs vary greatly in the strength of the framework, it is important to have a theoretical foundation for suggesting potential explanations for the possible relationships among the variables (Wood & Brink, 1989). The Model for the Study of Prediction of Success in Nursing Education and Nursing Practice (Higgs, 1984) provided the theoretical foundation for the variables in this study.

Second, a correlational design acknowledges the inability of the researcher to manipulate the independent variables or randomly assign subjects to groups (Polit & Hungler, 1991). Since it would have been ethically unwise to manipulate admission criteria without sound research to validate this manoeuvre, it was appropriate to use a design that was nonexperimental. Therefore, one does not intend to infer cause-and-effect relationships when using a descriptive correlational design, but rather describe the relationships among variables (Polit & Hungler, 1991). Also, the subjects in this study were recruited as a convenience sample in an attempt to obtain a reasonable size for statistical analysis. It would have been difficult to randomly select subjects for this study because students had already been chosen through the admission process of the nursing program.

Third, correlational research is an efficient way of collecting a large amount of data in a relatively short amount of time (Wood & Brink, 1989). Also, cross-sectional data collection and correlational analysis allowed the investigator to develop a description of the student nurse population based on data collected from the instruments to survey and test nursing students. A survey design was chosen, as opposed to a retrospective approach, because access to student records was found to be problematic.

Fourth, a correlational design can be used to determine if there is empirical evidence to support the development of a conceptual model in an area that has been understudied (Wood & Brink, 1989). This study provided unique information that was helpful for the development of the Model by Higgs (1984) in the pre-nursing major and nursing major categories. In this regard, the design chosen for this study helped to illuminate new, and support previous, relationships in areas that had otherwise received little attention in the research.

The descriptive correlational approach has the disadvantage of the researcher being unable to control the extraneous variables in order to determine the true nature of the relationships between variables under investigation (Polit & Hungler, 1991). For example, other unstudied characteristics of nursing students, such as mathematics anxiety and job experience, may be influential in how students score on the calculation tests. These factors cannot be controlled for unless they are identified and built into the design.

The inability to select a random sample of students from the total population was another limitation to the design chosen for this study. Although the best sample for a correlational study is a large random sample of the population (Wood & Brink, 1989), obtaining a random sample for this study would have been difficult due to time and financial constraints. While the population for this study was defined as all second-year nursing students enrolled in a four-year baccalaureate nursing program in Manitoba, generalization of the results from this study beyond the types of students which comprised the sample was, therefore, not a goal of this study.

Causal relationships cannot be suggested by the use of a descriptive correlational design since the assumptions of a controlled experimental design are violated with this approach (Wood & Brink, 1989). Therefore, the findings of correlational research are not as convincing and require confirmation through such approaches as replication (Polit & Hungler, 1991).

3.1 Procedures

This study included the collection of data related to demographic characteristics, pre-entrance academic status, and calculation ability of baccalaureate nursing students. Demographic characteristics and pre-entrance academic status data were compared to calculation ability measures for second year nursing students enrolled in the second term of the undergraduate baccalaureate nursing program offered by the University of Manitoba. The procedures used to address the research questions involved (a) identification of demographic characteristics, (b) identification of pre-entrance academic status variables, (c) collection of data on these demographic and academic variables, (d) determination of measurable indicators of calculation ability, (e) collection of data on these indicators, and (e) statistical analysis of the data collected on the demographic and academic variables, and indicators of calculation ability.

Data collection on the independent variables, those being the demographic characteristics and academic status variables, was conducted through the use of the Demographic and Academic Status Questionnaire designed for this study (see Appendix I). Demographic characteristics of nursing students in this study included the following variables: site of attendance of the nursing program, age of the student at the time of the study, marital status, number of years since high school graduation, location of high school attendance, type of student when admitted to the program, previous education, and completion of a Statistics, Calculus, or Algebra course. Academic status of nursing students included grades achieved in the pre-entrance admission criteria courses of Mathematics, English, and Science, as well as the students' cumulative Grade Point Average (GPA).

Data collection on the dependent variable, calculation ability, was achieved by using the Mathematics and Drug Calculation Test, also developed for this study (see Appendix M). Calculation ability was comprised of scores obtained on the Mathematics and Drug Calculation Test which included a Basic Mathematics Section (20 questions) and a Drug Calculation Section (20 questions). Total scores were then obtained by combining Section scores for a total of 40 possible marks.

Instruments.

It is important to use instruments that are reflective of the variables identified in the conceptual framework for the study (Wood & Brink, 1989) and that are considered logical extensions of the literature in the area. That is, the reason for using particular tools to measure certain constructs and concepts should be clear and obvious. The instruments used in this study reflect selected variables identified in the conceptual framework by Higgs (1984) as well as the supporting literature. From this perspective, tools were developed or adapted to measure the variables identified in the research questions.

The Washington Mathematics Test for Nursing, developed by Bindler and Bayne (1984), includes 65 items related to symbols and words, computation of whole numbers, fractions, decimals, ratios, and word problems. This instrument has been used extensively with different student groups between 1979 and 1983 (Bindler & Bayne, 1984). However, the authors have not reported the reliability coefficient for this tool. Students were allowed two hours to write this test and were required to achieve an 80% grade to be considered successful. Calculators were not allowed. A copy of this tool is found in Appendix K.

The Bayne-Bindler Medication Calculation Test (Bayne & Bindler, 1988) is a 20 item fill in the blank examination which was constructed by the researchers to evaluate the calculation skill of practising nurses working on general nursing units. Of the 20 questions, 10 relate to oral medications, four to subcutaneous or intramuscular medications, and six to intravenous drugs. Nurses were given one hour to write this test. This instrument has been pilot tested with 70 baccalaureate nursing students one month prior to graduation (Bayne & Bindler, 1988). Content validity was established by a panel of three nursing experts, and by a review of pharmacology and nursing literature. Reliability of 0.82 was established by an odd-even split half test upon administration to a population of 62 registered nurses (Bayne-Bindler, 1988). A copy of this instrument is found in Appendix L.

The previous two instruments provided the foundation for the Mathematics and Drug Calculation Test developed for this study. Permission to make modifications to both tools was received from the authors. The first tool, which is quite lengthy, has 65 items. It also contains items related to the American measurement system (grains) which is not suitable for Canadian testing purposes. The second tool contains items related to subcutaneous, intramuscular, and intravenous drugs. However, at the time of this study, students had not had the opportunity to study theory related to the calculation of these forms of drugs. Therefore, an adapted modified form of these two instruments was developed (Mathematics and Drug Calculation Test) and can be found in Appendix M.

The Mathematics and Drug Calculation Test consisted of two sections. The Basic Mathematics Section was comprised of 20 questions that included addition, subtraction, multiplication, division, decimals, fractions, ratio and proportions, and four word questions. The Drug Calculation Section focused on word problems that involved oral drug calculations of both tablet and solution types.

Reliability levels for the Mathematics and Drug Calculation Test as measured by Cronbach's alpha coefficient (Cronbach, 1984) were established as follows: (a) the internal consistency reliability coefficient for the Basic Mathematics Section (BMS) was .65, (b) internal consistency reliability coefficient for the Drug Calculation Section (DCS) was .77, and (c) the internal consistency reliability coefficient for the Total Test was .88. Additionally, reliability correlation coefficients of the "subscales" (BMS and DCS) between each other and compared to the Total Test were as follows: (a) BMS and DCS = .55, (b) BMS to Total = .86, and (c) DCS to Total = .90. These coefficients suggest that, although each Section had an acceptable level of reliability (.65 and .77) for relatively immature instruments (Nunnally, 1978), there was only a moderate relationship between the BMS and the DCS (.55) in terms of measuring the construct of calculation ability. However, the Drug Calculation Section appeared to be the most reliable measure of the two. Both Sections correlated well to the Total (.86 and .90), suggesting they were both relatively predictive of how students would perform overall and therefore, can be considered valuable measures in determining calculation ability. Also, the reliability coefficient for the

Total Test (.88) indicates that the Mathematics and Drug Calculation Test can be considered a reliable tool for measuring the calculation ability of students in this sample.

Pilot Test.

Validity of the Demographic and Academic Status Questionnaire and Mathematics and Drug Calculation Test developed for this study was established by conducting a pilot test of the instruments. Both instruments were administered to a group of 11 baccalaureate nursing students who were not a part of the study sample (attended the Brandon General Hospital Site). Since none of the second year nursing students at this site agreed to participate in the pilot test after three attempts, the investigator secured participation from the first year students. Students were asked to complete the instruments under the same conditions that were designed for the study. Following administration, students were asked to identify any problems they had completing the Questionnaire and Calculation Test and to make suggestions for improvement (see Appendix N).

Lynn (1986) recommends that a review of items by a minimum of three experts be used to establish validity of an instrument. Therefore, as part of the pilot test, the Mathematics and Drug Calculation Test was reviewed for content and criterion-related validity by three faculty members in the Baccalaureate nursing program. The faculty chosen for this task had extensive experience in the area of testing mathematics and drug calculation competency of nursing students. The structured procedure for the evaluation of this tool by faculty is found in Appendix O. Comments by students and faculty were then reviewed and suggestions for revision were incorporated into the final instruments used for the study.

Because the investigator was a Faculty member at the Brandon General Hospital site, the pilot test was conducted by a paid Research Assistant. The Research Assistant was orientated to the study and was given a script of instructions to follow. The script was created to keep the procedures used by the Research Assistant consistent with the procedures used by the investigator during the study (see Appendix G).

3.2 Setting

This study occurred within the generic Baccalaureate in Nursing Program offered by the University of Manitoba. Locations of the study included the sites of the Fort Garry Campus and St. Boniface Hospital. This setting was chosen for the study because it was the only generic baccalaureate in nursing program in Manitoba. The Health Sciences Centre site was not selected to be part of the sample because no second year students attended this site during the 1995 - 96 academic year. Also, the Brandon General Hospital site was excluded from the study sample since the second year students attending this site, at the time of data collection, had been admitted into the Faculty of Nursing under special circumstances. That is, most of this group had not completed the entrance requirements and were being allowed to complete them concurrently with their second year studies.

The University of Manitoba Faculty of Nursing currently requires that students applying to enter the four-year degree program meet certain admission criteria. High school applicants are required to have no less than 60% (Grade C) in English 300, Mathematics 300, and Chemistry or Physics 300 at the Grade 12 level, with an overall 63% average. Transfer students, or students who have completed some prior university course work in another faculty, are required to have a minimum cumulative grade point average of "C", and have a "C" in a 100-level English and 100-level Chemistry or Physics course.

3.3 Sample

The population, from which the sample was selected, was defined as all second-year nursing students enrolled in a generic baccalaureate nursing program in Manitoba. The convenience sample for this study was comprised of all consenting nursing students attending the second year of the University of Manitoba Baccalaureate in Nursing Program in the 1995 - 1996 academic year, drawn from the Fort Garry Campus and St. Boniface sites. The total number of second year students, from these two sites, that could have participated was 107. A convenience sample was appropriate for this study since it allowed all those students who wished to participate the opportunity to do so, thereby increasing the potential to recruit a larger sample size.

The students involved in this study included those who had entered the program directly from high school and those who had entered after having completed some previous university courses (transfer students). These two criteria for inclusion did not exclude any second-year student in this program from participating, according to current admission standards. Students attending the second year of the program were selected for the sample because of the way in which the mathematics and drug calculation theory had been scheduled in the nursing program. That is, for the academic year of 1995 - 96, the basic mathematics content was covered in the first term of second year and drug dosage calculation content was covered in the second term of second year. No other exposure to this content occurred before this time. The investigator believed that to fairly test these two types of skills (basic math and drug calculations), that students needed the opportunity to learn content related to these skills before being tested in the study. Therefore, students were approached to participate, and subsequently tested, in the latter part of second term.

For this study, it was recommended that the sample size be no fewer than 100 subjects (J. Sloan, personal communication, January 24, 1995). It was hoped that a good majority of the 107 students studying in the second year of the program, for 1995 - 1996, would agree to participate in the study. This would enhance the ability to obtain an acceptable sample size of a heterogeneous nature. Given this, the issue of representativeness, a type of external validity, would be addressed by using most of the students enrolled in the program at that time. Unfortunately, it was not possible to recruit 100 students and, in fact, the size of the sample was 33.

3.4 Data Collection

Data collection on the demographic characteristics and academic status variables was done by having the student nurses complete the Demographic and Academic Status Questionnaire developed for this study (see Appendix I). Responses from the Questionnaire were recorded according to the value tags identified in the Data Dictionary (see Appendix J). Calculation skills were measured by having the students complete the Mathematics and Drug Calculation Test. The data collection process was completed by the investigator without the use of assistants.

Protocol.

Random error refers to random influences that tend to make measurements differ from time to time or cause variations in performance from item to item on a single measure (Nunnally, 1978). Environmental and temporary subject fluctuations can act to create sources of random error during a data collection session, thereby influencing how subjects will score on an instrument. Therefore, it is necessary to make every effort to minimize the effects of random error so that measures are consistent and stable, and reliability is enhanced (Zeller & Carmines, 1980).

Controlling for random error was attempted by following a protocol in the administration of the instruments to the students.

a) Time - Since not all students attended the same site, separate data collection sessions were needed for each site. With the assistance of course leaders, a time convenient for the student groups at each site was arranged in order to administer the Demographic and Academic Status Questionnaire and Mathematics and Drug Calculation Test.

The first data collection session took place at the St. Boniface site. Three factors were noted that contributed to difficulty in data collection at this site. First, the investigator was late arriving from Brandon due to car trouble on the highway. It is possible that students who wanted to participate left the testing area because the investigator was not present at the time data collection was to begin. Second, students reported feeling very overwhelmed with their course work and that participating in a study was not a priority for them. It is possible that more students would have agreed to participate if the data collection had taken place at a time other than just prior to final exams. And finally, another data collection session was organized for the following week in an attempt to capture more students. However, due to workload pressures, this additional session yielded only 3 more students from the St. Boniface site who were willing to participate.

Similar workload pressures were reported by students at the Fort Garry site. It was additionally difficult to interest the students at the Fort Garry site to participate. Data collection at this site was scheduled to occur after the writing of an in-class test when it was suggested that all students would be present. However, without prior notice to the investigator, the course leader delivering the in-class test decided to have the students complete multiple course evaluation forms which significantly delayed the commencement of the data collection session. By the time the investigator was able to start data collection, several students had lost interest in participating in the study.

An element of time constraint is necessary in order to simulate the pressure one experiences in a clinical setting while administering medications. Within the literature, however, the effect of time limits during test-taking is not well addressed. Following the findings from the pilot test, sufficient time was arranged for the students to complete both tools. All students were able to complete both instruments within the allotted seventy-five minutes. This was the case for students at both sites.

b) Environment - Temperature, lighting, and noise control were important considerations during administration of the instruments. Arranging for comfortable seating and adequate space was also important. The investigator was able to use rooms at both sites which allowed for adequate light, space, and comfortable room temperature. However, at the St. Boniface site, the investigator noted that throughout the data collection session, a continuous clicking noise (from the heating system) could be heard in the testing room. It is possible that this distraction could have interfered with the students' level of concentration during data collection.

c) Calculators - The literature suggests mathematical and problem-solving skills are influenced both positively and negatively (respectively) by the use of calculators (Koop, 1982; Szetela, 1982; Shockley, McGurn, Gunning, Gravely, &

Tillotson, 1989). Bindler and Bayne (1984) did not allow student nurses to use calculators while writing the Washington Mathematics Test for Nursing during their series of studies between 1979 and 1983. This decision was based on the belief that calculators were not always available to practicing nurses and that an understanding of how to perform basic computation without calculator assistance is necessary for nurses. In congruence with these positions, calculators were not allowed in this study.

d) Delivery - The investigator chose to conduct all the orientation and data collection sessions to maintain consistency in providing instructions and direction to the students. Questions raised during the sessions were handled in a similar manner by the researcher. All testing sessions were completed before any analysis took place. This provision ensured there were no changes in protocol between groups that might influence the delivery of subsequent sessions and, therefore, influence the subjects' answers. However, a potential source of systematic error that could not be controlled would be the possibility of differences, between sites, in teaching strategies and content with regard to basic math and drug calculation theory. Such differences could have contributed to variations in how students performed on the calculation test.

3.5 Ethical Considerations

Ethical approval from the Ethical Review Committee of the Faculty of Nursing, University of Manitoba, was received prior to proceeding with the study (see Appendix P). Upon ethical approval from this committee, a letter requesting access to student nurses at Brandon General Hospital (for the pilot study), St. Boniface General Hospital, and Fort Garry Campus was submitted to the respective Directors of the Programs (see Appendix Q). Permission to proceed with the study at these sites was obtained (see Appendix R).

Orientation sessions for the pilot study and research study were advertised at each site. During the initial orientation sessions, a full and detailed description of the study was provided to the students by way of an Invitation Letter (see Appendix C and D), enabling them to make an informed decision about their desire to participate. Ethical considerations of the study were discussed. Students who wished to participate were asked to return to a data collection session and to sign a consent form at that time (see Appendix E and F). This allowed the students time to decide if they wished to participate and the opportunity to contact the investigator with additional questions or concerns. Friendly reminders about the date, time, and location of the impending data collection sessions were advertised. A copy of the consent form was provided to each participating student at the time of data collection.

The issues of voluntary consent, anonymity, confidentiality, and risks and benefits to subjects were addressed during the orientation sessions and were addressed in the consent form. Students were assured that their decision to participate or not participate would not jeopardize their progress in the nursing program and that their scores would not be shared with the administrators of the program. Students were given the opportunity to have their calculation test scores returned to them for self-assessment purposes.

Code names (mother's maiden name) were used to correlate responses between instruments. Confidentiality of these names was maintained by assigning each student an identification number and keeping the corresponding list of numbers on a separate sheet in a locked cabinet. All data collection sheets were stored in a locked cabinet in a separate location. Data were available only to the researcher, the researcher's advisors, and a statistician during the course of the study. Since the internal member of the researcher's Thesis Committee is involved in the administration of the U of M Baccalaureate in Nursing Program, this member had access only to group data that were coded, rather than individual test papers with the student code names identified.

Analysis of the data was described in a global sense to protect the identity of the subjects. As well, given the small number of male students in the sample, all students were referred to in the female gender to protect anonymity of male participants. The data collection sheets will not be destroyed for seven to ten years (MRC, 1993). During this time, permanent storage of all such documents will be at the investigator's home in a locked cabinet. After the proper time, these documents will be destroyed by a paper shredder.

Since the researcher is employed by the Brandon General Hospital site, the issue of bias and insider status was addressed. It was imperative the researcher be clear with the students that their participation was entirely voluntary. No measures of coercion to participate were used. A research assistant was hired to conduct the orientation and data collection session for the pilot test at the Brandon General Hospital site so the element of coercion was avoided. Once students at this site consented to participate, the research assistant administered the instruments according to the established protocol (see Appendix G). Responses from these subjects were treated in the same manner as those from the two study sites. The researcher had access to the subjects' code names and was obligated to keep this information confidential and separate from her role as an instructor at the Brandon General Hospital site.

3.6 Data Analysis

Statistical analysis of the collected data was completed through the use of the Statistical Package for the Social Sciences (SPSS) 6.1.3 Graduate Pack (SPSS, 1993). All data were coded and entered into the computer. Responses obtained on the Demographic and Academic Status Questionnaire were used to reflect the demographic (Research Question #1) and academic (Research Question #2) characteristics (grades obtained for the University of Manitoba admission requirements) for second year nursing students in the Baccalaureate Nursing Program. Calculation ability of nursing students (Research Questions # 1 and 2) was determined by calculating percentage of correct and incorrect responses to questions on the Mathematics and Drug Calculation Test. Scores were obtained for the Basic Mathematics Section (BMS; 20 marks), Drug Calculation Section (DCS; 20 marks), and for the Total test overall (40 marks).

All original data were collected without consideration to grouping categories of responses. However, an exploration of the distribution of variables led to the decision to categorize the responses to certain demographic and academic questions. When responses were both quite dispersed and appeared to have obvious clustering of responses, such as for age and years since graduation from high school variables, it seemed logical to consider analyzing particular variables in both their continuous and categorical forms. Also, for some variables, all response options were not utilized, such as the marital status and previous education variables. Therefore, it seemed reasonable to collapse some of the options for these variables. This allowed the investigator to analyze the data in different ways and enhanced the ability to detect differences between groups based on larger combined responses. The Data Dictionary, including original variables (Research Question 1 and 2), added variables arising from pilot study faculty review, and recoded and regrouped variables is found in Appendix G.

Reliability estimates of the Mathematics and Drug Calculation Test were obtained as measured by the Cronbach's alpha coefficient (Cronbach, 1970). Separate alpha coefficients were calculated for the Basic Mathematics section (BMS) (.6540), Drug Calculation section (DCS) (.7725), and for the Total test (.8817).

Correlations between the two "subscales" (BMS and DCS) (.5498) and between the subscales and the Total (BMS = .8571; DCS = .9016) were measured also as discussed earlier in this Chapter in the "Instruments" section.

Univariate descriptive procedures were performed including means, standard deviations, modes, ranges, frequencies, and percentages for all variables. One subject was identified as an outlier from this analysis. This subject outlier was notably different in the areas of age and number of years since graduation from high school as she was older than others in the sample. Removal of the subject outlier did not significantly alter the results and therefore this subject was left in the data set for all data analysis.

Correlation coefficients were calculated to describe the relationships between two variables (Polit & Hungler, 1991). The correlations provided information on the strength and direction of the relationships between variables. Correlation coefficients of less than .3 were considered weak, between .3 and .5 were considered moderate, and those greater than .5 were considered strong.

The most commonly used correlation coefficient is the Pearson's product moment correlation coefficient (Conover, 1980). However, appropriate use of this test assumes that the variables are normally distributed. Since none of the variables in the data set met this criteria, nonparametric Spearman's rho correlations were calculated on those variables measured on interval and ordinal scales (Polit & Hungler, 1991). Spearman's rho was used for the following independent variables:

(a) age ("age"),

(b) number of years since graduation from high school ("grad"),

(c) pre-admission Mathematics grade ("math" recoded),

(d) pre-admission English grade ("English" collapsed & recoded),

(e) pre-admission Science grade ("science" collapsed & recoded), and

(f) cumulative Grade Point Average ("GPA" recoded).

These variables were compared with the three dependent variables including Basic Mathematics score, Drug Calculation score, and Total score.

Non parametric t-tests were applied to those independent variables measured on a nominal scale and for which dependent variables did not follow a normal distribution (Polit & Hungler, 1991). The Mann-Whitney U test is a nonparametric procedure for testing the difference between two independent groups when the dependent variable is measured on an ordinal scale (Polit & Hungler, 1991). This test was used to determine the difference in Basic Mathematics scores, Drug Calculation scores, and Total scores when compared by levels of the following variables:

(a) site of attendance of nursing program ("site"),

(b) age group ("agegrp"),

(c) marital status ("marstat2"),

(d) place of high school attendance ("Gr12a" and "Gr12b"),

(e) type of student ("type"), and

(f) whether or not the student had taken Statistics, Calculus, or Algebra prior to the study ("Stats", "Calculus", "Algebra").

When the number of groups is greater than two and a test for independent groups is desired, one may use the Kruskall-Wallis test (Polit & Hungler, 1991). This nonparametric test was used to examine the difference with respect to two of the variables in the data set:

(a) number of years since graduation from high school ("gradhs") , and

(b) types of previous education ("prevedu").

As with the correlation coefficient tests, all independent variables used in the Mann-Whitney U and Kruskall-Wallis tests were analyzed with respect to the three dependent variables.

Some variables were analyzed by using both a correlation coefficient (Spearman's rho) and a nonparametric test for group differences. Original data were collected without being placed in discrete groups and, therefore, were first analyzed by using a correlation coefficient test. Later, based on a review of the frequency distributions of the data, some variables were recoded, grouped into categories of responses (see Appendix G), and subjected to nonparametric testing of differences between independent groups. Variables that underwent analysis by these two methods include the following:

(a) "age / agegrp", and

(b) "grad / gradhs".

The research proposal suggested the use of inferential statistics, such as the ANOVA and multiple linear regression, might be appropriate for data measured on interval and ratio scales. These procedures require the data to be normally distributed and drawn from a probability sample (Wood & Brink, 1989). Since this data set did not meet these specifications, the use of these inferential statistics was not considered for this study. The small sample size (n = 33) also contributed to the decision not to perform more sophisticated statistical tests on the data set.

P - values (significance values) were calculated for each statistical procedure. The investigator took advantage of the ability of the SPSS program to calculate actual p - values, rather than simply relying on assessing significance by comparing strength of evidence to a pre-determined alpha level (.05 or .01). This allowed the investigator to decide which results would be considered statistically significant based on a wider range of p - values. Decisions regarding significance and accompanying individual p - values are provided in the following Chapter on Results.

3.7 Summary of Chapter

This chapter provided a review of the research design, procedures, setting, sample, and data collection methods used in this study. Ethical considerations were addressed and data analysis procedures implemented in this study were outlined.

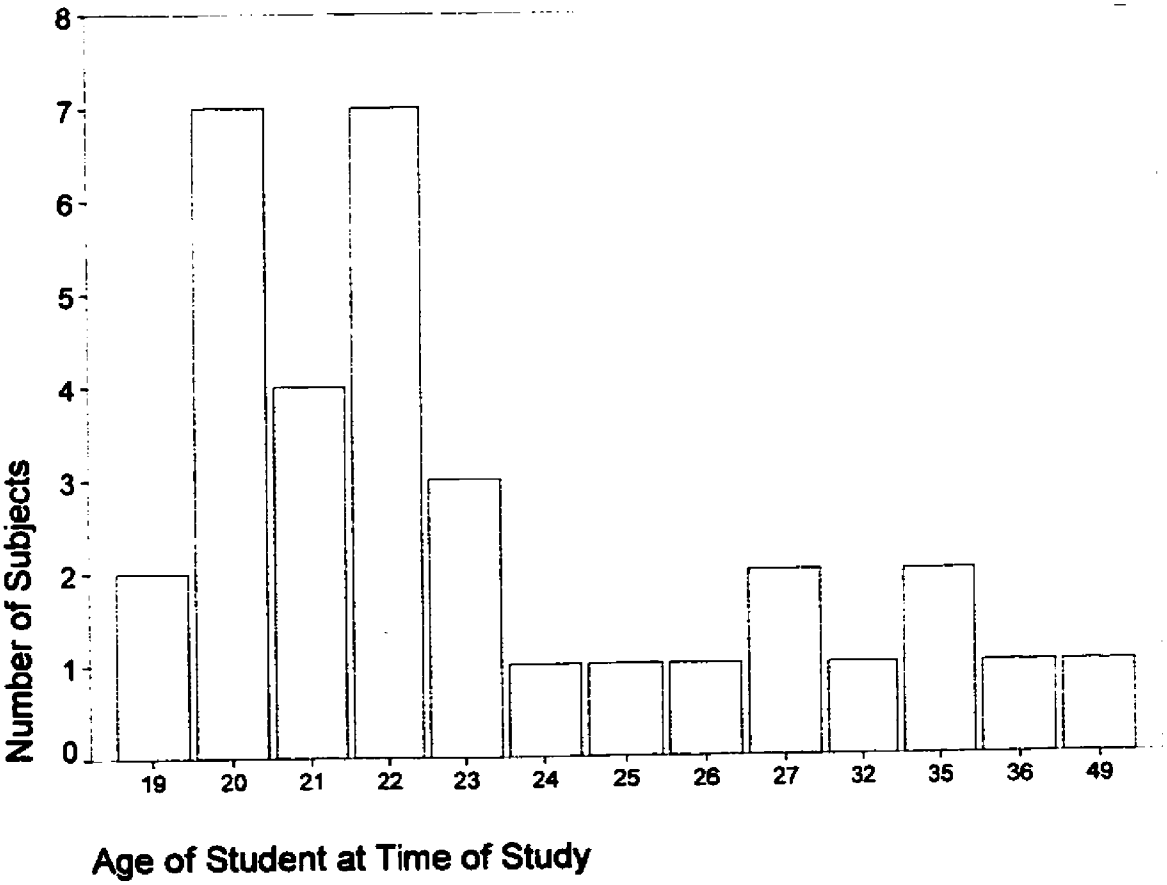
Chapter Four: Results

4.0 Sample

Demographic Characteristics.

Data were collected on 33 subjects. The average age of the subjects was 24 years with the range being 19 to 49 years (SD = 6.434). However, most subjects were clearly younger than 24 years of age (see Figure 1).

Figure 1



More subjects in the sample attended the St. Boniface site (St. B.) (n=21; 63.6%) than the Fort Garry (FG) site (n=12; 36.4%) of the undergraduate nursing program (SD = .489). Over 80% of the subjects were single or separated (n=27; 81.8%; SD = .392). Data on gender were not collected since the literature suggests that the number of males in most samples related to nursing is too small for meaningful analysis (Chenger, et al., 1988; McCann-Flynn & Moore, 1990; Segatore, et al., 1993). Almost equal numbers of subjects were admitted into the nursing program as either a high school student (n=16; 48.5%) or transfer student(n=17; 51.5%) (SD = .508) (see Table 1).

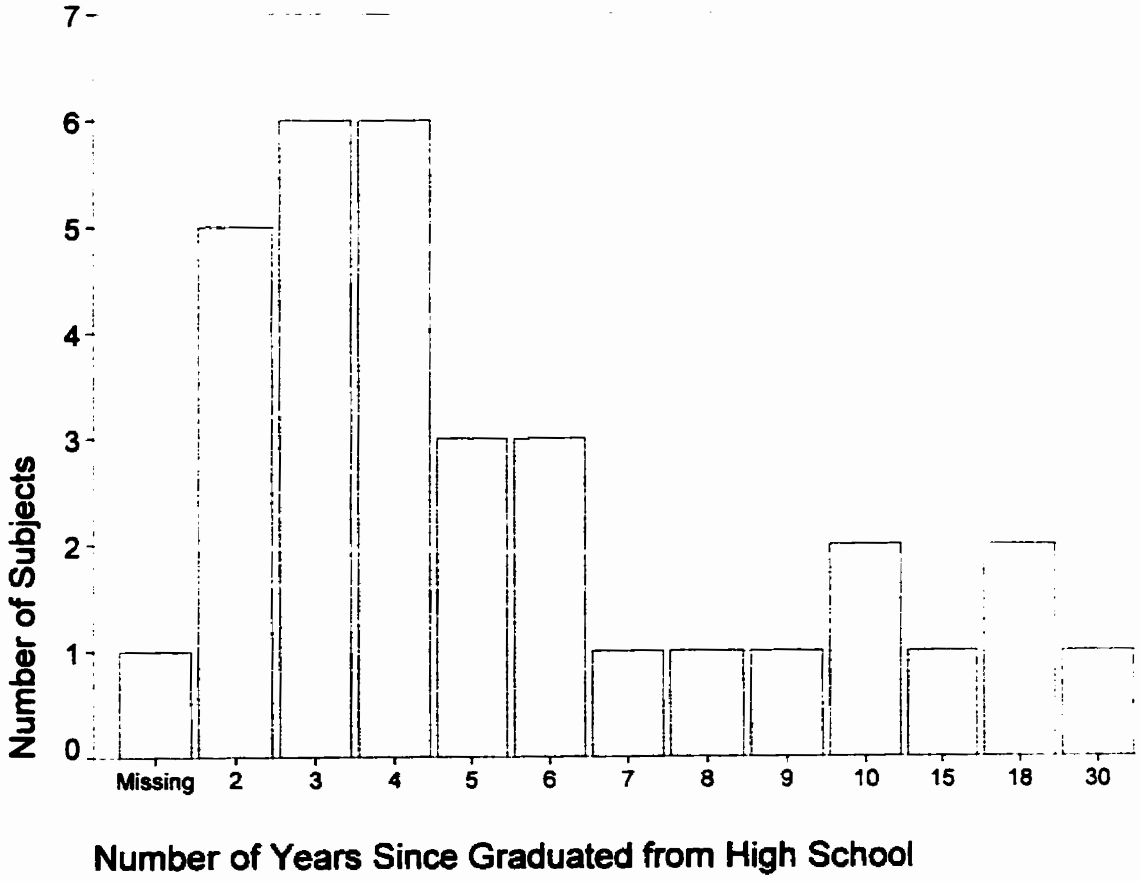
Table 1

<u>**Site Attended, Marital Status, and Type of Student**</u>

n = 33	Site		Marital Status		Type of Student	
	St. B.	FG	Single	Married	Transfer	High School
Frequency	21	12	27	6	17	16
Percentage	63.6	36.4	81.8	18.2	51.5	48.5

The mean number of years since graduation from high school was 6.6 years with the range being 2 to 30 years (SD = 6.07). However, most subjects had graduated from high school within the past 4 years (see Figure 2).

Figure 2



Over half of the subjects had attended high school in an urban centre (n=18; 54.5%) and primarily in Manitoba (n=28; 84.8%) (SD = .494 and .364 respectively) (see Table 2).

Table 2

<u>Place of High School Attendance</u>

n = 33	High School			
	Urban	Rural	Manitoba	Not Manitoba
Frequency	18	11	28	5
Percentage	54.5	33.3	84.8	15.2

Note: Values for urban and rural categories do not equal n = 33 or 100% since there were 4 (12.2%) missing responses.

Over 36% (n=12) of the subjects reported having no previous post secondary education prior to coming into the nursing program (36.4%; SD = 23.25). As mentioned in Chapter 3, Methodology, Data Analysis section, the previous education variable was recoded based on the finding that subjects did not require several of the response categories. The final range of responses determined for this variable were as follows: (a) none, (b) some related electives (arts, sciences courses), (c) some non-related electives (education, physical education, Bible study, nurse's aide program), and (d) previous degree (Bachelors or Masters).

Given the new categories for previous education, most subjects indicated they had taken no post-secondary education prior to nursing (n=12; 36.4%), and equal numbers of subjects indicated they had taken some related elective courses (n=6; 18.2%) and non-related elective courses (n=6; 18.2%). Surprisingly, 21.2% (n=7) of the subjects reported they had obtained a previous degree prior to entering the nursing program, one being at the Master's level (SD = 1.21) (see Table 3).

Table 3

Post-Secondary Education Obtained Prior to Nursing Program

n = 33	Prior Education			
	None	Some Related Electives	Some Non-Related Electives	Degree
Frequency	12	6	6	7
Percentage	36.4	18.2	18.2	21.2

Note: Frequencies and percentages do not equal n = 33 (100%) since there were two non-responses.

Subjects were also asked to indicate if they had taken any other university level mathematics-related courses prior to the study. Several (n=23; 69.7%) reported they had taken a Statistics course, while a Calculus course (n=7; 21.2%) or Algebra course (n=3; 9.1%) was taken less frequently (SD = .467, .415, and .292 respectively) (see Table 4).

Table 4

Mathematics Related Courses Taken Prior to Study

n = 33	Statistics		Calculus		Algebra	
	Stats	No Stats	Calculus	No Calculus	Algebra	No Algebra
Frequency	23	10	7	26	3	30
Percentage	69.7	30.3	21.2	78.8	9.1	90.9

Academic Characteristics.

Academic characteristics were described in terms of frequency distributions of grades for the Faculty of Nursing pre-admission criteria. Although subjects had the choice to indicate their grades in either the high school (eg., English 300, 40S) or transfer student (eg., English 100 level) category, whichever was relevant to their situation, there were inconsistencies between these responses and those made earlier in the Questionnaire. Some subjects indicated they were "high school students", in response to the question asking the type of student they were when they entered the nursing program, yet marked their pre-admission grades at the university (transfer student) level, and visa versa. Therefore, when entering the data into the SPSS program, the investigator decided not to distinguish between pre-admission 300, 40S, or 100 level (university) courses. Also, insufficient numbers of subjects reported grades in Physics to make analysis of differences between Chemistry and Physics meaningful. Thus, frequencies of grades were run in the general areas of pre-admission Mathematics, English, and Science grades, and cumulative Grade Point Average (GPA). When subjects recorded grades in both Chemistry and Physics in the area of pre-admission Science grade, only the higher grade was recorded (see Appendix G, Data Dictionary).

Grades in pre-admission Mathematics, Science, and English ranged from A+ to C. Average pre-admission Mathematics grade was B+, English was B+, and Science was B. Average cumulative GPA was B with GPAs ranging from A to C. Generally speaking, subjects in this data set could be described as "B" students upon entering the nursing program (see Figures 3, 4, 5, and 6; Table 5). These letter grades reflect those used by the Faculty of Nursing and are described in Table 5.

Table 5

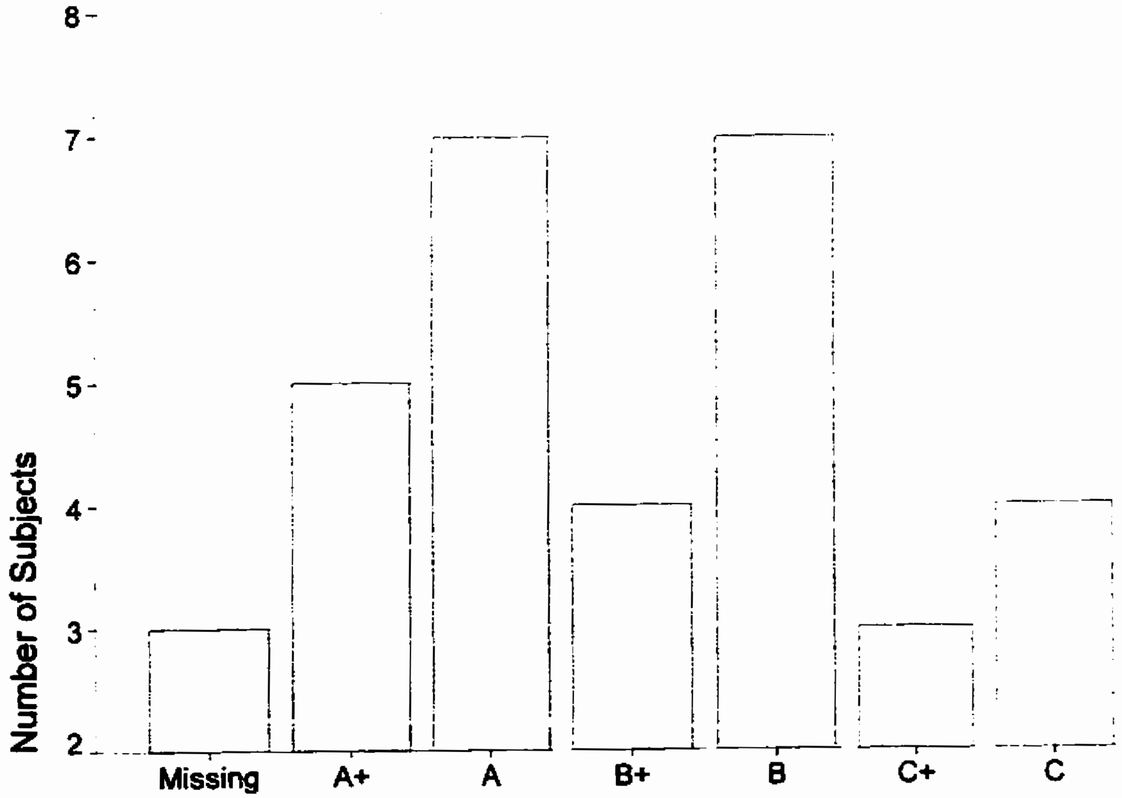
Profile of Grades in Pre-admission Criteria

n = 33	Pre-admission Criteria			
	Math (n = 30)	English (n = 33)	Science (n = 32)	GPA (n = 33)
Mean	B+	B+	B	B
Mode	A (n = 7) B (n = 7)	A (n = 11)	B+ (n = 12)	B (n = 11)
Range	A+ to C	A+ to C	A+ to C	A to C
SD	1.660	1.376	1.362	1.091

Note: The following ranges were used as determined by the Faculty of Nursing:

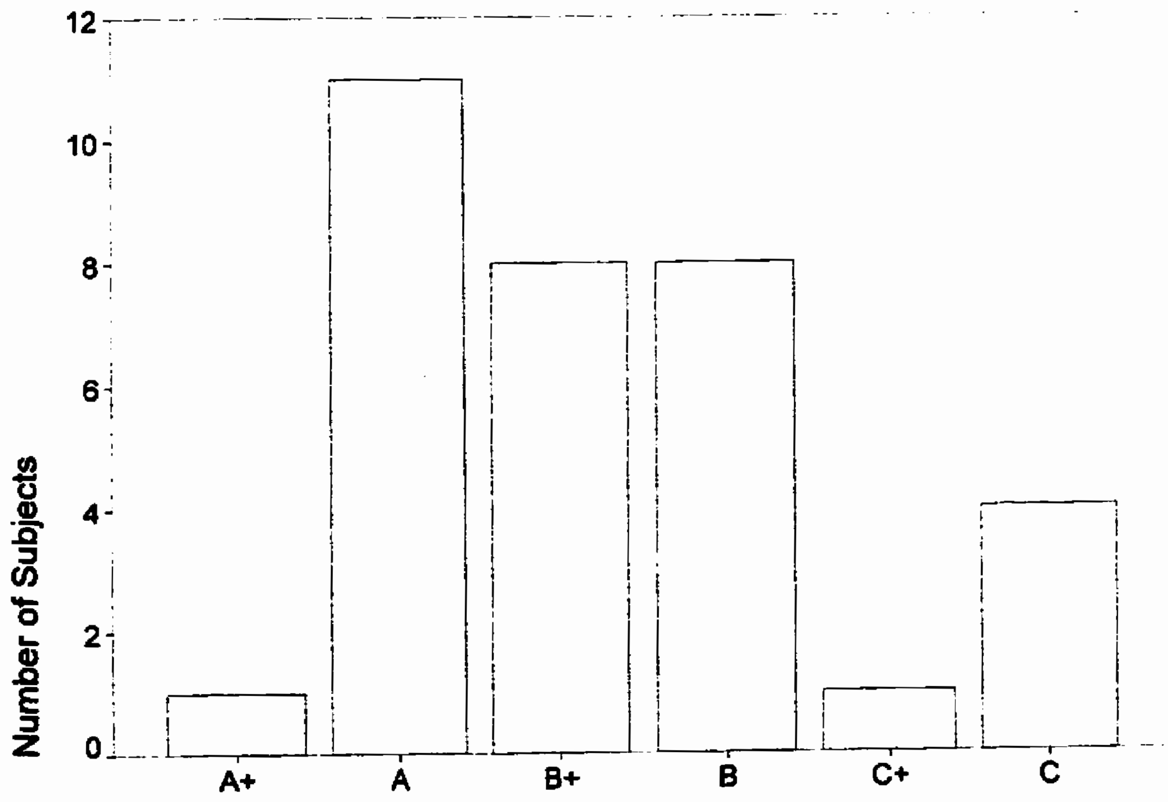
Grades:		GPA:	
	A+ = 91 - 100%		A+ = 4.25 - 4.50
	A = 80 - 90%		A = 3.75 - 4.24
	B+ = 75 - 79%		B+ = 3.25 - 3.74
	B = 70 - 74%		B = 2.75 - 3.24
	C+ = 65 - 69%		C+ = 2.25 - 2.74
	C = 60 - 64%		C = 2.00 - 2.24

Figure 3



Preadmission Mathematics Grade

Figure 4



Preadmission English Grade

Figure 5

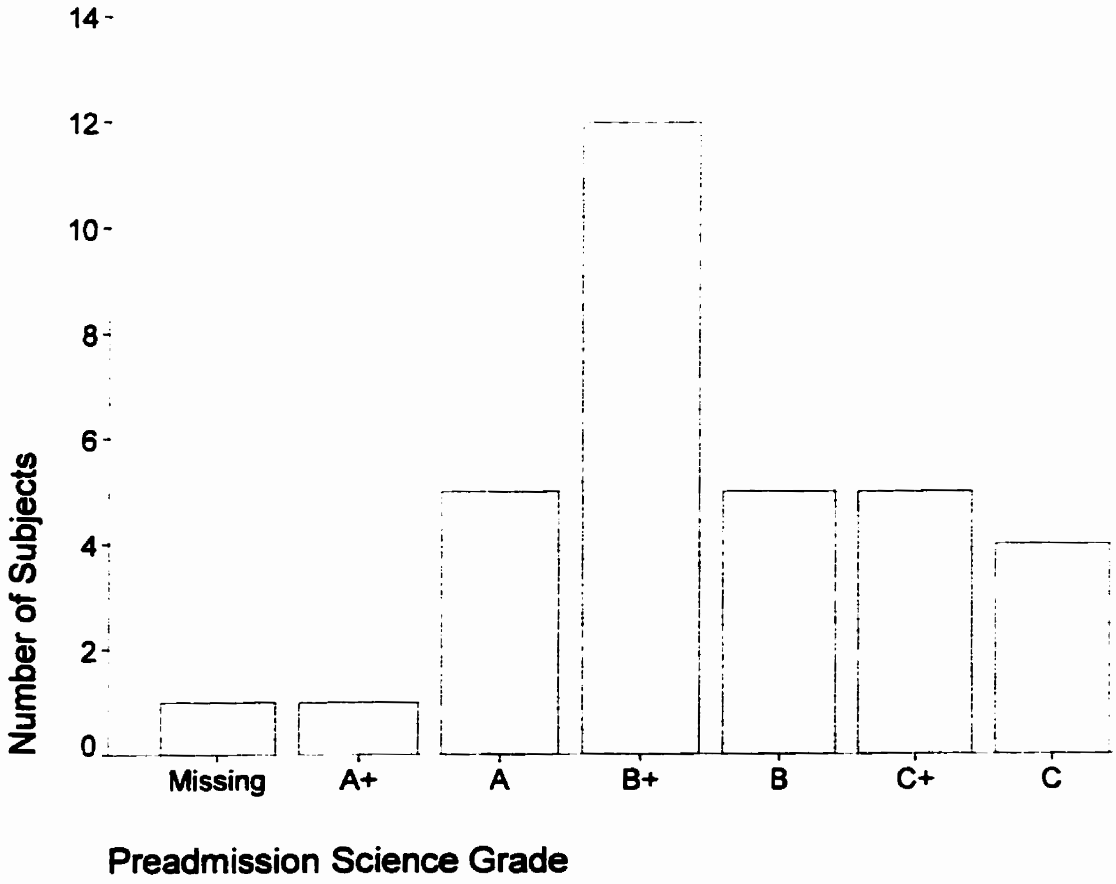
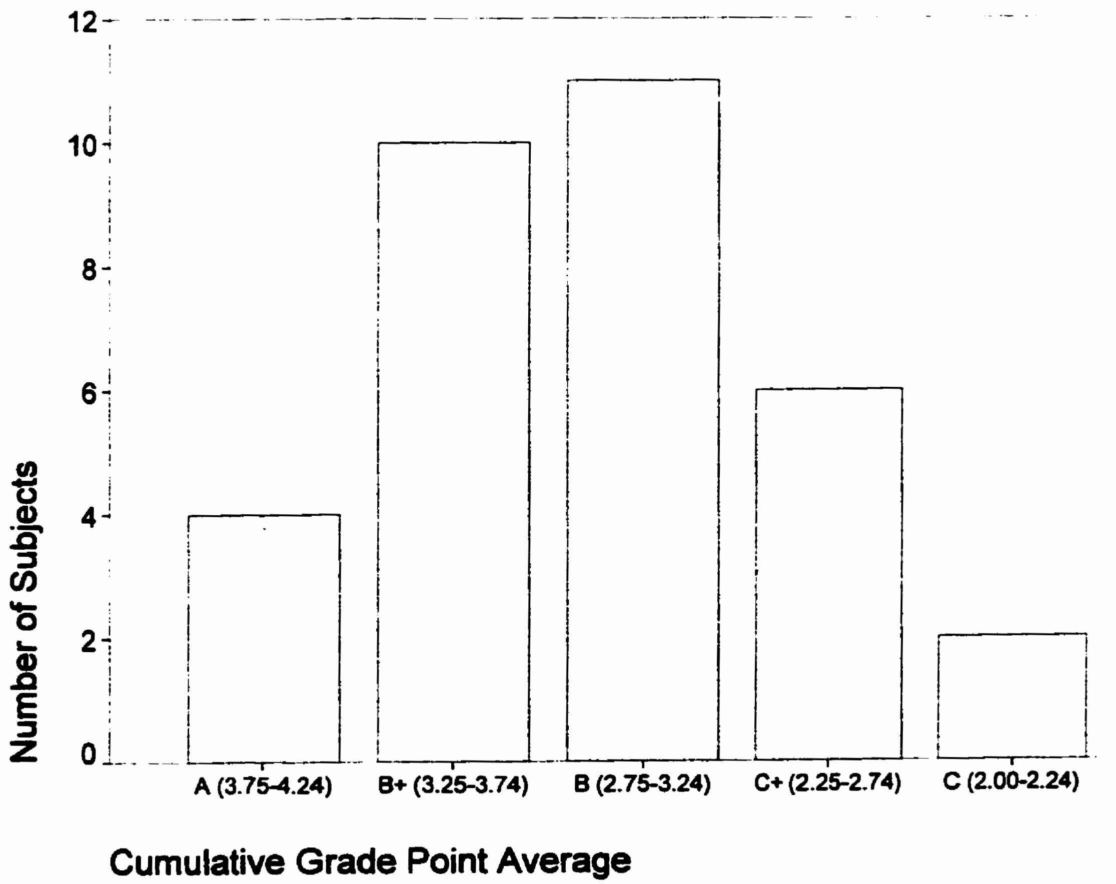


Figure 6



Calculation Ability.

Calculation ability was determined by recording the number of correct and incorrect answers on the Mathematics and Drug Calculation Test developed for this study. This test included a Basic Mathematics section (BMS) (20 items) and a Drug Calculation section (DCS) (20 items), and when combined, became the Total Score.

Scores on the BMS ranged from 50% to 100% (10/20 to 20/20) with a mean score of 75% (15/20) (mode = 14, SD = 2.751). All subjects achieved 50% or higher, 60.6% achieved 75% or more, and only 27.2% of the subjects earned 90% or better on this part of the test (see Table 6). Two subjects scored 100% on the BMS.

Table 6

Calculation Ability - A Summary of Scores and Means

n = 33	Percentage			Distribution		
	50%	75%	90%	Mean	Range	SD
BMS	100% n=33	60.6% n=20	27.2% n=9	75%	50 - 100%	2.75
DCS	90.9% n=31	81.9% n=27	36.4% n=12	80%	30 - 100%	3.28
Total Score	97% n=32	69.7% n=23	30.3% n=10	79%	43 - 100%	5.31

Scores on the DCS ranged from 30% to 100% (6/20 to 20/20) with a mean score of 80% (16/20) (mode = 19, SD = 3.276). Compared to the BMS, only 90.9% (n=31) of the subjects were able to score 50% or better. However, 81.9% (27/33) of the subjects earned 75% or better and 36.4% (12/33) scored 90% or higher. As with the BMS, two subjects scored 100% on the DCS (only one subject scored 100% on both sections). While scores on the DCS showed a greater range (14) and lower minimum score (6) than on the BMS (10 and 10 respectively), the sample as a group performed better on the DCS (see Table 6).

Total scores were calculated by adding BMS and DCS scores. Total scores ranged from 43% to 100% (17/40 to 40/40) with a mean score of 79% (31.7/40) (mode = 30, SD = 5.312). Overall, 97% of the subjects scored 50% and higher, 69.7% scored 75% and higher, and slightly less than one third of the subjects (30.3%) scored 90% or better (see Table 6). One subject achieved a perfect score of 100%.

Sample Summary.

In summary, the nursing students comprising this sample of 33 were on average, 24 years of age, single, and equally either a high school or transfer student. Most students had graduated from high school within the four years prior to entering the nursing program and had attended an urban high school in Manitoba.

Over one-third (36.4%) of the students reported having no previous post-secondary education prior to coming into the nursing program. However, the remaining 57.6% stated they had taken some previous university course work, with seven students having earned a Bachelor's degree or better. Most students (76%, n=25) had taken one mathematics-related course prior to the study, being primarily Statistics (69.7%).

In terms of academic standing upon admission to the nursing program, students could be described as "B" students. On average, students reported they had earned "B" grades in the pre-admission requirement courses and subsequent cumulative GPA.

Students, as a group, scored slightly better on the Drug Calculation section of the Mathematics and Drug Calculation Test than on the Basic Mathematics section. However, less than one-third (30.3%) of the group was able to achieve 90% or better on the Test as a whole.

4.1 Relationship of Demographic Characteristics and Calculation Ability (Research Question #1)

All demographic variables were compared to the calculation ability of the subjects as measured by scores on the BMS, DCS, and Total score on the Mathematics and Drug Calculation Test. Demographic variables included site, age, agegrp, marstat2, grad, gradhs, gr12a, gr12b, type, prevedu, stats, calculus, and algebra (see Appendix G).

None of the response variables followed a normal distribution. Therefore, non-parametric tests for differences between groups and correlation coefficients were used to analyze the data. Variables that were characterized as having two independent groups of subjects, for example, site of nursing program attendance (St. Boniface, Fort Garry), were analyzed with the Mann-Whitney U non-parametric t-test. The non-parametric Kruskall-Wallis t-test was used for variables characterized as having three or more independent subject groups, such as number of years since high school graduation. Finally, variables that had a range of scores, such as age, were analyzed by using the Spearman's rho correlation coefficient.

Two demographic variables (age and number of years since high school graduation) were analyzed by using both the Spearman's rho and Mann-Whitney U or Kruskall-Wallis, respectively. The investigator wanted to determine if analyzing these variables in different ways, that is, by range of scores or by groupings, would make a difference in the results. By grouping scores, thereby creating a larger number of responses by subject group, it was considered possible that relationships between groups and the dependent variables could be stronger and more meaningful. Upon analysis, it was found that this was not the case. It is likely the sample size was too small to detect a significant relationship or difference, regardless of the statistical procedure used.

As mentioned in Chapter 3 (Section 3.6), significance was not compared to the usual alpha = .05 or .01 levels, but rather, p-values were individually calculated for each procedure. As shown in Table 7, no significant relationships between any of the demographic variables and calculation ability of nursing students (BMS score, DCS score, Total score) were found at the $p<.05$ level.

Table 7

Relationship Between Demographic Characteristics and Calculation Ability

Variable x DV	Mann-Whitney U	Kruskall-Wallis	Spearman's rho
Site (n = 33)			
BMScore	125.0 (.9699)		
DCScore	107.0 (.4708)		
Total Score	112.5 (.6124)		
Age (n = 33)	**Agegrp**		**Age**
BMScore	43.0 (.1723)		.1551 (.389)
DCScore	44.0 (.1855)		.1805 (.315)
Total Score	42.0 (.1586)		.1463 (.417)
Marstat2 (n = 33)			
BMScore	76.0 (.8143)		
DCScore	60.0 (.3201)		
Total Score	60.0 (.4826)		
Grad (n = 32)		**Gradhs**	**Grad**
BMScore		2.8254 (.2435)	.3125 (.082)
DCScore		1.1261 (.5695)	.1289 (.482)
Total Score		2.0399 (.3606)	.2111 (.246)

Variable x DV	Mann-Whitney U	Kruskall-Wallis	Spearman's rho
Gr12a (n = 29)			
BMScore	84.0 (.4973)		
DCScore	96.0 (.8913)		
Total Score	97.0 (.9282)		
Gr12b (n = 33)			
BMScore	62.5 (.7046)		
DCScore	59.5 (.5928)		
Total Score	60.0 (.6146)		
Type (n = 33)			
BMScore	124.5 (.6767)		
DCScore	135.5 (.9854)		
Total Score	134.5 (.9568)		
Prevedu (n = 31)			
BMScore		6.6821 (.0828)	
DCScore		1.9267 (.5877)	
Total Score		4.9748 (.1736)	

Variable x DV	Mann-Whitney U	Kruskall-Wallis	Spearman's rho
Stats (n = 33)			
BMScore	99.0 (.5281)		
DCScore	114.0 (.9683)		
Total Score	109.5 (.8289)		
Calculus (n = 33)			
BMScore	74.5 (.4645)		
DCScore	82.5 (.7042)		
Total Score	76.0 (.5077)		
Algebra (n = 33)			
BMScore	22.5 (.1561)		
DCScore	27.5 (.2663)		
Total Score	23.0 (.1671)		

Table 7 Notes:

1. No significant results found at the $p < .05$ or $p < .01$ levels.
2. The number pairings for each variable represent the U value, X^2 value, or correlation coefficient, and the p-value respectively.

4.2 Relationship of Academic Characteristics and Calculation Ability (Research Question #2)

Academic characteristics were those variables that addressed the admission criteria of the University of Manitoba Baccalaureate in Nursing Program. These variables included grades in pre-admission Mathematics, English, Science, and GPA. Since these variables did not follow a normal distribution, the Spearman's rho correlation coefficient was used to determine the relationship between academic characteristics and calculation ability.

No significant relationships were found between English and Science grades and the calculation ability of nursing students. It was also found that Mathematics grades did not correlate significantly with BMScore or DCScore. However, Mathematics grades did show a moderate positive correlation with subjects' Total scores on the Mathematics and Drug Calculation Test (.3827, p = .037, n = 30). While no statistically significant relationships were found between GPA and DCScore, a strong positive association was revealed between GPA and BMScore (.4595, p = .007, n = 33) and Total Score (.4368, p = .011, n = 33) (see Table 8).

Table 8

Relationship Between Academic Characteristics and Calculation Ability

Academic Variable	BMScore	DCScore	Total Score
Math Grade (n = 30)	.2890 (.121)	.2899 (.120)	.3827 (.037)*
English Grade (n = 33)	.0975 (.589)	.0897 (.619)	.0297 (.869)
Science Grade (n = 32)	.0660 (.720)	.1591 (.384)	.1488 (.416)
GPA (n = 33)	.4595 (.007)*	.2725 (.125)	.4368 (.011)*

Note: Number pairings reflect the correlation coefficients and p - values respectively. Variables identified by an "*" suggest a statistically significant result.

In summary, the analysis of the relationship between academic characteristics and calculation ability suggests that students who scored higher in the pre-admission Mathematics course tended to do better on the Calculation Test in terms of Total Score. Also, students who had achieved a higher GPA tended to score higher on the Basic Mathematics Section of the Calculation Test and in the Total Score overall. This would suggest that pre-admission course grades in Mathematics and Cumulative GPA may be the most useful academic measures in identifying students' aptitude level for the calculation component of the nursing program.

4.3 Summary of Results

The data analysis for the complete data set reveals that demographic characteristics (Research Question #1) of nursing students do not correlate significantly with calculation ability in the second year of the program. Even when some demographic variables with a range of responses were reorganized into groups, the degree of association remained insignificant. Several variables, not originally identified in the research questions, were included in the analysis based on feedback from the pilot study. However, the variables did not play a significant role in the calculation ability of these students. A larger sample would have yielded higher statistical power for detecting relationships.

The findings suggest that pre-admission grades in Mathematics and cumulative GPA may play a meaningful role in how students perform on Basic Mathematics questions (GPA) and in calculation questions in general (Math grade and GPA). However, pre-admission English and Science grades were shown to be less helpful in determining calculation ability for nursing students in the second year of the nursing program.

Chapter 5: Discussion

5.0 Introduction

This study was designed to examine the relationships between student nurse characteristics, particularly demographic and academic variables, and calculation ability for second year students enrolled in the University of Manitoba, Faculty of Nursing, four-year baccalaureate program. The research questions addressed in this study were:

1. What is the relationship between demographic characteristics and calculation ability of second year baccalaureate nursing students?

2. What is the relationship between academic status, related to the admission criteria of the University of Manitoba Baccalaureate in Nursing Program, and calculation ability of second year baccalaureate nursing students?

5.1 Sample Representativeness

Comparison to the Literature.

Although the sample in this study was small, it well reflected the student nurse samples described in the literature. Several studies had an absence of demographic data (Allen et al., 1988; Bindler & Bayne, 1984; Chenger et al., 1988; Ptaszynski & Silver, 1981; Shockley et al., 1989; Timpke & Janney, 1981; Worrell & Hodson, 1989). However, many others (Bath & Blais, 1993; Blais & Bath, 1992; Brennan et al., 1996; Craig & Sellers, 1995; Felts, 1986; Fulton & O'Neill, 1989; McCann-Flynn & Moore, 1990; McKinney et al., 1988; Oliver, 1985; Pozehl, 1996;

Segatore et al., 1993; Wold & Worth, 1990) have consistently described student nurse samples, used in the past decade, as typically younger (mean age = 20.8 to 27.6 years) and single (Chacko & Huba, 1991; Oliver, 1985; Wold & Worth, 1990). The sample in this study is consistent with these reports.

Griffiths, Bevil, O'Connor, and Wieland (1995) suggest today's student population is becoming increasingly diverse. The wide age range (18 to 50 years) of students reported in the literature recently (Bath & Blais, 1993; Brennan et al., 1996; Craig & Sellers, 1995; Segatore et al., 1993), may indicate there is a growing contingency of "mature" students enrolling in nursing programs, with fewer students entering straight from high school (Gothler & Rosenfeld, 1986; Griffiths et al., 1995; Oliver, 1985) and many having obtained previous degrees prior to entering (Griffiths et al., 1995; Jacono et al., 1987; McCann-Flynn & Moore, 1990). Unfortunately, all but two studies (Brennan et al., 1996; Jacono et al., 1987) reported in the literature used American nursing students as samples. It would have been helpful to have more Canadian samples with which to compare the sample used in this study. Nonetheless, this sample of nursing students reflected the trends found in the literature with regard to demographic characteristics.

It is not possible to compare this sample with samples reported in the literature in terms of pre-nursing academic status. That is, the admission requirements for the University of Manitoba Baccalaureate in Nursing Program are unique to the program and are based primarily on high school and university coursework taken in Manitoba. Although students in this study reported a range of grades, from A+ to C, in the areas of pre-admission Mathematics, English, Science, and cumulative university GPA, mean grades in all areas were in the B and B+ categories. Therefore, the sample could be described as a group of "B" students upoı entering the nursing program.

Comparisons to the literature are meaningless because it would be presumptuous to suggest a student with a "B" average in the pre-admission requirements of the University of Manitoba program would necessarily be a B student in another country, such as the United States, where the majority of previous research has been conducted. Furthermore, data of this nature are not reported in the literature, likely due to the diversity of samples arising from a complex mixture of high school and nursing programs. Consequently, one may draw some comparisons between samples in terms of demographic variables but should use caution when doing so for academic status characteristics.

Nursing students in this sample demonstrated similar calculation ability to students reported in the literature (Bindler & Bayne, 1984; Blais & Bath, 1992; Chenger et al., 1988; Pozehl, 1996; Segatore et al., 1993). Although mean scores for the Basic Mathematics Section (75%), Drug Calculation Section (80%), and Total Tes (79%) were in the "B+" range, only 30% of the students obtained 90% or better on th Calculation Test overall. Since many nursing programs consider 90%, or even 100% to be a passing grade on a calculation test, the vast majority of students in this sample (70%) could be described as having failed the Mathematics and Drug Calculation Test. In other words, this sample of students could be considered to possess poor mathematical and drug calculation skills, such as those reported in the literature.

Comparison to the University of Manitoba Program.

Perhaps more relevant is the comparison of this study's sample with the population of students enrolled in the University of Manitoba, Baccalaureate in Nursing program. The 33 students who participated in the study were a convenience sample out of a possible 107 students (31%) enrolled in second year of the program during the 1995-1996 academic year. Student record information was not accessible and so comparisons, to a large extent, were not possible. The only available data with which to compare this sample came from the University of Manitoba, Faculty of Nursing Student Census of September 30, 1996. Unfortunately, the data did not distinguish students by age, marital status, type of student, or other demographic characteristics, nor did the census indicate academic status in the pre-admission requirements of Mathematics, Science, English, or GPA. However, the census data did indicate 17 students, in the 1995-96 year, had earned a Bachelor's Degree. It is interesting to note that seven students in the sample indicated they had earned a previous degree, one at the Master's level. Therefore, the sample was "over-representative" of the student body (7 of 17 = 41%) in this one area and could cautiously be described as more academically prepared than the general population of second year students. No other comparisons to the student population were made due to a lack of available data.

A comparison of the sample's calculation ability with that of the University of Manitoba student population would have required Course Leaders in the Nursing Skills courses to extract and compile an enormous amount of data. The investigator felt such a request would be a significant imposition on the Course Leaders' time. Thus, it is unknown whether or not the sample was representative of the student population in the area of calculation ability.

In summary, this sample was relatively similar to samples reported in the literature in terms of demographic profile and calculation ability. However, it is uncertain as to the representativeness of the sample in relation to the University of Manitoba, Faculty of Nursing, second year nursing student class of 1995-96. Therefore, caution should be exercised in generalizing the results of this study beyond the parameters of the sample.

5.2 Relationship Between Demographic Characteristics and Calculation Ability

Several demographic characteristics of nursing students were examined including: site, age, marital status, years since high school graduation, location of high school attendance, type of student, previous education, and attainment of other mathematics-related courses. None of these characteristics provided helpful information in relation to calculation ability. The results from tests for differences between groups and correlation coefficients were not significant. Also, the results from testing two of the variables, age and years since high school graduation, with both procedures were statistically insignificant.

The findings of this study, with regard to the relationship between demographic characteristics and achievement measures in a nursing program, are in keeping with most of the research in this area. Although being older (Aldag & Rose, 1983; Bailey, 1988; Higgs, 1984; Oliver, 1985; Safian-Rush & Belock, 1988) and being married (Yess, 1980) were reported as significant factors in the overall achievement of nursing students in an educational program, these same variables did not correlate significantly with measures of success in other studies (Allen et al., 1988; Beuche, 1986; Felts, 1986; Oliver, 1985; Weinstein et al., 1980; Yess, 1980). Brennan, Best, and Small (1996) found no relationship between any demographic or "non-cognitive" variables and achievement measures in nursing course work.

A similar pattern is found in the literature addressing the relationship between demographic characteristics and calculation ability of nursing students. While Dexter and Applegate (1980) report that older students do more poorly on calculation tests than their younger classmates, McCann-Flynn and Moore (1990) found the opposite to be true. Others found no significant relationships between age (Chenger et al., 1988; Segatore et al., 1993), prior nursing experience and previous degree (McCann-Flynn & Moore, 1990) and calculation ability. In general terms, demographic variables have not been found as useful indicators in identifying which students are more likely to do well in nursing programs and, in particular, the area of calculation ability.

The lack of any significant relationships between demographic characteristics and calculation scores for students in this study could be the result of several factors. The small sample size of 33 did not allow much room for analysis in terms of finding differences between groups of students with different characteristics in relation to calculation ability. That is, the number of subjects that fell into any category for a particular independent variable, such as previous education (none = 12; some prerequisites = 6; some non-prerequisites = 6; degree = 7), was likely too small to contribute to any significant variation in the means of both the independent and criterion variables.

The inconsistency of some responses between two related demographic variables may have diminished the ability to detect differences between groups of students. For example, students were asked to indicate if they had entered the nursing program as a high school student or a transfer student with previous university credits. As noted in Chapter 4, incongruencies were found between responses to this item and responses made in relation to grades achieved in the admission criteria courses of Mathematics, English, and Science. Several students indicated they were transfer students, yet reported their pre-admission grades in terms of high school courses, and visa versa. From this, it is not clear how many were actually high school or transfer students. Therefore, if there was in fact a difference in the calculation skills of high school and transfer students, the ability to detect this difference may have been undermined by unreliable responses.

None of the demographic variables produced a normal distribution of responses. Several variables, in fact, produced a clearly biased distribution of responses making it difficult to determine what the influence on calculation scores might have been for the relatively few subjects who responded differently from the majority of the sample. For example, most students were 24 years of age or younger (n=24; 73%) with only nine (27%) being in the "older" category. This makes it difficult to say anything conclusive about the influence of age on calculation ability. One may assume that students who are older and more "mature" may have gained some positive life or work experience that would contribute to the development of stronger problem-solving and conceptual skills (skills necessary for drug calculations) than those who have not had similar experience. On the other hand, younger students may be at an advantage due to the recency with which they have been in an educational environment requiring such thinking skills. This study did not provide evidence in either direction. Although a larger sample may have revealed a similar trend toward a younger age of student, it would have allowed for a greater number of subjects to be assigned to the "younger" and "older" student categories. Thus, more powerful statistical tests could have been used enabling one to be more confident in drawing conclusions from the results.

Similar remarks may be made with regard to other demographic variables. That is, most students were single (82%), had graduated from high school within the past four years (17 of 32; 53%), had attended a Manitoba high school (85%), and either did or did not take a mathematics-related course (Statistics = 69.7% "Yes"; Calculus = 78.8% "No"; Algebra = 90.9% "No") prior to the study. Therefore, as described for the age variable, it is difficult to say anything conclusive about the subjects who represented the minority in terms of these demographic characteristics.

It is also helpful to look at the scores achieved on the Mathematics and Drug Calculation Test used in this study. Although there was a broad range of scores on the Basic Mathematics (50 - 100%) and Drug Calculation (30 - 100%) sections of this Test, mean scores tended to be toward the upper end of the scale (BMS X=75%; DCS X=80%). Also, the majority of students scored in the "B+" range (75 - 79%), or better, on both sections of the Test (BMS = 60% of sample; DCS = 82% of sample). Therefore, once again, the students in this sample could be described as relatively homogeneous with regard to not only several demographic characteristics, but also calculation ability. Although homogeneity is helpful for describing the nature of a sample, it does not allow for much variation or diversity in determining how variables covary with each other. This is especially true with small convenience samples for which one cannot be sure if the sample studied is representative of the larger population.

In summary, the examination of demographic characteristics did not provide any useful information in explaining the calculation ability of nursing students. This lack of association is supported generally in the literature and is further complicated by sample and data issues arising from this study. Additional research in this area, using significantly larger samples across varied settings, would be helpful in clarifying the relationship between demographic characteristics and calculation ability of baccalaureate nursing students.

5.3 Relationship Between Academic Status and Calculation Ability

Academic status, as defined in this study, referred to the students' grades achieved in the pre-admission requirements of the University of Manitoba Baccalaureate in Nursing Program, in the areas of Mathematics, English, Science, and university grade point average (GPA). Correlation coefficients did not reveal any significant relationships between pre-admission English and Science and calculation ability (Basic Mathematics Score, Drug Calculation Score, and Total Score) of nursing students. It was also found that grades in Mathematics did not correlate significantly with Basic Mathematics or Drug Calculation Scores. Additionally, GPA had no significant association with Drug Calculation Scores.

However, three statistically significant results were found. Pre-admission Mathematics and GPA provided useful information in determining calculation ability for this sample. Mathematics grades showed a moderate positive correlation with subjects' Total Score, and a moderate positive correlation was also found between GPA and both Basic Mathematics Score and Total Score.

The literature describing the ability of pre-nursing academic variables to identify students who are more likely tc succeed, or do well in a nursing program, is ambiguous. Although it is generally believed that prior success leads to future success (Hayes, 1981; Talarczyk, 1989; Wold & Worth, 1990), this assumption has not been validated in the literature, at least with regard to the influence of pre-admission Science and English grades on future performance in a nursing program. High school Science grades were reported to correlate significantly with nursing GPA and other achievement measures (Felts, 1986; Oliver, 1985; Seither, 1980), yet others (Allen, Higgs, & Holloway, 1988; Hayes, 1981; Wold & Worth, 1990) did not find these same results. Similarly, while pre-nursing English grades were associated with nursing program success indicators in some studies (Chacko & Huba, 1991; Oliver, 1985; Wold & Worth, 1990), English grades did not play a helpful role in predicting success in others (Hayes, 1981; Yess, 1980).

Like Science and English grades, the decision to use pre-admission Mathematics grades to identify which students are likely to succeed or not in a nursing program, based on the literature, is questionable. Alichnie and Belluci (1981) and Weinstein et al. (1980) found grades in high school Mathematics to correlate significantly with nursing GPA, yet others (Chacko & Huba, 1991; Oliver, 1985; Yess, 1980) did not. Despite the uncertainty in the literature regarding the ability of Science, English, and Mathematics grades to estimate subsequent nursing program success, GPA has been found to be more useful in this regard.

Results from several studies (Allen et al., 1988; Brennan, Best, & Small, 1996;

Hayes, 1981; Higgs, 1984; Oliver, 1985; Wold & Worth, 1990) have implied the higher pre-nursing GPA is, the more likely nursing students are to do well in a nursing program. Only one study (Aldag & Rose, 1983), conducted over a decade ago, found no relationship between previous GPA and success in a nursing program. Therefore, previous research addressing the predictive value of the GPA has the most value in supporting the results of this study in a general way.

The relationship between academic status and performance in the area of calculation ability, more specifically, has received little attention in the literature. It is difficult to place the findings of this study within the context of the literature since only three studies have directly examined these relationships (Chenger et al., 1988; Dexter & Applegate, 1980; McCann-Flynn & Moore, 1990). However, the positive significant correlation between pre-admission Math grades and Total Scores on the Mathematics and Drug Calculation Test, in this study, is congruent with the findings reported by Dexter and Applegate (1980). Brennan, Best, and Small (1996) found "premath" grades to covary significantly with Year One Pharmacology grades, yet the report did not describe whether this course included calculation testing.

In addition to the literature attending to the role of GPA in predicting overall performance in a nursing program, there are two studies which have found GPA to be helpful in identifying students who are more likely to do well in the area of mathematics and drug calculation skills (Chenger et al., 1988; McCann-Flynn &

Moore, 1990). GPA was also reported to correlate significantly with Year One Pharmacology grades, but as mentioned above, it was not clear if this course included calculation testing (Brennan et al., 1996). Certainly, discussing the findings of this study within the context of the literature is a challenging task.

At a practical level, it is hard to explain why pre-admission Mathematics grades correlated only with Total Scores, and not with Basic Mathematics or Drug Calculation Scores more specifically. Perhaps the type of skills needed to do well in Mathematics 300 or 40S (high school), or first year university Mathematics, are different from those tested on the Mathematics and Drug Calculation Test. While high school (300 level) or university level math is presumably focused on advanced mathematical operations, such as trigonometry, geometry, and calculus, the Calculation Test included items requiring skill in basic arithmetic and algebra. It is possible there were an insufficient number of items in each separate section to capture students' basic competency in these areas, but given the 40 items in total, enough opportunity was present to elicit an overall indication of "calculation aptitude". Thus, students who had achieved higher grades than their classmates in the pre-admission Mathematics course, could demonstrate this skill in a general way over the course of the 40 items; whereas, students who did not do as well in the pre-admission Mathematics course, could not perform as well on the Calculation Test, regardless of how many items there were. These speculations regarding reasons for the relationship between Mathematics grades and Total Scores should be considered tentative at best.

The type of Mathematics course one takes in high school or university prior to entering a nursing program, may influence how well one performs in the calculation component of a nursing course. That is, it has been proposed by colleagues of the investigator, that a particular high school Mathematics course, such as "Mathematics 40G (301)", may assist the student to develop skills more in tune with the type of calculation skills tested in a nursing program. Basic arithmetic, ratio and proportion, and general algebraic operations required in setting up a drug dosage equation are a few examples of such skills. It would be interesting to investigate the difference in competencies developed as a result of various pre-admission mathematics courses and how these competencies correlate with calculation skills required in a nursing program. This information would be helpful in identifying appropriate and useful admission criteria that would assist admissions committees of nursing programs in terms of screening and counselling students. The value of pre-admission testing, during the application process, in the areas of basic arithmetic, ratio and proportion, and algebra should also be examined.

Grade point average is a composite academic measure that reflects the student's overall scholastic performance in a program of study. It is the investigator's experience that students who achieve high GPAs are often regarded as "strong" students who tend to do well generally, regardless of the content or clinical requirements. Therefore, in addition to what has been reported in the literature (Chenger et al., 1988; McCann-Flynn & Moore, 1990), it is conceptually comfortable to understand why students with high GPAs would tend to perform well on the Mathematics and Drug Calculation Test.

Explaining the possible reasons why GPA correlated significantly with Basic Mathematics Score and Total Score, and not with Drug Calculation Score, requires further thought. It is possible, like GPA, the Basic Mathematics Score and 40 items (Total Score) overall, captured "general ability" in mathematics. It is interesting to note the relationship between GPA and Basic Mathematics Score (.4595, $p<.007$) was stronger than between GPA and Total Score (.4368, $p<.011$). Perhaps the influence of the Drug Calculation questions, as part of the Total Score, was sufficient to "dilute" the correlation between GPA and Total Score in comparison to GPA and Basic Mathematics Score. This might suggest the Drug Calculation Section posed questions that were conceptually different from the "more general" items, and in fact, required the application of specific skills for which students had limited knowledge and experience.

It is important to note that students had just covered the content and practice component of drug calculations in the nursing program prior to this study. This could explain why, compared to Basic Mathematics Scores, more students performed better overall on the Drug Calculation questions. However, it is interesting to find while GPA could identify students who were more likely to perform well in mathematics in a general way (BMS and Total Score), it was not sensitive enough to identify those who were able to apply more advanced skills on the Drug Calculation Section. Therefore, this suggests the GPA may more helpful as a measure of general proficiency, rather than a measure capable of detecting students who are more likely to perform "above average" in particular areas.

In summary, the examination of academic characteristics produced more helpful information, than did demographic factors, in explaining calculation ability of students in this study. The absence of significant associations between calculation ability and demographic variables such as age, years since high school graduation, and type of student, does not allow one to propose whether these characteristics should be considered as advantages or disadvantages for students. However, one can be reasonably confident that pre-admission Mathematics grades and cumulative GPA may continue to offer some direction to the Admissions Committee and faculty in identifying students who are more likely to do well in the calculation component of the nursing program. Furthermore, the findings from this study are helpful, since the nature of the relationships are relatively consistent with those reported in the literature with regard to the differing value of demographic and academic characteristics in identifying students who are more likely to do well generally, and more specifically in the area of calculation ability.

5.4 Considerations of the Study

Design issues and other factors impacting on the results are important to address when attempting to place the findings in proper perspective. Therefore, the following considerations should be made when interpreting the findings of this study.

1. External validity was limited in this study due to the use of a small convenience pre-selected sample resulting from prescribed admission criteria employed by the University of Manitoba (Brennan, Best, & Small, 1996). That is, the uniqueness of the program limits the ability to generalize the findings of this study to other nursing programs. The use of a non-experimental design also makes it important to obtain a sufficiently large sample size to have confidence in the representativeness of the sample (Buckwalter & Maas, 1989; Polit & Hungler, 1991; Wood & Brink, 1989). However, the sample in this study would be considered small (33 of a possible 107 subjects = 31%). Establishing external validity was further complicated by the inability to compare this sample with the general population of students due to the lack of census data. Additionally, the sample was relatively homogenous in many areas (age, marital status, took stats) and as such, made it difficult to draw inferences about the calculation ability of students who did not possess the dominant characteristics. Therefore, it was not only difficult to know how representative this sample was of the target population, but also how well they reflected second year nursing students in general.

2. Internal validity is another concern with this study. Content validity is dependent upon the ability of instruments to adequately capture the intended universe of content (Isaac & Michael, 1974; Nunnally, 1978; Polit & Hungler, 1991).

The Demographic and Academic Status Questionnaire used in this study was not subjected to reliability analysis. The tool was not intended to capture one or two specific constructs (construct validity), but rather it was anticipated a range of responses would be obtained on the various questions designed to describe a number of student characteristics. However, some items offered a range of options which were not used by subjects and consequently, did not generate sufficient variation upon which to analyze differences between groups of subjects. Therefore, content validity could have been greater if these items had more closely reflected the range of responses obtained in this study.

The finding that some students responded in a contradictory fashion to the items related to student status (high school or transfer) and pre-admission grades, raises concern about the clarity of the items. The items asking students to indicate grades in pre-admission English and Science courses could have been confusing for transfer students. Transfer students enter the program with letter grades only and, therefore, the numerical distributions accompanying the letter grades may not have been familiar to the students. Or, perhaps students simply reported the grades they could remember at either the high school or university level, regardless of the type of student they were upon admission. Certainly, the ability of the Questionnaire to obtain reliable responses in this area is debatable.

The characteristic, or construct, of calculation ability was measured by the use of the Mathematics and Drug Calculation Test, developed for this study. This instrument was an adapted composite of two tools found in the literature for which adequate reliabilities were reported (Bayne & Bindler, 1988; Bindler & Bayne, 1984). The alpha coefficients (Cronbach, 1970) determined for the Mathematics and Drug Calculation Test were considered sufficient for an immature tool (Nunnally, 1978), and therefore, the construct of "calculation ability" was adequately reflected in the scores obtained on the Test. However, given the lack of empirical testing, it would be useful to employ this Test in future research using larger randomized samples in order to further establish its construct validity.

3. Another threat to internal validity was the potential for inaccuracy of responses obtained on the Demographic and Academic Status Questionnaire. Since utilizing student record data was not possible, it was necessary to rely upon the ability of the subjects to respond to the items from memory. As such, the potential existed for inaccuracies in the reporting of personal characteristics, especially grades. Also, the inability to verify responses with documented records, raises the possibility that some students may have responded inaccurately due to apathy or the desire to "look good".

4. Control of extraneous influences on calculation scores was not possible and therefore, several other factors should be acknowledged as possible explanations for the outcomes obtained in this study. The influence of math anxiety (Aiken, 1976; Betz, 1978; Stodolsky, 1985), math attitude (Eaton, 1989; McCann-Flynn & Moore, 1990), math learning style (Bath & Blais, 1993), inability to use a

calculator during data collection (Bliss-Holtz, 1994; Koop, 1982; Szetela, 1982; Shockley et al.,1989), gender differences (Armstrong & Price, 1982; Ethington & Wolfle, 1984), use of various teaching formulas and content covered in solving drug calculation problems (Craig & Sellers, 1995), and environmental influences such as time pressure and preoccupation with wanting to return to other activities, could all have contributed significantly to within-subject variations in scores.

5. A lack of standardization in grading policies across high schools and in university course work adds a source of variance in terms of what is considered an "A" or "B" in a particular pre-admission course such as Mathematics or Science (Friedemann & Valentine, 1988; Higgs, 1984; Wold & Worth, 1990). Regardless of the accuracy of students' recall, it is conceivable students who reported having achieved the same grade in a high school pre-admission course could be quite different in their knowledge and skill levels as a result of having come from different school systems. Therefore, it is important to describe student academic status in a general way, rather than suggesting definitively that all students with the same grades possess the same prerequisite skills.

6. The small sample size resulted in lower power of the statistical procedures to detect a large effect. Therefore, the lower statistical power causes one to have greater confidence in the significant results. Furthermore, a larger sample size may have provided an opportunity to identify more subtle relationships between variables that did not correlate significantly in this study.

7. Statistical analysis was conducted on group data and therefore offers information about how the group of students performed. Information on individual students, however, was not examined. Therefore, it is important to emphasize that specific students may have performed in a completely different manner from that demonstrated by the sample statistics.

8. It became apparent during the review of the literature that students' calculation ability was often described in terms of mathematical skill. Several of the instruments described in the literature, however, tested basic arithmetic skills more so than mathematical operations. That is, simple procedures of adding, subtracting, and multiplication, for example, were referred to as mathematical skills. This error in nomenclature was consistent throughout the literature.

It is acknowledged that the Mathematics and Drug Calculation Test, developed for this study, was also in error in that the Basic Mathematics Section was comprised, for the most part, of basic arithmetic items. This distinction is necessary because it is important to be clear about which calculation skills were actually tested. In a practical sense, knowing this information is central to identifying the needs of students in terms of remediation.

9. The study does not address the many other variables which may contribute to calculation ability as identified in the Model for the Study of Prediction of Success in Nursing Education and Nursing Practice (Higgs, 1984). However, the value of investigating the possible role of these factors is recognized.

5.5 Support for the Model for the Study of Prediction of Success in Nursing Education and Nursing Practice

As suggested by Higgs (1984), the model allows for the identification of relevant variables at various stages, depending upon the purpose of the study and the problems under investigation. In keeping with this assumption, the student characteristics examined in this study were identified primarily from the demographic (age, marital status) and scholastic performance (high school grades by subject, GPA on previous coursework) categories within the "pre-major variables" component. Several other variables were also examined and, although not all were identified in the model, considered within the demographic or sociological categories. The outcome variable, calculation ability, was considered an example of a clinical behaviour, identified in the performance criteria category in the nursing major component of the model. All other variables identified by the model in the component areas of pre-major, nursing major, and post graduation were not addressed in this study. Therefore, the findings of this study are helpful to the extent of understanding the relationships between select variables in particular components of the model.

The findings of this study are consistent with assumptions proposed by Higgs (1984) and others (Allen, Higgs, & Holloway, 1988; Brennan, Best, & Small, 1996) who have utilized the model as an organizing framework. Although the model has been used as a mechanism for examining the prediction of success in a more general way than that chosen for this study, it is interesting to find similar patterns have emerged in terms of the value of demographic and academic characteristics in predicting calculation ability.

Academic variables, such as pre-admission course grades (mathematics) and GPA, were found to correlate significantly with calculation ability, yet the relationship between demographic factors and calculation ability yielded insignificant results. This pattern of "fit" between academic achievement and success, especially with regard to GPA and pre-admission course grades, supports the work by Higgs (1984) and several others (Allen et al., 1988; Brennan et al., 1996; Clemence & Brink, 1978; Hayes, 1981; Oliver, 1985; Seither, 1980; Sharp, 1984; Weinstein et al., 1979, 1980; Wold & Worth, 1990) who have found these academic measures to be the most powerful predictors of success in a nursing program. Demographic variables on the other hand, as reported by Higgs and others throughout the literature, continue to be less useful in identifying students who are more or less likely to be successful.

The other pre-nursing variables included in the model must be considered as possible influences on calculation ability. Aptitude tests, learning style, high school rank, number of electives, sex, number of dependents, motivation, self concept, personality inventories, anxiety, interview data, letters of reference, ethnicity, socioeconomic status, parent's occupation, and education are among several other variables identified that were not examined, but have the potential to explain performance levels of students. Therefore, research opportunities are endless within the scope of the model to further investigate factors that may best identify students at risk for demonstrating difficulty with calculation competencies.

Higgs (1984) makes the assumption that the fit between academic variables and subsequent performance in a nursing program is a function of time. The findings of this study support this belief, since cumulative GPA, a more recent measure than grades achieved in the pre-admission courses of English, Mathematics, and Science, correlated most often and strongest with calculation scores. Therefore, the recommendation (Higgs, 1984) for admission committees to use the most recent data to determine the potential of applicants is well taken.

The model also allows for the development of both static and process-oriented time sequenced research. This study examined the existence of relationships between variables at one point in time in relation to the pre-nursing and nursing major components of the model. However, studies including both pen-and-paper and clinical testing of calculation skill, as well as research following students from the time of admission, through the program, and into practice, would allow use of more components of the model. Such research would help to cross-validate findings related to calculation competence. Although these approaches may not assist in determining the best admission criteria, they could be helpful in identifying needs for remediation and counselling. Upon reflection on the findings and supporting literature, this study has been helpful in highlighting the ability of the model to provide guidance and direction for further nursing research in the pre-nursing, nursing major, and post-graduation components of the model.

5.6 Summary of Discussion

The sample in this study was relatively similar to those reported in the literature in terms of demographic characteristics. However, it was difficult to compare this sample on the basis of academic status, both to the literature and to the target population. It was also problematic to draw comparisons between the sample and the target population in terms of demographic characteristics due to the lack of census data. Nursing students in the sample demonstrated similar calculation ability to students reported in the literature; however, it was not possible to determine the degree of similarity with their non-participating classmates. Therefore, the inability to determine representativeness of the sample is a major limitation of this study.

The three significant relationships found during data analysis were between the pre-admission Mathematics grades and cumulative GPA and the Basic Mathematics Section and Total Scores on the calculation test. No other significant results were identified. Therefore, academic variables provided more helpful information than did demographic variables in identifying students who were more likely to demonstrate calculation ability.

Several reasons impacting on the results were discussed. Small sample size, inconsistency of responses between related items, lack of normally distributed data, and relative homogeneity of the sample were identified as complicating factors and possible explanations for the lack of significant results. Issues related to instrument reliability, accuracy of responses, and the role of other influencing factors prior to and during data collection were explored.

5.7 Implications for Nursing Research

The present study has reinforced the significance of future research in the area of calculation ability. Demographic characteristics were not found to be as effective as academic variables in identifying which students were more likely to do well on the Calculation Test. With consideration to the limitations identified in this study, it would be helpful to replicate this study with a larger sample from the target population, and, if possible, with the use of student records from which to glean demographic and academic data. Data regarding calculation ability could be collected as they were in this study to maintain consistency in measurement of the dependent variable. Replication could help to either verify or establish the limits of the findings of this study. The representativeness of the sample used in the present study could also be established with the use of a larger percentage of the target population. Findings from a replication study, although program specific, would possibly be more helpful for the Admissions Committee, faculty, and students of the University of Manitoba Baccalaureate in Nursing Program.

The literature review revealed many factors that may play a significant role in influencing how students perform in the area of calculation ability. Personal and situational factors, such as gender, personality, motivation, math anxiety, attitude, learning style, use of calculators, and state anxiety, are variables that, if studied in relation to calculation ability, could help to illustrate why some students perform better than others, regardless of academic achievement. The use of large samples along with the employment of multiple regression or discriminant analysis procedures might help to determine which background variables predict calculation ability when other variables, such as a grades and GPA, are held constant. This information would help faculty to address some of the more subtle influences of performance when identifying which students may have difficulty with calculation competence.

With the commencement of an introductory preparation year at the University of Manitoba, known as University I, the rules regarding admission to various faculties will change dramatically. Grades achieved in University I will likely become the deciding factors upon which Admissions Committees will base decisions about who will be eligible for admission to a particular program of study. This has implications and provides new opportunities for research in the area of predicting success in nursing education. In fact, the underlying premise of University I is that a preparatory year should provide all students with the opportunity to strengthen basic skills and knowledge necessary to achieve success in higher education. The Faculty of Nursing could embrace this opportunity to identify what it values most in prospective students, including calculation ability, and design a mechanism for studying the impact of University I on subsequent competencies once students are admitted to the program.

A related area of research that has received significant attention in the American literature, but negligible regard in Canadian studies, is the use of psychometric tests as predictor variables in nursing education. The SAT and ACT are the two tests documented most frequently, yet there is a lack of consensus about what these tools actually measure (Jensen, 1980; Sternberg, 1985). There is also a debate in the literature regarding whether programs should use standardized predictors or institution-specific predictors when setting admission criteria for a particular program (Higgs, 1984). Furthermore, there is concern over how the results of these tests are used to screen applicants and that these scores measure only one aspect of an applicant's potential (Brody & Brody, 1976; Estes, 1981; Jensen 1980; Wigdor & Garner, 1982). However, some professional programs in the United States and Canada, like medicine and law for example, have traditionally required applicants to submit scores on standardized tests such as the MCAT (Medical College Admission Test) and LSAT (Law School Admission Test) as part of the admissions process. Given the wide use, yet diversity of opinion with regard to the value of standardized testing prior to entering a professional program, research focusing on the use and predictive ability of standardized tests in Canadian nursing programs would help to shed some light on whether such tools might be helpful in pre-testing students in the area of mathematical ability.

Since the overall intent of research in this area is to enhance the ability to produce graduates with the skills necessary to practise safely, studies of the relationships between performance on pen-and-paper tests and actual performance in the clinical setting would be appropriate. For example, it would be useful to compare the calculation ability of nursing students on paper with clinical performance during drug administration practice. Also, as suggested by Brennan, Best, and Small (1996), a longitudinal study, beginning at the point of admission and ending after a specified period of time once graduates are in the workplace, would facilitate the tracking of performance over time. This would produce valuable information with regard to the development of calculation competence over time, influence of intervening personal and academic factors during the program, and effectiveness of the curriculum to produce skilled practitioners who are able to meet the demands of the work environment.

5.8 Implications for Nursing Education

Based on the findings of this study, and from the review of the literature, it would seem appropriate to suggest that the pre-admission grade in Mathematics and cumulative GPA continue to be used as admission criteria for the selection of candidates into the Faculty of Nursing. To further the understanding in the area of predicting success in calculation ability, it may be helpful to explore the use of standardized testing in the area of arithmetic or mathematics prior to admission. The Faculty of Nursing should be cautious about introducing this measure, however, since the practice of pretesting may be expensive and impractical, relative to the benefits achieved. Another strategy is to consider the possibility and value of accepting a more relevant Mathematics prerequisite for admission. The Faculty of Nursing may be turning away students who would be as successful as those who have taken Mathematics 300 or 40S.

The Faculty of Nursing may find it helpful to collect data during admission in both the demographic and academic areas. It is not suggested that demographic factors be scored since this is unethical and their contribution beyond academic factors is negligible. However, an overall description of each applicant may help in the development of a "risk profile" for students with the ability to identify the need to monitor and assist particular students throughout program.

To aid in the development of reliable "risk profiles", nursing programs should develop ongoing data banks containing pre-admission through graduation data to provide a basis for further evaluation studies in this area. Data collection should be broad-based and include academic, demographic, and personal data, as well as interviews at various points in the program to identify students' personal perspectives of factors contributing to their ability to demonstrate calculation skills.

It is important that faculty, or clinical facilitators, continue to supervise students in the clinical area when giving medications until students are considered to be safe enough to practise independently. Despite scores on calculation tests given in the program, there is a lack of research which can substantiate the connection between performance on a written test and performance in the clinical setting. Calculation skills should be monitored throughout the nursing curriculum, with ongoing testing and remediation in place for those who require extra help.

Efforts should be made to identify curricular design, teaching strategies, methods of review and testing, and availability of remediation and tutoring within a program, or within the university system, which may affect success in developing calculation competencies. If calculation skill is valued, then faculty needs to become committed to formalizing a mechanism to see that these competencies are in fact developed and tested. The implementation of testing prior to graduation should also be examined.

It has been recommended that the use of a consistent method of problem-solving or use of a common calculation formula be instituted throughout a program to reduce confusion for students (Craig & Seller, 1995). Some faculty would argue that problem-solving drug calculations, in itself, is a form of conceptual thinking that should not be restricted by the use of one method. Others might say that consistency in teaching leads to consistency in results. Faculties should explore the results of various teaching strategies and use of formulas to determine which approach provides the best outcomes for students.

Nursing programs need to distinguish what is being tested in the curriculum and be clear about which skills students lack in order to arrange or suggest the appropriate remediation and tutoring (Bliss-Holtz, 1994; Mishel, 1989). It is important to understand whether students lack basic arithmetic skills or more complex problem-solving skills when deciding upon the best approach in helping them be successful. It should be recognized that not all students learn mathematics in the same way, nor do they all possess the same level of understanding in conceptualizing drug dosage problems.

With the growth of computer use in nursing education, it would be helpful to examine the value of CAI programs in tutoring students in the area of calculation skills. Computers have been found to reduce anxiety, improve confidence, and enhance performance (Day & Payne, 1984; Pozehl, 1996; Reynolds & Pontious, 1986; Timpke & Janney, 1981) in the development of calculation competence. Tutoring students who are in jeopardy is very time intensive for faculty. Therefore, the use of computers may be a viable alternative in providing relevant, and perhaps more appealing, remediation for students who need repetition and ongoing practice.

With declining enrollments and the impending shortage of nurses, the issue of using selective admission criteria presents a dilemma for faculties of nursing. If the priority is to maintain a constant flow of applicants into the program, then questions are raised with regard to the use of criteria that deny access to applicants who may be successful students and future practising nurses. An open-door admission policy necessitates, then, the employment of supports within the program to assist students who struggle along the way. However, if the desire is to admit only those applicants who are deemed to be the most likely to succeed, then faculties of nursing need to consider how to best identify those students, and in turn, how to locate and recruit these "ideal" candidates into programs of nursing. In either case, nursing programs have a central role to play in determining how to identify which students are most likely to be successful in the calculation component of the program. Furthermore, the responsibility of producing graduates who are capable of practising safely lies in the hands of the faculty who work with students every day. Understanding early on which students need help the most would enable faculty to meet this responsibility.

5.9 Summary of Research Study

This study examined the relationships between student nurse characteristics and calculation ability. Results of the data analysis showed that demographic variables were not helpful in identifying which students were more likely to do well on a calculation test. Pre-admission Mathematics grades and cumulative GPA, however, demonstrated a positive relationship with scores on the Mathematics and Drug Calculation Test.

Nursing education programs have a challenging job to identify students who are most likely to succeed in the calculation component of the program. Once students are admitted to programs of study, faculty must assist them to achieve the required competencies to practise safely in the challenging and changing work environment. Although the ability to calculate and administer drugs correctly is, in many cases, objective and quantifiable, the consequences to patients and their families as a result of medication errors can be immeasurable. The findings of this study provided support for the Model for the Prediction of Success in Nursing Education and Nursing Practice (Higgs, 1984) in the pre-nursing and nursing major components. The multidimensional view of success presented by the model provides direction for future nursing research in this and other areas of study.

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Appendix A

Definition of Terms

Variable and Definition

***Site:**

Site of nursing program attendance identified as either Fort Garry Campus or St. Boniface General Hospital.

Age:

Student nurse age at the time of testing rounded to the nearest year.

Marital Status:

Marital status at the time of testing identified as one of the following: Legally married (and not separated), Married (common-law), Legally married and separated, Divorced, Widowed, Never married (single).

***Graduation:**

Number of years since student graduated from high school.

*** Grade 12 Attendance (A):**

Location of students' high school identified as either Urban/city high school or Rural/town high school.

Definition of Terms

Variable and Definition

*** Grade 12 Attendance (B):**

Location of students' high school identified as either in Manitoba or Not in Manitoba.

Type of Student:

Status of the student upon entering the nursing program identified as one of the following: High school graduate (no university experience), or Transfer student (university experience).

Previous Education:

The attainment of post-secondary education that has been completed upon entering the nursing program identified as one of the following: No post-secondary education, Licensed Practical Nurse Certificate, Registered Psychiatric Nurse Diploma, Bachelor's Degree (Science, Arts, etc.), or Other post-secondary program (to be specified by the student).

Definition of Terms

Variable and Definition

***Statistics / Calculus / Algebra:**

Other mathematics-related courses taken either before entering or during the nursing program.

Pre-entrance Mathematics Grade:

Grade achieved in the Mathematics (300, 40S) course required for admission to nursing program, identified as one of the following: A+, A, B+, B, C+, or C. This variable relates only to high school graduates since transfer students are not required to have a Mathematics course for admission to the program.

Pre-entrance English Grade:

Grade achieved in the English course required for admission to nursing program, identified as one of the following: A+, A, B+, B, C+, C. This variable relates to both high school and transfer students, although the type of English course will be different for these groups.

Definition of Terms

Variable and Definition

Pre-entrance Science Grade:

Grade achieved in the Science course required for admission to nursing program. This course will be either Chemistry or Physics and the grade is identified as one of the following: A+, A, B+, B, C+, C. This variable relates to both high school and transfer students, although the type of science course will be different for these two groups. The student will be asked to identify the course with the higher grade if they have taken both Chemistry and Physics.

Cumulative Grade Point Average:

Cumulative grade point average achieved at university as indicated on the most recent transcript at the time of data collection, identified as one of the following: A+ (4.25-4.50), A (3.75-4.24), B+ (3.25-3.74), B (2.75-3.24), C+ (2.25-2.74), or C (2.00-2.24). This variable will relate to both high school and transfer students, since all students in this study will have taken some university courses at the time of testing, which will be second term of second year.

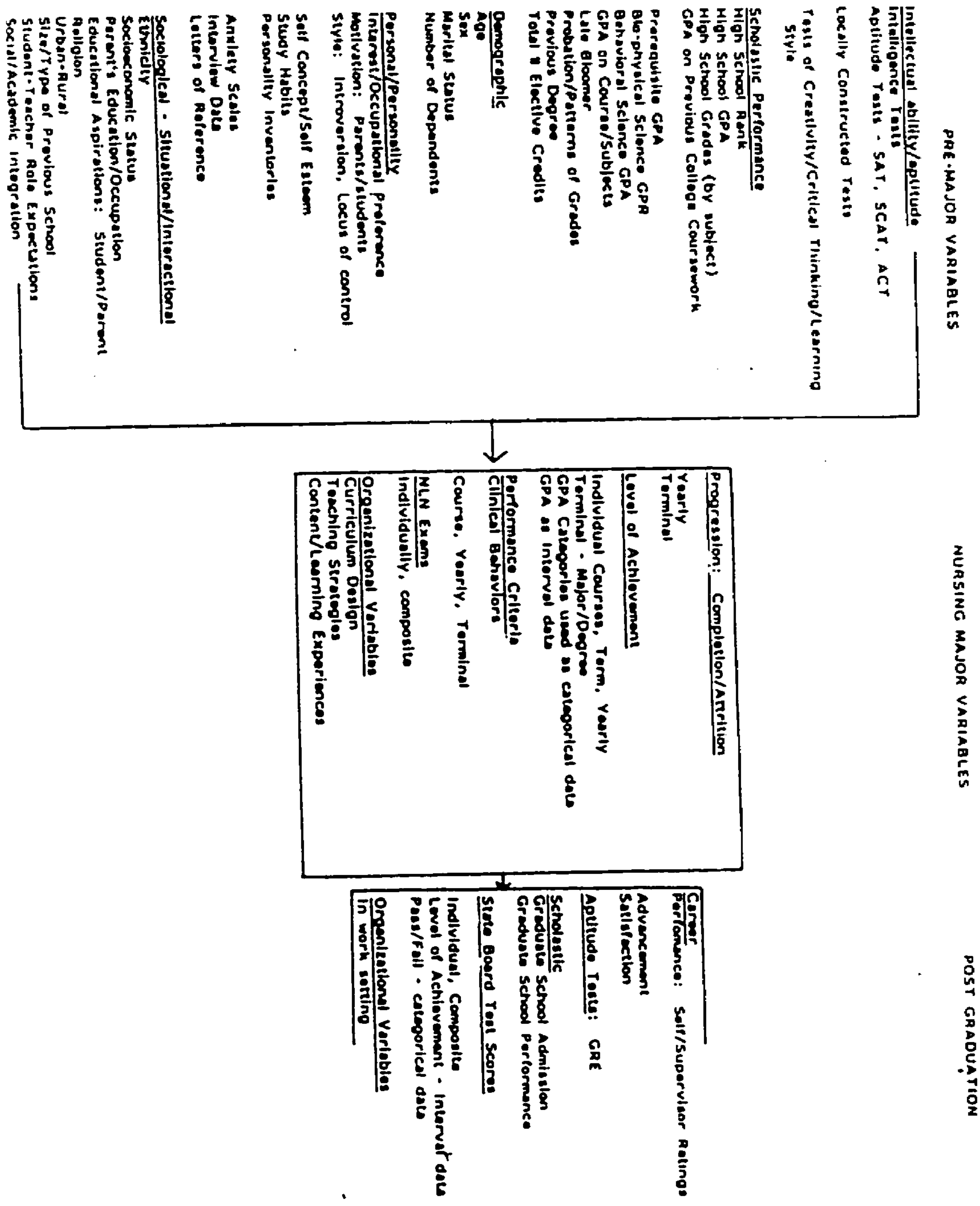
Definition of Terms

Variable and Definition
Calculation Ability:
Numerical score(s) achieved on the "Mathematics and Drug Calculation test". Separate scores for the Basic Mathematics Section and Drug Calculation Section are calculated (20 items each) and when combined, become the Total score (40 items in total).
Baccalaureate Nursing Students:
Students who are enrolled in the second term of second year of the Baccalaureate in Nursing Program offered by the University of Manitoba. Students attending the Fort Garry Campus and St. Boniface General Hospital sites are included in this sample. Brandon General Hospital site students comprise the pilot study sample. Note that students attending the Health Sciences Centre site of the program are not included as part of the sample because there were no second year students attending this site at the time of data collection.

Note: Variables indicated by an asterisk (*) denote those variables added to the Demographic and Academic Status Questionnaire following remarks made by Faculty expert reviewers during the pilot study. Therefore, these variables were not included in the Research Questions but became a part of the data analysis.

Appendix B

Model for the Study of Prediction of Success in Nursing Education and Practice



Source: Higgs (1984).

Appendix C

Letter of Invitation to Participate in a Pilot Study

Dear Student Nurse,

My name is Laurie Clark. I am a nursing instructor and a student in the Master's of Nursing program at the University of Manitoba. As part of my nursing program, I am conducting a study to examine the relationships between baccalaureate nursing student characteristics and mathematical and drug calculation ability. The study has been approved by the Ethical Review Committee of the Faculty of Nursing, University of Manitoba.

I would like to invite you to participate in this pilot study. The study will take about 90 minutes. Approximately half of this time will be arranged during your Growth & Development class time so that the time you spend outside of class will be minimized. There will be a 15 minute orientation session followed by a 75 minute data collection session, arranged at a separate time. You will be asked to complete three measures. The first task will involve answering some questions which describe you (e.g., age, marital status, education, grades achieved prior to nursing program). You may need to refer to your previous high school and/or university transcripts to answer these questions accurately. The second task will be a basic mathematics and oral drug calculation test of 40 items in length. Questions on this test will include a section about basic arithmetic operations and a section about calculation of oral drug dosages. The third task will be to complete a brief evaluation form about the previous two measures in terms of clarity, fairness, and structure. This last task will be very important in helping me to determine how students are able to complete the other two measures in an easy and accurate way.

Your participation in this study is voluntary, and if you choose not to participate, it will in no way affect your progress in the nursing program. If you decide to stop part way through completing the measures, you will be free to do so. Participation in this study will result in no direct benefits to you, but it may provide you with an opportunity to learn more about the research process and to assess your calculation skills. Your performance on the calculation test will be available to you upon your request. There are no known risks of participating in this study.

Your involvement in this study will remain strictly confidential, and the information will be kept in a locked filing cabinet in my home. Your identity and the information that you provide me with will be identified by a code name. Your name will not be recorded anywhere. The written report and any further publication coming out of this study will describe only group information and will not identify you in any way. The only people who will have access to the data from this study are Asst. Professor Judith Scanlan (Thesis Advisor, University of Manitoba, Faculty of Nursing), and a Statistician from the University of Manitoba.

The **ORIENTATION SESSION** for this pilot study is being held **February 27** near the end of **Growth & Development class**. During the orientation session, the study will be explained in detail and a consent form will be reviewed with you by my Research Assistant, Christine Trowell. The **DATA COLLECTION SESSION** will be held **February 29** during **Growth & Development class time**. Students who wish to have their calculation scores returned to them for self-assessment purposes will be required to identify themselves and their corresponding code name on the consent form. In this case, I will be aware of individuals' scores and I will protect your identity by not sharing your scores with anyone else in any way. You will learn about the consent form during the orientation session and will be asked to sign the form prior to completing the three measures at the data collection session. Your signature on the consent form will indicate your willingness to participate in the study.

If you have any questions about this study, I can be contacted at (204) 727-3251 or (204) 726-2369. You do not have to identify yourself when you call and you may call me collect at the first number above. If you wish to speak to my study supervisor, Asst. Professor Judy Scanlan, you can call her at (204) 474-8175. **Thank you for your time and attention.**

Appendix D

Letter of Invitation to Participate in a Study

Dear Student Nurse,

My name is Laurie Clark. I am a nursing instructor and a student in the Master's of Nursing program at the University of Manitoba. As part of my nursing program, I am conducting a study to examine the relationships between baccalaureate nursing student characteristics and mathematical and drug calculation ability. The study has been approved by the Ethical Review Committee of the Faculty of Nursing, University of Manitoba.

I would like to invite you to participate in this study. If you agree to participate, it will take about 90 minutes of your time, which includes this brief orientation session. In the other 75 minutes, arranged at a separate time, you will be asked to complete two measures. The first task will involve answering some questions which describe you (e.g., age, marital status, education, grades achieved prior to nursing program). You may need to refer to your previous high school and/or university transcripts to answer these questions accurately. The second task will be a basic mathematics and oral drug calculation test. Questions on this test will include a section about basic arithmetic operations (e.g., addition, multiplication, fractions, decimals, ratios, and word problems) and a section about calculation of oral drug dosages (metric system).

Your participation in this study is voluntary, and if you choose not to participate, it will in no way affect your progress in the nursing program. If you decide to stop part way through completing the measures, you will be free to do so. Participation in this study will result in no direct benefits to you, but it may provide you with an opportunity to learn more about the research process and to assess your calculation skills. Your performance on the calculation test will be available to you upon your request. There are no known risks of participating in this study.

Your involvement in this study will remain strictly confidential, and the information will be kept in a locked filing cabinet in my home. Your identity and the information /responses that you provide me with will be identified by a code name. Your name will not be recorded anywhere. The written report and any further publication coming out of this study will describe only group information and will not identify you in any way. The only people who will have access to the data from this study are Asst. Professor Judith Scanlan (Thesis Advisor, University of Manitoba, Faculty of Nursing), and a Statistician from the University of Manitoba.

During the orientation session today, I will explain the study (by reviewing this letter and answering questions) and I will read a consent form with you. Following the **Data Collection** session to be conducted **March 25 - during Nursing Skills Lab Time**, I will know which students have chosen to participate by the consent forms signed, but I will not be able to identify individual responses because they will be coded. However, students who wish to have their calculation scores returned to them for self-assessment purposes will be required to identify themselves and their corresponding code name on the consent form. In this case, I will be aware of individuals' scores and I will protect your identity by not sharing your scores with anyone else in any way. Your signature on the consent form will indicate your willingness to participate in the study. You will be asked to sign the consent form prior to the data collection session.

If you have any questions about this study, I will be happy to answer them. I can be contacted at (204) 727-3251 or (204) 726-2369. You do not have to identify yourself when you call and you may call me collect at the first number above. If you wish to speak to my study supervisor, Asst. Professor Judy Scanlan, you can call her at (204) 474-8175. **Thank you for your time and attention.**

Appendix E

Consent Form - Pilot Study

In signing this document, I am giving consent to participate in a pilot study for the research project "A Study of the Relationships between Student Nurse Characteristics and Calculation Ability" conducted by Laurie Clark from the Master's in Nursing Program at the University of Manitoba. I understand the goal of the study is to examine the relationship between student nurse characteristics and mathematical and drug calculation ability. I understand participation in the project is entirely voluntary and I may withdraw at any time. I am agreeing to complete a demographic and academic status questionnaire as well as a mathematics and drug calculation test. I will also be completing a brief evaluation form related to the previous two measures. The study has been approved by the administration of my nursing program and by the Ethical Review Committee of the Faculty of Nursing of University of Manitoba.

I understand the research will be conducted by Laurie Clark. The demographic and academic status questionnaire will include questions related to my age, marital status, student status, previous education, high school or university level pre-admission course grades, and grade point average. This questionnaire should take approximately 15 minutes to complete. The mathematics and drug dosage calculation test will include 40 questions on basic mathematics and oral drug calculations. This test should take approximately one hour to complete. The evaluation form will include questions related to the clarity, fairness, structure, and experience of completing the previous two measures. This evaluation should take approximately five minutes to complete.

Information from the questionnaire and calculation test will be identified by a code name in order to make comparisons between the data. All information obtained will be kept confidential and will not be made available to the administrators of my nursing program. The Thesis Chair for this study, Prof. Judith M. Scanlan, and a statistician will have access to the original coded data whereas, other members of Laurie Clark's Thesis Committee will see only group data and will be unable to identify individual scores to ensure anonymity. If I choose to have my scores returned to me for self-assessment purposes, I agree to give my name and address and code name at the end of this consent form in order to identify my responses from others in the study.

I have been informed that participation or nonparticipation will not influence my progress in the nursing program. Students attending the Brandon

General Hospital site will be recruited and data collected by a Research Assistant to minimize the element of persuasion since Laurie Clark is a faculty member at this site. My name will not be used in any reports about the study or in any future publications. I have been given the opportunity to have the results of my calculation test returned to me for self-assessment purposes by providing my assigned code name, name, and address. I can choose not to do this, and therefore, acknowledge there are no other benefits to me personally except for the experience of participating and learning more about the research process. My participation would also help to improve the understanding about nursing students' mathematical skills and how they relate to the current admission standards of the University of Manitoba undergraduate nursing program.

I understand that findings from this study may be used in future studies. I understand the only risk or disadvantage for participating is the time spent completing the instruments. I understand that during and after the research, all documents will be securely locked and kept from seven to ten years and then destroyed. A summary of this study will be available to those who request it and the findings may be published in a nursing journal at a later date.

I have had an opportunity to have all my questions answered. Any additional questions I may have can be asked at any time by contacting Laurie Clark collect at (204) 727-3251 or her Advisor Judith Scanlan at (204) 474-8175. I have been offered a copy of the summary of the project and have been given a copy of this consent form.

Date ______________________ Participant's Signature ____________________

Researcher's Signature ____________________

Please send me a summary of the research report.

Send to: ______________________________ (Name)

______________________________ (Address)

____

Please send me the results of my calculation test.

Send to: ______________________________ (Code Name)

______________________________ (Name)

______________________________ (Address)

Appendix F

Consent Form - Research Study

In signing this document, I am giving consent to participate in a study for the research project "A Study of the Relationships between Student Nurse Characteristics and Calculation Ability" conducted by Laurie Clark from the Masters in Nursing Program at the University of Manitoba. I understand the goal of the study is to examine the relationship between student nurse characteristics and mathematical and drug calculation ability. I understand participation in the project is entirely voluntary and I may withdraw at any time. I am agreeing to complete a demographic and academic status questionnaire as well as a mathematics and drug calculation test. The study has been approved by the administration of my nursing program and by the Ethical Review Committee of the Faculty of Nursing of University of Manitoba.

I understand the research will be conducted by Laurie Clark. The demographic and academic status questionnaire will include questions related to my age, marital status, student status, previous education, high school or university level pre-admission course grades, and grade point average. This questionnaire should take approximately 15 minutes to complete. The mathematics and drug dosage calculation test will include approximately 40 questions on basic mathematics and oral drug calculations. This test should take approximately one hour to complete.

Information from the questionnaire and calculation test will be identified by a code name in order to make comparisons between the data. All information obtained will be kept confidential and will not be made available to the administrators of my nursing program. The Thesis Chair for this study, Prof. Judith M. Scanlan, and a statistician will have access to the original coded data whereas, other members of Laurie Clark's Thesis Committee will see only group data and will be unable to identify individual scores to ensure anonymity. If I choose to have my scores returned to me for self-assessment purposes, I agree to give my name and address and code name at the end of this consent form in order to identify my responses from others in the study.

I have been informed that participation or nonparticipation will not influence my progress in the nursing program. My name will not be used in any reports about the study or in any future publications. I have been given the opportunity to have the results of my calculation test returned to me for self-assessment purposes by providing my assigned code name, name, and address. I can choose not to do this, and therefore, acknowledge that there are no other benefits to me personally except for the experience of participating and learning more about the research process. I understand findings from this study may be used in future studies. I understand the only risk or disadvantage for participating is the time spent completing the instruments. I understand that during and after the research, all documents will be securely locked and kept from seven to ten years and then destroyed. A summary of this study will be available to those who request it and the findings may be published in a nursing journal at a later date.

I have had an opportunity to have all my questions answered. Any additional questions I may have can be asked at any time by contacting Laurie Clark collect at (204) 727-3251 or her Advisor Judith Scanlan at (204) 474-8175. I have been offered a copy of the summary of the project and have been given a copy of this consent form.

Date ______________________ Participant's Signature ____________________

Researcher's Signature ____________________

Please send me a summary of the research report.

Send to: ______________________________ (Name)

______________________________ (Address)

____

Please send me the results of my calculation test.

Send to: ______________________________ (Code Name)

______________________________ (Name)

______________________________ (Address)

Appendix G

Research Assistant Instructions - Pilot Test

The objective for this study is to examine the admission criteria of the University of Manitoba (U of M) Baccalaureate in Nursing Program and selected demographic factors in relation to the calculation abilities of nursing students enrolled in this program. Your job, as a Research Assistant, is to be a neutral individual responsible for orientating, recruiting, and collecting data from nursing students in the pilot test group. It is most important to the results of this study that you do not pressure or deceive the students into participating and that you do not bias their responses on the instruments in any way.

The research questions, design, consent form, data collection instruments, and evaluation form for the study will be reviewed with you. We will role play an orientation/recruitment session and a data collection session so that you are at ease with the content to be discussed and the process of each session. If possible, I will ask you to accompany me to an orientation/recruitment session and data collection session at one of the other sites involved in this study so that you become familiar with what is expected at these sessions. It is your responsibility to read this page of instructions, review the research questions, design, consent form, data collection instruments (Demographic and Academic Status Questionnaire and Mathematics and Drug Calculation Test), and evaluation form prior to the role play. We will review the process of conducting an orientation/recruitment and data collection session until you feel comfortable and until consistency with the approach taken at other sites is achieved. In order for the results of this study to be reliable, the sessions must be conducted in a consistent way. Reliability is essential to the investigator and you have an important role to play in making this happen.

All students attending the orientation/recruitment session and subsequent data collection must have their identity protected. I am asking you to conduct these sessions at the Brandon General Hospital site because of my relationship and familiarity with the students. I do not want my presence to influence their decision to participate in the pilot study and they must be reassured that you will not disclose their identity to me or anyone else. All responses on the data collection instruments will be identified by a code name and I will not be able to identify individual student nurses' responses. The consent forms that the students sign at BGH site will be given to me only after data collection and evaluation has taken place and I will be unable to connect the responses with particular students. During the orientation/recruitment session, students will be guaranteed anonymity and confidentiality for their responses. These are ethical obligations for yourself as a Research Assistant, as well as for the investigator. No names will appear on the data collection instruments, and all documents (consents and instruments) will be kept locked in a cabinet when not in use. You are obliged to not talk about any students, responses, or identifying information to others.

Script for Conducting the Orientation/Recruitment Session
Research Assistant Copy - Pilot Study - BGH Site

Good afternoon everyone. Thank you so much for coming to this orientation session today. My name is ______________ and I am the Research Assistant for the study you read about in the Letter of Invitation sent to you earlier this term. As you may remember reading, the research study being conducted is about examining the relationship between student nurse characteristics and mathematical and drug calculation ability. More specifically, the information to be collected will include demographic factors, such as age, marital status, type of student (transfer or high school candidate), and previous education in the way of diplomas or degrees. This study will also look at the grades students have achieved on the pre-admission courses (Science, Math, English) as well as the most recent GPA. The purpose of today's session is to tell you more about the study and to invite you to participate in this research project. I need to assure you that this study has been approved by the Ethical Review Committee of the Faculty of Nursing from the University of Manitoba.

You have been invited to participate in this pilot study because you are nursing students in the second year of the program and have been exposed to the material related to the calculation of oral drug dosages. It is the intent of this study to find out whether there are any relationships between the factors just mentioned and the nursing student's ability to correctly calculate drug dosages. It is important to gain an understanding of these relationships so that students who may be considered at a disadvantage (due to age, grades, or whatever) can be identified early in the nursing program and helped to improve their calculation skills.

If you choose to participate in this pilot study, you will be asked to spend approximately two hours, inclusive of this orientation session. This session will last about one-half hour, and the remaining 1 and 1/2 hours to be arranged at a later date, will involve having you complete two research measures and a brief evaluation form. These instruments were described in the Letter of Invitation. Does anyone have any questions about these instruments and what they will be asking?

(Pause... respond to questions)

It was mentioned in the Letter of Invitation that you may need to refer to your high school and university transcripts to refresh your memory about your grades. Specifically, those of you who entered this program following high school and used your Grade 12 courses for the entrance requirements, will be asked to record your letter grades in Mathematics 300, Science 300 (Chemistry or Physics, whichever was the higher grade), and English 300. Those of you who entered as a transfer student, that is having done some university following high school and entered the program based on your grades in the first year of your university program, will be asked to record your letter grades in English 100 and Science 100 (Chemistry or Physics, whichever was the higher grade). Those of you who have a different background in terms of Pre-entrance courses will be assisted to record your grades appropriately on the Demographic Questionnaire. All of you who participate will be asked to record your most recent university GPA according to your last transcript. It is very important that you record these grades as accurately as possible so that the results of this study are reliable and valid. That is, in order to accurately determine the relationship between these grades and your scores on the Mathematics and Drug Calculation Test, the grades you report must be true. Therefore, it would be helpful for this study if you would **bring these documents to refer to, if possible, to the next session at which time this data will be collected.** If your (high-school) grades are in percent form rather than letter form, a conversion scale will be used. I will be able to assist those of you who are unsure how to convert your grades to letters at the next session.

Those who participate need to know that following the completion of the first measure just described, which will take approximately 15 minutes, you will be asked to complete the second measure being the Mathematics and Drug Calculation Test. This test will be 40 questions in length including twenty basic arithmetic questions and 20 oral drug dosage calculation questions. You will be given one hour to complete this test. You will not be allowed to use a calculator. You may bring your own pencils and erasers, but these will be supplied for you should someone forget. You will not be allowed to talk to one another about the questions since it is important that your responses remain your own. When the time is up, I will come around and collect the papers from you. I will then ask you to complete a brief evaluation form about the previous two measures. This will take about five minutes to complete.

Your participation in this study is entirely voluntary and is your choice alone. If you decide to become involved and change your mind part-way through and want to withdraw, you may do this at any time without any consequences. Students who do not wish to participate in this study will not be penalized or jeopardized in terms of your progress in the nursing program. The administration and teachers of your program will not be aware of who chooses to participate or not participate.

I would like to describe the benefits of participating in this study. You may find participating in this study a valuable learning experience in terms of what it is like to be a part of nursing research. Many of you are studying Nursing Research at this time and this experience may help you to understand the process of research in a personal and meaningful way. Another advantage may be the opportunity of having your mathematics and drug calculation skills assessed in a way that will have no influence on your grades. It was mentioned in the Letter of Invitation that some of you may choose to have your Calculation Test scores returned to you. This would allow you to see how well you did and to determine the areas that may benefit from further practice.

The only known disadvantage of participation identified at this time is the amount of time that will be involved in attending the data collection session in addition to this session today. You may find it difficult to find your transcripts so this could be considered a disadvantage as well.

I wish to reassure you that your identity will remain confidential and that your responses will be kept confidential from others, in a securely locked cabinet. Your responses will be identified by code name only and your names and student numbers will not be used in any way. Any reports or publications from this study will include only group data and individuals' responses will not be identifiable. The individuals who will have access to the data will include the Thesis Advisor for the project, Professor Judith Scanlan, members of the Thesis committee, Dr. Sheila Dresen and Dr. Alexander Gregor, and a Statistician from the MNRI. Some of you will know Dr. Sheila Dresen as the Program Director at the Health Sciences Centre site. Please know that she will not be seeing individual papers, only group data. She will not be aware of who participates and what the individual responses are of students.

As the Research Assistant, I will not be sharing students' identities with the Investigator, Laurie Clark. My role in essence, is to conduct these sessions at this site so that your identity is protected and so you do not feel obligated to participate because of your familiarity with Laurie Clark. She has asked me to assist her in this way so that you feel at ease with your decision and that your decision is free from pressure by her presence. You need to know that once data collection is complete, the investigator will know who has participated by the names on the consent forms. However, Laurie Clark will not be able to connect your responses to names because the data will be coded. As the investigator of the study, Laurie Clark is obliged to keep all information confidential. She will not be sharing your identities with anyone.

To summarize, this orientation session was designed to inform you of the opportunity to participate in a research project and to have your questions about participation addressed. Does anyone have any questions at all about what has been shared today so far?

(Pause... answer questions)

(Note to Research Assistant: If you are unable to answer any of the questions, advise the student to contact the investigator at (204) 727-3251 or (204) 726-2369. The student does not have to identify him or her self and may call collect at the first number. The student may also choose to call the Thesis Advisor, Judy Scanlan at (204) 474-8175 for further direction if they feel uncomfortable with contacting the investigator.)

Now, I would like to distribute a copy of the written consent form for you to follow. I will read the consent form out loud once everyone has received a copy.

(Distribute and read the consent form out loud to the students)

You will note that there is a section at the bottom of this consent form that gives you the choice of having your calculation test scores returned. You can choose not to do this and therefore would leave this section blank. However, for those of you who would like to participate in the study and wish to have your scores returned, you may fill in this section when it is time to do so. I need to make you aware that by filling in this bottom section, you will be disclosing your code name which will enable the investigator to identify your individual responses so that it is possible to retrieve your papers to return your scores to you.

Does anyone have any questions about this consent form?

(Pause... answer questions)

You do not have to decide today if you want to participate. Please take the consent form you have home with you to read over again. Everyone here today will receive an invitation to attend the data collection session later this term. Those who attend and therefore want to participate, will be asked to sign the consent form at that time.

Please feel free to call the investigator or Thesis Advisor if you have any questions following this orientation and recruitment session. If there are no more questions, I would like to thank you all again for coming today and for taking the time to learn more about this study. All the best to you in your studies.

End of Script - Orientation - Pilot

Script for Conducting the Data Collection Session
Research Assistant Copy - Pilot Study - BGH Site

Hello again everyone. Thank you for attending this data collection session. As you recall, this study is about examining the relationships between student nurse characteristics and calculation ability. Before we begin, it is important that I give you the opportunity to ask any questions you may still have about participating in this pilot project. I will begin by reading out loud the consent form again to refresh your memory.

(Read the consent form out loud)

Does anyone have any questions?

(Pause... answer questions)

If there is anyone who would like to leave this study before we go on, please feel free to do so now. However, I want to thank you very much for your interest and wish you the best in your studies.

(Pause... allow students to leave)

Now, to everyone remaining in the room, thank you for staying on and getting involved!

I will start the next part of the session by distributing consent forms and the study instruments.

(Distribute the consents [2 copies], Demographic and Academic Status Questionnaires, The Mathematics and Drug Calculation Tests, and Evaluation Forms)

Please find the consent form and place the remaining papers face-down on

the table. Please proceed to sign the consent form at the end, and indicate whether you want a summary report sent to you after the study is complete.
(Pause...)

Now indicate whether you wish to have your Calculation Test scores returned by recording a CODE NAME, your mother's maiden name for example, where it states CODE NAME.
(Pause...)

Now, please turn over the Demographic and Academic Status Questionnaire and Mathematics and Drug Calculation Test. Record your CODE NAME on both of these papers. If you have decided to not have your scores returned, then your CODE NAME will only appear on these two papers.
(Pause...)

Please check now to make sure that both the Demographic Questionnaire and Calculation Test have the same CODE NAME identified at the top. PLEASE DO NOT MAKE ANY OTHER MARKS ON THE PAPERS UNTIL I HAVE ASKED YOU TO BEGIN.

(Pause...)

Please turn the Demographic Questionnaire and Calculation Test over face-down on the table. I will be coming around to collect your signed consent form. You may keep the second copy of the consent form for yourself.

(Collect the consent forms)

Now, I would like to review the instructions for completing the Demographic and Academic Status Questionnaire. You may need to get out your high school and university transcripts at this point.

(Allow a few minutes for students to get ready)

Does everyone have a pencil and eraser? Please raise your hand if you do not.

(Hand out pencils and erasers to those who do not have them)

Alright, the completion of this first measure is self-explanatory. You may turn over the Questionnaire now. Once I finish explaining the instructions, you may begin to complete the Demographic Questionnaire. Please do not separate the pages. Keep them attached together. If you have any questions about how to record your answer at any time, please raise your hand and I will come by and assist you. This Questionnaire should take about 15 minutes at those most. If you need more time, it will be allowed.

WHEN YOU ARE DONE WITH THIS FIRST PAPER, PLEASE PUT YOUR PENCILS DOWN, TURN YOUR PAPER OVER, AND WAIT. PLEASE DO NOT BEGIN THE MATHEMATICS AND DRUG CALCULATION TEST. KEEP THE CALCULATION TEST TURNED FACE-DOWN ON THE TABLE. IT IS VERY IMPORTANT THAT YOU FOLLOW THIS INSTRUCTION. NOW, YOU MAY BEGIN THE DEMOGRAPHIC QUESTIONNAIRE.

(Time started: ______________________; Time finished: __________________)

(Assist students as necessary in recording their grades accurately on the Questionnaire. Use the conversion scale consistently when changing percentages or numerical grades to letter grades. Students who are not able to record grades in English/Math/Science 300 will need help. Some will be able to record grades for some courses but not others. Have these students write down the course they took in Grade 12 [for example, Algebra/301/Biology] if it is something other than a 300 course. Tell students to leave the section blank if they have no course grade in that area at all)

(Wait for approximately 10 - 12 minutes, look about the room to get a sense of how the students are doing; and then ask...)

May I have your attention please? Those of you who are finished the Questionnaire, please raise your hand.

(If everyone is done, then proceed to the next step. If there are still students who require more time, then tell the students to continue. Remind students that are finished to turn their papers over face-down and to wait quietly. Respond to students' questions quietly if they raise their hand during this process. Continue to repeat this process until all students have finished the Demographic Questionnaire)

Now that everyone has completed the Demographic and Academic Status Questionnaire, please turn over the Mathematics and Drug Calculation Test, BUT DO NOT BEGIN UNTIL I ASK YOU TO DO SO.

I will review the instructions with you now and I'll ask that you follow

along. If you have any questions, please raise your hand.
(Read out loud the instructions for students as printed on the Mathematics and Drug Calculation Test)

Are there any questions about these instructions?
(Pause... answer questions)

YOU WILL BE ALLOWED ONE HOUR. AT THAT TIME, I WILL GET YOUR ATTENTION, ASK YOU TO STOP AND PUT DOWN YOUR PENCILS, AND I WILL COLLECT ALL THE PAPERS. YOU MAY BEGIN NOW. GOOD LUCK!

(Time started: ________________________; Time finished: ______________)

(Allow 1 hour to complete the Calculation Test. If a student asks a question about the Calculation Test, do not give the answer or encourage the student to answer in any particular way. Encourage the student to consider moving to another question and to return to the problematic question later for reconsideration. If the student cannot resolve their question, instruct them to do their best and tell them that you are unable to give them any further information.)

(At the end of the one hour, ...)

May I have your attention please? Please stop now and put down your pencils. Turn your papers over face-down. I will now come around and collect the papers.
(Collect the papers, EXCEPT FOR THE EVALUATION FORMS)

Now, I would appreciate you spending another few minutes to complete the evaluation form you should still have in front of you. Please start now.

(Pause... wait about 5 minutes and ask...)

May I have your attention please?

I want to thank you all very much for participating in the study and for taking the time to complete these instruments. This study would not have been possible without your participation. I hope you have found this to be a valuable learning experience and I remind you that if you have any further concerns about your participation in this study that you are free to contact myself/the investigator at (204) 726-2369 or (204) 727-3251 or the Study Advisor Judith Scanlan at

(204) 474 - 8175.

A copy of this study, once it is complete, will be available in the Brandon General Hospital Library, and a summary of the report will be made available to you if you have requested so on your consent form.

Those of you who have no questions may leave and thank you very much for participating. Good-bye and good luck in your studies. Those of you who have questions, please stay on and I will help you. I will collect your evaluation form as you leave the room.

(Stand at the door and collect evaluation forms)

(If students change their mind about indicating that they would like/not like to have their scores returned, or have a copy of the summary sent to them, then locate the appropriate papers and make the appropriate changes in their presence; ie. record or remove the code name on the consent form)

(Complete these changes and then say...)

Thank you again. Good-bye and good luck in your studies.

Recording the environment during data collection

To gain an understanding of what the circumstances are like for the students during the data collection session, it is important to record details about the atmosphere during this time. Making notes about the lighting, temperature, seating, and other environmental factors will help to identify possible sources of influence on the students' scores. Please make note of the time of day, day of the week and ability of students to follow directions. Record all questions asked by students during data collection on a sheet of paper so that these may be used to help explain the findings. Try to determine the reasons for students not being able to complete the Demographic Questionnaire or Mathematics and Drug Calculation Test (not sufficient time, didn't understand the question, didn't know how to complete the question).

If you have any questions or concerns about this process or how to conduct either session, please do not hesitate to contact the investigator. Thank you for your assistance. Enjoy your sessions with the students.

End of Script - Data Collection - Pilot Study

Appendix H

Script for Conducting the Orientation/Recruitment Session
Investigator Copy - St. Boniface and Fort Garry Sites

Good afternoon everyone. Thank you so much for coming to this orientation session today. My name is Laurie Clark and I am the Investigator for the study that you will hear about today. I am conducting a research study about the relationship between student nurse characteristics and mathematical and drug calculation ability. More specifically, the information to be collected will include demographic factors, such as age, marital status, type of student (transfer or high school candidate), and previous education in the way of diplomas or degrees. This study will also look at the grades students have achieved on the pre-admission courses (Science, Math, English) as well as the most recent GPA. The purpose of today's session is to tell you more about the study and to invite you to participate in this research project. I need to assure you that this study has been approved by the Ethical Review Committee of the Faculty of Nursing from the University of Manitoba.

(Distribute Letter of Invitation to Participate... review/read with the students)

You have been invited to participate in this study because you are nursing students in the second year of the program and have been exposed to the material related to the calculation of oral drug dosages. It is the intent of this study to find out whether there are any relationships between the factors just mentioned and the nursing student's ability to correctly calculate drug dosages. It is important to gain an understanding of these relationships so that students who may be considered at a disadvantage (due to age, grades, or whatever) can be identified early in the nursing program and helped to improve their calculation skills.

If you choose to participate in this study, you will be asked to spend approximately 90 minutes of time which will be scheduled during your regular class time so that the time involved is minimized. This session will be brief and the remaining 75 minutes to be held on **March 19 (St. B.) March 25 (Fort Garry)**, will involve having you complete two research measures. These two instruments were described in the Letter of Invitation. Does anyone have any questions about these instruments and what they will be asking?

(Pause... respond to questions)

It was mentioned in the Letter of Invitation that you may need to refer to your high school and university transcripts to refresh your memory about your grades. Specifically, those of you who entered this program following high school and used your Grade 12 courses for the entrance requirements, will be asked to record your letter grades in Mathematics 300, Science 300 (Chemistry or Physics, whichever was the higher grade), and English 300. Those of you who entered as a transfer student, that is having done some university following high school and entered the program based on your grades in the first year of your university program, will be asked to record your letter grades in English 100 and Science 100 (Chemistry or Physics, whichever was the higher grade). All of you who participate will be asked to record your most recent university GPA according to your last transcript. It is very important that you record these grades as accurately as possible so that the results of this study are reliable and valid. That is, in order to accurately determine the relationship between these grades and your scores on the Mathematics and Drug Calculation Test, the grades you report must be true. Therefore, **it would be helpful for this study if you would bring these documents to refer to, if possible, to the next session at which time this data will be collected.**

Those who participate need to know that following the completion of the first measure just described, which will take approximately 10 minutes, you will be asked to complete the second measure being the Mathematics and Drug Calculation Test. This test will be 40 questions in length including twenty basic arithmetic questions and 20 oral drug dosage calculation questions. You will be given one hour to complete this test. You will not be allowed to use a calculator. You may bring your own pencils and erasers, but these will be supplied for you should someone forget. You will not be allowed to talk to one another about the questions since it is important that your responses remain your own. When the time is up, I will come around and collect the papers from you.

Your participation in this study is entirely voluntary and is your choice alone. If you decide to become involved and change your mind part-way through and want to withdraw, you may do this at any time without any consequences. Students who do not wish to participate in this study will not be penalized or jeopardized in terms of your progress in the nursing program. The administration and teachers of your program will not be aware of who chooses to participate or not participate.

I would like to describe the benefits of participating in this study. You may find participating in this study a valuable learning experience in terms of what it is like to be a part of nursing research. Many of you are studying Nursing Research at this time and this experience may help you to understand the process of research in a personal and meaningful way. Another advantage may be the opportunity of having your mathematics and drug calculation skills assessed in a way that will have no influence on your grades. It was mentioned in the Letter of Invitation that some of you may choose to have your Calculation Test scores returned to you. This would allow you to see how well you did and to determine the areas that may benefit from further practice.

The only known disadvantage of participation is the amount of time involved in attending the data collection session in addition to this session today. You may find it difficult to find your transcripts so this could be considered a disadvantage as well.

I wish to reassure you that your identity will remain confidential and that your responses will be kept confidential from others, in a securely locked cabinet. Your responses will be identified by code name only and your names and student numbers will not be used in any way. Any reports or publications from this study will include only group data and individuals' responses will not be identifiable. The individuals who will have access to the data will include the Thesis Advisor for the project, Professor Judith Scanlan, members of the Thesis committee, Dr. Sheila Dresen and Dr. Alexander Gregor, and a Statistician from the MNRI. Some of you will know Dr. Sheila Dresen as the Program Director at the Health Sciences Centre site. Please know that she will not be seeing individual papers, only group data. She will not be aware of who participates and what the individual responses are of students.

As the Investigator, I am obliged to keep all information confidential. I will not be sharing the students' identities and individual responses with anyone.

To summarize, this orientation session was designed to inform you of the opportunity to participate in a research project and to have your questions about participation addressed. Does anyone have any questions at all about what has been shared today so far?

(Pause... answer questions)

Now, I would like to distribute a copy of the written consent form for you to follow. I will read the consent form out loud once everyone has received a copy.

(Distribute and read the consent form out loud to the students)

You will note that there is a section at the bottom of this consent form that gives you the choice of having your calculation test scores returned. You can choose not to do this and therefore would leave this section blank. However, for those of you who would like to participate in the study and wish to have your scores returned, you may fill in this section when it is time to do so. I need to make you aware that by filling in this bottom section, you will be disclosing your code name which will enable me (the investigator) to identify your individual responses so that it is possible to retrieve your papers to return your scores to you.

Does anyone have any questions about this consent form?

(Pause... answer questions)

You do not have to decide today if you want to participate. Please take the consent form you have home with you to read over again. Everyone here today is invited to attend the data collection session on **March 19 (St. B.) March 25 (Fort Garry)**. Those who attend will be asked to sign the consent form at that time.

Please feel free to call me or my Thesis Advisor if you have any questions following this orientation and recruitment session. If there are no more questions, I would like to thank you all again for coming today and for taking the time to learn more about this study. All the best to you in your studies.

End of Script - Orientation

Script for Conducting the Data Collection Session
Investigator Copy - St. Boniface and Fort Garry Sites

Hello again everyone. Thank you for attending this data collection session. As you recall, this study is about examining the relationships between student nurse characteristics and calculation ability. Before we begin, it is important that I give you the opportunity to ask any questions you may still have about participating in this project. I will begin by reading out loud the consent form again to refresh your memory.

(Read the consent form out loud)

Does anyone have any questions?

(Pause... answer questions)

If there is anyone who would like to leave this study before we go on, please feel free to do so now. However, I want to thank you very much for your interest and wish you the best in your studies.

(Pause... allow students to leave)

Now, to everyone remaining in the room, thank you for staying on and getting involved!

I will start the next part of the session by distributing consent forms and the study instruments.

(Distribute the consents [2 copies], Demographic and Academic Status Questionnaires, and the Mathematics and Drug Calculation Tests)

Please find the consent form and place the remaining papers face-down on the table. Please proceed to sign the consent form at the end, and indicate whether you want a summary report sent to you after the study is complete.

(Pause...)

Now indicate whether you wish to have your Calculation Test scores returned by recording a CODE NAME, your mother's maiden name for example, where it states CODE NAME.

(Pause...)

Now, please turn over the Demographic and Academic Status Questionnaire and Mathematics and Drug Calculation Test. Record your CODE NAME on both of these papers. If you have decided to <u>not</u> have your scores returned, then your CODE NAME will only appear on these two papers.
(Pause...)

Please check now to make sure that both the Demographic Questionnaire and Calculation Test have the same CODE NAME identified at the top. PLEASE DO NOT MAKE ANY OTHER MARKS ON THE PAPERS UNTIL I HAVE ASKED YOU TO BEGIN.

(Pause...)

Please turn the Demographic Questionnaire and Calculation Test over face-down on the table. I will be coming around to collect your signed consent form. You may keep the second copy of the consent form for yourself.

(Collect the consent forms)

Now, I would like to review the instructions for completing the Demographic and Academic Status Questionnaire. You may need to get out your high school and university transcripts at this point.

(Allow a few minutes for students to get ready)

Does everyone have a pencil and eraser? Please raise your hand if you do not.

(Hand out pencils and erasers to those who do not have them)

Alright, the completion of this first measure is self-explanatory. You may turn over the Questionnaire now. Once I finish explaining the instructions, you may begin to complete the Demographic Questionnaire. Please do not separate the pages. Keep them attached together. If you have any questions about how to record your answer at any time, please raise your hand and I will come by and assist you. This Questionnaire should take about 15 minutes at those most. If you need more time, it will be allowed.

WHEN YOU ARE DONE WITH THIS FIRST PAPER, PLEASE PUT YOUR PENCILS DOWN, TURN YOUR PAPER OVER, AND WAIT. PLEASE DO NOT BEGIN THE MATHEMATICS AND DRUG CALCULATION TEST. KEEP THE CALCULATION TEST TURNED FACE-DOWN ON THE TABLE. IT IS VERY IMPORTANT THAT YOU FOLLOW THIS INSTRUCTION. NOW, YOU MAY BEGIN THE DEMOGRAPHIC QUESTIONNAIRE.

(Time started: ______________________; Time finished: _________________)

(Assist students as necessary in recording their grades accurately on the Questionnaire. Use the conversion scale consistently when changing percentages or numerical grades to letter grades)

(Wait for approximately 10 - 12 minutes, look about the room to get a sense of how the students are doing; and then ask...)

May I have your attention please? Those of you who are finished the

Questionnaire, please raise your hand.

(If everyone is done, then proceed to the next step. If there are still students who require more time, then tell the students to continue. Remind students that are finished to turn their papers over face-down and to wait quietly. Respond to students' questions quietly if they raise their hand during this process. Continue to repeat this process until all students have finished the Demographic Questionnaire)

Now that everyone has completed the Demographic and Academic Status Questionnaire, please turn over the Mathematics and Drug Calculation Test, BUT DO NOT BEGIN UNTIL I ASK YOU TO DO SO.

I will review the instructions with you now and I'll ask that you follow along. If you have any questions, please raise your hand.

(Read out loud the instructions for students as printed on the Mathematics and Drug Calculation Test)

Are there any questions about these instructions?

(Pause... answer questions)

YOU WILL BE ALLOWED ONE HOUR. AT THAT TIME, I WILL GET YOUR ATTENTION, ASK YOU TO STOP AND PUT DOWN YOUR PENCILS, AND I WILL COLLECT ALL THE PAPERS. YOU MAY BEGIN NOW. GOOD LUCK!

(Time started: ______________________; Time finished: ______________)

(Allow 1 hour to complete the Calculation Test. If a student asks a question about the Calculation Test, do not give the answer or encourage the student to answer in any particular way. Encourage the student to consider moving to another question and to return to the problematic question later for reconsideration. If the student cannot resolve their question, instruct them to do their best and tell them that you are unable to give them any further information.)

(At the end of the one hour, ...)

May I have your attention please? Please stop now and put down your pencils. Turn your papers over face-down. I will now come around and collect the papers.

(Collect the papers)

I want to thank you all very much for participating in the study and for taking the time to complete these instruments. This study would not have been possible without your participation. I hope you have found this to be a valuable learning experience and I remind you that if you have any further concerns about your participation in this study that you are free to contact myself/the investigator at (204) 726-2369 or (204) 727-3251 or the Study Advisor Judith Scanlan at (204) 474 - 8175.

A copy of this study, once it is complete, will be available in the Brandon General Hospital Library, and a summary of the report will be made available to you if you have requested so on your consent form.

Those of you who have no questions may leave and thank you very much for participating. Good-bye and good luck in your studies. Those of you who have questions, please stay on and I will help you.

(If students change their mind about indicating that they would like/not like to have their scores returned, or have a copy of the summary sent to them, then locate the appropriate papers and make the appropriate changes in their presence; ie. record or remove the code name on the consent form)

(Complete these changes and then say...)

Thank you again. Good-bye and good luck in your studies.

<u>Recording the environment during data collection</u>

To gain an understanding of what the circumstances are like for the students during the data collection session, it is important to record details about the atmosphere during this time. Making notes about the lighting, temperature, seating, and other environmental factors will help to identify possible sources of influence on the students' scores. Please make note of the time of day, day of the week and ability of students to follow directions. Record all questions asked by students during data collection on a sheet of paper so that these may be used to help explain the findings. Try to determine the reasons for students not being able to complete the Demographic Questionnaire or Mathematics and Drug Calculation Test (not sufficient time, didn't understand the question, didn't know how to complete the question).

Appendix I

Demographic and Academic Status Questionnaire

Thank you for agreeing to participate in this study. Your answers will be kept confidential and identified only by a code name for analysis purposes. Please answer the following questions according to the directions provided for each item. Feel free to approach the investigator if you have any questions.

****

1. **Code Name:** _______________ (eg., Mother's Maiden Name)

2. What **site** are you attending? (Mark one).

   ❒ 1. Fort Garry Campus

   ❒ 2. St. Boniface General Hospital

3. What is your **age**? ___________________ (Years)

4. What is your present **Marital Status**? (Mark one).

   ❒ 1. Legally married (and not separated) ❒ 2. Married (common-law)

   ❒ 3. Legally married and separated ❒ 4. Divorced

   ❒ 5. Widowed ❒ 6. Never married (single)

5. What year did you **graduate** from Grade 12? __________________ (Year)

6. Where did you **attend** Grade 12?

   ❒ A.1. Urban/city high school ❒ A.2. Rural/town high school

   ❒ B.1. Manitoba ❒ B.2. Other Province/Country, please specify __________________

7. When you entered the nursing program, what **type of student** were you? (Mark one).

- ❒ 1. High school graduate (no university experience)
- ❒ 2. Transfer student (previous university experience)

8. When you entered the nursing program, what **previous education** did you have? (Mark the one that is the most recent).

- ❒ 1. No post-secondary education
- ❒ 2. Licensed Practical Nurse Certificate
- ❒ 3. Registered Psychiatric Nurse Diploma
- ❒ 4. Bachelor's Degree (Science, Arts, etc.)
- ❒ 5. Other: Please specify ____________________

9. What was your grade in your pre-admission **Mathematics** course? (Mark one).

(Note: This question may apply only to High School Graduates).

Mathematics 300	❒ 1. A+	(91 - 100%)	❒ 2. A	(80 - 90%)
	❒ 3. B+	(75 - 79%)	❒ 4. B	(70 - 74%)
	❒ 5. C+	(65 - 69%)	❒ 6. C	(60 - 64%)

10. What was your grade in your pre-admission **English** course? (Mark one).

For High School Graduates ...

English 300	❒ 1. A+	(91 - 100%)	❒ 2. A	(80 - 90%)
	❒ 3. B+	(75 - 79%)	❒ 4. B	(70 - 74%)
	❒ 5. C+	(65 - 69%)	❒ 6. C	(60 - 64%)

For Transfer Students ...

English 100 level	❐ 7. A+	(91 - 100%)	❐ 8. A	(80 - 90%)
	❐ 9. B+	(75 - 79%)	❐ 10. B	(70 - 74%)
	❐ 11. C+	(65 - 69%)	❐ 12. C	(60 - 64%)

11. What was your grade in your pre-admission **Science** course(s)? (Mark one).

For High School Graduates ...

Chemistry 300:		Physics 300:	
❐ 1. A+	(91 - 100%)	❐ 1. A+	(91 - 100%)
❐ 2. A	(80 - 90%)	❐ 2. A	(80 - 90%)
❐ 3. B+	(75 - 79%)	❐ 3. B+	(75 - 79%)
❐ 4. B	(70 - 74%)	❐ 4. B	(70 - 74%)
❐ 5. C+	(65 - 69%)	❐ 5. C+	(65 - 69%)
❐ 6. C	(60 - 64%)	❐ 6. C	(60 - 64%)

For Transfer Students...

Chemistry 100:		Physics 100:	
❐ 7. A+	(91 - 100%)	❐ 7. A+	(91 - 100%)
❐ 8. A	(80 - 90%)	❐ 8. A	(80 - 90%)
❐ 9. B+	(75 - 79%)	❐ 9. B+	(75 - 79%)
❐ 10. B	(70 - 74%)	❐ 10. B	(70 - 74%)
❐ 11. C+	(65 - 69%)	❐ 11. C+	(65 - 69%)
❐ 12. C	(60 - 64%)	❐ 12. C	(60 - 64%)

12. What is your cumulative **Grade Point Average** on your most recent university transcript? (Mark one).

☐ 1. A+ (4.25-4.50)	☐ 2. A (3.75-4.24)
☐ 3. B+ (3.25-3.74)	☐ 4. B (2.75-3.24)
☐ 5. C+ (2.25-2.74)	☐ 6. C (2.00-2.24)

13. Please indicate below any **other university level mathematical-related courses** you have taken either before entering or during the nursing program (eg., Statistics, Calculus). If possible, identify the course name and number and name of institution from which you took the course(s).

____

____

****

Thank you for your participation.

Appendix J

Data Dictionary

VARIABLE NAME	VARIABLE LABEL	LEVEL	VALUES/ TAGS
Id	Subject number of student		1 - 33
Site	*Site of program attended*	*Nominal*	*1= Fort Garry Campus*
			2= St. Boniface Hospital
Age	Age of student	Ordinal	1 - n
Agegrp	**Age group of student**	**Ordinal**	**1= 19 - 27 years**
			2 = 32 - 49 years
Marstat	Marital status	Nominal	1= Legally Married
			2= Common Law
			3= Separated
			4= Divorced
			5= Widowed
			6= Never married (single)
Marstat2	**Marital status group**	**Nominal**	**1= Married**
			2= Not married / separated

VARIABLE NAME	VARIABLE LABEL	LEVEL	VALUES/ TAGS
Grad	*Number of years since high school graduation*	*Interval*	*1 -n*
Gradhs	**Number of years since high school - grouped**	**Interval**	**1= 2 - 5 years**
			2= 6 - 10 years
			3= 15 - 30 years
Gr12a	*Place of high school*	*Nominal*	*1= Urban/city high school*
			2= Rural/town high school
Gr12b	*Place of high school*	*Nominal*	*1= Manitoba*
			2= Not Manitoba
Type	Type of student	Nominal	1= High school student
			2= Transfer student
Preved	Previous Education	Nominal	1= No post-secondary
			2= Licensed Practical Nurse
			3= Reg. Psychiatric Nurse
			4= Bachelor's Degree
			5= Other (please specify)

VARIABLE NAME	VARIABLE LABEL	LEVEL	VALUES/ TAGS	
Prevedu	**Previous Education**	**Nominal**	**1= None**	
			2= Some related electives	
			3= Some non-related electives	
			4= Degree	
Stats	*Statistics Course*	*Nominal*	*0= Did not take statistics*	
			1= Took statistics	
Calculus	*Calculus Course*	*Nominal*	*0= Did not take calculus*	
			1= Took calculus	
Algebra	*Algebra Course*	*Nominal*	*0= Did not take algebra*	
			1= Took algebra	
Math	Pre-entrance Mathematics Grade	Ordinal	1= A+	4= B
			2= A	5= C+
			3= B+	6= C

VARIABLE NAME	VARIABLE LABEL	LEVEL	VALUES/ TAGS	
Math	**Pre-entrance Mathematics**	**Ordinal**	**1= C**	**4= B+**
	Grade (recoded)		**2= C+**	**5= A**
			3= B	**6= A+**
English	Pre-entrance English	Ordinal	High School Students:	
	Grade		1= A+	4=B
			2= A	5= C+
			3= B+	6= C
			Transfer Students:	
			7= A+	10=B
			8= A	11= C+
			9= B+	12= C
English	**Pre-entrance English**	**Ordinal**	**1= C**	**4= B+**
	Grade (collapsed & recoded)		**2= C+**	**5= A**
			3= B	**6= A+**

VARIABLE NAME	VARIABLE LABEL	LEVEL	VALUES/ TAGS	
SciChem	Pre-entrance Chemistry Grade	Ordinal	High School Students:	
			1= A+	4= B
			2= A	5= C+
			3= B+	6= C
			Transfer Students:	
			7= A+	10=B
			8= A	11= C+
			9= B+	12= C
SciPhi	Pre-entrance Physics Grade	Ordinal	High School Students:	
			1= A+	4=B
			2= A	5= C+
			3= B+	6= C
			Transfer Students:	
			7= A+	10=B
			8= A	11= C+
			9= B+	12= C

VARIABLE NAME	VARIABLE LABEL	LEVEL	VALUES/ TAGS	
Science	**Pre-entrance Science**	**Ordinal**	**1= C**	**4= B+**
	Grade (collapsed & recoded)		**2= C+**	**5= A**
			3= B	**6= A+**
GPA	Grade Point Average	Ordinal	1= A+ (4.25-4.50)	
			2= A (3.75-4.24)	
			3= B+ (3.25-3.74)	
			4= B (2.75-3.24)	
			5= C+ (2.25-2.74)	
			6= C (2.00-2.24)	
GPA	**Grade Point Average**	**Ordinal**	**1= C (2.00-2.24)**	
	(recoded)		**2= C+ (2.25-2.74)**	
			3= B (2.75-3.24)	
			4= B+ (3.25-3.74)	
			5= A (3.75-4.24)	
			6= A+ (4.25-4.50)	

VARIABLE NAME	VARIABLE LABEL	LEVEL	VALUES/ TAGS
Bmathsc	Basic Math Score	Ratio	0 - 20
Drugsc	Drug Score	Ratio	0 - 20
Totalsc	Total Score	Ratio	0 - 40

Notes:

1. The differentiation of categories for particular variables, in their original and recoded forms, were included in the Data Dictionary to clearly reflect the changes made from how the data were collected to how the data were organized to facilitate analysis.

2. Variables written in *italics* indicate added or new variables following feedback from faculty review during pilot study. These variables became part of the data analysis.

3. Variables written in **bold** indicate those that were recoded or grouped into response categories following a review of the data in terms of response distribution and frequencies. Three variables (English: High school vs Transfer students; SciChem: High school vs Transfer students; and, SciPhi: High school vs Transfer students) were collapsed into unidimensional variables (no distinction between high school and transfer student categories) given the incongruencies between these responses and responses to the "Type of Student" variable. Some variables remained essentially unchanged **(bold with same variable name)** except for a reordering of values.

4. Variables written in plain text (as in this note) indicate variables originally selected for analysis as reflected in the Research Questions.

Appendix M

Mathematics and Drug Calculation Test

Code Name: ___________ (Note: Must be the same as on Questionnaire)

Instructions for Students: Please answer the following questions showing computation of problems. **Calculators may not be used**. There are 40 questions. You will be allowed 1.5 minutes per question for a total of 1 hour.

A. Basic Mathematics		**Answer**
1. Write the following as a decimal:	six-tenths	1.
2. Write the following as a decimal:	five-hundredths	2.
3. Write the following in words:	2.50	3.
4. Add:	7614 + 2837 =	4.
5. Subtract:	7318 - 699 =	5.
6. Multiply:	271 x 43 =	6.
7. Add:	2/4 + 1/6 + 3/12 =	7.
8. Divide and reduce to lowest terms:	3/5 ÷ 1/3 =	8.
9. Which is smaller?	1/2 or 1/3	9.
10. Write the decimal 0.0001 as a fraction:		10.
11. Subtract:	11.34 - 9.7 =	11.
12. Divide:	2.8 ÷ 0.4 =	12.
13. Write the fraction 3/4 as a decimal:		13.
14. Complete the ratio:	3.5 : 10.5 = 2 : ___	14.
15. Complete the ratio:	1/3 : 1/2 = 4 : ___	15.

Page 2	Answer
16. Complete the ratio: 1.7% : 3.4% = 4.3% : ___%	16.
17. Each 30 ml of baby formula contains 20 calories. In a 180 ml feeding, a baby will consume _____ calories.	17.
18. A senior citizen tells you that a 375 gram jar of peanut butter costs $2.10. She wishes to compare the cost with a larger jar so you tell her that the cost of 100 grams of peanut butter from the 375 gram jar is $____.	18.
19. If 0.75 grams of a solute are dissolved in 3 litres of solution, 0.125 grams are found in ____ ml of solution.	19.
20. If a patient must take 2 penicillin tablets every 6 hours for a total of 10 days, a total of _____ tablets will be needed.	20.

End of Section A **Total:**

B. Oral Drug Calculation Section (p. 3) **Answer**

** **Please indicate the appropriate unit of measure in your answer.**

1. Ordered: Amoxicillin 250 mg oral. The Amoxicillin on hand contains 1 gm in each tablet. How many tablets should the patient receive? 1.

2. Ordered: Lanoxin elixir 0.2 mg oral. The drug on hand is Lanoxin elixir 100 mcg (ug)5 ml. How many ml should the patient receive? 2.

3. Ordered: Acetaminophen 500 mg oral. The medication is available in a liquid of 1 gm/10 ml. You would administer _____ ml. 3.

4. Your patient weighs 100 kg and is receiving Zofran. This drug's recommended dosage is 0.15 mg/kg. How much Zofran should be ordered for this patient? 4.

5. If a physician orders 10 ml of a certain medication to be given 3 times per day for 20 doses, you will need a total of ____ml. 5.

Page 4	Answer
6. Ordered: Atropine 0.4 mg. The label on the bottle reads 0.2 mg Atropine per tablet. How many tablets should be given?	6.
7. Ordered: 1 gm Gantrisin. The drug is available in 400 mg tablets. How many tablets should be given?	7.
8. Ventolin syrup is available in a liquid form labelled 2 mg/5 ml. How much Ventolin is contained in each ml ?	8.
9. Ordered: Ceftin 250 mg 2 times per day x 10 days. How many doses will be taken by the patient by the end of 10 days?	9.
10. A cortisone acetate solution contains 25.0 mg in 1.0 ml. If 80 mg of the solution is ordered, how much should be given?	10.

Page 5	Answer
11. Morphine 5 mg oral is ordered. You have on hand Morphine 2.5 mg tablets. How many tablets will you give?	11.
12. Penicillin G 400,000 U is ordered. You have on hand a solution of Penicillin G 100,000 U/5 ml. You will administer _____ ml.	12.
13. Your patient has an order for Digoxin 0.0625 mg. The tablet container available reads Digoxin 0.125 mg per tablet. How many tablets should your patient receive?	13.
14. Prednisone 80 mg is ordered. You have a stock supply of 5 mg, 10 mg, and 15 mg tablets. What combination and number of tablets will you give?	14.
15. You have poured 10 ml of liquid Tylenol. The bottle reads Tylenol 250 mg/5 ml. What dose of Tylenol have you prepared?	15.

16. Ordered: Digoxin 0.125 mg oral. You have on hand Digoxin 0.250 mg tablets. How many tablets will you give? 16.

17. Your patient weighs 16 kg. Ventolin 0.025 mg/kg is ordered. What dose of Ventolin will you give? 17.

18. You are to administer Tylenol 325 mg 2 tablets 3 times per day to your patient. What is the total dose your patient will receive in the day? 18.

19. K-Lor 40 mEq is dissolved in 240 ml of water. If your patient drinks only 1/2 of the water, he/she has received _____ mEq of K-Lor. 19.

20. A child is being given Tempra syrup for a fever. The syrup contains 100 mg of drug in 5 ml. In order to administer the required dose of 125 mg, the mother will need to give _____ ml of Tempra syrup. 20.

End of Section B **Total:**

Mathematics and Drug Calculation Test - Answer Key

Section A

1. 0.6
2. 0.05
3. two and five-tenths or two and one-half
4. 10,451
5. 6,619
6. 11,653
7. 11/12
8. 1 4/5 or 1.8
9. 1/3
10. 1/10,000
11. 1.64
12. 7
13. 0.75
14. 6
15. 6
16. 8.6%
17. 120 calories
18. $ .56
19. 500 ml
20. 80

Section B

1. 1/4 tablet
2. 10 ml
3. 5 ml
4. 15 mg
5. 200 ml
6. 2 tablets
7. 2.5 tablets
8. 0.4 mg
9. 20 doses
10. 3.2 ml
11. 2 tablets
12. 20 ml
13. 0.5 tablets
14. 5 x 15 mg and 1 x 5 mg tablets
15. 500 mg
16. 0.5 tablet
17. 0.4 mg
18. 1,950 mg or 1.95 gm
19. 20 mEq
20. 6.3 ml (6.25 ml)

Appendix N

Pilot Test Evaluation for Students

Now that you have completed the two instruments, the Demographic and Academic Status Questionnaire and the Mathematics and Drug Calculation Test, I would like you to help me evaluate these tools as well as the experience in general. Kindly answer the following questions:

A. Demographic and Academic Status Questionnaire Evaluation

1. Were the questions fair and appropriate? Yes____ No____

   If no, please explain: ________________________________

2. Were the questions worded clearly? Yes____ No____

   If no, please explain: ________________________________

3. Did you have any difficulty completing the Questionnaire?

   Yes____ No____

   If yes, please explain: ________________________________

4. Did you have enough time to complete the Questionnaire?

   Yes ____ No____

   If no, please explain: ________________________________

5. Do you have any suggestions on how to make the Questionnaire better?

   Yes ____ No____

   If yes, please explain: ________________________________

B. Mathematics and Drug Calculation Test Evaluation

1. Were the questions fair and appropriate? Yes____ No____

   If no, please explain: ________________________________

2. Were the questions worded clearly? Yes____ No____

   If no, please explain: ________________________________

3. Did you have any difficulty completing the Calculation Test?

Yes____ No_____

If yes, please explain: ____

4. Did you have enough time to complete the Calculation Test?

Yes ____ No_____

If no, please explain: ____

5. Were the number of questions on the Calculation Test reasonable in terms of testing what you know about basic mathematics and oral drug calculation?

Yes ____ No ____

If no, please explain: ____

6. Do you have any suggestions on how to make the Calculation Test better?

Yes ____ No____

If yes, please explain: ____

C. The Experience

1. Were the seating and space arrangements appropriate? Yes ____ No ____

If no, please explain: ____

2. Did you find any environmental conditions distracting such as lighting, room temperature, or noise? Yes ____ No____

If yes, please explain: ____

3. Was the time of day or day of the week appropriate for completing these instruments? Yes ____ No ____

If no, please explain: ____

Thank you for your participation and assistance in this project.

Appendix O

Faculty Expert Evaluation Tool

Thank you for agreeing to evaluate the "Demographic and Academic Status Questionnaire" and "Mathematics and Drug Calculation Test". These instruments are intended to measure the demographic and academic characteristics and basic mathematics and oral drug calculation skills of second year baccalaureate nursing students. The students who will be completing these instruments will be in their second term and will have taken content related to basic mathematics and oral drug calculations in their Nursing Skills course. Please review each item carefully and answer the following questions:

1. Are the instructions to the students clear and easy to understand?

   Demographic Questionnaire: Yes _____ No _____

   Basic Mathematics Section: Yes _____ No _____

   Drug Calculation Section: Yes _____ No _____

   Comments: ____

   ____

2. Are the questions worded clearly?

   Demographic Questionnaire: Yes _____ No _____

   Basic Mathematics Section: Yes _____ No _____

   Drug Calculation Section: Yes _____ No _____

   Comments: ____

   ____

3. Are the questions fair for this level of student?

   Demographic Questionnaire: Yes _____ No _____

   Basic Mathematics Section: Yes _____ No _____

   Drug Calculation Section: Yes _____ No _____

   Comments: ____

   ____

4. Is the time allotted to complete these tools, one and one half hours, reasonable?

Yes _____ No _____

Comments: ____

____

5. Do the questions measure the attributes of common demographic and academic status data as well as basic mathematics skill and oral drug calculation skill in a valid and reasonable manner?

Demographic Questionnaire: Yes _____ No _____

Basic Mathematics Section: Yes _____ No _____

Drug Calculation Section: Yes _____ No _____

Comments: ____

____

6. Is the number of questions on the calculation test reasonable in terms of adequately testing the intended attributes?

Basic Mathematics Section: Yes _____ No _____

Drug Calculation Section: Yes _____ No _____

Comments: ____

____

7. Do you have any suggestions for improvement of the instruments?

Demographic Questionnaire: Yes _____ No _____

Basic Mathematics Section: Yes _____ No _____

Drug Calculation Section: Yes _____ No _____

Comments: ____

____

____

____

Thank you very much for your assistance.

Appendix P

University of Manitoba
Faculty of Nursing
Ethical Review Committee Approval Form

The University of Manitoba

FACULTY OF NURSING
ETHICAL REVIEW COMMITTEE

APPROVAL FORM

Proposal Number N#95/52

Proposal Title: "A STUDY OF THE RELATIONSHIPS BETWEEN STUDENT NURSE CHARACTERISTICS AND CALCULATION ABILITY."

Name and Title of Researcher(s): LAURIE A. CLARK, RN, BSc., BScN
Master of Nursing Graduate Student
Faculty of Nursing University of Manitoba

Date of Review: DECEMBER 04, 1995.

APPROVED BY THE COMMITTEE: DECEMBER 04, 1995.

Comments: APPROVED WITH SUBMITTED CHANGES TO THE CHAIR.

Date: DECEMBER 12, 1995.

Linda J. Kristjanson, PhD, RN — Chairperson
Associate Professor
University of Manitoba Faculty of Nursing

Position

NOTE:
Any significant changes in the proposal should be reported to the Chairperson for the Ethical Review Committee's consideration, in advance of implementation of such changes.

Revised: 92/05/08/se

Appendix Q

Letter Requesting Access to Student Nurses

(J. MacKay, MN, Acting AED, BGH - Pilot Site) Date:________
(K. Neufeld, MN, Program Director, St. B.)
(Dr. J. Beaton, PhD, Dean, Faculty of Nursing, U of M)

Dear ____________:

As you may know, I am a student in the Master of Nursing Program at the University of Manitoba (U of M) and I am writing to request access to the students enrolled in the U of M Baccalaureate in Nursing Program (Fort Garry, St. Boniface, BGH site), for research purposes. The purpose of my study is to examine the relationships between demographic factors and admission criteria of the undergraduate program and student nurse calculation ability. I hope to further understand the ability of the admissions process in identifying those students who may demonstrate difficulty in the ability to correctly calculate drug dosages.

I would like permission to invite students who are enrolled in the second year of the program for the academic year 1995 - 1996 to participate in my (pilot study for the purposes of testing the instruments I plan to use in my thesis) study. Data collected from the students will include demographic information, academic grades achieved in the courses required for admission to the program, and performance scores on a Mathematics and Drug Calculation Test. All data sheets will be coded to ensure confidentiality and anonymity and no names will be used to identify the data. Data will be stored under lock and key in my home. Coded data will be shared with my Thesis Committee and analyzed from a group perspective. I have attached a copy of the research proposal for your referral.

I do not anticipate extensive involvement of the Faculty of Nursing staff other than collaboration with Course Leaders in order to plan appropriate dates and times of the orientation/recruitment and data collection sessions. (BGH pilot site: I would like permission to ask three faculty colleagues to review my instruments as part of the pilot study). Requirements of supplies and equipment of the Faculty of Nursing will be limited to the use of a seminar/classroom for the orientation and data collection process.

The study is being supervised by a Thesis Committee consisting of Professor Judith Scanlan, Faculty of Nursing, University of Manitoba; Dr. Sheila Dresen, Faculty of Nursing, University of Manitoba; and Dr. Alexander Gregor, Centre for Higher Education Research & Development, University of Manitoba. (BGH pilot site: I plan to enlist the services of a Research Assistant to conduct the sessions for this pilot study in order to protect the identity of the students and to avoid the element of coercion or feeling of obligation on the part of the students to participate as a result of my position as a Faculty Member. The Research Assistant will be someone who does not and will not know the students in the immediate future; perhaps someone from the Department of Nursing & Health Studies.) The study has been approved by the Ethical Review Committee of the Faculty of Nursing, University of Manitoba. A copy of this approval is attached.

Data collection is planned to begin in February or March, 1996 and will be completed by the end of the term. A copy of the results will be made available to the Faculty of Nursing upon request. If you require further information regarding this study please contact me at (204) 726-2369 or (204) 727-3251. I would be pleased to meet with you to discuss my project further if you wish.

Kindest Regards,

Laurie Clark, RN., BScN.

Appendix R

Letters of Permission to Proceed with Study

BRANDON GENERAL HOSPITAL
150 McTavish Avenue East Brandon, Manitoba R7A 2B3

January 19, 1996

Laurie Clark
46 Wascana Drive
Brandon, MB.
R7B 3B4

Dear Ms. Clark:

Your request for approval to proceed with the implementation of a Research Project, "A Study of the Relationships Between Student Nurse Characteristics and Calculation Ability", was presented to Senior Management at their meeting on January 8, 1996.

I am pleased to advise you that the Research Project was approved at this meeting and you may proceed accordingly.

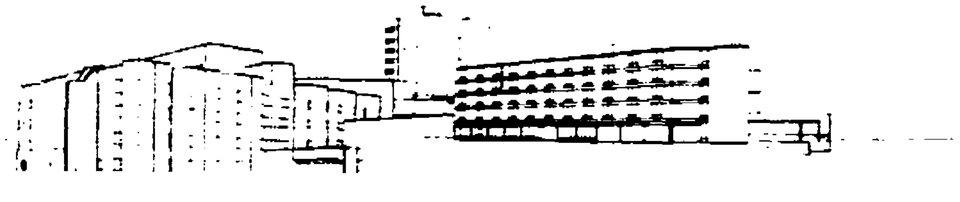
Good luck with your project.

Yours truly,

Larry E. Todd
Executive Director

/mt

cc: D. Kinley
K. Hyndman



REQUEST FOR ACCESS TO STUDENTS/FACULTY IN THE FACULTY OF NURSING FOR STUDENT PROJECTS

1) Name: LAURIE CLARK

2) Address: 46 WASCANA DR
BRANDON MB
R7B3B4

Year in Program: final

Phone Number: 727-3251

3) Review is requested to fulfil the following course requirements: thesis study

4) Academic Program: Masters in Nursing

5) Faculty Advisor: Judith Scanlan.

Department: Nursing Faculty.

6) Title of Proposed Project: A Study of the Relationships Between Student Nurse Characteristics and Calculation Ability.

7) Purpose of Proposed Project: to examine the potential of identify nursing students (upon admission to the U of M undergraduate program) who may demonstrate difficulty in the area of dr dosage calculation.

8) Anticipated Starting Date: as soon as possible

Anticipated Date of Completion: end of term 1996 winter

9) Signature of Faculty Sponsor: please see ERC form attached. checklist.

Date: January 31/96

I understand if the data from the project are employed beyond the purpose of fulfilling a class requirem permission must be obtained from the participants.

10) Signature of Student: Laurie Clark.

Date: January 31/96.

11) Faculty Approval [signature]

Date: 31.1.96.

ATTACH A COPY OF THE OUTLINE OF THE PROJECT, FOLLOWING THE PROVI GUIDELINES.

K:\NRS\GNRL\ACCESS.MS

Hôpital général St-Boniface General Hospital

February 1, 1996

Laurie Clark
46 Wascana Drive
Brandon, Manitoba
R7B 3B4

Re: Access to SBGH for Study Entitled:
A STUDY OF THE RELATIONSHIPS BETWEEN STUDNT NURSE CHARACTERISTICS AND CALCULATION ABILITY

Dear Laurie Clark:

I am pleased to inform you that your research access request has been approved. You may proceed with your study on the understanding that:

1) any significant changes in your proposal will be submitted to my attention prior to implementation;
2) you review the enclosed policy on confidential information and then sign and return the enclosed Pledge of Confidentiality;
3) you inform us when your data collection is complete. This information helps us coordinate research access requests and minimize competing demands of research study protocols on patients and nursing staff time;
4) you inform us of the funding status of your study.

We may call you to make presentations to hospital staff about your research at our Brown Bag Research Luncheons held monthly. Upon completion of your study, we request that you provide us with a brief summary of your final report.

Thank you for selecting St. Boniface as the site for recruiting participants for your study. Please feel free to contact me with your questions or concerns. Should you encounter any site-related difficulties during the course of your study, I would appreciate being notified of these.

All the best with the completion of your study.

Sincerely,

M Jones for Katherine Stansfield

Katherine Stansfield, R.N., M.N.
Nursing Program Development
and Evaluation Specialist
Tel. (204) 235-3480

KS/mj

Encl: Confidential Policy & Pledge

7\Access\Letters\Clark.J96

409 Taché, Winnipeg, Manitoba, Canada R2H 2A6
Tel (204) 233-8563 Fax (204) 231-0640

A Grey Nun Corporation/Une corporation des Soeurs Grises
Affiliated with the University of Manitoba/Affilié à l'Université du Manitoba

IMAGE EVALUATION TEST TARGET (QA-3)

150mm

6"

APPLIED IMAGE, Inc
1653 East Main Street
Rochester, NY 14609 USA
Phone: 716/482-0300
Fax: 716/288-5989