THE USE OF COMPUTER-ASSISTED INSTRUCTION TO TEACH CALCULATION AND REGULATION OF INTRAVENOUS FLOW RATES TO BACCALAUREATE NURSING STUDENTS

By

Donna Elliott Larson

A DISSERTATION

Submitted to
Michigan State University
in partial fulfillment of the requirements
for the degree of

DOCTOR OF PHILOSOPHY

Department of Administration and Higher Education

1981

ABSTRACT

THE USE OF COMPUTER-ASSISTED INSTRUCTION TO TEACH CALCULATION AND REGULATION OF INTRAVENOUS FLOW RATES TO BACCALAUREATE NURSING STUDENTS

By

Donna Elliott Larson

The purpose of this study was to determine if a computer simulation developed by this investigator could effectively and efficiently teach the calculation and regulation of intravenous flow rates, a basic nursing skill with both psychomotor and cognitive components. The subjects were 48 basic baccalaureate nursing students enrolled in the Nursing II course at Grand Valley State Colleges in Allendale, Michigan, during Winter Semester, 1981.

Two questions were addressed. First, was the computer simulation as effective as a laboratory simulation (the conventional teaching methodology) for instructing students? Second, was the computer simulation more efficient in terms of student learning-time and cost than the laboratory simulation?

All students were provided with initial instruction on calculating and regulating intravenous flow rates. The experimental group (N=24) practiced the skill using the computer simulation on TRS-80 Model I microcomputers;

the control group (N=24) practiced the skill using actual intravenous equipment in the skills laboratory simulation.

Students were tested on their abilities to calculate an intravenous flow rate and then to regulate an actual intravenous system so that it delivered the prescribed fluid volume. All students were tested both immediately following the initial treatment and ten weeks later.

Data were analyzed with analysis of covariance and analysis of variance. The conclusions based upon the findings were: (1) when scoring criteria accommodated the use of either of two acceptable calculation methods, computer learners were able to calculate an intravenous flow rate and regulate an actual intravenous system as well as laboratory learners; (2) computer learners were able to complete significantly more practice problems in significantly less time than laboratory learners; (3) when costs of computer hardware and software were not included, and when instructional and research costs were combined, the cost per student for computer learners ($.94) was less than half the cost per student for laboratory learners ($2.17); and (4) when projected costs of computer hardware and software were amortized over three years, and when instructional costs were separated from research costs, the cost per student for computer learners ($1.44) remained less than the cost per student for laboratory learners ($2.01).

To my husband, Harold,
who shared with me his
knowledge and love, so
that I might know and
enjoy success in this
endeavor.

ACKNOWLEDGMENTS

I thank each member of my doctoral guidance committee, Richard Featherstone, George Sargent, Howard Hickey, and Norman Bell. I particularly thank Dr. Hickey, who guided my progress through my academic program, and Dr. Bell, who guided my development of this dissertation.

I am grateful to all of my faculty colleagues in the School of Nursing at Grand Valley State Colleges. Their professional cooperation and personal support will always be appreciated. I especially thank my five faculty colleagues and friends who gave so much of their time and expertise while serving as observers and proctors during data collection: Janet Banta, Emily Bielak, Ruth Hager, Sue Perkins, and Joan Shedd.

I also thank the students in the 1982 graduating class of the School of Nursing at Grand Valley State Colleges for their patience and enthusiasm while participating as subjects in this study.

Furthermore, I am grateful to Necia Black, who provided me with statistical and methodological assistance.

Finally, I thank my family. I am grateful to my husband, Harold, and our daughters, Katherine and Elizabeth; they gave so much of themselves to and for me.

TABLE OF CONTENTS

Chapter		Page

Chapter Page

LIST OF TABLES

LIST OF APPENDICES

CHAPTER I

INTRODUCTION

This chapter is organized into eight sections: (1) identification of the problem; (2) purpose of the study; (3) importance of the study; (4) research questions and hypotheses; (5) definition of terms; (6) research objective; (7) limitations of the study; and (8) organization of the dissertation. Each section is discussed separately.

Identification of the Problem

The correct performance of basic nursing skills is an essential component of professional nursing practice. Nurses must perform urinary bladder catheterizations, change sterile dressings, irrigate wounds, suction tracheostomies, measure vital signs, calculate and administer fractional medication dosages, calculate and regulate intravenous flow rates, and so on. Obviously, the mastery of such skills is very important to the safety and well-being of patients. The teaching of basic nursing skills is, therefore, a significant component of nursing education curricula.

One of these essential nursing skills is the calculation and regulation of intravenous (i.e. IV) flow rates. Before a student nurse can safely apply this skill to the care of patients in clinical settings, the skill must be taught to the student, opportunity must be provided for supervised practice, and individual student competency must be verified. This skill is usually taught in a controlled laboratory setting, often called a "skills laboratory". The skills laboratory generally contains necessary actual equipment and supplies and serves as an environmental simulation of the clinical practice setting.

When teaching the calculation and regulation of intravenous flow rates in a skills laboratory, a faculty member usually presents the essential elements of the skill and then demonstrates the skill to a large group of students. Students then break into small groups to practice. The faculty member circulates among the groups, supervising individual performance, answering questions, and providing feedback. Students practice the skill during their assigned laboratory times and on their own, when the skills laboratory is not being used by other students or for other instruction.

Such laboratory instruction is usually cumbersome, time-consuming, and costly. Students and faculty spend many hours in the skills laboratory; however, major instructional problems still occur. Because faculty may be "spread too thin" to be aware of individual student needs, students may not receive needed feedback and additional instruction. Moreover, students themselves may not even be aware that they are performing a skill incorrectly, thus learning something that has to be unlearned later. If a student does require additional instruction and practice, it is often logistically difficult to provide. Problems with availability of faculty, skills laboratory, and student study time, in addition to laboratory equipment costs and set-up requirements, often make such additional needed student instruction and practice very difficult to schedule and provide.

This situation presents an opportunity for an alternative instructional strategy that would enable students to learn independently and reinforce their basic nursing skills, without the problems inherent in the usual skills laboratory. It appears obvious that such an alternative could have a significant impact on both the quality of nursing education and health care for the public.

Purpose of the Study

Computer-assisted instruction (i.e. CAI) may provide such an alternative instructional strategy for the teaching of selected basic nursing skills. Previous research in health professional education has demonstrated that computer-assisted instruction is effective and learning-time efficient for teaching cognitive and problem-solving skills; however, very little of this research has been conducted in nursing education. Moreover, no reports of research have been found on the use of computer-assisted instruction for the teaching of basic skills which have a psychomotor component, either in nursing or in other health professional education.

The purpose of this study was to determine if a computer simulation could effectively and efficiently teach the basic nursing skill of calculation and regulation of intravenous flow rates. This purpose was delineated into two questions. First, was a computer simulation as effective as a laboratory simulation for instructing students in the calculation and regulation of intravenous flow rates? Second, was a computer simulation more efficient in terms of learning-time and cost than a laboratory simulation for the teaching of this skill?

Importance of the Study

The basic nursing skill of calculating and regulating intravenous flow rates has two components. The student must first use available patient and equipment data in performing three interrelated and sequential mathematical calculations. These calculations determine the flow rate of fluid to be intravenously administered to the patient. The student must count the number of drops per minute infusing into the patient and then adjust the equipment so that the system actually delivers fluid into the patient at the previously calculated rate. The skill, therefore, has both cognitive and psychomotor aspects.

The calculation and regulation of intravenous flow rates is an important and essential basic nursing skill; this skill has been identified as one in which all student nurses should be proficient prior to their graduation from their basic educational programs (Moore & Grams, 1980; Sweeney, Regan, O'Malley, & Hedstrom, 1980). If either the calculation is incorrect or the regulation is inaccurate, serious consequences can result for the patient. For example, dehydration or overhydration can occur. Moreover, if the intravenous fluid contains medication, as is frequently the case, serious medication dosage errors can result.

Because this skill is important, students should be provided with ample opportunity to learn and repeatedly practice it. Such opportunities are currently provided on a limited basis through costly and time-consuming laboratory simulations. It would be an advancement for nursing education if a computer simulation were found to be less costly and time-consuming but equally or more effective in teaching this basic nursing skill.

Research Questions and Hypotheses

Researchers in nursing and other health professional education have previously demonstrated the effectiveness and efficiency of computer-assisted instruction for teaching cognitive and problem-solving skills. The purpose of this study was to determine if a computer simulation could be used to effectively and efficiently teach the calculation and regulation of intravenous flow rates, a basic nursing skill with both cognitive and psychomotor components.

Two general research questions needed to be answered. First, was the computer simulation as effective as the conventional laboratory simulation for teaching this nursing skill? Second, when compared to the laboratory simulation, was the computer simulation more efficient in teaching this skill?

Research Questions

This study attempted to answer the following research questions:

1) Was the computer simulation as effective as the laboratory simulation for teaching the calculation and regulation of intravenous flow rates? Specifically, were students who practiced the skill with the computer simulation able to calculate flow rates as correctly and regulate actual flowing intravenous systems as accurately as

students who practiced the skill with the conventional laboratory simulation?

2) Was the computer simulation more efficient than the conventional laboratory simulation for teaching the calculation and regulation of intravenous flow rates? Specifically, did students spend less time learning the skill with the computer simulation than with the laboratory simulation?

Research Hypotheses

After practicing with either the computer simulation or the laboratory simulation, nursing students were tested on their ability to calculate and regulate intravenous flow rates. It was hypothesized that:

1) The mean flow rate calculation score for the computer learners would be greater than that of the laboratory learners on an immediate posttest.

2) The mean flow rate calculation score for the computer learners would be greater than that of the laboratory learners on a delayed posttest.

3) The mean flow rate regulation score for the computer learners would be greater than that of the laboratory learners on an immediate posttest.

4) The mean flow rate regulation score for the computer learners would be greater than that of the laboratory learners on a delayed posttest.

5) The mean time spent in learning would be less for the computer learners than for the laboratory learners.

6) The mean number of learning scenarios experienced by the computer learners would be greater than that of the laboratory learners.

Definition of Terms

For the purposes of this study, the following definitions were used:

Basic nursing skills: Essential components of beginning-level professional nursing practice. Basic nursing skills have various combinations of components: psychomotor, cognitive, and affective. The basic nursing skill focused upon in this study was the calculation and regulation of intravenous flow rates, a skill which has both psychomotor and cognitive components.

Baccalaureate nursing students: Students enrolled in the Nursing II course at Grand Valley State Colleges, Allendale, Michigan, during Winter Semester, 1981.

Computer simulation: The computer program, "Calculation and Regulation of Intravenous Flow", authored by this investigator and programmed for a TRS-80 Model I microcomputer. The program presented the student with a randomly generated hypothetical patient intravenous fluid calculation problem. After the student solved all segments of the calculation problem, the computer simulated an intravenous system with flowing fluid; a graphical representation was presented on the video display screen. The student, by pressing specified keys on the computer keyboard, regulated the flow of the simulated intravenous system to correspond to the previously calculated rate. Throughout the program, appropriate feedback and additional instruction were provided to the student when needed.

Laboratory simulation: The skills laboratory learning exercise wherein the student was presented with a hypothetical patient intravenous fluid calculation problem. After the student solved all segments of the calculation problem, he or she then manipulated equipment on an actual intravenous system with flowing fluid so that the flow rate corresponded to the previously calculated rate. A nursing faculty member circulated among small groups of four to five students, providing feedback and additional instruction as needed. This laboratory simulation was the conventional instructional strategy used in this setting for teaching students to calculate and regulate intravenous flow rates.

Laboratory learners: Those students who used the skills laboratory simulation to practice the calculation and regulation of intravenous flow rates.

Computer learners: Those students who used the computer simulation to practice the calculation and regulation of intravenous flow rates.

Calculation of intravenous (IV) flow rates: The use of patient and equipment data in the application of three interrelated and sequential mathematical formulas for deriving: (a) the volume of fluid to be infused per hour; (b) the volume of fluid to be infused per minute; and (c) the number of drops to be infused per minute.

Regulation of intravenous (IV) flow rates: The adjustment of an intravenous fluid delivery system so that its flow rate corresponded to a prescribed rate.

Calculation score: The total score on the calculation section of the Immediate Posttest Evaluation Form or the Delayed Posttest Evaluation Form.

Regulation score: The total score on the regulation section of the Immediate Posttest Evaluation Form or the Delayed Posttest Evaluation Form.

Immediate posttest: The assessment of student ability to calculate and regulate intravenous flow rates immediately following the students' experiences with either the laboratory simulation or the computer simulation during the regularly scheduled skills laboratory session on calculating and regulating intravenous flow.

Delayed posttest: The assessment of student ability to calculate and regulate intravenous flow rates ten weeks after the initial student experiences with either the laboratory simulation or the computer simulation.

Number of learning scenarios: The total number of hypothetical clinical intravenous fluid calculation and regulation problems that a student reported he or she had completed in either the computer simulation or laboratory simulation. Each student was asked to record the completion of a problem on the Student Practice Report; the Reports were submitted to the investigator and tallied at the end of the ten weeks.

Research Objective

In addition to the research questions previously cited, this study also attempted to determine and compare the cost per student using the computer simulation with the cost per student using the conventional laboratory simulation. Cost per student was defined as the average cost needed for each student's learning experiences. Costs were determined by purchases of consummable equipment and supplies and faculty time used in setting up, dismantling, and instructing in the intravenous calculation and regulation portions of regularly scheduled, impromptu individual instruction, and "open practice sessions" of the laboratory and computer simulations.

Limitations of the Study

The findings of this study are limited to the baccalaureate nursing students enrolled in the Winter, 1981, Nursing II course at Grand Valley State Colleges. These students volunteered to participate in this study. The findings may not be generalizable beyond this group. However, beginning level nursing students have in common the need to learn how to correctly calculate and accurately regulate intravenous flow rates. Therefore, the findings of this study should be of interest to other nurse educators.

Because of the potential for cross-contamination between treatment groups throughout the ten week duration of this study, subjects were assigned to treatments on the basis of intact groups. A limitation of this study, therefore, concerns this non-random assignment of subjects to treatment groups. It could be argued that the findings of this study could be attributed to characteristics of the groups rather than to the treatment. To compensate for this limitation, those characteristics that were believed to potentially have the greatest influence upon the dependent variables were identified before the study began. These characteristics were then measured and used as covariates during data analysis. In this way, an attempt was made to equalize the differences between groups.

A limitation with the instruments used in this study concerns the self-report nature of some of the data. Whenever the source of data is self-report, there is a potential problem with inaccuracy. Subjects may over- or under-estimate, forget, or deliberately distort data. In this study, an attempt was made to counteract this limitation by providing orientation sessions for subjects; self-report data collection procedures were described, and the importance of accurate recording of data was stressed.

A limitation concerning both the instruments and the treatments used in this study is the fact that they were all developed by this investigator. Therefore, the instruments and treatments were not subject to large-scale testing, refinement, and evaluation by outside experts.

Another limitation of this study concerns the treatments. Prior to the treatments, all subjects were exposed to a required programmed instruction text on mathematics for medication dosage calculations. The last chapter of this text contained instruction on two methods for calculating intravenous flow rates. This exposure to the programmed text was an unplanned part of this study; it constituted an additional treatment (in series, not in parallel) for learning to calculate intravenous flow rates.

Because of this augmentation of the programmed instruction on calculating intravenous flow rates, it was impossible to determine the effect that either of the planned treatments alone had on students' abilities to perform the calculations (the cognitive part of the skill). What was measured in this study regarding intravenous flow rate calculation was actually the combination effect of the treatment plus the programmed instruction text. However, because the planned treatments did represent the initial instruction for regulating intravenous flow rates, the effect that these planned treatments had on students' abilities to regulate intravenous flow rates (the psychomotor part of the skill) was able to be determined.

Organization of the Dissertation

This dissertation is organized into five chapters. The contents of the remaining four chapters are described.

Chapter II provides a review of the literature related to the two major foci of this study: the basic nursing skill of calculating and regulating intravenous flow rates, and the use of computer-assisted instruction in nursing education.

Chapter III presents the design, methodology, and procedures used in this study.

Chapter IV reports and discusses the results of the analysis of data.

Chapter V provides a summary of findings and conclusions. Limitations of the study and recommendations for future research are discussed.

CHAPTER II

REVIEW OF RELATED LITERATURE

The review of related literature is organized under two main headings, corresponding to the major themes in this study. These major themes are: (a) calculation and regulation of intravenous flow rates; and (b) computer-assisted instruction in nursing education. A third section provides a summary of the literature review.

Calculation and Regulation of Intravenous Flow Rates

Basic nursing skills are essential components of professional nursing practice. A nurse must use basic skills frequently while caring for patients, particularly those in acute care settings. Nursing education has an obligation to prepare nurses who are competent beginning level practitioners. The teaching of basic nursing skills is, therefore, an important part of any nursing education program.

A basic nursing skill consists of at least two parts: a psychomotor (or manipulative skill) component and a cognitive component. Examples of basic nursing skills include such activities as medication dosage calculation and administration, wound care, urinary bladder catheter insertion and care, insertion and care of naso-gastric tubes, measurement of vital signs, and calculation and regulation of intravenous flow rates.

Moore and Grams (1980) reported the results of a survey of Arizona hospitals conducted by the Arizona Hospital Association and the Arizona Society for Nursing Service Administrators. Nursing service administrators were asked to submit listings of basic nursing skills which were viewed in their hospitals as essential for newly graduated nurses to possess. These listings were then combined to form an inventory of essential nursing skills for new graduates in Arizona. The inventory was organized into three levels of basic skills. The calculation and regulation of intravenous flow rates was classified as a Level I skill (a task that newly graduated nurses were expected to perform safely, without supervision, following routine orientation to the hospital).

Data about the hospitals participating in the survey were not reported, nor were the number, complete listing, or weighting of the skills contained in the inventory. Nursing educators were minimally involved with the compilation of the inventory; therefore, the inventory of basic nursing skills reflected the values of nursing practitioners, not necessarily those of nursing educators.

Sweeney, Regan, O'Malley, and Hedstrom (1980) recently completed a study to identify those basic nursing skills which were viewed by both nursing educators and nursing practitioners as essential for all new baccalaureate graduates. Fifteen full-time undergraduate nursing faculty from a baccalaureate program and fifteen nursing practitioners (head nurses and unit instructors) from a large university-affiliated teaching hospital in Boston were selected as subjects. The nursing faculty were randomly selected. However, the nursing practitioners were specifically chosen because of their previous experiences with newly graduated baccalaureate nurses; the investigators believed that it was important that all nursing practitioners in the study were familiar with the skill level of newly graduated nurses.

Through the use of a modified Q-sort procedure, the subjects categorized 291 basic nursing skills into four categories: essential, bonus, graduate, and non-nursing. Ninety-one skills were identified as essential for new graduates by both faculty and practitioners. One of these identified essential skills was the calculation and regulation of intravenous flow rates. Both nursing educators and nursing practitioners agreed that all newly graduated baccalaureate nurses should be competent in the performance of this and ninety other basic nursing skills.

The large number of basic nursing skills viewed as essential, in addition to an extensive amount of cognitive, problem-solving, and affective aspects of learning also considered essential, presents a problem for nursing education. The problem is how best to manage the teaching-learning process in such a way that the students are able to learn the essential elements of professional practice in the limited time available in the educational programs.

In a recent article about nurse-midwifery education, Rhode, Kauchak, and Eggen (1980) stated that a major educational problem was how to teach the essential basic skills "in a manner that is efficient in terms of faculty teaching time, provides for maximum skill acquisition in terms of safety and accuracy of performance in the shortest period of time, allows the student to make the most of limited clinical experiences, minimizes student anxiety, and frees the student to move on to learning the complexities of management of patient care" (p. 27). Although the authors were speaking of graduate level nursing education, their words are equally or more applicable to undergraduate nursing education, where the students do not have a broad base of professional knowledge or experience upon which to draw.

In summary, the calculation and regulation of intravenous flow rates is one of the many basic nursing skills considered essential by both nursing educators and practitioners. A significant problem for nursing education is the large number of essential nursing skills that students must learn in addition to the cognitive and affective aspects of professional nursing practice, within educational programs of limited duration.

Computer-Assisted Instruction in Nursing Education

Computer-assisted instruction is an instructional strategy that can be used to decrease the problem of too much to learn in too little time. Computer-assisted instruction has been used for the last twenty years or so in various capacities and by various disciplines. The remainder of this chapter discusses: (1) general research findings about computer-assisted instruction; (2) specific research findings about computer-assisted instruction in nursing education; (3) advantages for the use of computer-assisted instruction in nursing education; and (4) the use of microcomputers for computer-assisted instruction. Each topic is discussed separately; a summary is provided.

General Research Findings About CAI

Ludwig Braun (1980) summarized research that has been conducted concerning the effectiveness and efficiency of computer-assited instruction in elementary and secondary education. He stated, "when the computer is used to aid instruction in the elementary- and secondary-school level, the achievement and/or the time reduction to learn materials is significantly improved" (Braun, 1980, p. 10). After assessing studies that cut across all levels of education, Braun concluded, "The majority of these studies show savings in the learners' time to complete a course of study (as much as 50% savings), greater efficiency in terms of achievement per unit of time, improved skills, and the provision of instruction not previously available by the conventional method" (p. 108).

Kulik, Kulik, and Cohen (1980) used meta-analytic techniques to integrate findings from 59 studies which compared computer-based college teaching with conventional college instruction. Five major outcomes described in each of the 59 studies were compared: student achievement as measured on a unit or final examination, the correlation between student aptitude and achievement in college courses, course completion, student attitudes, and time required for instruction.

"This meta-analysis showed that for the most part the computer has made a small but significant contribution to the effectiveness of college teaching. In the typical implementation, computer-based instruction raised examination scores by about three percentage points, or about one-quarter standard deviation. . . . The boost that computer-based teaching gave to student achievement was about as noticeable in high- and low-aptitude students as it was in average students. . . . Computer-based teaching also had small and positive effects on attitudes of college students toward instruction and toward the subject matter that they were taught. . . . The most dramatic finding in this meta-analysis, however, is related to instructional time. In every study in which computer-based instruction substituted for conventional teaching, the computer did its job quickly - - - on the average in about two-thirds the time required by conventional teaching methods" (Kulik, et al., pp. 537-538).

As a first step in this study, the investigators conducted computer searches of eight bibliographic data bases in order to compile an initial listing of over 500 titles of studies comparing computer-based instruction with conventional instruction in college classrooms. Unfortunately, the bibliographic data bases searched did not include MEDLINE, a primary data base for health care related literature. Therefore, this study did not include those studies specific to the use of computer-based instruction in the education of health professionals. However, the investigators reported that their findings "were similar among 'hard' and 'soft' disciplines, in pure and applied areas, and in life studies and other content areas. Findings were also the same for courses at different levels" (Kulik, et al., 1980, p. 539).

Specific Research in the Use of CAI in Nursing Education

Although computer-assisted instruction presents many advantages for nursing education, it has been used very little, especially when compared to the relatively heavy use in the education of other health professionals. Kearsley (1976) reported that the health professions were second only to mathematics in the number of computer-assisted instruction programs classified in indexes between 1970 and 1976. However, a survey conducted in 1972 reported that of 352 school of nursing and allied health responding, only 17 were using any computer-assisted instruction. This same survey reported that of 362 computer-assisted instruction programs listed for health professions education, only 54 were categorized as nursing or allied health programs (Brigham & Kamp, 1974). Furthermore, the latest Index to Computerized Teaching in Health Sciences listed only 32 programs designed for nursing (Kamp, 1975).

Teaching cognitive skills with CAI. Even though the documented use of computer-assisted instruction in nursing education is small, there has been some research on its effectiveness in teaching cognitive skills. Bitzer, Boudreaux, and Avner (1973) used a pretest-posttest control group with matching experimental design to compare 22 computer-assisted instruction lessons on PLATO (Programmed Logic for Automatic Teaching Operations) with the traditional lecture course on maternity nursing at Mercy

Hospital School of Nursing in Urbana, Illinois. For the 22 students who participated in the study, there was no significant difference in learning as measured by the course final exam scores. However, the computer learners spent a mean time of 54 hours on the PLATO lessons, whereas the traditional learners spent a mean time of 84 hours attending classroom lectures.

Furthermore, after graduation, 68% of the computer learners scored above average on the maternity nursing portion of the Illinois State Board of Nursing Examination for licensure. Unfortunately, the researchers did not report how the graduates who had been in the traditional learning group performed on the same exam; therefore, the reader could not judge the relative long-term retention effects of the computer-assisted instruction over the traditional teaching method. Another limitation of this study was the small sample (N = 22), drawn from a population of unreported size.

This particular small study was only one part of a large project at the University of Illinois, Urbana. Over the course of seven years, more than 300 student nurses from local diploma and associate degree programs used the 22 maternity nursing and 11 pharmacology lessons written and taught on the University of Illinois PLATO system.

Kirchhoff and Holzemer (1979) studied 100 nursing students at the University of Illinois, Chicago, to determine the learning effectiveness of a PLATO computer-assisted instruction program on post-operative nursing care. A modified posttest-only design was used. Students selected whether they would be in the experimental group (work through the PLATO program) or the control group (where a written assignment covering the same material was assigned). All 100 students chose to be in the experimental group; therefore, no control group was used.

Even though the authors called their study a posttest-only design, they administered both a pretest and posttest to the students. The authors did not discuss their rationale for administering a pretest in a posttest-only design. The Kuder-Richardson reliability coefficients were low (.37 for the pretest and .42 for the posttest). The authors accepted these low reliability coefficients, however, because of the small number of items (N = 15) on each test. The data were analyzed, and it was found that students did learn the material through use of the PLATO program.

These researchers also attempted to identify those characteristics of students who learned the most from the PLATO program. Through the use of multiple regression analysis, it was determined that students who learned most with PLATO: (a) had prior experience with PLATO; (b) had concurrent clinical experiences with surgical patients; (c) scored higher on "active experimentation" on a learning styles inventory; and (d) indicated higher interest in learning with computer-assisted instruction.

A study conducted by Rubinson and Robinson (1977-1978) used a pretest-posttest control group experimental design to compare the teaching effectiveness of four PLATO computer-assisted instruction lessons on general first aid with the conventional textbook-lecture format. Students enrolled in the Standard First Aid Course at the University of Illinois, Champaign, were randomly assigned to either the experimental (PLATO) or the control (textbook-lecture) group. The experimental group completed each PLATO lesson and then met with the instructor four times each week. The control group read the textbook and met with the same instructor for 50 minute sessions, four times each week. Alternate forms of a standardized test were used as the pretest and posttest.

The investigators found that: (a) computer learners did as well on the posttest as the traditional learners; (b) computer learners used one-half the amount of learning time as the traditional learners; and (c) the department incurred no additional instructional costs for the computer learners. A limitation of this study was that the role of the instructor in relation to both the experimental and control groups was unclear. Furthermore, the amount of time the PLATO students spent with the instructor was not specified. Generally, the descriptions of the teaching-learning activities in both groups were unclear.

Huckabay, Anderson, Holm, and Lee (1979) studied the effect of computer-assisted instruction versus lecture-discussion on cognitive learning and transfer of learning in 31 graduate nurse practitioner students at the University of California, Los Angeles. A pretest-posttest control group experimental design was used; the content area was the clinical management of hypertensive patients. All students received the same lecture-discussion instruction. In addition, the students in the experimental group experienced a computer-assisted instruction program which consisted of 15 clinical case studies. The four-hour program provided a clinical simulation in which the student interacted with the "patient" to gather data by interview and by access to physical examination results and laboratory reports. The student then made a nursing diagnosis and planned the nursing care. Feedback and additional instruction were provided when needed. The control group was assigned extra readings on the clinical management of hypertensive patients.

All students were pretested and posttested with two exams; one was designed to measure cognitive learning and the other to measure transfer of learning. No significant differences between the groups in either cognitive learning or transfer of learning were found. However, there were significant differences between the groups in three specific posttest item scores; both groups learned significantly, but only the experimental group transferred learning significantly on these three items.

A limitation of this study was the unaccounted for confounding effect of the number of hypertensive patients the students actually cared for prior to and during the study. Additionally, some unanswered questions concerned the nature of the assigned readings for the control group. Were these readings equivalent in nature to the content of the computer program? Further, did the control group students actually complete the readings?

Valish and Boyd (1975) conducted a study to determine if three Ohio State University computer-assisted instruction programs on medical-surgical nursing and nursing management could be used for verifying and augmenting prior clinical knowledge of employed registered nurses. A posttest-only control group design was used. One-hundred, twenty-four registered nurses were randomly selected from the nursing staff of George Washington University Medical Center in Washington, D.C.; they were assigned to either the experimental or the control group. The experimental group used the three computer-assisted instruction programs and was then posttested. The control group was posttested only.

Posttest performance showed no significant differences between the two groups. A serious limitation of this study was the fact that the three computer-assisted instruction programs used were all designed for beginning level basic nursing students, not graduate nurses. Further, the posttest content did not reflect the content in the computer-assisted instruction programs. Rather, the postest was constructed to test "universal knowledge" about medical-surgical nursing and nursing management.

The most recent research, conducted by Droste-Bielak (1980), studied the effectiveness of a computer simulation in teaching beginning interviewing techniques to nursing students at Grand Valley State Colleges in Allendale, Michigan. A posttest-only control group design was used. Forty-five beginning level nursing students were randomly assigned to either the experimental or control group. All students received initial instruction on interviewing techniques. The experimental group practiced interviewing by using a computer program that simulated a patient. The control group practiced interviewing by role-playing in small groups in a skills laboratory setting. All students then tape-recorded their first interview with an actual patient. The tapes were independently rated by four judges. Both groups collected the same amount of patient data and with the same amount of use of correct interviewing techniques. However, the computer learners completed their patient interviews in significantly less time than the role-play learners.

A limitation in this study resulted from experimental mortality. One-third of the subjects were lost to the study because of various problems with tape recording their actual patient interviews. Forty-seven percent of the experimental group and eighteen percent of the control group were lost. The missing data and experimental group mortality raised questions about the validity of the results.

In summary, the research reported on the use of computer-assisted instruction in nursing education has demonstrated that computer-assisted instruction, when compared to conventional teaching methodologies, is as effective but more efficient in terms of learning-time. However, all of the studies cited so far have concerned the use of computer-assisted instruction for cognitive skill development; there has been no mention of the use of computer-assisted instruction in psychomotor skill development.

Teaching psychomotor skills with CAI. Even though there have been no reports in the literature concerning the use of computer-assisted instruction for teaching psychomotor skill development in nursing, there have been a few such reports in disciplines outside of nursing.

Mockovak (1974) and Dallman (1977) reported on the development and use of a series of PLATO lessons to teach a special vehicle maintenance course at Chanute Air Force

Base, Illinois. This was an attempt to apply computer-assisted instruction to a curriculum oriented toward manipulative skills.

A series of studies were designed to compare the effectiveness of the PLATO lessons to the conventional lecture-laboratory format and programmed texts. Four-hundred, twenty-six Air Force personnel participated in the studies. The findings indicated that the PLATO lessons were effective and reliable. Further, they had a positive impact on learner attitudes.

Very few details concerning the design and methodologies of these studies were reported. It was difficult, therefore, to evaluate the findings. However, the reports did state that the effectiveness of the PLATO lessons in teaching manipulative (psychomotor) skills was tested by paper-and-pencil, multiple-choice examinations; actual skill performance was not evaluated.

A further attempt to apply computer-assisted instruction to teaching psychomotor skills was reported by Mockovak (1974) and Steinkerchner and Deignan (1977). They discussed the development of a PLATO-based curriculum to train military physician assistants at Shephard Air Force Base, Texas. Much of the content in that curriculum concerned psychomotor skill development. The reports of this new curriculum concerned the developmental phase only; no discussion was presented on evaluation of the effectiveness of the PLATO lessons for teaching psychomotor skills.

An earlier report by Yens (1969) described the initial evaluation of a computer-based pure tone audiometer trainer. Twenty-four subjects of various audiology backgrounds participated in this study at Pennsylvania State University. After using the computer-trainer, all students were tested on their ability to produce an accurate audiogram on an actual client. Sixteen of the twenty-four students were able to produce an accurate audiogram.

Unfortunately, the report provided little information about the specifics of the computer-trainer, the nature of the learning activities involved for the students, or the length of the exposure to the treatment. However, it was clear from the report that a performance test was used to evaluate the effectiveness of the computer-trainer for teaching an audiometry skill.

Most recently, Buchanan (1981) reported on a PLATO project used at United Airlines Flight Training Center in Chicago to train flight crews in the use of the Omega Navigation System, a computerized in-flight guidance system. This particular project is different from the others previously cited in that this project used traditional teaching methodologies to present training to the learners. The PLATO program simulated the in-flight check that would previously have been required on the airplane. The PLATO graphic simulations presented situations that required the pilot and crew to recognize a situation and then choose and execute the correct procedure.

Buchanan reported that considerable savings of pilot, crew, and instructor time had occurred with the use of the PLATO program. Furthermore, the project represents the first time that the Federal Aviation Administration approved a computer simulation in lieu of an airplane in-flight check. Again, very few details of the project were provided in the report.

In summary, the literature provides only a few reports of the use of computer-assisted instruction to teach psychomotor skills. Moreover, the majority of these reports have been descriptive in nature; little evaluative research has been reported.

Advantages for the Use of CAI in Nursing Education

In addition to the often voiced general advantages for using computer-assisted instruction in education in the broad sense, there are a number of very specific advantages for the use of computer-assisted instruction in nursing education (Kuramato, 1978; Meadows, 1977; Olivieri, 1979; Reed, 1972; Silva, 1973). Following are listed some of these special advantages:

(a) Allows students equal learning opportunities. Many clinical experiences are not consistently available to all students due to scheduling problems, variations in patient populations, and delicate and sometimes transient contractural agreements with clinical facilities.

(b) Allows students to learn using experiences which are not ordinarily available. For example, a student would be able to practice his or her therapeutic communication techniques with a computer programmed to respond as if it were a suicidal patient.

(c) Allows students repeated practice prior to trying techniques on actual patients. This is currently not always possible because of constraints on time, resources, and faculty availability.

(d) Allows students to make errors in a "safe" environment. For example a computer will not become gravely ill because of a student's erroneous medication dosage calculation.

(e) Allows students to purposely make errors in order to validate their own abilities to problem-solve in remedying a deteriorating patient situation. This, of course, is ethically prohibited in an actual patient care situation.

(f) Allows students to experiment with hypothetical patient care situations and to purposely manipulate variables to "see what happens when I . . ." This sort of experimentation is also ethically prohibited in actual patient situations.

Use of Microcomputers for CAI in Nursing Education

All of the research studies cited so far used computer-assisted instruction on terminals within time-sharing computer systems. In fact, only one reference in the professional literature has been found on the use of microcomputers in nursing education.

Olivieri and Sweeney (1980) described their use of four computer simulations on Apple II microcomputers. These simulations were used to evaluate the entry-level clinical expertise of nursing students at Boston College. The series of simulations portrayed a heart attack victim as he progressed through an emergency room, cardiac care unit, medical unit, and cardiac rehabilitation program after discharge from the hospital. The student interacted with the simulated patient and other members of the health care team to collect data, make nursing diagnoses, and plan and implement nursing care. The programs branched in response to the student's decisions. Therefore, the complexity and resolution of various patient problem situations developed dependent upon the clinical decision-making expertise of each student. This was a project description, not a report of research findings.

Summary

Even though research on the use of computer-assisted instruction in nursing education has been limited in amount and sometimes of questionable validity, the results have paralleled those found in research related to other disciplines. These findings indicate that computer learners usually achieve the same level of learning as students using conventional methods, but in significantly less time. There are many additional advantages in using computer-assisted instruction in nursing education.

The nursing research that has been reported to date has investigated the use of computer-assisted instruction in cognitive and problem-solving skill development; there is no mention in the literature about the use of computer-assisted instruction in teaching psychomotor skills in nursing. However, a few studies and projects have been reported concerning the use of computer-assisted instruction in teaching psychomotor skills in other disciplines. Finally, to date, all of the nursing research reported has been conducted on large time-share computer systems. Only one project reporting the use of microcomputers in nursing education has been found.

Summary

The calculation and regulation of intravenous flow rates is viewed by both nursing educators and nursing practitioners as a basic skill that is essential for inclusion in nursing education curricula. However, the problem is that this skill, although essential, is one of but many skills and much knowledge deemed essential. There exists a pressing need in nursing education to develop effective and efficient instructional strategies so that students can learn the essential components of professional nursing practice in the limited time available in the educational programs.

As with other disciplines, the research that has been conducted in nursing education regarding the use of computer-assisted instruction has demonstrated that it is effective and efficient for teaching cognitive and problem-solving skills. However, this investigator has been unable to find results of research concerning the effectiveness or efficiency of computer-assisted instruction for the teaching of nursing skills that have psychomotor components. Furthermore, all of the research conducted on computer-assisted instruction in nursing education has been with time-sharing computer systems; this investigator has been able to find only one project report describing the use of microcomputers for computer-assisted instruction in nursing education.

CHAPTER III

METHODS AND PROCEDURES

This chapter presents a description of the methods and procedures used in this study. The research design is described, both in relation to the design over time and the design over variables. The procedures are discussed within the framework of the developmental and implementation phases. Instrumentation and data collection are also described, and a summary is provided.

Research Design

The research design used in this study is described both in relation to time and variables. Each is presented separately.

Design over Time

This study was a posttest-only, control group quasi-experiment. The design was similar to Campbell and Stanley's (1963) static-group comparison; subjects were assigned to treatment groups non-randomly, on the basis of previously existing intact groups. Multiple observations and a delayed posttest constituted modifications to the static-group comparison design of Campbell and Stanley. Table 3.1 shows the relationships between the assignment of subjects, the two treatments, and the measurements over time.

As can be seen from Table 3.1, subjects were assigned to treatment groups on the basis of their regular skills laboratory assignment. Students in the Monday skills laboratory group were the experimental group and were exposed to the computer simulation as their treatment. Students in the Tuesday skills laboratory group were the control group; they received the conventional skills laboratory simulation as their treatment.

All subjects were posttested on their abilities to calculate and regulate intravenous flow rates immediately following the treatment. All subjects were tested again on this skill ten weeks later. Measurements were also made of the amount of time all subjects spent practicing the skill and the number of learning scenarios they worked through while practicing.

The design of this study posed two possible threats to internal validity. One of these threats was the extraneous variable of subject selection. Intact groups (regular Monday and Tuesday skills laboratory group assignments) rather than random assignment of subjects were used because of concern about the potential for cross-contamination. It was felt that if subjects within groups were assigned to different treatment groups, there was a strong possibility that subjects would "try out" the alternate treatment at sometime during the ten weeks of the study. Contamination of the treatment groups by interaction between groups was a major concern. Therefore, random assignment of the intact groups to treatments rather than random assignment of individual subjects to treatment groups was used.

By using intact groups rather than random assignment of subjects to experimental and control groups, posttest differences between groups might be attributed to characteristics of the groups rather than to the treatment. It was believed that a student's prior mathematics ability and prior clinical experiences in caring for patients receiving intravenous fluid therapy were the variables that would cause the greatest potential dissimilarity between treatment groups. Therefore, these variables were treated as covariates to further equalize the groups.

Another possible threat to internal validity present in this design related to history. Specifically, the number of patients receiving intravenous fluid therapy that a student cared for during the ten week interim between the immediate posttest and the delayed posttest was thought to possibly augment the treatment to affect the student's performance on the delayed posttest. To control for this cross-contamination. It was felt that if subjects within groups were assigned to different treatment groups, there was a strong possibility that subjects would "try out" the alternate treatment at sometime during the ten weeks of the study. Contamination of the treatment groups by interaction between groups was a major concern. Therefore, random assignment of the intact groups to treatments rather than random assignment of individual subjects to treatment groups was used.

By using intact groups rather than random assignment of subjects to experimental and control groups, posttest differences between groups might be attributed to characteristics of the groups rather than to the treatment. It was believed that a student's prior mathematics ability and prior clinical experiences in caring for patients receiving intravenous fluid therapy were the variables that would cause the greatest potential dissimilarity between treatment groups. Therefore, these variables were treated as covariates to further equalize the groups.

Another possible threat to internal validity present in this design related to history. Specifically, the number of patients receiving intravenous fluid therapy that a student cared for during the ten week interim between the immediate posttest and the delayed posttest was thought to possibly augment the treatment to affect the student's performance on the delayed posttest. To control for this possible augmentation, the number of intravenous flow rate calculations and regulations that any student perfomed clinically while caring for patients during the period between the immediate posttest and the delayed posttest was recorded and treated as a covariate.

In addition to the two threats to internal validity mentioned above, this particular design also presented a possible threat to external validity due to the potential influence of the immediate posttest upon the students' performance on the delayed posttest. In other words, the immediate posttest may have acted as a pretest for the delayed posttest. However, with such an extended period of time (ten weeks) between the two posttests, it was believed unlikely that there was a significant carry-over effect of interaction between testing and treatment.

Design over Variables

The dependent variables of this study fall into two categories, effectiveness and efficiency. The variable matrices are different for each; therefore, each will be discussed separately.

Effectiveness Dependent Variables There are two effectiveness variables: calculation and regulation of intravenous flow rates. Each is presented in a separate variable matrix.

<u>Calculation of intravenous flow rates</u> The independent variable in the calculation variable matrix (see Table 3.2) is the treatment (computer simulation versus skills laboratory simulation). The measure is repeated (immediate posttest and delayed posttest). Each cell in the matrix contains the posttest intravenous calculation scores of twenty-four students.

Table 3.2.--Intravenous flow rate calculation matrix.

Treatment	Measure: Immediate Posttest	Measure: Delayed Posttest
Computer Simulation X_1	S_1 to S_{24}	S_1 to S_{24}
Skills Lab Simulation X_2	S_{25} to S_{48}	S_{25} to S_{48}

<u>Regulation of intravenous flow rates</u> The independent variable in the regulation variable matrix (see Table 3.3) is the treatment (computer simulation versus skills laboratory simulation). The measure is repeated (immediate posttest and delayed posttest). Each cell in the matrix contains the posttest intravenous regulation scores of twenty-four students.

Table 3.3.--Intravenous flow rate regulation matrix.

Treatment	Measure: Immediate Posttest	Measure: Delayed Posttest
Computer Simulation X_1	S_1 to S_{24}	S_1 to S_{24}
Skills Lab Simulation X_2	S_{25} to S_{48}	S_{25} to S_{48}

Efficiency Dependent Variables There are two efficiency variables: student learning time and number of learning scenarios. Each is presented in a separate variable matrix.

Student learning time The independent variable in the student learning time variable matrix (see Table 3.4) is treatment group (computer simulation versus skills laboratory simulation). The measure is repeated (time spent during the initial treatment and cumulative practice time spent by the end of ten weeks). Each cell in the matrix contains the number of minutes spent in the learning activity for the twenty-four students in each treatment group.

Table 3.4.--Student learning time matrix.

Treatment	Measure: Initial O_{31}	Measure: Cumulative O_{32}
Computer Simulation X_1	S_1 to S_{24}	S_1 to S_{24}
Skills Lab Simulation X_2	S_{25} to S_{48}	S_{25} to S_{48}

Number of learning scenarios The independent variable in the number of learning scenarios variable matrix (see Table 3.5) is the treatment (computer simulation versus skills laboratory simulation). The measure is repeated (number of practice problems completed during the initial treatment and cumulative number completed by the end of ten weeks). Each cell in the matrix contains the number of learning scenarios students in each treatment group reported at each reporting time (initially and at the end of the study).

Table 3.5.--Number of learning scenarios matrix.

Treatment	Measure Initial O_{41}	Measure Cumulative O_{42}
Computer Simulation X_1	S_1 to S_{24}	S_1 to S_{24}
Skills Lab Simulation X_2	S_{25} to S_{48}	S_{25} to S_{48}

Research Hypotheses

The research hypotheses previously listed in Chapter I are repeated here for the reader's convenience:

After practicing with either the computer simulation or the laboratory simulation, nursing students were tested on their abilities to calculate and regulate intravenous flow rates. It was hypothesized that:

1) The mean flow rate calculation score for the computer learners would be greater than that of the laboratory learners on an immediate posttest.

2) The mean flow rate calculation score for the computer learners would be greater than that of the laboratory learners on a delayed posttest.

3) The mean flow rate regulation score for the computer learners would be greater than that of the laboratory learners on an immediate posttest.

4) The mean flow rate regulation score for the computer learners would be greater than that of the laboratory learners on a delayed posttest.

5) The mean time spent in learning would be less for the computer learners than for the laboratory learners.

6) The mean number of learning scenarios experienced by computer learners would be greater than that of the laboratory learners.

Hypotheses 1, 2, 3, and 4 all pertain to the "effectiveness" of the computer simulation when compared to the laboratory simulation. Hypotheses 5 and 6 pertain to the "efficiency" of the computer simulation when compared to the laboratory simulation. The level of significance for all hypotheses was set at 0.05.

Research Objective

In addition to the research hypotheses, determining and comparing the cost per student in each of the treatment groups (computer simulation versus skills laboratory simulation) was an objective of this study. Cost per student was computed on the basis of amount of faculty time spent in instructional activities, as well as the costs of consumable materials.

Summary

This study was a posttest-only control group quasi-experiment, similar in design to Campbell and Stanley's static group comparison (1963). The independent variable was the treatment (computer simulation versus skills laboratory simulation). The dependent variables were the effectiveness and efficiency of the treatment. The effectiveness variable was measured by the abilities of the students to correctly calculate and accurately regulate intravenous flow rates on both immediate and delayed (ten weeks after the treatment) posttests. The efficiency variable was measured by both the amount of time students spent with the treatment and the number of times students used the treatment. As an additional research objective, this study also determined the relative cost per student for each of the treatments.

Procedures

The procedures used in this study occurred in two phases: developmental and implemental. Each phase is discussed separately.

Developmental Phase

The developmental phase of this study consisted of three activities: (1) developing the computer simulation; (2) selecting and training the observers; and (3) eliciting faculty cooperation. Each activity is described.

Computer Program. In 1979, as part of a course on the use of computers in education, this investigator first developed the computer simulation, "Calculation and Regulation of Intravenous Flow". The program was written in BASIC and designed for use on a TRS-80 Model I, Level II microcomputer with sixteen kilobytes of random access memory.

The program was designed to assist beginning level nursing students to correctly calculate and accurately regulate intravenous flow rates. The program guides the student through three interrelated calculations and then culminates in the simulation of the regulation of a flowing intravenous system.

The program randomly selects the number of hours in which an intravenous solution of 1000 cc is to infuse into a hypothetical patient. The student must calculate: a) the flow per hour, and b) the flow per minute. The program then randomly selects the "drop factor" (number of drops per cc) that the particular intravenous equipment will deliver. The student must use this information to calculate the number of drops per minute needed to administer the previously calculated cc per minute. The program then causes a simulated intravenous bottle, drip chamber, and tubing to be displayed on the cathode ray tube (i.e. CRT). The program causes drops to flow through the simulated intravenous drip chamber at a randomly selected rate. The student must regulate the simulated intravenous drop rate to correspond to the calculated drop rate.

If the student makes an error in any of the calculations, the program provides a prompt in the form of the appropriate formula. If the student continues to make an error in the same calculation, the program provides a stronger prompt by displaying the entire calculation, correctly worked through. If the student incorrectly regulates the simulated intravenous flow, the program directs the student to re-regulate the flow rate.

The program features graphics and real-time animation. Each hypothetical patient problem requires approximately seven minutes to complete, although time requirements vary according to the skill of the student.

The program was developed with four specific student learning objectives in mind. Upon successful completion of the program, the student will be able to:

1) calculate the hourly intravenous flow rate.
2) calculate the intravenous flow rate per minute.
3) calculate the intravenous drop rate per minute.
4) regulate a simulated intravenous to deliver the previously calculated number of drops per minute, within plus or minus three drops.

The Abstract, Instructor's Guide, and Student Guide for this program are all in Appendix A. Moreover, a listing of the program is in Appendix B, and a sample run is in Appendix C.

Selection and Training of Observers. Three Grand Valley State College School of Nursing faculty colleagues of this investigator were asked to serve as observers for this study; all agreed. The observers were all full-time faculty who were not involved with the clinical instruction of or assignment of grades to the students in either acute pediatric or acute medical-surgical nursing (where there was the greatest likelihood of caring for patients receiving intravenous fluid therapy). The observers all had master's degrees in nursing; in addition, one observer possessed an earned Ph.D. degree in educational psychology. The observers represented the clinical specialty areas of psychiatric-mental health, obstetric, and medical-surgical nursing.

Two weeks prior to the beginning of the study, the three observers met with this investigator for a training session. The observers evaluated and assigned scores to three mock student solutions to intravenous flow rate calculation problems. The observers then evaluated and assigned scores to three flowing intravenous systems which had previously been regulated by this investigator to represent intravenous fluid systems that were flowing too fast, too slow, and accurate when compared to the prescribed rate.

There was 100% agreement between observers on the evaluation and scoring of the calculations. Further, the observers were within plus or minus one drop of each other in evaluating the rates of the three flowing intravenous systems. When comparing the actual flow rates to the prescribed rates and then assigning scores based upon written criteria, the observers were again in 100% agreement. The interrater reliability was, therefore, very high.

A simulation of the posttesting procedure was also conducted during the training session. The observers made several suggestions as to how the posttesting setting could be improved. Because of changes in the setting that occurred due to the observers' suggestions, an additional brief training session was conducted one week prior to the beginning of the study. Thus, two training sessions for the observers were conducted during the developmental phase, one to establish interrater reliability and the other to simulate the actual posttesting procedure.

In addition to the three observers, another full-time Grand Valley State College nurse faculty member was recruited to serve as proctor. The proctor's duties were primarily to assist the students in progressing through the posttesting situations. The proctor attended both observer training sessions.

Written instructions were given to both the proctor and the observers during the training sessions. These instructions are in Appendix D.

Faculty Cooperation. Three months prior to the beginning of the study, during a regularly scheduled total faculty meeting, this investigator described and discussed the study with the School of Nursing faculty. After the discussion, faculty stated their support of and intent to cooperate with the study. This investigator left a written abstract and copies of the data collection instruments on file in the School of Nursing Office.

Additionally, one month prior to the study, this investigator met with the faculty team responsible for teaching the students who would be the subjects of the study. At this meeting, the study was again briefly described and various data collection instruments were discussed. Again, faculty stated their support of and intended cooperation with the research.

During the course of the study, this investigator met twice more with the faculty team to answer questions and to further describe various data collection strategies. At the request of this investigator, the coordinator of the faculty team also periodically relayed messages and reminders about various aspects of the study to the rest of the teaching team.

Summary. The developmental phase of this study began in 1979, with the initial writing of the computer simulation, "Calculation and Regulation of Intravenous

Flow". After this study was planned and approved, expert observers and a proctor were selected and trained for the evaluation of student performance on posttests. Faculty support of and cooperation with the study were actively solicited through a series of discussions during meetings of total faculty and the teaching team. These discussions occurred both prior to and throughout the course of the study.

Implementation Phase

The implementation phase of this study is described within the framework of descriptions of the subjects and the treatments.

Subjects. The subjects in this study were forty-eight junior level generic students in the baccalaureate nursing program at Grand Valley State Colleges, a federation of small cluster colleges with a total student enrollment of 5000, located in a suburban-rural area near Grand Rapids, Michigan. The students were all enrolled in Nursing II, the second course in a four course upper division nursing major. Nursing II is a fourteen week course which emphasizes the care of acutely ill patients of all ages. Students have clinical experiences caring for patients and their families in two out of three possible acute care clinical rotations: pediatric, adult medical-surgical, or psychiatric care. The remaining clinical rotation is experienced during the first half of the following course, Nursing III. Theoretical content includes the impact of acute illness and hospitalization upon man and his family throughout the life span; also focused upon are nursing concepts such as the nursing process, communication theory, teaching-learning process, and legal-ethical issues.

At the conclusion of a Nursing I lecture on nursing research during Fall Semester, 1980, this investigator spoke with students about this study. At that time, this investigator: a) described the research project; b) verified that participation was voluntary and the findings of the study would not affect student grades; c) asked for volunteers to participate; and d) had students who did volunteer sign the Student Consent Form (see Appendix E). All but one student volunteered to participate in the study.

Subjects were assigned to treatment groups on the basis of their regular skills laboratory day assignment. This investigator selected from a container one of two slips of paper on which either Monday or Tuesday was written. On the basis of this procedure, the Monday skills laboratory group was assigned to the experimental (computer) group, and the Tuesday skills laboratory group was assigned to the control (skills laboratory) treatment group. Twenty-four students were thereby assigned to the experimental group, and twenty-six were assigned to the control group (two students in the control group were later eliminated from the study because of incomplete data).

Treatment. During the first portion of each of the two regularly scheduled skills laboratory sessions on calculating and regulating intravenous flow rates, students chose identification code numbers by drawing slips of paper from a container. Students were thereafter identified only by their code numbers. Each student then completed and submitted a Student Data Form (see Appendix F) which requested various demographic data. A written description of the procedures to be followed during the study was distributed to each student (see Appendix G). Information on this handout was discussed by this investigator. Particularly, students were cautioned to stay in their assigned treatment group until after the completion of the study.

Students were then asked to complete a Student Practice Report (see Appendix H) whenever they practiced the calculation and/or regulation of intravenous flow rates. Students were instructed to record both the time they spent and the number of learning scenarios they completed on each occasion they used either treatment. Reports were to be submitted to this investigator immediately after any session with either treatment. The importance of accurate record-keeping for this study was stressed.

This investigator then provided instruction to the students on how to correctly calculate intravenous flow rates. The calculation method presented was one of two methods described in the last chapter of a 123 page programmed instruction text on mathematics for medication dosage calculations (Weaver, M.E., and Koehler, V.J. Programmed mathematics of drugs and solutions. New York: J.B. Lippincott Company, 1979). This text had been assigned as required reading for the students three weeks prior to the beginning of this study. The three interrelated and sequential mathematical formulas which constitute the method for calculating volume per hour, volume per minute, and drops per minute were presented. Moreover, sources of essential patient and equipment data were also discussed. Using a blackboard, this investigator worked through a sample hypothetical patient intravenous flow rate calculation problem. Using actual equipment, this investigator then demonstrated the procedure for accurately regulating intravenous systems so that they deliver fluid at the prescribed rate. Questions were answered about the performance of the skill or the procedures to be followed in the study. From this point on, the experimental and control groups were treated differently.

Experimental Group. The twenty-four students in the experimental (computer) group were divided, on the basis of their identification code numbers, into two smaller groups of twelve students each. While one group of twelve students participated in this study for one hour, the other twelve students remained in the skills laboratory and observed a nurse faculty member demonstrate various techniques for sterile dressing changes and wound irrigations. At the end of one hour, the groups changed, so that the students who had been observing the skills laboratory demonstration now participated in the study and the students who participated first in the study now observed the demonstration.

When a group of twelve students participated in the study, they walked across campus to the Microcomputer Laboratory, a large classroom in which there were approximately twenty microcomputers, twelve of which were TRS-80 Model I microcomputers. After the students were seated in front of the TRS-80's, they were instructed on how to "run" the program, which had previously been loaded into the microcomputers.

As each student began to run the program, he or she noted the time on a Student Practice Report. The program presented the student with a randomly generated hypothetical patient intravenous flow rate calculation problem. Using the patient and equipment data suplied by the program, the student worked through the problem. Appropriate feedback and additional instruction were provided throughout by the program, in response to the student's answers to the various segments of the problem.

After the student worked through all three parts of the calculation, he or she was advised to place a watch against the CRT. When the student indicated readiness, a graphical representation of an intravenous system (bottle, drip chamber, tubing) appeared on the CRT. The student saw drops flowing from the bottle through the drip chamber and into the tubing. The student timed the rate of flow by placing his or her watch next to the drip chamber on the CRT and counting the number of drops falling in one minute. The student then adjusted the flow rate by pressing certain keys on the keyboard so that the flow rate increased (by pressing the "F" key) or decreased (by pressing the "S" key).

The student continued to time and adjust the drop rate until he or she determined that the rate corresponded to the rate previously calculated. At that time, the student pressed the "C" key on the keyboard, signaling the computer to check the accuracy of the student's regulation. The computer compared the adjusted flow rate with the calculated flow rate and provided feedback to the student as to his or her accuracy of regulation. If the student regulated the intravenous flow rate to within three drops of the calculated rate, positive reinforcement was given. If the student was not within three drops of the calculated rate, negative reinforcement was given. The student was then directed to readjust the intravenous flow and check the accuracy again. The student continued in the program until the rate was accurately regulated. At this point, one learning scenario was completed; the student recorded the time, along with noting the completion of one learning scenario on his or her Student Practice Report.

When the student accurately regulated the intravenous flow rate, the computer program asked if he or she wished to work through another problem. If so, another patient problem was randomly generated and presented to the student. On the other hand, if the student did not wish another problem, the program ended. A sample "run" of the program is in Appendix C.

The student could go through the program with new randomly generated patient problems as many times as he or she wished, within the time constraints of thirty minutes. The student proceeded to the posttesting area when he or she felt "comfortable" with the skill or when the thirty minutes had passed, whichever occurred first.

Control Group. On the following day, after the same initial instruction and data collection, the twenty-six students in the control group were divided, on the basis of identification code numbers, into two smaller groups of thirteen students each. While one group of thirteen students participated in the study, the other thirteen students observed a nurse faculty member demonstrate various techniques for sterile dressing changes and wound irrigations; the same faculty member performed the same demonstration for both the experimental and control groups. The groups of thirteen students exchanged at the end of one hour.

When a group of thirteen students participated in the study, they remained in the skills laboratory. Groups of three to four students were directed to one of four areas in the skills laboratory where flowing intravenous systems (fluid filled intravenous bottles, drip chambers, and tubing) had been previously set up. Also in each of the four areas was a set of twelve hypothetical patient intravenous flow calculation problems. Each of the problems was typed on an index card, and the solutions to the three segments of the problem were provided on the back of the card (see Appendix I for a sample). Each of the four intravenous areas in the skills laboratory contained the same set of problem cards, and the twelve problems contained in each set were the same as those randomly generated by the computer program.

Each student was directed to select one of these hypothetical patient intravenous flow calculation problems. After selection of the problem, the student was instructed to note the time on his or her Student Practice Report. Using the patient and equipment data supplied on the problem card, each student worked through his or her selected problem. Students were encouraged to check each segment of their calculations by comparing their answers with the solutions on the reverse side of the problem cards. Meanwhile, this investigator circulated among the four small groups of students, answering questions and providing feedback either spontaneously or in direct response to student requests.

When a student completed the calculation, he or she moved to an intravenous system; this investigator had previously set each intravenous system so that the fluid was flowing at a random rate through the drip chamber and tubing. The student timed the rate of flow by placing his or her watch next to the drip chamber and counting the number of drops falling in one minute. The student then adjusted the flow rate by manipulating a thumb screw on the tubing so that the flow rate increased or decreased. The student continued to time and adjust the drip rate until the rate corresponded to that previously calculated. The student was encouraged to have this investigator check the accuracy of the regulation and provide feedback. When the student's regulated flow rate corresponded to the calculated flow rate, one learning scenario was completed. The student noted the time and recorded the completion of one scenario on his or her Student Practice Report.

The student could then select another patient problem and proceed through the practice exercise. The sequence could be repeated as many times as he or she wished, within the time constraints of the thirty minute session. The student proceeded to the testing area when he or she felt "comfortable" with the skill or when the thirty minutes had passed, whichever occurred first.

With the exception of the student record-keeping activities required for the study, this skills laboratory simulation was conducted in the "usual" manner. This particular skills laboratory simulation has been one of this investigator's regular teaching responsibilities for the past five years; attempts were made to make certain that the skills laboratory simulation used in this study was an accurate representation of the conventional instructional methodology.

Posttesting. The testing area was on another floor of the building in which the skills laboratory was located. As students entered the testing area, the proctor gave each student a Posttest Evaluation Form (see Appendix J); this form presented the student with a hypothetical patient intravenous flow rate calculation problem. The proctor had a large supply of twelve different patient intravenous problems; these were the same problems that the students used for practice, both with the computer simulation and the skills laboratory simulation. The proctor directed each student to sit at a work table and calculate the intravenous flow rate in drops per minute, without the aid of calculators, notes, texts, faculty, or peers.

When the student completed the calculation, he or she randomly selected his or her intravenous regulation testing station assignment by drawing a slip of paper from a container held by the proctor. On the slip of paper was written either "Testing Station #1", "Testing Station #2", or "Testing Station #3". After selecting his or her testing station assignment, the student replaced the slip of paper in the container so that the next student would have an equal chance of selecting any of the three. When there was an opening at the selected testing station, the proctor directed the student to proceed to it and begin the intravenous regulation portion of the posttest.

The three intravenous regulation testing stations were located in separate offices. These offices were connected via a hallway to the workroom used as the calculation testing area. Each intravenous regulation testing station contained two intravenous systems with fluid flowing at random rates. A room divider separated the two intravenous systems from each other. An observer remained in each of the three intravenous regulation testing stations.

As the student entered the assigned intravenous regulation testing station, the observer directed him or her to time and adjust one of the flowing intravenous systems so that the actual flow rate matched the rate that he or she had just calculated. When the student believed that the intravenous system was delivering the calculated rate, he or she indicated readiness to the observer. The observer collected the Posttest Evaluation Form from the student and then timed the intravenous flow rate herself for one minute. The observer recorded this observation in the space provided on the student's Posttest Evaluation Form; the observer also placed her initials on the form. At this point, the student left the testing area.

At the conclusion of each day's posttesting procedure, each observer scored each student's calculations. The observers used a scoring key (see Appendix K) in determining the correctness of each student's calculation. A score of zero, one, two, or three was assigned to the student's calculation, depending upon the correctness of the three interrelated problem segments. The observers referred to the Scoring of Calculations section of the "Observer Scoring Guide" (see Appendix L) for criteria for the assignment of points to the student's calculation.

Each observer then compared the student's calculated drop rate with the observer's own determination of the actual drop rate (the flow rate that the student regulated the intravenous system to deliver). A score of zero, one, two, or three was assigned as the student's regulation score. This score was dependent upon how accurately the student was able to regulate the flowing intravenous system to actually deliver the calculated flow rate. The observers referred to the Scoring of Regulation section of the "Observer Scoring Guide" (see Appendix L) for criteria for the assignment of points to the student's intravenous flow rate regulation.

Each observer scored each student's calculation and regulation. Therefore, each student's calculation and regulation was scored three times by three different observers.

Ten weeks later the students returned to the testing area for a delayed posttest. One week prior to the delayed posttest, this investigator sent each student a letter reminding them of the posttest date (see Appendix M); additionally, an announcement was made to the students in class. The format for the delayed posttest was the same as for the immediate posttest.

The observers and proctor all participated in another brief training session one week prior to the delayed posttest. At the conclusion of the delayed posttest, students were asked to complete and submit a Follow-up Questionnaire (see Appendix N); this questionnaire was designed to provide feedback to the investigator about the students' perceptions concerning the computer or skills laboratory simulations.

Interim Period. During the ten weeks between the immediate and delayed posttests, students could continue to practice their skill in calculating and regulating intravenous flow rates by using either the computer simulation or the skills laboratory simulation, according to which treatment group they were assigned. Students were instructed to complete and submit to this investigator a Student Practice Report each time they practiced with either the skills laboratory or computer simulation; supplies of Student Practice Reports were kept both in the skills laboratory and in the "computer room" in the School of Nursing.

Students in the experimental (computer) group were directed to practice using the TRS-80 Model I microcomputer located in the "computer room" in the School of Nursing. The computer program on calculating and regulating intravenous flow rates was left beside this computer; in addition, a photographic display on how to load and run the program was also adjacent to the computer. All students in the experimental (computer) group had, in the previous nursing course, experienced loading and running programs on a TRS-80 microcomputer. Students in the control (skills laboratory) group were directed to practice in the skills laboratory, where an intravenous system remained set up; also, a set of twelve hypothetical patient intravenous flow rate problem cards was kept adjacent to the intravenous system.

Finally, all pediatric and adult medical-surgical clinical faculty recorded the number and nature of each student's experiences caring for patients receiving intravenous fluid therapy. These data were recorded on the Clinical IV Experiences Record (see Appendix O) and submitted to this investigator at the end of the ten weeks.

Also, faculty were asked to note the time they spent with instructional activities related to helping students learn to calculate and regulate intravenous flow rates. Each faculty member was asked to record this information on a Faculty Time Form (see Appendix P) and to submit the form to this investigator at the end of the ten weeks.

Summary. During the implementation phase of this study, forty-eight Nursing II students at Grand Valley State Colleges were assigned to either the experimental or control group, based upon their regular skills laboratory assignment day. Both groups received instruction in how to calculate and regulate intravenous flow rates. The experimental group used a computer simulation to practice the skill; the control group used the conventional skills laboratory simulation for practice. After a maximum of thirty minutes of practice, students were posttested on their abilities to correctly calculate and accurately regulate flow rates on actual intravenous systems. Ten weeks later the students were again posttested for the same abilities.

During the ten week interim between the immediate and delayed posttests, data were collected on the amount of time students spent in practicing the skill, the number of learning scenarios completed, the amount and nature of the students' care for actual patients receiving intravenous fluid therapy, and the faculty time spent in instructional activities related to teaching students how to calculate and regulate intravenous flow rates.

Instrumentation and Data Collection

To answer the research question of "the effectiveness of computer simulation when compared to skills laboratory simulation", data were gathered at both the immediate and delayed posttests; the Posttest Evaluation Forms are contained in Appendix J. The face validity for these instruments was determined by a panel of experts (three nurse faculty, each of whom were clinical specialists in acute care nursing). Each expert rated each instrument. All three experts agreed that the hypothetical patient intravenous flow rate problems presented on the Posttest Evaluation Forms accurately reflected potential clinical situations and were of the same degree of difficulty.

The criteria used for assigning scores according to the accuracy of students' calculations and intravenous system regulations were also judged to be valid by this same panel of experts. The criteria were derived from the criteria previously used by the faculty teaching team when evaluating student performance during skills laboratory final examinations.

Student self-reports on amount of time spent in practicing the skill and the number of learning scenarios completed were recorded on Student Practice Reports (Appendix H) and then submitted to this investigator. Furthermore, data concerning the amount of faculty time spent in instructional activities related to the intravenous learning experiences were gathered through self-reports on the Faculty Time Form (see Appendix P). Records of purchase orders were used to determine the costs of consummable equipment and supplies for instruction related to the calculation and regulation of intravenous flow rates.

Data on the potentially confounding variable of the amount of clinical experience students had caring for patients receiving intravenous fluid therapy during the study were collected on the Clinical IV Experiences Record (see Appendix O). All five of the pediatric and adult medical-surgical nursing faculty were trained in the use of this form and urged to consistently record the data. The completed forms were submitted to this investigator at the end of the ten weeks.

Additionally, at the beginning of the study, minimum demographic data were collected from the students on the Student Data Form (Appendix F). The information collected included such items as age, sex, previous contact with computer-assisted instruction, previous experience caring for patients receiving intravenous fluid therapy, and grade point average. Further, data concerning students' scores on a mathematics for medication dosage calculation examination administered one week prior to the beginning of the study were gathered from student records. These data were later analyzed to determine their relationships to the dependent variables. The dosage calculation exam scores and previous intravenous clinical experiences were then treated as covariates to further equalize the treatment groups.

The data gathered through the Follow-up Questionnaire (Appendix N) were used by this investigator to receive feedback from the students as to their perceptions of the treatment and its helpfulness.

Also collected were student scores on a series of examinations on the content of the previously assigned medication dosage calculation programmed instruction text. Each student was required to achieve 100% mastery on one of these exams before he or she was allowed to clinically administer medications to patients. Only three students achieved mastery on the first examination (administered one week prior to the start of this study). With the exception of these three students, all other students were required to take additional exams until they demonstrated mastery

(100%). All but ten students achieved mastery on the second exam. Seven of those ten students achieved mastery on the third exam. The three remaining students achieved mastery on the fourth exam.

After the first exam, subsequent exams were taken outside of scheduled class time; the School of Nursing secretary administered the exams at the students' convenience. The second exam was the only one in the series that contained an intravenous flow rate calculation problem. The entire series of exams is in Appendix Q.

A Post-Study Questionnaire (see Appendix R) was administered to the students one week after the delayed posttest. This questionnaire asked the student: (1) whether he or she had taken the second programmed instruction math exam (the one with the intravenous flow rate calculation problem) before or after first participating in this study; (2) if he or she had specifically studied in preparation for the delayed posttest and, if so, what learning resources he or she used to study; (3) to rank the perceived helpfulness of the programmed instruction text, the clinical instructor(s) and whichever treatment (computer simulation or skills laboratory simulation) they experienced; and (4) which of the two methods for calculating intravenous flow rates he or she preferred to use when working with actual patients.

Finally, the five acute care clinical nurse faculty involved in the study were surveyed by this investigator either by phone or in person to determine if any of them expressed to students their preference for either of the two methods for calculating intravenous flow rates.

Summary. A number of instruments were developed for and used in this study. Posttest evaluation instruments were developed and judged to possess face validity for attempting to answer the research question concerning "the effectiveness of computer simulation when compared to skills laboratory simulation". Instruments for recording student and faculty self-reports were also developed to assist in answering the research question about "the efficiency of computer simulation when compared to skills laboratory simulation". Moreover, instruments were developed for collecting data about the potentially confounding variable of prior mathematics ability and prior and concurrent experiences caring for patients receiving intravenous fluid therapy. Finally, data were collected from a variety of sources to assist in analyzing the impact of a previously assigned programmed instruction text and a prior and concurrent series of medication dosage calculation examinations on the students' abilities to calculate intravenous flow rates.

Summary

Forty-eight junior-level baccalaureate nursing students participated in this posttest-only control group quasi-experimental study during Winter Semester, 1981. The research design was similar to Stanley and Campbell's (1963) static group comparison, modified to include multiple observations and a delayed posttest.

Students were assigned to one of two treatment groups on the basis of their regular skills laboratory assigned day. Students in the Monday skills laboratory were placed in the experimental (computer simulation) group, while students in the Tuesday skills laboratory were placed in the control (skills laboratory simulation) group. Three weeks prior to the beginning of the study, all students were assigned to work through a programmed instruction text on mathematics for medication dosage calculation; the final chapter of this text presented two methods for calculating intravenous flow rates.

Using one of these methods, this investigator provided further instruction to both groups on how to calculate and regulate intravenous flow rates. Students in the experimental group practiced the skill for a maximum of thirty minutes using a computer simulation on TRS-80 Model I, Level II microcomputers. Students in the control group practiced the skill for a maximum of thirty minutes using a skills laboratory simulation. Both treatments reinforced the same intravenous flow rate calculation method that had earlier been presented to the students by this investigator. All students were posttested immediately after the thirty minute treatment and again ten weeks later.

The independent variable was the treatment (computer simulation versus skills laboratory simulation). The dependent variables fell into two categories: effectiveness and efficiency.

Effectiveness of the treatment was determined by measuring the students' correctness of calculation and accuracy of regulation of intravenous flow rates. Prior mathematics ability and prior and concurrent clinical experiences with patients receiving intravenous fluid therapy were used as covariates to further equalize differences between groups. Efficiency of the treatment was determined by the amount of time students spent in learning the skill and the number of learning scenarios they worked through by the conclusion of the delayed posttest, ten weeks after the treatment with either simulation.

The research hypotheses stated that:

1) The mean flow rate calculation score for the computer learners would be greater than that of the laboratory learners on an immediate posttest.

2) The mean flow rate calculation score for the computer learners would be greater than that of the laboratory learners on a delayed posttest.

3) The mean flow rate regulation score for the computer learners would be greater than that of the laboratory learners on an immediate posttest.

4) The mean flow rate regulation score for the computer learners would be greater than that of the laboratory learners on a delayed posttest.

5) The mean time spent in learning would be less for the computer learners than for the laboratory learners.

6) The mean number of learning scenarios experienced by the computer learners would be greater than that of the laboratory learners.

Data were also collected to in order to achieve the research objective of determining the cost per student for the two treatments.

CHAPTER IV

FINDINGS AND DISCUSSION

This chapter presents a statistical analysis of the data and discussion of the results. The chapter is organized into two major parts; the first part reports the findings of the study, while the second part discusses these findings.

Findings

The findings are organized into five major areas: (1) description of the subjects; (2) effectiveness of the treatment; (3) efficiency of the treatment; (4) cost; and (5) findings of special interest.

Description of Subjects

The characteristics of the forty-eight students who participated in this study are summarized in Table 4.1. As is evident from the table, students in the experimental and control groups were very similar to each other. The two groups differed substantially from one another on only one characteristic, prior experience caring for patients receiving intravenous fluid therapy.

Eight computer learners reported previous experience caring for patients receiving intravenous fluid therapy; only one laboratory learner reported such previous clinical intravenous experience. This is a significant difference between the groups (chi square = 4.92; significant at the 0.05 level). In an attempt to equalize the differences between the groups, this variable was used as a covariate in the analysis of the immediate posttest intravenous regulation scores.

Table 4.1 also presents important findings related to other subject characteristics which were used as covariates during data analysis. Specifically, the findings related to numbers of clinical intravenous calculations and regulations performed during the duration of the study and the medication dosage examination scores are of particular interest in this study.

The mean number of calculations of intravenous flow rates performed clinically throughout the study was 3.25 for the computer learners and 3.38 for the laboratory learners. This variable was used as a covariate in the analysis of delayed posttest calculation scores.

Further, the mean number of regulations of intravenous flow rates performed clinically throughout the study was 3.29 for the computer learners and 3.46 for the laboratory learners. This variable was used as a covariate in the analysis of delayed posttest regulation scores.

Table 4.1.--Comparison of treatment groups by various characteristics.

Characteristic	Treatment Group	
	Computer Learners	Laboratory Learners
Age (years)	21.9 ± 2.4	21.0 ± 1.3
Sex	22 Female 2 Male	24 Female
Grade Point Average	3.270 ± 0.412	3.185 ± 0.387
Previous Computer Experience	16 Minimum 8 More	19 Minimum 3 More 2 None
Previous IV Experience	8 Yes 16 No	1 Yes 23 No
Potential Weeks of IV Clinical Experience	6.34 ± 2.16	6.21 ± 1.91
Number of IV Patients Cared For	2.13 ± 1.42	2.38 ± 1.86
Number of IV Calculations	3.25 ± 2.25	3.38 ± 2.35
Number of IV Regulations	3.29 ± 7.06	3.46 ± 5.26
Medication Dosage Exam 1 Score	83.21 ± 10.61	81.25 ± 13.30
Medication Dosage Exam 2 Sequence	13 Before Trtmt. 11 After Trtmt.	11 Before Trtmt. 13 After Trtmt.

The mean score on the medication dosage calculation examination adiministered one week prior to the beginning of the study was 83.20 for the computer learners and 81.25 for the laboratory learners. This variable was used as a covariate in the analysis of immediate posttest calculation scores.

Summary. The computer learners and the laboratory learners differed significantly from one another in only one variable measured, the reported amount of previous experience in caring for patients receiving intravenous fluid therapy. The computer learners had significantly more (at the 0.05 level) previous clinical intravenous experiences then did the laboratory learners. This variable was used as a covariate in the analysis of the immediate posttest regulation scores.

The first medication dosage calculation examination scores were used as a covariate in the analysis of immediate posttest calculation scores. Further, the number of intravenous calculations and regulations preformed clinically during the ten weeks of the study were used, respectively, as covariates in the analysis of delayed posttest calculation and regulation scores.

Effectiveness of Treatment

Treatment effectiveness in this study is composed of two dependent variables: the calculation of intravenous flow rate and the regulation of intravenous flow rate. Each variable was measured twice, at the conclusion of the treatment (the immediate posttest) and ten weeks later (the delayed posttest). The findings related to these two variables are presented separately.

Calculation of Intravenous Flow Rate.

> Hypothesis 1: The mean flow rate calculation score for the computer learners would be greater than that of the laboratory learners on an immediate posttest.

Analysis of covariance was used to analyze the student calculation scores on the immediate posttest. The student scores on the medication dosage calculation examination given one week prior to the treatment were used as the covariate. As can be seen from Table 4.2, there was no significant difference in the immediate posttest calculation scores between the computer learners and the laboratory learners. Therefore, Hypothesis 1 was rejected. The null hypothesis of no difference between the groups was accepted.

> Hypothesis 2: The mean flow rate calculation score for the computer learners would be greater than that of the laboratory learners on a delayed posttest.

Analysis of covariance was again used to analyze the student calculation scores on the delayed posttest. The covariate used in this analysis, however, was the number of intravenous flow rate calculations that students performed clinically (while caring for patients) during the ten week

Table 4.2.--ANCOVA for immediate posttest calculation score*.

Treatment Group	Mean Calculation Score	Standard Deviation	F	Significance of F
Computer Learners	2.792	0.588	0.420	0.52
Laboratory Learners	2.625	0.875		

* Possible range of scores: 0 to 3.

Table 4.3.--ANCOVA for entire calculation score* on delayed posttest.

Treatment Group	Mean Calculation Score	Standard Deviation	F	Significance of F
Computer Learners	1.292	0.908	6.986**	0.011
Laboratory Learners	2.0	1.18		

* Possible range of scores: 0 to 3.
** Significant at 0.05 level.

interim between the immediate and the delayed posttests. As shown in Table 4.3, there was a significant difference in the delayed posttest calculation scores between the computer learners and the laboratory learners. Therefore, on the basis of this analysis, the null hypothesis of no difference would have to be rejected. The laboratory learners scored significantly higher on the calculation segment of the delayed posttest than did the computer learners. This finding was opposite to the direction of the research hypothesis, however.

Upon examining the raw data, it was apparent that on the delayed posttest some students used a calculation method different from the one reinforced in either the laboratory or the computer simulation. In fact, fifteen of the twenty-four computer learners and four of the twenty-four laboratory learners used this alternative calculation method during the delayed posttest. Significantly more computer learners used the alternative method (chi square = 8.71; significant at the 0.05 level).

The data were reanalyzed for the correctness of the last part of the calculation segment of the delayed posttest only (the drops per minute determination). In this way, the scores of all students could be compared, regardless of which calculation method was used. Analysis of covariance was used to analyze the data; the number of intravenous flow rate calculations performed clinically during the ten week interim between the immediate and delayed posttests was again used as a covariate.

As can be seen in Table 4.4, when only the last part of the calculation segment of the delayed posttest was scored, there was no significant difference in the scores between groups. The null hypothesis of no difference between groups was therefore accepted.

Table 4.4.--ANCOVA for the score* on the last part of calculation segment of the delayed posttest.

Treatment Group	Mean Calculation Score	Standard Deviation	F	Significance of F
Computer Learners	0.833	0.381	1.040	0.313
Laboratory Learners	0.708	0.464		

* Possible range of scores: 0 to 1.

Regulation of Intravenous Flow Rates.

Hypothesis 3: The mean flow rate regulation score for the computer learners would be greater than that of the laboratory learners on an immediate posttest.

Analysis of covariance was also used to analyze the student regulation scores on the immediate posttest. Previous experience in caring for patients receiving intravenous fluid therapy was used as a covariate for the immediate posttest regulation scores. Table 4.5 presents the findings of this analysis; there was no significant difference between the immediate posttest intravenous regulation scores of the two treatment groups. Thus, Hypothesis 3 was rejected. Instead, the null hypothesis of no difference between the computer learners and the laboratory learners was accepted.

Table 4.5.--ANCOVA for immediate posttest regulation score*.

Treatment Group	Mean Regulation Score	Standard Deviation	F	Significance of F
Computer Learners	2.917	0.282	0.345	0.560
Laboratory Learners	2.833	0.637		

* Possible range of scores: 0 to 3.

> Hypothesis 4: The mean flow rate regulation score for the computer learners would be greater than that of the laboratory learners on a delayed posttest.

Analysis of covariance was also used to analyze the student regulation scores on the delayed posttest; the covariate was the number of intravenous flow rate regulations that students performed clinically (while providing care to patients) during the ten week interim between the immediate and the delayed posttests. As reflected by Table 4.6, there was again no significant difference between the delayed posttest intravenous regulation scores of the computer learners and the laboratory learners. Thus, Hypothesis 4 was rejected. The null hypothesis of no difference between groups was accepted.

Table 4.6.--ANCOVA for delayed posttest regulation score*.

Treatment Group	Mean Regulation Score	Standard Deviation	F	Significance of F
Computer Learners	2.875	0.448	0.158	0.693
Laboratory Learners	2.917	0.282		

* Possible range of scores: 0 to 3.

Summary. When the criteria for scoring the calculation on the delayed posttest were adjusted so that performance comparisons could be made among all students, regardless of which of two calculation methods they used, there were no significant differences between the groups on any of the effectiveness measures. The computer learners and the laboratory learners demonstrated equal ability to calculate and regulate intravenous flow rates on both the immediate posttest and the delayed posttest that was administered ten weeks after the treatment.

The following research hypotheses were rejected:

1) The mean flow rate calculation score for the computer learners would be greater than that of the laboratory learners on an immediate posttest.

2) The mean flow rate calculation score for the computer learners would be greater than that of the

laboratory learners on a delayed posttest.

3) The mean flow rate regulation score for the computer learners would be greater than that of the laboratory learners on an immediate posttest.

4) The mean flow rate regulation score for the computer learners would be greater than that of the laboratory learners on a delayed posttest.

Rather, the null form of each of the above hypotheses was accepted.

Efficiency of Treatment

Treatment efficiency for this study consists of two dependent variables: student time spent in practicing the skill and the number of learning scenarios students worked through. Each variable was measured throughout the ten weeks of the study.

Student Time.

> Hypothesis 5: The mean time spent in learning would be less for the computer learners than for the laboratory learners.

Analysis of variance was used to analyze the amount of time students in each treatment group spent in practicing the skill of calculating and regulating intravenous flow rates. As can be seen in Table 4.7, the computer learners spent significantly less time practicing the skill than did the computer learners (significant at the 0.05 level). Hypothesis 5, therefore, was accepted.

Table 4.7.--ANOVA for time spent practicing the skill.

Treatment Group	Mean Minutes Spent	Standard Deviation	F	Significance of F
Computer Learners	23.6	6.14	4.35**	0.0425
Laboratory Learners	28.8	10.3		

** Significant at 0.05 level.

Table 4.8.--ANOVA for learning scenarios students worked through.

Treatment Group	Mean Number of Learning Scenarios	Standard Deviation	F	Significance of F
Computer Learners	3.71	1.73	25.75**	0.0000
Laboratory Learners	1.58	1.10		

** Significant at 0.05 level.

Number of Learning Scenarios.

> Hypothesis 6: The mean number of learning scenarios experienced by computer learners would be greater than that of the laboratory learners.

Analysis of variance was also used to analyze the number of learning scenarios worked through by students in both treatment groups during the course of the study. Table 4.8 presents the results of this analysis. The computer learners worked through significantly more learning scenarios than did the laboratory learners (significant at the 0.05 level). Therefore, Hypothesis 6 was accepted.

Summary. There were significant differences between the treatment groups for both of the efficiency variables. The computer learners spent significantly less time (at 0.05 level) practicing the calculation and regulation of intravenous flow rates than did the laboratory learners. Moreover, the computer learners worked through significantly more (at 0.05 level) learning scenarios than did the laboratory learners. Thus, the computer learners were able to practice significantly more in significantly less time.

Costs

In addition to testing the hypotheses concerning effectiveness and efficiency of the two treatments, an objective of this study was to determine the relative cost per student. Table 4.9 presents the categories and amounts of expenditures that were used in calculating the actual cost per student for each treatment. This cost reflects combined actual expenditures for both instruction and research in this particular study. When the cost of reported faculty teaching and preparation time was combined with the actual cost of consummable materials and then divided by the number of students in each treatment group (N=24), the cost per computer learner was $ .94, while the cost per laboratory learner was $2.17. On this basis, the cost per laboratory learner was more than double the cost per computer learner.

Table 4.9.--Costs of faculty time and consummable materials (combined instructional and research costs).

Treatment Group	Faculty Time ($18000/yr av. salary)	Intravenous Equipment	Total Cost	Cost per Student
Computer Learners (N=24)	$17.28 (120 min)	$5.21 (1 set)	$22.49	$ .94
Laboratory Learners (N=24)	$31.25 (217 min)	$20.84 (4 sets)	$52.09	$2.17

Faculty time accounted for the greatest actual expense. Table 4.10 further categorizes the various instructional activities engaged in by faculty for each treatment group. The time required for initial instruction and supervision was the same for both groups (90 minutes). However, the time required for laboratory preparation, set-up, and clean-up was much greater for the laboratory learners (108 minutes) than for the computer learners (30 minutes). Faculty time per student was 5.00 minutes per computer learner compared to 9.01 minutes per laboratory learner. The cost of this faculty time was then computed on the basis of the average salary ($18000 for a nine month academic year) for Grand Valley State Colleges School of Nursing faculty.

The setting in which this study took place already had sufficient numbers of TRS-80 microcomputers for the purposes of the experiment, so no additional computer hardware purchases were necessary. Also, since this investigator was the author of the computer program used in this study, no computer software purchase or developmental costs were incurred. Therefore, these findings on cost per student do not reflect computer hardware and software costs. A discussion of projected costs per student for instruction alone, including computer hardware and software costs, is presented later in this chapter, in the discussion section.

Table 4.10.--Faculty time expenditures for activities related to the instruction of intravenous flow calculation and regulation (combined instructional and research time).

Treatment Group	Initial Instruction/ Supervision (minutes)	Additional Supervision (minutes)	Laboratory Preparation/ Set-up (minutes)	Laboratory Clean-up (minutes)	Total Time (min)	Time Per Student (min)
Computer Learners	90	------	30	------	120	5.00
Laboratory Learners	90	9	108	10	217	9.01

Summary. The cost per student in each treatment group was determined by combining the costs of faculty time and consummable materials and then dividing by the number of students. The cost per computer learner was $ .94 compared to $2.17 per laboratory learner. Faculty spent an average of 5.00 minutes for each computer learner and 9.01 minutes for each laboratory learner.

Findings of Special Interest

In addition to findings related to the description of subjects, the research hypotheses, and the research objective, there remain some findings which are of special interest to this study. Findings relative to the students' perceptions of the helpfulness of the treatments, the students' comments about the treatments, the alternate method for calculating intravenous flow rates, and a computer malfunction are presented in this section.

Perceptions of helpfulness. In a post-study questionnaire, students were asked to indicate whether they perceived the treatment as helpful in preparing them for their first clinical experience with caring for patients receiving intravenous fluid therapy. Twenty-one of the twenty-four computer learners reported that the computer simulation was helpful, and nineteen of the twenty-four laboratory learners reported that the laboratory simulation was helpful.

Each student was also asked to rank which of the following he or she perceived to be the most helpful in assisting him or her in learning to calculate and regulate intravenous flow rates: (1) the treatment (either laboratory or computer simulation); (2) the required medication dosage calculation programmed instruction text; or (3) his or her clinical instructors.

As can be seen in Table 4.11, both computer learners and laboratory learners ranked the programmed instruction text as the most helpful for learning to calculate intravenous flow rates. The laboratory learners ranked the laboratory simulation as the most helpful for learning to regulate intravenous flow rates. The computer learners, however, were fairly evenly divided in their perceptions that the computer simulation or their clinical instructors were the most helpful for learning to regulate intravenous flow rates.

Students' comments about the simulations. At the conclusion of this study, all students were asked to respond in writing to questions about the simulation experience. The most often stated responses are presented here.

For the computer learners, positive aspects of the computer simulation were identified as: (1) the large number of practice problems generated; (2) immediate feedback; (3) no waiting for available equipment or instructor; (4) the novelty of using new technology; (5) independence

Table 4.11.--Instructional methodologies ranked most helpful by students for learning to calculate and regulate intravenous flow rate.

Ranked Most Helpful	Treatment Group	
	Computer Learners	Laboratory Learners
For Calculation:		
Treatment	7	8
Programmed text	14	10
Clinical instructors	3	6
For Regulation:		
Treatment	9	16
Programmed text	5	1
Clinical instructors	10	7

in learning; and (6) provision of privacy. The computer learners also identified some negative aspects of the computer simulation: (1) unrealistic simulation, as it was much easier to regulate an intravenous system by pressing a key on a keyboard than manipulating a thumb screw on intravenous tubing; (2) more like a fantasy game than a simulation of clinical reality; (3) the uncomfortable long walk across campus to the microcomputer laboratory on a very cold and snowy early February morning; and (4) the frustration of a computer malfunction.

Positive aspects of the laboratory simulation identified by the laboratory learners were: (1) the reality of the simulation; (2) working with actual equipment; and (3) practicing at one's own pace. Negative aspects of the laboratory simulation also identified by the laboratory learners included: (1) waiting for the equipment to be available; (2) waiting for an instructor; and (3) not receiving consistent feedback.

Detailed comments from both the computer learners and laboratory learners are in Appendix S.

Computer malfunction. Five computer learners experienced a brief computer malfunction during the intravenous regulation segment of the simulation. The mean calculation and regulation scores for these five students did not differ from the mean calculation and regulation scores for the group as a whole. However, on a post-study questionnaire, each of these five students commented negatively about the computer simulation; each stated that the malfunction was frustrating and threatening to his or her confidence. Further, each of these students stated that he or she did not like working with the computer simulation.

Alternate calculation method. On the delayed posttest, fifteen computer learners and four laboratory learners (40% of all subjects) used an alternative calculation method that had been presented by the previously assigned programmed instruction text on medication dosage calculation. Significantly more computer learners than laboratory learners used the alternate calculation method on the delayed posttest (chi square = 10.54; significant at 0.05 level).

In an attempt to ascertain why some students used the method that had not been reinforced in either treatment, a personal and phone survey of all clinical faculty was conducted to determine if faculty had reinforced one calculation method over another. All faculty reported that they reinforced the correctness of the students' calculations, regardless of the method used.

Further, students were asked if they studied prior to the delayed posttest. Three computer learners and four laboratory learners responded that they did study for the delayed posttest. All of these students reported that they used the programmed instruction text as their resource for studying. Further, all seven of these students used the alternate calculation method on the delayed posttest.

Summary. Both computer learners and laboratory learners perceived their respective treatments to be helpful to them in preparing for their first clinical experiences in caring for patients receiving intravenous fluid therapy. For learning to calculate intravenous flow rates, most (N=14) computer learners and most (N=10) laboratory learners ranked the programmed instruction text as the most helpful resource. For learning to regulate intravenous flow rates, most laboratory learners ranked the laboratory simulation as the most helpful; computer learners were almost equally divided in their ranking between the computer simulation and their clinical instructors.

Forty percent of all subjects used an alternate calculation method on the delayed posttest; significantly more (at the 0.05 level) computer learners used this alternate method. Clinical faculty reported that they did not reinforce one calculation method over another when working with students. Those students who studied for the delayed posttest all reported using the programmed text as the primary resource for their studies (this text presented both intravenous calculation methods). Those students who studied for the delayed posttest all used the alternate calculation method on that posttest.

During the treatment, five computer learners experienced a brief computer malfunction. The immediate posttest scores for these students were no different from the scores of students who did not experience the malfunction. However, on a post-study questionnaire, all five of these students commented negatively about the computer simulation, particularly noting their frustration with the malfunction.

Computer learners and laboratory learners provided both postive and negative comments regarding the simulation they experienced.

Discussion of Findings

The results of this study are discussed within the framework of the research hypotheses and objective. The discussion is presented in three sections: effectiveness, efficiency, and cost.

Effectiveness

The effectiveness of the treatments are represented by two dependent variables, calculation and regulation of intravenous flow rates. Both variables were measured twice, immediately after the treatment (the immediate posttest) and again ten weeks later (the delayed posttest). Findings related to both calculation and regulation of intravenous flow rates are discussed separately.

Calculation. For the immediate posttest calculation scores, no difference between treatment groups was demonstrated. Both the computer learners and the laboratory learners performed equally as well on the calculation segment of the immediate posttest. The null hypothesis, that of no difference between groups, was accepted. This finding is supported by the findings of previous research cited in Chapter II (Bitzer, et al., 1973; Braun, 1980; Droste-Bielak, 1980; Kirchhoff & Holzemer, 1979; Kulik, et al., 1980; Rubinson & Robinson, 1977-1978).

An interesting pattern emerged during the analysis of the delayed posttest calculation scores. The laboratory learners scored significantly higher (at the 0.05 level) than the computer learners on the calculation segment of the delayed posttest. Upon investigation of the raw data, it became apparent that many students used an alternative calculation method during the delayed posttest.

This alternative method was one of two intravenous flow rate calculation methods presented to all students in the medication dosage programmed instruction text that was assigned to the students as required reading three weeks prior to the beginning of this study. Both methods are acceptable and accurate ways to calculate intravenous flow rates. However, the posttest asked the student to calculate three distinct flow rates within the one problem (volume per hour, volume per minute, and drops per minute). The alternate calculation method (a one-step formula) allows the student to derive only the final flow rate in drops per minute.

By using this alternate calculation method, the intermediate calculations were not performed. Because each part of the calculation was scored on the posttest, the total calculation scores for those students who used the alternate method were automatically lower than the scores for those students who used the calculation method reinforced by either treatment. Students who used the reinforced method could receive a score of zero, one, two, or three on their calculation, depending upon the accuracy of each part of the calculation. However, those students who used the alternate method could receive a score of only zero or one. It is obvious that the scores generated by the two methods are not comparable.

In order to compare scores among all students, regardless of the calculation method used, the data were analyzed again, this time considering the correctness of only the last segment of the calculation problem. When these data were analyzed, it was found that there was no difference between the delayed posttest calculation scores of the computer learners and the laboratory learners. Both the computer learners and the laboratory learners performed equally as well on the last calculation segment of the delayed posttest. On the basis of this newer data analysis, then, the null hypothesis of no difference between groups was accepted. This finding is supported by evidence in the literature previously cited (Bitzer, et al., 1973; Braun, 1980; Droste-Bielak, 1980; Kirchhoff & Holzemer, 1979; Kulik, et al., 1980; Rubinson & Robinson, 1977-1978).

Alternate calculation method. Both intravenous flow rate calculation methods presented in the programmed instruction text are acceptable in most clinical practice situations. One method is a three-part process, each part yielding an answer to one part of the entire calculation problem. The first part of this method yields the volume that should infuse into a patient in one hour; the second part determines the volume that should infuse each minute; and the third part determines the number of drops that should infuse each minute. The other calculation method combines the three parts into one formula, which yields the final value, the number of drops per minute that should infuse.

The three-part calculation method was chosen for reinforcement with the treatments because of the need for nurses to be able to derive the two intermediate intravenous flow rate values, as well as the final value. When caring for "fragile" patient populations (such as infants and young children, aged adults, or persons of any age with acute circulatory or renal problems), it is necessary for the nurse to know the intermediate intravenous flow rates in order to adequately make clinical decisions relative to the maintenance of fluid balance with these types of patients. The three-part calculation method provides the nurse with these intermediate flow rates, while the one-part formula provides the last flow rate only.

However, the subjects in this study were beginning level nursing students and, therefore, had limited clinical contact with such "fragile" patients. Therefore, the students' clinical experiences probably did not reinforce the importance of using the three-part calculation method. Rather, for the usual clinical experiences of these student nurses, the last flow rate (the number of drops per minute) was the "important" value. This value could be derived by using either calculation method. The rationale for the appropriate clinical use of either of the two calculation methods were neither discussed with or presented to the students by this investigator, the treatments, or the programmed instruction text.

What are some other possible reasons why so many students chose to use the alternate calculation method on the delayed posttest? Perhaps the choice of calculation method reflected the method that was first learned by the students as they worked through the assigned medication dosage calculation programmed instruction text three weeks before either treatment. Perhaps the reinforcement of one method during the treatments was not strong enough to cause students to change an already established preference.

Further, for those students who studied for the delayed posttest, all studied by reviewing the programmed instruction text. All of these students used the alternate calculation method on the delayed posttest. Therefore, of the forty per cent of the students who used the alternate calculation method on the delayed posttest, over one-third used the programmed instruction text to study for the test. This may indicate the importance of the programmed text in reinforcing the alternative calculation method.

Also, the alternate method is a one-step formula whereas the reinforced method is a three-step problem solving process. A short one-step formula is much easier to memorize than is a three-step process. For those students who find it easier to memorize a formula rather than logically deduce a solution to a problem, the alternate method would be favored over the reinforced method.

Finally, although clinical faculty stated that they did not reinforce the students' use of one calculation method over the other, the use of the alternate method may still have been reinforced in the clinical area. For example, in caring for patients receiving intravenous fluid therapy, students may have called upon nursing practitioners and/or hospital procedure manuals for assistance. Such resources as these may have reinforced student use of the alternate calculation method.

Another question about the alternate calculation method concerns the rationale for why students who used the alternate method during the delayed posttest used the reinforced method during the immediate posttest. Students may have used the reinforced method on the immediate posttest because of the consistent and repeated reinforcement of this method during both of the treatments. The treatments were quickly followed by the immediate posttest. For the delayed posttest, there was a ten week time delay between the treatments and the testing situation. Time and reinforcement may, therefore, have been important factors in determining whether a student would use the reinforced or alternate calculation method during the posttests.

<u>Summary.</u> The findings that the computer simulation was as effective as the laboratory simulation in

teaching the calculation of intravenous flow rates (a cognitive skill) is supported by reports of previous research.

During the delayed posttest, forty percent of the students used a calculation method that was different from that reinforced during both treatments. Possible explanations for why students chose to use the alternate calculation method include: (1) lack of clinical contact with patients whose condition warranted the calculation of the intermediate flow rates; (2) persistent preference for the first method learned; (3) ease of memorization of a short one-step formula over a three-step deductive process; and (4) potential clinical reinforcement of the alternate method by learning resources "outside" of the college learning environment.

Regulation. For both the immediate and delayed posttest regulation scores, no difference between treatment groups was demonstrated. Both the computer learners and the laboratory learners performed equally as well in accurately regulating an actual flowing intravenous system. The null hypotheses of no difference between groups were accepted.

This finding is of particular interest because the support in the literature for the effectiveness of computer-assisted instruction for teaching psychomotor skills is not as strong as for teaching cognitive skills. By demonstrating that a computer simulation is equally as effective as a laboratory simulation for teaching students to accurately regulate intravenous flow rates on actual equipment, this particular study helps to fill a gap that currently exists in the research concerning the use of computer-assisted instruction for teaching psychomotor skills.

Also of particular interest is the fact that a brief computer malfunction during the psychomotor skill simulation part of the program did not adversely affect the students' posttest performance of that skill. When one of the twelve randomly generated flow rate problems resulted in a drop rate of 60 drops per minute, the computer failed to recognize as correct the student's correct regulation of the simulated flow. Therefore, these students received negative reinforcement for their correct responses. The computer problem was quickly corrected when this investigator became aware of the malfunction.

Even though the five affected students voiced frustration over the malfunction and general dislike for the computer simulation, their posttest scores (both calculation and regulation) were equal to both those students who experienced the computer simulation without the malfunction and those students who experienced the laboratory simulation.

Some computer learners commented that they did not believe the computer simulation was a realistic representation of actual equipment. Further, these students stated that the skills required to regulate the computer simulated intravenous system did not seem sufficiently similar to the skills required to regulate actual intravenous equipment. However, the immediate posttest regulation scores indicated that these students were able to transfer the skill they had developed with the computer simulation directly to actual equipment.

Perhaps some students felt the need to actually work with "real" equipment. For the computer learners, their only opportunity to manipulate actual equipment, outside of the posttesting situations, was in the clinical areas, caring for patients. For those computer learners who stated that they perceived their clinical instructors to be the most helpful to them in learning to regulate intravenous flow rates, the clinical instructors may have provided reinforcement for the skill previously learned with the computer simulation.

Summary. As measured by posttest regulation scores, the computer simulation was as effective as the laboratory simulation for teaching students to accurately regulate intravenous flow rates, a psychomotor skill. Students were able to transfer skill learned from the computer simulation to actual equipment. These findings add to the scope of previous research on the effectiveness of computer-assisted instruction for teaching psychomotor skills.

Efficiency

Two efficiency variables were measured in this study: (1) amount of student time spent practicing the skill of calculating and regulating intravenous flow rates; and (2) number of learning scenarios students worked through when practicing the skill. Findings related to each of these variables are discussed in this section.

Student time. The computer learners spent significantly less (at the 0.05 level) time practicing calculating and regulating intravenous flow rates than did the laboratory learners. The null hypothesis of no difference between groups was, therefore, rejected.

This finding is supported by the findings of previous research cited in Chapter II. Many investigators have found that students using computer-assisted instruction learn in significantly less time than their peers using conventional learning resources (Bitzer, et al., 1973; Braun, 1980; Kirchhoff & Holzemer, 1979; Kulik, et al., 1980; Rubinson & Robinson, 1977-1978).

Some computer learners in this study commented positively on the computer program's speed of problem generation and consistent feedback to students. On the other hand, some laboratory learners commented negatively concerning the amount of time spent in waiting for equipment to become available for practice. For the laboratory learners, time was sometimes spent waiting for a turn at the equipment, while the computer learners spent their time actually practicing the skill with the computer simulation.

Number of learning scenarios. The computer learners worked through significantly more (at the 0.05 level) learning scenarios than did the laboratory learners. Therefore, the null hypothesis of no difference between groups was rejected. As was true with the previously discussed efficiency variable (student learning-time), this finding is also supported by findings of research already cited in Chapter II (Braun, 1980; Kulik, et al., 1980).

Many computer learners commented favorably about the relatively large number of different practice calculation and regulation problems that were quickly presented to them by the computer program. These students also commented on their enjoyment of working with a microcomputer; some students stated that they enjoyed experiencing "new technology". Conversely, some computer learners commented that they disliked working with the computer and would have preferred working with actual equipment in the skills laboratory. Perhaps students with various learning styles and attitudes concerning instructional methodologies might best be taught by attempting to match their learning attributes with teaching methodologies that strengthen the learning potential of persons with those attributes.

Summary. The computer learners were able to practice significantly more in significantly less time. The null hypotheses related to both efficiency variables were rejected. When measured by amount of student learning time and amount of practice, the computer simulation was significantly more efficient than the conventional laboratory simulation for teaching students to calculate and regulate intravenous flow rates. The significantly greater efficiency of the computer simulation is a finding supported by results of previous research in nursing and other disciplines.

Cost

The cost per student was calculated by determining the cost of consummable materials and faculty time for instructional and research activities related to teaching the calculation and regulation of intravenous flow rates. The amount thus calculated for each treatment group was then divided by 24, the number of students in each treatment group.

The cost per laboratory learner was $2.17. This amount took into account the purchase of intravenous fluid bottles and tubing for demonstration and practice, and the cost of faculty time for teaching and supervising practice during the laboratory simulation as well as for laboratory preparation, set-up, and clean-up.

By comparison, the cost per computer learner was $ .94. This amount included the purchase of an intravenous fluid bottle and tubing for demonstration and the cost of faculty time for teaching and supervising practice during the computer simulation, as well as for loading and unloading the programs into the computers.

These costs per student reflect the actual combined costs for instruction and research incurred in this particular study. Also, because the setting in which this study was conducted already had the necessary computer hardware and software, the above costs per student do not reflect these expenses. The remainder of this section discusses the projected cost per student when instructional expenses are separated from expenses incurred because of the additional requirements of a research study, and when computer hardware and software expenses are included.

When the cost of instruction is calculated apart from the costs incurred because of the special requirements of a research study, the costs for both computer learners and laboratory learners decrease. For example, in this study, 60 minutes of faculty time was spent in direct supervision of computer and laboratory practice. While faculty supervision of laboratory practice would still be necessary in order to provide feedback and direction to the students, such faculty time could be omitted or greatly preparation, set-up, and clean-up.

By comparison, the cost per computer learner was $ .94. This amount included the purchase of an intravenous fluid bottle and tubing for demonstration and the cost of faculty time for teaching and supervising practice during the computer simulation, as well as for loading and unloading the programs into the computers.

These costs per student reflect the actual combined costs for instruction and research incurred in this particular study. Also, because the setting in which this study was conducted already had the necessary computer hardware and software, the above costs per student do not reflect these expenses. The remainder of this section discusses the projected cost per student when instructional expenses are separated from expenses incurred because of the additional requirements of a research study, and when computer hardware and software expenses are included.

When the cost of instruction is calculated apart from the costs incurred because of the special requirements of a research study, the costs for both computer learners and laboratory learners decrease. For example, in this study, 60 minutes of faculty time was spent in direct supervision of computer and laboratory practice. While faculty supervision of laboratory practice would still be necessary in order to provide feedback and direction to the students, such faculty time could be omitted or greatly reduced for students practicing with the computer simulation. Because the computer simulation provides feedback and direction to students, it would not ordinarily be necessary to have a faculty member in attendance while students practice with the computer. Therefore, for the computer learners, faculty time for initial instruction and supervision of practice could be reduced from 90 to 30 minutes for each skills laboratory session.

Furthermore, 30 minutes of faculty time was spent in this study for the loading and unloading of computer program tapes into the microcomputers. With the use of initial student orientations and pictorial displays of step-by-step instructions (already available to students), students could readily become self-sufficient in loading and unloading computer programs themselves. Since faculty time is a very costly part of any instruction, decreases in the amount of necessary faculty time will thereby likely decrease the cost per student.

Table 4.12 presents a comparison of the projected faculty time that would be spent on instructional activities alone when all 48 students (i.e. two skills laboratory sessions) practice with either the computer simulation or the laboratory simulation. The projected 60 minutes spent in initial instruction and supervision for the 48 computer learners in two skills laboratory sessions was derived by doubling the previously discussed estimate of 30 minutes required for 24 students in one skills laboratory session. Likewise, the projected 180 minutes spent in initial instruction and supervision, 18 minutes for additional supervision, and 20 minutes for laboratory clean-up were all derived by doubling the actual amount of faculty time reported expended in these activities during this study (for 24 students in one skills laboratory session). In this study, faculty reported expending 108 minutes for laboratory preparation and set-up for the 24 students in one skills laboratory session. Because preparation and set-up for instructional activities usually require less time on subsequent teaching occasions, the 108 minutes was increased by one-half to a projection of 162 minutes of faculty time needed to prepare and set-up for 48 students in two skills laboratory sessions.

As can be seen from Table 4.12, if all 48 students practiced with the computer simulation, it is projected that there would be 1.25 minutes of faculty time spent on each student. If all 48 students practiced with the laboratory simulation, however, it is projected that 7.67 minutes of faculty time would be spent for each student. This represents a considerable difference in projected faculty time expenditures for the two treatments.

The setting in which this study was conducted already had microcomputers in sufficient numbers to accommodate this research. If the purchase of computers had been

Table 4.12.--Comparison of projected faculty time expenditures for instruction alone.

Treatment Group	Initial Instruction/ Supervision (minutes)	Additional Supervision (minutes)	Laboratory Preparation/ Set-up (minutes)	Laboratory Clean-up (minutes)	Total Time (min)	Time Per Student (min)
Computer Learners (N=48)	60	------	------	------	60	1.25
Laboratory Learners (N=48)	180	18	162	20	380	7.92

necessary, the cost per computer learner would, of course, have risen. The type of computer used in this study was a TRS-80 Model I microcomputer with 16 kilobytes of memory and Level II BASIC. Educational institutions can currently purchase these microcomputers for approximately $700 each.

Twelve such TRS-80 microcomputers were used for this study. However, if instruction were separated from the research aspects of this study, the teaching activities could have been accommodated with five microcomputers for the 48 students. When five microcomputers are provided for the 48 students, each microcomputer services 10 students. As was found in this study, computer learners spent an average of 23 minutes practicing with the computer simulation. On this basis, each of the five microcomputers would average 230 minutes (i.e. 3.8 hours) of usage exclusively by the 48 students using the computer simulation on intravenous flow rate calculation and regulation.

Because of off-campus clinical instruction, nursing students have limited amounts of on-campus time during which they could have access to the microcomputers. The nursing students in this study are on-campus only three days out of every five. The three days on-campus provide the potential of at least 24 hours of instruction (eight hours a day for each of the three days). Of these 24 hours, 13 are committed to classroom and laboratory instruction. Each student potentially has 11 hours of "available" time, therefore, during which he or she could "fit in" independent work on a computer. Due to clinical patient care requirements, the instruction for intravenous flow rate calculation and regulation needs to be provided within a one week (three day) period. Therefore, five microcomputers would be sufficient to provide ample access to instruction for the 48 students in the limited time available to them.

The initial cost for the purchase of five TRS-80 Model I microcomputers with Level II BASIC and 16 kilobytes of memory would be approximately $3500. If this cost is amortized over a three year period, the cost for computer hardware per year is $1166.66. If the computer simulation on calculation and regulation of intravenous flow rates were the only program run on these computers, then the $1166.66 would be divided by the 48 students to determine the cost per student for the hardware ($24.31 per student per year). This exclusive use of five microcomputers for only one program is, however, highly unlikely.

If the five microcomputers were additionally used by nursing and other students for other programs, the cost per student, of course, decreases. In the semester system at Grand Valley State Colleges, there are 28 instructional weeks of five days each in the two semesters. If the microcomputers were used for the intravenous simulation program during one of the 28 weeks and for other programs during the remaining 27 weeks, then the microcomputers would cost $41.66 for each five day week. However, because nursing students are only on-campus for three days out of every five, the cost of the microcomputers for three-fifths of a five day week would be $24.99. When this amount is divided by the 48 students, the cost per student for the computer hardware is $ .52.

Another cost which this study does not reflect is the cost of the computer program itself. Because this investigator was also the author of the computer simulation used in this study, no purchase or developmental costs were incurred. Although the particular computer simulation used in this study is not as yet commercially distributed, the cost can be estimated by looking at the market price of short computer tutorials and simulations from other disciplines. The usual cost for such programs is approximately $15. Five copies of the program would need to be purchased, one for each of the five microcomputers. Therefore, $75 would be needed to purchase the software necessary for instruction of 48 students. If the software costs are amortized over three years, the cost per year is $25. When this amount is divided by the 48 students, the cost per student for the computer software is $ .52.

Table 4.13 presents a comparison of the projected costs for instruction when all 48 students (two skills laboratory sessions) practice with either the computer simulation or the laboratory simulation. When projected

Table 4.13--Comparison of projected costs for instruction alone.

Treatment Group	Faculty Time ($18000/yr av. salary)	Intravenous Equipment	Computer Hardware (amortized over 3 yrs)	Computer Software (amortized over 3 yrs)	Total Cost	Cost Per Student
Computer Learners (N=48)	$8.64 (60 minutes)	$10.42 (2 sets)	$24.99 (5 TRS-80 Model I's used 1 week out of 28)	$25.00 (5 copies of computer program on tape)	$69.05	$1.44
Laboratory Learners (N=48)	$54.72 (380 minutes)	$41.68 (8 sets)	-----	-----	$96.40	$2.01

costs for faculty time, consummable materials, and computer hardware and software are considered, the projected cost per student using the computer simulation is $1.44, and the projected cost per student using the laboratory simulation is $2.01.

Summary. In this study, the cost per computer learner ($ .94) was less than half the cost per laboratory learner ($2.17). However, these costs reflected a combination of costs incurred for instruction and for the special requirements of the research. Moreover, since the setting in which this study was conducted already had the necessary computers and program, the actual cost per student did not reflect purchase costs of computer hardware and software. When instructional costs are separated from research costs, and when computer hardware and software purchase costs are amortized over three years, the projected cost per computer learner ($1.44) remains less than the projected cost per laboratory learner ($2.01).

Summary

Student abilities to calculate and regulate actual intravenous flow rates were measured immediately after the treatment (the immediate posttest) and ten weeks later (the delayed posttest). The computer learners and laboratory learners performed equally as well with both intravenous flow rate calculation and regulation on the immediate posttest. Further, both groups did equally as well with regulating intravenous flow rates on the delayed posttest.

On the delayed posttest, however, forty percent of all students used an alternate method for calculating intravenous flow rates. Significantly more (at the 0.05 level) computer learners than laboratory learners used the alternate calculation method. Students who used this alternate method received a lower score on their calculation problem because the method did not derive the values for two intermediate flow rates.

In order to compare scores among all students, regardless of the calculation method used, delayed posttest calculation scores were reanalyzed using only the last segment of the calculation problem. When the data were analyzed in such a fashion, there were no differences in the delayed posttest calculation scores between computer learners and laboratory learners.

Students may have selected to use this alternate calculation method because: (1) it was the method used most often clinically; (2) it was the first method learned and it remained the preferred method; (3) it was easier to memorize because of its relative shortness of expression; and/or (4) it was reinforced by clinical learning resources "outside" of the usual campus learning environment.

In addition to the equal effectiveness of the computer simulation as compared to the laboratory simulation, students using the computer simulation were able to work through significantly more (at the 0.05 level) practice problems in significantly less (at the 0.05 level) time. Also, for this study, the cost per student using the computer simulation ($ .94) was less than half the cost per student using the laboratory simulation ($2.17). When instructional costs are separated from research costs, and when projected computer hardware and software costs are amortized over three years, the cost per computer learner ($1.44) still remains less than the cost per laboratory learner ($2.01).

In summary, when teaching forty-eight beginning level nursing students to calculate and regulate intravenous flow rates, the computer simulation was shown to be more efficient and less costly than the laboratory simulation. Furthermore, the computer simulation was as effective as the laboratory simulation for teaching the regulation of intravenous flow rates, a psychomotor skill.

When the criteria for scoring were adjusted so that comparisons could be made among all students, regardless of which of two acceptable calculation methods was used, the computer simulation was as effective as the laboratory simulation for teaching calculation of intravenous flow rates, a cognitive skill. If the scoring criteria were not adjusted to accommodate the different calculation methods used, the laboratory simulation was more effective than the computer simulation for teaching calculation of intravenous flow rates.

CHAPTER V

SUMMARY AND CONCLUSIONS

This chapter is organized into five sections: (1) summary of the study and its findings; (2) limitations of this study; (3) conclusions; (4) implications of this study; and (5) recommendations for further research. Each section is discussed separately.

Summary of the Study and its Findings

The purpose of this study was to determine if a computer simulation could effectively and efficiently teach the basic nursing skill of calculation and regulation of intravenous flow rates. Two questions were addressed. First, was a computer simulation as effective as a laboratory simulation (the conventional teaching methodology) for instructing students in the calculation and regulation of intravenous flow rates? Second, was a computer simulation more efficient in terms of student learning time and cost than a laboratory simulation for the teaching of this skill?

This study was a posttest-only, control group quasi-experiment, similar to Campbell and Stanley's (1963) static-group comparison design. The subjects were forty-eight junior-level baccalaureate nursing students enrolled in the Nursing II course at Grand Valley State Colleges in Allendale, Michigan, during Winter Semester, 1981.

Students were assigned to either the experimental or control group on the basis of their assignment to the regular skills laboratory. Students in the Monday skills laboratory were assigned to the experimental group (N=24), while students in the Tuesday skills laboratory were assigned to the control group (N=24).

Three weeks prior to the beginning of this study, as part of the regular instruction in the course, students were assigned to read and work through a programmed instruction text on mathematics for medication dosage calculation. The last chapter of this text presented two methods for calculating intravenous flow rates. One week prior to the study, students took a paper-and-pencil test on the content covered by the programmed instruction text; however, no test questions related to intravenous flow rate calculation.

Using one of the calculation methods in the programmed instruction text, this investigator presented the calculation and regulation of intravenous flow rates in classroom demonstrations to both treatment groups. Students in the experimental group then practiced the skill for a maximum of 30 minutes using a computer simulation on TRS-80

Model I microcomputers. Students in the control group practiced the skill for a maximum of 30 minutes using actual equipment in a skills laboratory simulation. Both treatments reinforced the same intravenous flow rate calculation method that had been presented in the classroom demonstration.

After practicing with either the computer simulation or the laboratory simulation for a maximum of 30 minutes, all students were tested on their ability to correctly calculate an intravenous flow rate and then to accurately regulate an actual intravenous system to deliver the prescribed volume. Ten weeks later, all students were again tested on these skills.

The major findings of this study are summarized and presented according to the two basic research questions.

Research Question One:

Was a computer simulation as effective as a laboratory simulation for teaching students the calculation and regulation of intravenous flow rates?

On both the immediate and the delayed posttests, there were no significant differences between groups in their ability to accurately regulate intravenous flow rates (a psychomotor skill). Computer learners were able to accurately regulate an actual intravenous system as well as laboratory learners. Data were analyzed by analysis of covariance; previous experience in caring for patients receiving intravenous fluid therapy was used as the covariate for the immediate posttest. Clinical experience with regulating intravenous flow rates during the ten week interim between the immediate and delayed posttests was used as the covariate for the delayed posttest.

Furthermore, on the immediate posttest, there was no significant difference between groups in their ability to correctly calculate intravenous flow rates (a cognitive skill). Computer learners were able to calculate intravenous flow rates as well as laboratory learners on the immediate posttest. Data were analyzed by analysis of covariance; the covariate was the student scores on the medication dosage mathematics examination taken one week prior to the treatment.

When data from the delayed posttest were first analyzed, the laboratory learners scored significantly higher (at the 0.05 level) on their ability to correctly calculate all three segments of intravenous flow rates (volume per hour, volume per minute, and drops per minute). However, forty percent of all students used an alternate calculation method on the delayed posttest. Because this alternate method did not provide all three of the answers to the flow rate calculation problem, students who used this alternate method scored lower on the posttest. Significantly more (at the 0.05 level) computer learners than laboratory learners used this alternate method.

To compare scores among all students, regardless of calculation method used, it was necessary to change the scoring criteria (only solutions to the last segment of the calculation problem were scored, rather than the solutions to the additional two intermediate segments). When these data were analyzed, there was no significant difference between groups. Computer learners were able to correctly calculate intravenous flow rates as well as laboratory learners on the delayed posttest. Data were analyzed by analysis of covariance. The number of intravenous flow rate calculations performed clinically during the ten weeks between the immediate and the delayed posttests was used as the covariate.

Research Question Two:

Was a computer simulation more efficient in terms of student learning-time and cost than a laboratory simulation for teaching students the calculation and regulation of intravenous flow rates?

Throughout this study, records were kept of both the amount of time students spent practicing calculating and regulating intravenous flow rates and the number of learning scenarios they worked through. Data were analyzed by analysis of variance.

The computer learners spent significantly less (at the 0.05 level) time practicing calculating and regulating intravenous flow rates than did the laboratory learners.

Furthermore, the computer learners worked through significantly more (at the 0.05 level) practice problems than did the laboratory learners. The computer learners practiced significantly more in significantly less time than the laboratory learners. Therefore, the computer simulation was more efficient in terms of student learning-time.

The cost per student for the instructional methods used in this study was calculated by determining the cost of consummable materials and faculty time for instructional activities related to teaching the calculation and regulation of intravenous flow rates for each of the treatment groups. This amount was then divided by the number of students in each treatment group.

The cost per computer learner was \$ .94. The cost per laboratory learner was \$2.17. Therefore, the computer simulation was also more efficient in terms of cost per student. It should be noted, however, that these costs reflect a combination of costs incurred for instruction and this research study. Also, these costs do not reflect the costs of computer hardware and software, since the research setting already possessed the necessary computers and program. When instructional and research costs are separated, and when projected costs for computer hardware and software are amortized over three years, the cost per computer learner is \$1.44, while the cost per laboratory learner is \$2.01. The computer simulation remains more efficient in terms of cost per student.

Limitations of this Study

It is obvious that understanding the limitations of this study is necessary for accurate interpretation and use of the findings. In any experimental study, there are factors that operate beyond the investigator's control. These factors have the potential for influencing the study in such a way as to question the findings. Limitations that were evident before the study began were presented earlier, in Chapter I. This section discusses further limitations of this study, those limitations that resulted from events that occurred during the course of the study.

A limitation concerning the instrumentation used in this study is a potential problem with observer bias. An attempt was made to minimize possible observer bias by having students randomly select which observer would evaluate their intravenous flow rate calculation and regulation. Attempts were also made to insure that observers did not know the treatment group assignment of students they were evaluating. However, because of the behavior of the subjects in the testing area, the observers reported that students in the two treatment groups were easily distinguishable from one another during the immediate posttest. Observers reported that the laboratory learners initially approached and handled the intravenous equipment with much greater confidence than did the computer learners.

A further attempt was made to minimize the problem of potential observer bias by having each observer evaluate and score every other observer's scoring. In this way, an individual student's posttest evaluation scores (both calculation and regulation) were evaluated and scored independently by each of the three observers. However, the potential for observer bias still exists for the initial determination of the posttest regulation score, because only one observer actually counted the drops flowing through the intravenous system that any one student previously regulated.

Student exposure to the programmed instruction text presented another problem for this study. Because some students used the alternate calculation method presented in the programmed instruction text, scoring criteria for the delayed posttest calculation score were altered. This alteration may have affected the findings by lowering the discrimination possible in the scoring (instead of a score that ranged from zero to three, the altered criteria provided a scoring range of zero to one).

A final limitation concerns the delivery of the treatments to the students. Five of the twenty-four computer learners experienced a malfunction of the computer simulation; the computer gave negative reinforcement for correct student responses. Although the malfunction was brief, minor, and corrected in a short period of time, it was reportedly annoying and frustrating for the students who experienced it. While the computer learners experienced an equipment malfunction, the laboratory learners experienced a human malfunction. This investigator was ill while teaching students during the laboratory simulation. Consequently, the style and energy of the delivery was affected by the physical state of the instructor.

Conclusions

The purpose of this study was to determine if a computer simulation could effectively and efficiently teach the calculation and regulation of intravenous flow rates to beginning level baccalaureate nursing students. Within the limitations of this study, the following conclusions were drawn:

1. When scoring criteria were altered to accommodate the use of either of two acceptable calculation methods, nursing students who practiced calculating and regulating intravenous flow rates with the computer simulation were able to calculate an intravenous flow rate and regulate an actual intravenous system as well as nursing students who practiced with actual equipment in the laboratory simulation.

2. Nursing students who practiced calculating and regulating intravenous flow rates with the computer simulation were able to complete significantly more practice problems in significantly less time than nursing students who practiced with the laboratory simulation.

3. When costs of computer hardware and software are not included, and when instructional and research costs are combined, the cost per student for nursing students who practiced with the computer simulation was less than half the cost per student for nursing students who practiced with the laboratory simulation.

4. When instructional costs are separated from research costs, and when projected computer hardware and software costs are amortized over three years, the cost per student for nursing students who practiced with the computer simulation is still less than the cost per student for nursing students who practiced with the laboratory simulation.

Implications of this Study

The findings of this study indicate that a computer simulation is an effective, efficient, and economical methodology for teaching beginning level nursing students to calculate and regulate intravenous flow rates, a basic nursing skill with both cognitive and psychomotor components. These findings have implications for nursing education, both in educational institutions and in health care agencies, and for patients themselves.

There are many essential basic nursing skills that are similar in nature (having cognitive and/or psychomotor components) to the calculation and regulation of intravenous flow rates. Examples include medication dosage calculations, fractional medication dosage calculations, preparation of fractional dosages and mixtures of medications for injection in a single syringe, blood and urine testing, measurement of vital signs, and so on. Skills such as these may lend themselves to potential presentation by computer-assisted instruction in any of its four modes (drill and practice, tutorial, simulation, and problem-solving). However, these skills are currently usually taught with laboratory simulations, which are costly in terms of equipment and student and faculty time. Furthermore, the laboratory simulations may not provide students with close supervision and consistent feedback concerning the correctness of the skill performance. Perhaps some of these skills could also be effectively and efficiently taught with some form of computer-assisted instruction. This provides an interesting and potentially meaningful area for further research.

In addition to basic nursing skills of a rather simple nature, nursing requires more complex skills. Examples include clinical decision making, therapeutic communication, and management strategies for individuals and groups of patients and personnel. Perhaps complex skills such as these might also be effectively and efficiently taught with computer-assisted instruction. This, also, is an area for future research.

Computer-assisted instruction might also be used for validating previous knowledge, as well as for providing initial instruction and practice. For example, computer-assisted instruction might be used for non-traditional students who have some prior health care experience. Students such as these might be able to demonstrate their competency in specific nursing care areas by using computer-assisted instruction. In this way, areas in which competency was demonstrated could be omitted from that student's academic program, thus saving time and resources for both the student, the faculty, and other students in the same program. This, of course, provides another area for future research.

Areas outside of nursing education institutions for which computer-assisted instruction might be useful include inservice "refresher" courses for nursing personnel. For example, nurses changing from one practice area to another (such as moving from a psychiatric unit to a medical-surgical patient care area) might be able to upgrade their skills in the new area by practicing with computer-assisted instruction. Also, nurses returning to work after an extended absence might be able to "refresh" their previous skill level through the use of computer-assisted instruction. This potential use of computer-assisted instruction has particular implications for the cost and effectiveness of health care; it also provides yet another area for future research.

Further, patients themselves might be able to use computer-assisted instruction to assist them in learning to provide their own health care needs. Examples include using computer-assisted instruction in teaching diabetic patients and their families how to prepare and administer insulin, plan prescribed diets and exercise regimes, and test blood and urine for the purpose of monitoring vital body functions. Of course, this is also an area for future research.

Another implication of this study concerns the use of microcomputers for computer-assisted instruction in nursing education. As discussed in Chapter II, all of the reported research about computer-assisted instruction in nursing education has involved main-frame, time-sharing computer systems. To this investigator's knowledge, this study represents the first research into the use of microcomputers for computer-assisted instruction in nursing education.

Because of the newness of microcomputer technology, it is not surprising that there has been no reported research as yet on the use of microcomputers for computer-assisted education in nursing. However, there are many noteworthy advantages of microcomputers over terminals on time-sharing, main-frame computer systems.

One very clear advantage of microcomputers is their capability for low cost graphics, animation, color, and, in particular, real-time animation. Real-time animated graphics were an essential part of the computer simulation used in this study. The real-time animation made it possible for the students in this study to learn and practice timing and regulating intravenous flow rates without using actual intravenous equipment. Unlike microcomputers, current main-frame computer systems do not have the capability to provide real-time animation.

Another advantage of microcomputers is the relative cost; the purchase of microcomputers is much less expensive than the purchase or up-grading of a time-sharing, main-frame computer system. Accessability is another advantage. Microcomputers are less vulnerable to "down time" problems; if one unit happens to malfunction, other microcomputers are not affected, unlike what happens when a main-frame computer malfunctions.

Moreover, another advantage with microcomputers is their potential for widely distributed software. The low cost of microcomputers has substantially broadened the potential user market; few educational institutions can afford large, costly systems such as PLATO. Therefore, computer-assisted instruction programs developed on microcomputers have much greater potential for distribution for use on other microcomputers.

A further advantage is the ease with which microcomputers can control other media, such as tape recorders, slide projectors, and video recorders. Thus, microcomputers provide the capability for multimedia learning environments that are responsive to and able to interact with individual students and their learning needs.

Given all of the advantages of microcomputers over terminals on time-sharing, main-frame computer systems, it is obvious that their use has substantial potential for improving the quality of nursing education. Because of these advantages, this investigator predicts that microcomputers will soon be the subject of much research on computer-assisted instruction, in nursing as well as in other disciplines.

Recommendations for Further Research

In discussing some of the implications of this study, the previous section outlined some areas for future research. Specifically mentioned were the need to examine the effectiveness and efficiency of the use of computer-assisted instruction in teaching other basic nursing skills, teaching complex nursing skills, validating competencies of non-traditional nursing students, upgrading and "refreshing" skill levels of current practitioners, teaching self-care to patients and families, and using the special capabilities and advantages of microcomputers for computer-assisted instruction in nursing education. These all represent large and new areas of inquiry, apart from this study.

In addition, several recommendations are made concerning how this particular study could be improved if it were to be repeated. Specific recommendations for revisions include:

1. Separate the effects of the programmed instruction text from the treatments. Either omit the programmed instruction text as a requirement prior to the treatments, or form a third treatment group in which the programmed instruction text is a treatment by itself. In either of these ways, the posttest measurements would then reflect the effects of each of the treatments alone on the ability of students to calculate intravenous flow rates, rather than the "combination" effect which this study measured.

2. Have more than one observer simultaneously count the drops flowing through the intravenous system after each student finished regulating it. In this way, the reliability of the observers' judgments about each student's intravenous regulation ability would be increased.

3. Locate the microcomputers in the same building as the nursing classrooms and skills laboratory. Almost all of the computer learners in this study commented negatively about the necessity for walking across campus in the cold to the microcomputer laboratory. It is possible that their perceptions of the entire computer simulation experience were influenced by the necessity for physical discomfort in order to have access to the microcomputers during the initial treatment.

4. Change the computer program so that the graphics control and student response subroutines are located at the beginning of the program. In this way, the computer program malfunction experienced by some students in this study would be prevented. The location change for the two subroutines would allow the BASIC interpreter to respond more quickly to the students' keyed responses. Also, the real-time response of the program would transport intact from one version of

TRS-80 Level II BASIC to another, regardless of the ROM (i.e. Read-Only Memory) used. An alternative approach is to write the graphics control and student response subroutines in machine language.

Additionally, the following variations in design and methodology are suggested as possible ways to answer questions generated by this study:

1. Add a device to the microcomputers so that half of the computer learners could regulate the simulated intravenous flow rate by turning a control knob. The remaining computer learners would regulate the simulated intravenous flow rate in the original fashion, by pressing specific keys on the computer keyboard. Compare the abilities of the two groups to accurately regulate the intravenous flow rate on actual equipment. In this way, it would be possible to test whether a closer approximation to reality makes a difference in the posttest ability of students to control intravenous flow rates by manipulating a thumbscrew on intravenous tubing. This kind of addition to the TRS-80 microcomputer is simple and temporary.
2. Form two groups of computer learners. Provide one group with access to an intravenous system so that they could, at will, examine and manipulate

the actual equipment prior to the posttest. Do not have this equipment available to the other computer group. It would then be possible to test whether contact with actual equipment makes a difference in students' perceptions of the "reality" of the computer simulation and their confidence in their ability to transfer learning from the computer simulation.

3. Omit the delayed posttest and randomly assign students to the treatment groups. Consequently, two limitations of this present study could be relaxed: non-equivalent groups and self-report data. The random assignment of students to treatment groups would more likely result in equivalent groups, a condition that was questioned in this study because of the non-random assigment of intact groups to treatments.

Intact groups were used in this study to decrease the chance of cross-contamination between the treatment groups during the ten week period between the immediate and the delayed posttests. By omitting the delayed posttest, there would be no problem with cross-contamination, as there would be no data collection beyond the immediate posttest.

Further, omitting the delayed posttest would decrease the potential problem with self-reported data. Most of the self-reported data in this study pertained to student clinical intravenous experiences; these data were mainly generated in the interim period between the immediate and delayed posttests and were used as covariants in the analysis of delayed posttest scores. With no delayed posttest, of course, there would be no need for this type of data.

Summary

Given the limitations of this quasi-experiment, this study found that a computer simulation was significantly more efficient both in terms of student learning time and amount of practice and less costly than a laboratory simulation when teaching beginning level baccalaureate nursing students the basic nursing skill of calculating and regulating intravenous flow rates. Furthermore, a computer simulation was as effective as a laboratory simulation in teaching the regulation of intravenous flow rates, the psychomotor component of the skill.

When the evaluative criteria were altered to accommodate student use of either of two acceptable calculation methods, it was found that a computer simulation was as effective as a laboratory simulation for teaching calculation of intravenous flow rates, the cognitive component of the skill. However, when the evaluative criteria were not altered to accommodate student use of either calculation method, students who practiced with a laboratory simulation scored significantly higher on their ability to calculate intravenous flow rates on a delayed posttest (ten weeks after the treatment).

This study has implications for nursing education, both within and outside of educational institutions. Specific implications are for the potential use of computer-assisted instruction to: (1) teach other basic nursing psychomotor and cognitive skills; (2) teach complex nursing skills, such as clinical problem-solving; (3) validate prior knowledge of non-traditional nursing students; (4) "refresh" and update knowledge and clinical skills of current practitioners; and (5) teach patients and their families to monitor and provide for their own health care needs. Additional implications of this study concern the potential for microcomputers, with their many advantages and special capabilities, to upgrade the quality and individualization of nursing education.

The implications of this study focus attention on many areas for future research. The recommendations for future research range from specific suggestions for improvement of repetitions of this study to suggestions for areas of inquiry beyond the immediate focus of this study.

REFERENCES

REFERENCES

Bitzer, M., & Bitzer, D. Teaching nursing by computer: an evaluative study. Computers in Biology and Medicine, 1973, 3, 187-204.

Bitzer, M., Boudreaux, M., & Avner, R.A. Computer-based instruction of basic nursing utilizing inquiry approach. Urbana, Illinois: Computer-based Education Research Laboratory, February, 1973.

Borg, W.R., & Gall, M.D. Educational research: an introduction (3rd ed.). New York: Longman, 1979.

Brigham, C.R., & Kamp, M. The current status of computer-assisted instruction in the health sciences. Journal of Medical Education, March, 1974, 49, 278-279.

Braun, L. Computers in learning environments: an imperative for the 1980's. BYTE: The Small Systems Journal, July, 1980, 5, 6-10; 108-114.

Buchanan, C. Omega Navigation System (ONS) Flight Crew Training. Paper presented at the meeting of the Association for the Development of Computer-Based Instructional Systems, Atlanta, March, 1981.

Campbell, D.T., & Stanley, J.C. Experimental and quasi-experimental designs for research on teaching (Chapter 5), in N.L. Gage (Ed.), Handbook of research on teaching. Chicago: Rand McNalley & Company, 1963.

Dallman, B.E. Evaluation of PLATO IV in vehicle maintenance training. Lowry AFB, Colorado: Air Force Human Resources Lab, November, 1977. (ERIC Document Reproduction Service No. ED 153 638)

Droste-Bielak, E. The use of computer simulation in teaching interviewing techniques to beginning nursing students in a baccalaureate program. Unpublished doctoral dissertation, University of Michigan, 1980.

Hoffer, E.P., Mathewson, H.O., Loughrey, A., & Barnett, G.O. Use of computer-aided instruction in graduate nursing education: a controlled trial. JEN, March-April, 1975, 1, 27-29.

Huckabay, L., Anderson, N., Holm, D., & Lee, J. Cognitive, affective, and transfer of learning consequences of computer-assisted instruction. Nursing Research, July-August, 1979, 28, 228-233.

Kamp, M. Index to computerized teaching in the health sciences. San Francisco: University of California, 1975.

Kearsley, G.P. Some "facts" about CAI: trends 1970-1976. Journal of Educational Data Processing, 1976, 13, 1-12.

Kirchhoff, K.T., & Holzemer, W. Student learning and a computer-assisted instruction program. Journal of Nursing Education, March, 1979, 18, 22-30.

Kulik, J.A., Kulik, C.C., & Cohen, P.A. Effectiveness of computer-based college teaching: a meta-analysis of findings. Review of Educational Research, Winter, 1980, 50, 525-544.

Kuramato, A.M. Computer-assisted instruction: will it be used? Nursing Leadership, June, 1978, 1, 10-13.

Meadows, L.S. Nursing education in crisis: a computer alternative. Journal of Nursing Education, May, 1977, 16, 13-21.

Mockovak, W.P. The application and evaluation of PLATO IV in AF technical training. Lowry AFB, Colorado: Air Force Human Resources Lab, 1974. (ERIC Document Reproduction Service No. ED 096 957)

Moore, J.F., & Grams, R.J. Hospitals list nurse graduate expectations. Hospitals, June 1, 1980, 73-75.

Olivieri, P., & Sweeney, M.A. Evaluation of clinical learning: by computer. Nurse Educator, July-August, 1980, 5, 26-31.

Rhode, M.A., Kauchak, D., & Eggen, P. Skill acquisition in nurse-midwifery education. Journal of Nursing Education, September, 1980, 19, 27-35.

Rubinson, L.G., & Robinson, J.A. Computer-assisted instruction in health education: a pilot study. International Journal of Instructional Media, 1977-1978.

Steinkerchner, R.E., & Deignan,.M. Computer-assisted instruction in Air Force medical training: preliminary findings. Lowry AFB, Colorado: Air Force Human Resources Lab, May, 1977. (ERIC Document Reproduction Service No. ED 144 573)

Sweeney, M.A., Regan, P., O'Malley, M., & Hedstrom, B. Essential skills for baccalaureate graduates: perspectives of education and service. Journal of Nursing Administration, October, 1980, 37-44.

Valish, A.U., & Boyd, N.J. The role of computer-assisted instruction in continuing education of registered nurses: an experimental study. Journal of Continuing Education in Nursing, January-February, 1975, 6, 13-32.

Weaver, M.E., & Koehler, V.J. Programmed mathematics of drugs and solutions. New York: J.B. Lippincott Company, 1979.

Yens, D.P. The development and evaluation of a computer-based pure tone audiometer trainer. University Park, Pennsylvania: Pennsylvania State University, September, 1969. (ERIC Document Reproduction Service No. ED 043 236)

BIBLIOGRAPHY

BIBLIOGRAPHY

Bitzer, M., & Bitzer, D. Teaching nursing by computer: an evaluative study. Computers in Biology and Medicine, 1973, 3, 187-204.

Bitzer, M., Boudreaux, M., & Avner, R.A. Computer-based instruction of basic nursing utilizing inquiry approach. Urbana, Illinois: Computer-based Education Research Laboratory, February, 1973.

Borg, W.R., & Gall, M.D. Educational research: an introduction (3rd ed.). New York: Longman, 1979.

Brigham, C.R., & Kamp, M. The current status of computer-assisted instruction in the health sciences. Journal of Medical Education, March, 1974, 49, 278-279.

Braun, L. Computers in learning environments: an imperative for the 1980's. BYTE: The Small Systems Journal, July, 1980, 5, 6-10; 108-114.

Buchanan, C.C. Omega Navigation System (ONS) Flight Crew Training. Paper presented at the meeting of the Association for the Development of Computer-Based Instructional Systems, Atlanta, March, 1981.

Buchholz, L.M. Computer-assisted instruction for the self-directed professional learner? Journal of Continuing Education in Nursing, January, 1979, 10, 12-14.

Campbell, D.T., & Stanley, J.C. Experimental and quasi-experimental designs for research on teaching (Chapter 5), in N.L. Gage (Ed.), Handbook of research on teaching. Chicago: Rand McNalley & Company, 1963.

Cavin, C.S., Cavin, E.D., & Lagowski, J.J. The use of computer-assisted instruction to provide optional assistance to students. Educational Technology, June, 1979, 19, 42-45.

Collart, M.E. Computer-assisted instruction and the teaching-learning process. Nursing Outlook, August, 1973, 21, 527-532.

Commission on Nursing Education. Standards for nursing. Kansas City, Missouri: American Nurses' Association, 1975.

Dallman, B.E. Evaluation of PLATO IV in vehicle maintenance training. Lowry AFB, Colorado: Air Force Human Resources Lab, November, 1977. (ERIC Document Reproduction Service No. ED 153 638)

de Tornyay, R. Instructional technology and nursing education. Journal of Nursing Education, April, 1970, 9, 3-8.

Donabedian, D. Computer-taught epidemiology. Nursing Outlook, September, 1976, 24, 749-751.

Droste-Bielak, E. The use of computer simulation in teaching interviewing techniques to beginning nursing students in a baccalaureate program. Unpublished doctoral dissertation, University of Michigan, 1980.

Dwyer, J.M., & Schmitt, J.A. Using the computer to evaluate clinical performance. Nursing Forum, 1969, 8, 266-275.

Farnsworth, J. CAMP: computer and me: psychotherapeutically. Journal of Nursing Education, November, 1974, 13, 26-29.

Grimm, F.M. Computer simulations as a teaching tool in community colleges. The American Biology Teacher, September, 1978, 40, 362-364.

Hannah, K. The computer and nursing practice. Nursing Outlook, September, 1976, 24, 555-558.

Hoffer, E.P., Mathewson, H.O., Loughrey, A., & Barnett, G.O. Use of computer-aided instruction in graduate nursing education: a controlled trial. JEN, March-April, 1975, 1, 27-29.

Huckabay, L., Anderson, N., Holm, D., & Lee, J. Cognitive, affective, and transfer of learning consequences of computer-assisted instruction. Nursing Research, July-August, 1979, 28, 228-233.

Kamp, M. Index to computerized teaching in the health sciences. San Francisco: University of California, 1975.

Kamp, M., & Burnside, I.M. Computer-assisted learning in graduate psychiatric nursing. Journal of Nursing Education, November, 1974, 13, 18-25.

Levine, D., & Wiener, E. Let the computer teach it. American Journal of Nursing, August, 1975, 8, 1300-1302.

Kearsley, G.P. Some "facts" about CAI: trends 1970-1976. Journal of Educational Data Processing, 1976, 13, 1-12.

Kirchhoff, K.T., & Holzemer, W. Student learning and a computer-assisted instruction program. Journal of Nursing Education, March, 1979, 18, 22-30.

Kulik, J.A., Kulik, C.C., & Cohen, P.A. Effectiveness of computer-based college teaching: a meta-analysis of findings. Review of Educational Research, Winter, 1980, 50, 525-544.

Kuramato, A.M. Computer-assisted instruction: will it be used? Nursing Leadership, June, 1978, 1, 10-13.

Maatsch, J.L., Hoban, J. D., Sprafka, S.A., Hendershot, N.A., & Messick, J.R. A study of simulation technology in medical education. East Lansing: Michigan State University, Office of Medical Education Research and Development, 1977.

Meadows, L.S. Nursing education in crisis: a computer alternative. Journal of Nursing Education, May, 1977, 16, 13-21.

Mockovak, W.P. The application and evaluation of PLATO IV in AF technical training. Lowry AFB, Colorado: Air Force Human Resources Lab, 1974. (ERIC Document Reproduction Service No. ED 096 957)

Moore, J.F., & Grams, R.J. Hospitals list nurse graduate expectations. Hospitals, June 1, 1980, 73-75.

Nie, N.H., Hull, C.H., Jenkins, J.G., Steinbrenner, K., & Bent, D.H. Statistical package for the social sciences (2nd ed.). New York: McGraw-Hill, 1975.

Olivieri, P., & Sweeney, M.A. Evaluation of clinical learning: by computer. Nurse Educator, July-August, 1980, 5, 26-31.

Porter, S.F. Applications of computer-assisted instruction to continuing education in nursing: review of the literature. Journal of Continuing Education in Nursing, 1978, 9, 5-9.

Reed, F.C., Collart, M.E., & Ertel, P.Y. Computer-assisted instruction for continued learning. American Journal of Nursing, November, 1972, 72, 2035-2039.

Rhode, M.A., Kauchak, D., & Eggen, P. Skill acquisition in nurse-midwifery education. Journal of Nursing Education, September, 1980, 19, 27-35.

Rubinson, L.G., & Robinson, J.A. Computer-assisted instruction in health education: a pilot study. International Journal of Instructional Media, 1977-1978.

Silva, M.C. Nursing education in the computer age. Nursing Outlook, February, 1973, 21, 94-98.

Steinkerchner, R.E., & Deignan, G.M. Computer-assisted instruction in Air Force medical training: preliminary findings. Lowry AFB, Colorado: Air Force Human Resources Lab, May, 1977. (ERIC Document Reproduction Service No. ED 144 573)

Sumida, S.W. A computerized test for clinical decision-making. Nursing Outlook, July, 1972, 20, 458-461.

Sweeney, M.A., Regan, P., O'Malley, M., & Hedstrom, B. Essential skills for baccalaureate graduates: perspectives of education and service. Journal of Nursing Administration, October, 1980, 37-44.

Valish, A.U., & Boyd, N.J. The role of computer-assisted instruction in continuing education of registered nurses: an experimental study. Journal of Continuing Education in Nursing, January-February, 1975, 6, 13-32.

Weaver, M.E., & Koehler, V.J. Programmed mathematics of drugs and solutions. New York: J.B. Lippincott Company, 1979.

Yens, D.P. The development and evaluation of a computer-based pure tone audiometer trainer. University Park, Pennsylvania: Pennsylvania State University, September, 1969. (ERIC Document Reproduction Service No. ED 043 236)

Zinn, K.L. Personalized access to higher education: an assessment of social impact of new technology. _NCC '78 Personal Computing Digest_, 95-107.

APPENDICES

APPENDIX A

ABSTRACT, INSTRUCTOR GUIDE, AND STUDENT GUIDE FOR COMPUTER PROGRAM

APPENDIX A

ABSTRACT

Computer-Assisted Instruction Unit

"Calculation and Regulation of Intravenous Flow"

A. Identification

1. Unit Title: Calculation and Regulation of Intravenous Flow
2. Unit Author: Donna E. Larson, R.N.
3. Date: April, 1979
4. Copyright: (c) 1979 by Donna Larson

B. Educational Description

1. Course:
   This program was designed primarily for use by students in the SN 321 (Nursing II) course at Grand Valley State Colleges. The program would, however, be applicable to any nursing students at the beginning level of acute care nursing.

2. Student Learning Objectives:
   Upon successful completion of this program, the student will be able to:
   a. correctly calculate hourly IV flow rate.
   b. correctly calculate IV flow rate per minute.
   c. correctly calculate IV drop rate per minute.
   d. accurately regulate an IV system to deliver the previously calculated number of drops per minute.

3. Narrative:
   This program assists students to correctly calculate intravenous flow rates for hypothetical patient situations. The program guides the student through three interrelated calculations and then culminates in the simulation of IV flow rate regulation. Access to the TRS-80 Level II microcomputer and beginning familiarity with a standard typewriter keyboard are the only student skills required for the execution of this program.

C. Technical Information

1. Programming Language: TRS-80 Level II BASIC

2. Computer: TRS-80 Model I microcomputer with 16 kilobytes of RAM

3. Operating System: Tape or DOS version 2.2

4. Computer Program:
   a. Title: "Calculation and Regulation of Intravenous Flow"
   b. Mnemonic: "IV"
   c. Author: Donna E. Larson, R.N.
   d. Technical Description:

      The program randomly selects the number of hours in which 1000 cc of an IV solution is to infuse into a hypothetical patient. The student then calculates: a) the flow per hour; and b) the flow per minute. The program selects the "drop factor" (number of drops per cc) that the particular IV equipment will deliver. The student then calculates the number of drops per minute needed to administer the previously calculated cc per minute. The program then causes a simulated IV bottle, drip chamber, and tubing to be displayed on the CRT. The student regulates the simulated drop rate to correspond to the calculated drop rate.

      If the student makes an error in any of calculations, the program will provide a prompt in the form of the formula. If the student continues to make an error in the same calculation, the program will provide a stronger prompt by displaying the entire calculation, correctly worked through.

      If the student incorrectly regulates the simulated IV flow, the program directs the student to re-regulate the flow. If the student fails to correctly regulate the flow after ten trials, the program ends by directing the student to seek help from the instructor.

INSTRUCTOR GUIDE

Computer-Assisted Instruction Unit

"Calculation and Regulation of Intravenous Flow"

A. Recommended Usage Procedures

1. Integration: This program should be used as an adjunct to the instruction currently taking place in the Skills Laboratory. Students should first be exposed to the faculty demonstration of flow rate calculation and regulation, using actual equipment. After the initial opportunity for supervised practice in the Skills Laboratory, students should be directed to this computer program for further practice.

2. Demonstration: For those students who are unfamiliar with the TRS-80 microcomputer, it is advised to actually demonstrate the use of this program (a "mock run" with faculty executing the program in front of a small group of students).

3. Discussion of Results: Presently, there is no provision for a permanent record of a student's performance with this program. The program is intended to provide practice, not testing, for the student. A student may use this program as much or as little as he or she desires. Each segment of the program keeps track of the number of trials the student makes in correctly solving the problem --- the prompts become more directive as the incidence of student errors increases. If the student exceeds ten trials in assessing the correct simulated drip rate, the program terminates with a message encouraging the student to seek additional help from the instructor.

4. Estimated Hours:
   a. In Classroom: Each student should cycle through the regular Skills Laboratory demonstration and practice session.
   b. Out of Classroom: The normal program run is approximately seven minutes in length. Each student will probably elect to work through at least two complete learning scenarios (the calculation and the regulation).
   c. Frequency of Usage: Variable --- as much or

as little as the student deems necessary for his or her own learning.

B. Author's Comments

1. Constraints: This program is not intended to be used as the sole source of instruction for this content. It is important to keep in mind that the students still need "hands on" experience with "real" equipment attached to actual patients. This program is designed to be a useful adjunct to the more conventional teaching strategies. Importantly, this program can serve to maximize student opportunities in a "safe" environment --- free from potential hazards to actual patients.

2. Possible Misuse: This program should not be used as a substitute for actual clinical experience. Rather, it should augment clinical learning opportunities.

   If faculty are not comfortable with computer-assisted instruction, it is likely that students will not be motivated to use this learning resource. Probably the greatest potential misuse of this program is lack of use.

3. Student Materials: Each student should be encouraged to read beforehand and take with him or her a copy of the "Student Guide" into the computer learning area. The computer learning area should contain a copy of the "Student Guide" and a photographic display of operating instructions for the TRS-80 microcomputer. Also, the computer area should contain a supply of paper and pencils and the phone numbers of faculty who are available to answer questions.

4. Student-Computer Dialogue: The language used by this program is conversational in nature, with clear directives to the student. A student should encounter no difficulty in successfully executing this program.

STUDENT GUIDE

Computer-Assisted Instruction Unit

"Calculation and Regulation of Intravenous Flow"

A. Substantive Content:

1. General Description:
This program will present you with a random, realistic IV calculation problem which you are to solve. The program will guide you through the various necessary phases of the solution, giving feedback to you along the way. The program will then present you with a simulation of an actual "IV set-up" which you will regulate to deliver the correct amount of IV fluid.

2. Learning Statement:
This program will assist you in correctly calculating intravenous fluid flow rates. Furthermore, it will simulate an actual IV patient situation, allowing you to practice the accurate regulation of IV flow rates. If you make a mistake, the program will assist you to correct the error.

3. Measurement of Subject Mastery:
This program will allow you to practice your IV flow rate calculation and regulation skills as much as you wish. In no way will your performance with this program influence your course grade --- this is a learning tool for students, NOT an evaluation tool for faculty! Mastery of IV calculation skills is evident when you are able to correctly solve a series of these calculation problems. If you are unable to correctly regulate the simulated IV after repeated attempts, the program will terminate and you will be directed to seek additional help from your instructor.

4. Application to Coursework and Objectives:
This program will assist you to fulfill one of the contributory course objectives for Nursing II, "Plans and implements safe and appropriate care: demonstrates skill in technical aspects of care." You will be practicing your IV calculation and regulation skills in a totally "safe" environment --- away from potential harm to any actual patients. After mastery of the content of this

program, you should encounter no difficulty in transferring the knowledge and skills gained with the computer to your care of actual patients in clinical situations.

5. Reference Materials:
None are required. If you find that you are encountering difficulty in calculating the flow rates, it may be helpful to review your Nursing II Syllabus and appropriate sections in your textbook; then work through the program again.

B. Student Usage:

1. Role of the Computer to:
   a. Student Learning Objectives:
      This program will guide you through the various steps necessary to correctly calculate and regulate intravenous flow rates. If you make errors, the program will draw them to your attention and assist you in correcting them.
   b. Student Participation:
      You may use this program as often as you like. It is suggested that you continue to use the program until you can calculate and regulate a series of at least three IV problems, without errors.

2. Sample Student-Computer Dialogue:
Computer:
    You've determined that your patient should receive 100 cc per hour in order to infuse 1000 cc in 10 hours. Good.
    You now need to calculate how many cc should infuse each minute. When you have this figured out, type in the number of cc per minute, and then press the white ENTER key.
Student:
    10
Computer:
    Sorry, but that answer is incorrect. To help you out, here's the formula:

```
        # of cc per hour
        ----------------   =  # of cc per minute
         60 minutes
```

3. Student Materials:
You should bring the following materials with you when you "run" this program:
   a. watch with sweep second hand
   b. pencil and scratch paper

4. <u>Instructions for Operating the Microcomputer:</u>
   a. The microcomputer is located in 112 Lake Michigan Hall, the "Computer Room".
   b. If the room is locked, you can get the key from the School of Nursing Secretary.
   c. Go in and make yourself comfortable (but, PLEASE, no food, drinks, or smoking in the "Computer Room").
   d. Turn on the microcomputer and load the disk ("IV"). If you need help with this, refer to the photographic display of operating instructions which should be located on top of the desk, right next to the microcomputer.
   e. When the program is ready to execute, the video screen will show READY.
   f. Type RUN and press the white ENTER key.
   g. The microcomputer will take over from here. It will provide you with clear instructions; just follow the instructions as they are printed on the video screen.
   h. Remember, if you make an error in typing, just press the backspace key to erase your mistake; then re-type your correct response.
   i. When you have completed the program and wish to leave, turn off the computer and properly store the disk (refer to the specific instructions on the photographic display).
   j. Relax and have fun learning this way!

APPENDIX B

COMPUTER PROGRAM LISTING

APPENDIX B

COMPUTER PROGRAM LISTING

```
10 REM TITLE: CALCULATION AND REGULATION OF INTRAVENOUS
          FLOW
20 REM MNEMONIC: IV
30 REM AUTHOR:  DONNA E. LARSON, R.N.
40 REM DATE: APRIL, 1979
50 REM LANGUAGE: TRS-80 LEVEL II BASIC
60 REM (C) 1979 BY DONNA LARSON
70 REM ABSTRACT: THIS PROGRAM IS DESIGNED TO BE USED AS
       1) A TUTORIAL FOR THE CALCULATION OF INTRAVENOUS
          FLOW RATES, AND
       2) A SIMULATION EXERCISE FOR THE REGULATION OF
          INTRAVENOUS FLOW RATES
80 REM INSTRUCTIONS: TYPE "RUN" AND THE COMPUTER WILL LEAD
       THE STUDENT THROUGH THE PROGRAM
90 REM VARIABLES:
100 REM     T=TIME FOR TOTAL INFUSION (IN HOURS)
110 REM          T = 6, 8, 10, OR 12 HOURS
120 REM     V=TOTAL VOLUME TO BE INFUSED (IN CC)
130 REM          V = 1000 CC
140 REM     D=DROP RATIO (DROPS PER CC IN IV EQUIPMENT)
150 REM          D = 10, 15, OR 20 DROPS PER CC
160 REM SUBROUTINES:
170 REM     POSITIVE REINFORCERS (6000-6999)
180 REM     NEGATIVE REINFORCERS (7000-7999)
190 REM     GRAPHICS (5000-5114)
200 REM     ANIMATION (5114-5999)
210 REM     PAUSE (8000-8999)
220 REM     GRAPHICS POSITIVE REINFORCERS (9000-9999)
230 REM     GRAPHICS NEGATIVE REINFORCERS (10000-10999)
235 REM     SCREEN BORDER (550-599)
240 REM DICTIONARY:
250 REM     P$=POSITIVE REINFORCER
260 REM     A$=NEGATIVE REINFORCER
270 REM     N$=STUDENT NAME
280 REM     PG$=GRAPHICS POSITIVE REINFORCER
290 REM     NG$=GRAPHICS NEGATIVE REINFORCER
300 REM     TC=TRIAL COUNTER
310 REM     T=TIME FOR TOTAL INFUSION (IN HOURS)
320 REM     V=TOTAL VOLUME TO BE INFUSED (IN CC)
330 REM     H=CC PER HOUR
340 REM     M=CC PER MINUTE
350 REM     D=DROP RATIO
360 REM     G=DROPS PER MINUTE
370 REM     RG=RANDOM DROP RATE
380 REM     C=CORRECT FLOW RATE
390 REM     S=FLOW RATE SHOULD BE SLOWED
```

```
400 REM     F=FLOW RATE SHOULD BE INCREASED
410 REM     SH=STUDENT CALCULATED CC PER HOUR
420 REM     SM=STUDENT CALCULATED CC PER MINUTE
430 REM     SG=STUDENT CALCULATED DROPS PER MINUTE
500 REM *** TITLE PAGE ***
505 GOSUB 550 ' SCREEN BORDER
510 PRINT @ 211, "CALCULATION AND REGULATION";
515 PRINT @ 278, "OF INTRAVENOUS FLOW";
520 PRINT @ 465, "AUTHOR:  DONNA E. LARSON, R.N.";
525 PRINT @ 783, "COPYRIGHT (C) 1979 BY DONNA LARSON";
530 FOR I=1 TO 1500:NEXT I
535 GOTO 590
540 REM *** END TITLE PAGE ***
550 REM *** SCREEN BORDER SUBROUTINE ***
555 CLS
560 FOR X=0 TO 127
565 SET(X,0):SET(X,47):NEXT X
570 FOR Y=0 TO 47
575 SET(0,Y):SET(127,Y):NEXT Y
580 RETURN
590 CLEAR 2500
599 REM *** END SCREEN BORDER SUBROUTINE ***
600 REM *** INTRO/NEED INSTRUCTIONS? ***
605 CLS
610 PRINT:PRINT:PRINT"HI.  WHAT'S YOUR NAME?"
615 PRINT:PRINT:PRINT"JUST TYPE YOUR FIRST NAME AND PRESS
THE WHITE <ENTER> KEY."
617 INPUT N$
620 CLS
625 PRINT:PRINT:PRINT"HELLO, "+N$
630 PRINT:PRINT:PRINT"IN THIS PROGRAM YOU'LL BE CALCULATING
AND THEN MONITORING"
632 PRINT"INTRAVENOUS (IV) INFUSION RATES."
633 PRINT:PRINT:PRINT"HOPEFULLY, YOU'LL MAKE ALL YOUR
MISTAKES HERE WITH THE"
634 PRINT"COMPUTER, AND NONE WITH YOUR ACTUAL PATIENTS!"
635 GOSUB 8000 ' PAUSE SUBROUTINE
640 CLS
645 PRINT:PRINT:PRINT"BEFORE BEGINNING, DO YOU NEED A FEW
INSTRUCTIONS ON HOW TO"
647 PRINT"WORK WITH THIS MICROCOMPUTER?"
650 PRINT:PRINT:PRINT"IF YOU WISH SHORT INSTRUCTIONS, PRESS
THE <Y> KEY."
655 PRINT:PRINT:PRINT"IF YOU WISH TO OMIT THE INSTRUCTIONS
AND GO ON INTO THE "
657 PRINT"ACTUAL IV PROGRAM, PRESS THE <N> KEY."
660 REM *** KEY INPUT ROUTINE ***
665 K$=INKEY$:IF K$="" THEN 665
670 IF K$="Y" THEN GOSUB 800 ELSE 680
675 GOTO 1000
680 IF K$="N" THEN 1000 ELSE 685
685 PRINT:PRINT:PRINT"PLEASE TYPE EITHER <Y> OR <N>,
"+N$:GOTO 660
```

```
690 REM *** END KEY INPUT ROUTINE ***
800 REM *** COMPUTER INSTRUCTIONS SUBROUTINE ***
810 CLS
815 PRINT:PRINT:PRINT"IN THIS PROGRAM YOU WILL BE ASKED TO
CALCULATE VARIOUS"
820 PRINT"INTRAVENOUS FLOW RATES.  YOU CAN ANSWER BY
PRESSING THE"
825 PRINT"KEYS ON THE KEYBOARD - - - - - "
830 PRINT "          MUCH LIKE A TYPEWRITER."
835 GOSUB 8000 ' PAUSE SUBROUTINE
840 CLS
845 PRINT:PRINT:PRINT:PRINT:PRINT"YOU'LL BE TYPING NUMBERS
OR SINGLE LETTERS."
850 PRINT:PRINT:PRINT"DON'T TYPE THE UNITS OF MEASUREMENT
(E.G. CC OR GTTS) - - - -"
855 PRINT"JUST THE NUMBERS OR LETTERS."
860 PRINT:PRINT:PRINT"IF YOU MAKE AN ERROR IN TYPING, JUST
PRESS THE BACKSPACE"
865 PRINT"KEY (";CHR$(93);") TO ERASE.  THEN RETYPE YOUR
CORRECT ANSWER."
870 GOSUB 8000 ' PAUSE SUBROUTINE
875 RETURN
880 REM *** END COMPUTER INSTRUCTIONS SUBROUTINE ***
1000 REM IV CALCULATION OF HOURLY FLOW
1010 CLS
1020 TC=0
1030 V=1000
1040 REM ROUTINE TO SELECT TIME FOR INFUSION
1045 IF HC = 0 THEN HC = RND(4)
1050 ON HC GOTO 1060,1070,1080,1090
1060 T=6:GOTO 1100
1070 T=8:GOTO 1100
1080 T=10:GOTO 1100
1090 T=12:GOTO 1100
1100 HC = HC + 1:IF HC > 4 THEN HC = 1
1110 REM END OF TIME SELECTION ROUTINE
1120 H=INT(V/T+.5)
1125 PRINT:PRINT:PRINT
1130 PRINT "YOUR CLIENT IS TO RECEIVE ";V;" CC OF
INTRAVENOUS"
1140 PRINT "FLUID IN ";T;" HOURS.  HOW MANY CC SHOULD BE "
1150 PRINT"INFUSED EACH HOUR (TO THE NEAREST WHOLE
NUMBER)?"
1160 PRINT:PRINT:PRINT
1170 PRINT "JUST TYPE THE NUMBER OF CC PER HOUR YOU'VE "
1180 PRINT "CALCULATED.  THEN PRESS THE WHITE <ENTER> KEY."
1185 INPUT SH
1190 REM TEST FOR CORRECT CALCULATION, WITH BRANCHING
1200 IF SH<>H THEN 1220 ELSE GOSUB 6000 ' POSITIVE
REINFORCER SUBROUTINE
1210 GOTO 1440
1220 CLS:GOSUB 7000 ' NEGATIVE REINFOCER SUBROUTINE
1230 IF TC>=1 THEN 1370
```

```
1240 REM INCREMENT TRIAL COUNTER
1250 TC=TC+1
1260 REM SUPPLY FORMULA
1270 PRINT:PRINT:PRINT"TAKE A LOOK AT THE FORMULA:"
1280 PRINT:PRINT:PRINT
1290 PRINT "TOTAL VOLUME TO BE INFUSED"
1300 PRINT "-------------------------  =  CC PER HOUR"
1310 PRINT "         TOTAL TIME"
1325 GOSUB 8000 ' PAUSE SUBROUTINE
1340 CLS
1350 REM END SUPPLY FORMULA
1360 GOTO 1125
1370 REM SUPPLY ANSWER
1380 PRINT:PRINT:PRINT"HERE'S HOW TO WORK IT OUT:"
1390 PRINT:PRINT:PRINT
1400 PRINT V; " CC"
1410 PRINT "--------- = ";H;" CC PER HOUR"
1420 PRINT T; " HOURS"
1440 GOSUB 8000 ' PAUSE SUBROUTINE
1999 REM END OF HOURLY FLOW CALCULATION
2000 REM IV CALCULATION OF FLOW PER MINUTE
2010 CLS
2020 TC=0
2030 M=INT(H/60+.5)
2035 PRINT:PRINT:PRINT
2040 PRINT "YOU'VE DETERMINED THAT YOUR CLIENT SHOULD
RECEIVE "
2050 PRINT ;H;" CC PER HOUR IN ORDER TO INFUSE ";V;" CC IN
"
2060 PRINT ;T;" HOURS."
2065 PRINT:PRINT
2070 PRINT "YOU NOW NEED TO CALCULATE HOW MANY CC SHOULD
INFUSE"
2080 PRINT "EACH MINUTE."
2090 PRINT:PRINT
2100 PRINT "WHEN YOU HAVE THIS FIGURED OUT, TYPE IN THE
NUMBER "
2110 PRINT"OF CC PER MINUTE (TO THE NEAREST WHOLE NUMBER)."
2120 INPUT "THEN PRESS THE WHITE <ENTER> KEY.";SM
2130 REM TEST FOR CORRECT CALCULATION, WITH BRANCHING
2140 IF SM<>M THEN 2160 ELSE GOSUB 6000 ' POSITIVE
REINFORCER SUBROUTINE
2145 PRINT:PRINT:PRINT
2150 GOTO 2400
2160 CLS:GOSUB 7000 ' NEGATIVE REINFORCER SUBROUTINE
2170 IF TC>=1 THEN 2320
2180 REM INCREMENT TRIAL COUNTER
2190 TC=TC+1
2200 REM SUPPLY FORMULA
2220 PRINT:PRINT:PRINT "TO HELP YOU OUT, HERE'S THE
FORMULA"
2230 PRINT:PRINT:PRINT
2240 PRINT "NUMBER OF CC PER HOUR"
```

```
2250 PRINT "-------------------- = NUMBER OF CC PER MINUTE
2260 PRINT "     60 MINUTES"
2280 GOSUB 8000 ' PAUSE SUBROUTINE
2290 CLS
2300 REM END SUPPLY FORMULA
2310 GOTO 2035
2320 REM SUPPLY ANSWER
2340 PRINT:PRINT:PRINT "HERE'S HOW IT'S CALCULATED.  TAKE A
LOOK. "
2350 PRINT:PRINT:PRINT
2360 PRINT H;" CC PER HOUR"
2370 PRINT "-------------- = ";M;" CC PER MINUTE
2380 PRINT "   60 MINUTES"
2400 GOSUB 8000 ' PAUSE SUBROUTINE
2410 CLS
2420 REM END SUPPLY ANSWER
2999 REM END MINUTE FLOW CALCULATION
3000 REM IV CALCULATION OF DROP RATE
3010 CLS
3020 TC=0
3030 REM ROUTINE TO SELECT DROP FACTOR
3035 IF DC = 0 THEN DC = RND(3)
3040 ON DC GOTO 3050,3060,3065
3050 D=10:GOTO 3070
3060 D=15:GOTO 3070
3065 D=20:GOTO3070
3070 DC = DC + 1:IF DC > 3 THEN DC = 1
3090 REM END OF DROP FACTOR SELECTION ROUTINE
3100 G=INT(M*D + .5)
3105 PRINT:PRINT:PRINT
3110 PRINT "YOU'VE CALCULATED THAT YOUR CLIENT SHOULD
RECEIVE "
3120 PRINT ;M;" CC PER MINUTE.  tHE NEXT STEP IS TO
DETERMINE"
3130 PRINT "HOW MANY DROPS PER MINUTE SHOULD INFUSE."
3140 PRINT:PRINT
3150 PRINT "OF COURSE, THIS FINAL CALCULATION WILL DEPEND
UPON "
3160 PRINT "THE 'DROP FACTOR' OF YOUR EQUIPMENT."
3165 GOSUB 8000 ' PAUSE SUBROUTINE
3168 CLS
3170 PRINT:PRINT
3180 PRINT "THE 'DROP FACTOR' OF THE EQUIPMENT YOU'RE USING
TODAY"
3190 PRINT "IS ";D;" DROPS PER CC.  (REMEMBER, YOU WANT TO
"
3195 PRINT "INFUSE ";M;" CC PER MINUTE). "
3200 PRINT:PRINT
3210 PRINT "WHEN YOU'VE CALCULATED WHAT YOUR DROP RATE
SHOULD BE,"
3220 PRINT "TYPE IN THE NUMBER OF DROPS PER MINUTE (TO THE
"
3230 PRINT "NEAREST WHOLE NUMBER).  tHEN PRESS THE WHITE "
```

```
3235 INPUT "<ENTER> KEY.";SG
3240 REM TEST FOR CORRECT CALCULATION, WITH BRANCHING
3250 IF SG<>G THEN 3270 ELSE GOSUB 6000 ' POSITIVE
REINFORCER SUBROUTINE
3260 GOTO 3990
3270 CLS
3275 CLS:GOSUB 7000 ' NEGATIVE REINFORCER SUBROUTINE
3280 IF TC>=1 THEN 3400
3290 REM INCREMENT TRIAL COUNTER
3300 TC=TC+1
3310 REM SUPPLY FORMULA
3320 PRINT:PRINT:PRINT "HERE IS THE FORMULA FOR CALCULATING
THE DROP RATE:"
3330 PRINT:PRINT:PRINT
3340 PRINT "CC PER MINUTE  X  DROP FACTOR = DROPS PER
MINUTE"
3360 GOSUB 8000 ' PAUSE SUBROUTINE
3370 CLS
3380 REM END SUPPLY FORMULA
3390 GOTO 3170
3400 REM SUPPLY ANSWER
3410 PRINT:PRINT:PRINT"HERE'S HOW TO CALCULATE THE DROP
RATE:"
3420 PRINT:PRINT:PRINT
3430 PRINT M;" CC PER MINUTE  X  ";D;" DROPS PER CC = "
3433 PRINT
3435 PRINT "                              " ;G;" DROPS PER
MINUTE"
3990 GOSUB 8000 ' PAUSE SUBROUTINE
3999 REM END OF DROP RATE CALCULATION
4000 REM MONITORING IV DROP RATE
4010 CLS
4020 TC=0
4030 PRINT:PRINT:PRINT "YOU HAVE DETERMINED THAT ";G;"
DROPS SHOULD INFUSE "
4040 PRINT "EACH MINUTE IN ORDER TO INFUSE ";V;" CC IN ";T;
4045 PRINT "HOURS."
4050 PRINT:PRINT:PRINT
4055 PRINT "YOU WILL NOW BE TIMING THE DROPS PER MINUTE FOR
YOUR"
4056 PRINT "IV.  hAVE YOUR WATCH READY TO PLACE NEAR THE "
4057 PRINT "COMPUTER SCREEN."
4060 GOSUB 8000 ' PAUSE SUBROUTINE
4070 CLS
4072 REM INPUT G
4075 RG=G+(-1)[RND(2)*RND(3)*5 ' GENERATE RANDOM DROP RATE
4077 IF RG<5 THEN RG=5:IF RG>100 THEN RG=100
4080 GOSUB 5000  'GRAPHICS SUBROUTINE
4090 PRINT@ 0, "HERE IS A SIMULATION OF YOUR IV";
4100 PRINT@ 64, "BOTTLE AND DRIP CHAMBER.";
4110 PRINT@ 128,"";
4112 GOSUB4118
4114 GOTO 4320
```

```
4118 'GRAPHICS CONTROL SUBROUTINE
4120 PRINT@ 192, "COUNT THE NUMBER OF DROPS IN-";
4130 PRINT@ 256, "FUSING.  ADJUST THE RATE OF ";
4140 PRINT@ 320, "FLOW TO MATCH THE CALCULATED ";
4150 PRINT@ 384, "RATE OF ";G;" DROPS/MINUTE.";
4170 PRINT@ 448,"";
4230 PRINT@ 512, "TO MAKE THE IV INFUSE FASTER,";
4240 PRINT@ 576, "PRESS THE <F> KEY.";
4250 PRINT@ 640,"";
4260 PRINT@ 704, "TO MAKE THE IV INFUSE SLOWER,";
4270 PRINT@ 768, "PRESS THE <S> KEY.";
4280 PRINT@ 832,"";
4290 PRINT@ 896, "IF THE IV IS INFUSING AT THE";
4300 PRINT@ 960, "CORRECT RATE, PRESS THE <C> KEY.";
4305 RETURN
4310 REM END OF GRAPHICS CONTROL ROUTINE
4320 REM KEY INPUT & DROP ROUTINE
4350 IF TC>=10000 THEN 4355 ELSE 4380
4355 CLS
4360 PRINT N$;", YOU NEED MORE HELP.  SEE YOUR INSTRUCTOR."
4370 GOTO 4630 ' END FRAME
4380 TC=TC+1
4390 DT=5450/RG-33.33
4400 FOR TD =0 TO DT
4402 K$=INKEY$:IF K$<>"" THEN 4410 ELSE NEXT TD
4404 GOSUB 5115  'DROP A DROP
4406 GOTO 4400 'CONTINUE SEARCH FOR VALID KEY PRESS
4410 IF K$ = "C" THEN 4420 ELSE 4450
4420 REM TEST FOR CORRECT DROP RATE
4430 IF RG>G-3.5 AND RG<G+3.5 THEN 9000 ELSE GOSUB 10000
'POS/NEG GRAPHICS REINFORCERS
4440 GOTO 4320
4450 IF K$ = "S" THEN 4460 ELSE 4470  'TEST SLOWING DRIP
RATE
4460 RG=RG-4:GOTO 4390  'SLOW GRAPHICS DRIP RATE & RESTART
4470 IF K$ = "F" THEN 4480 ELSE 4484  'TEST INCREASE DRIP
RATE
4480 RG=RG+4:GOTO 4390 'INCREASE GRAPHICS DRIP RATE &
RESTART
4484 PRINT@ 0,"USE KEYS <S>, <F>,             ";
4486 PRINT@ 64,"AND <C>, ONLY                  ";
4488 GOTO 4320  'RESTART
4490 REM END KEY INPUT & DROP ROUTINE
4500 REM IV CALCULATION END ROUTINE
4510 CLS
4520 PRINT "DO YOU WISH TO DO ANOTHER IV PROBLEM, " +N$;"?"
4530 PRINT:PRINT:PRINT
4540 PRINT "IF YES, PRESS THE <Y> KEY."
4550 PRINT:PRINT:PRINT
4560 PRINT "IF NO, PRESS THE <N> KEY."
4570 REM KEY INPUT ROUTINE
4580 K$=INKEY$: IF K$= "" THEN 4580
4590 IF K$="Y" THEN 1000 ELSE 4600
```

```
4600 IF K$="N" THEN 4630 ELSE 4610
4610 PRINT:PRINT:PRINT
4620 PRINT "PLEASE TYPE EITHER <Y> OR <N>."
4625 GOTO 4580
4630 CLS
4635 GOSUB 550 ' SCREEN BORDER SUBROUTINE
4640 PRINT @ 404, "GOODBYE, "+N$;
4645 FOR I=1 TO 1000:NEXT I
4999 END
5000 REM GRAPHICS SUBROUTINE
5010 CLS
5020 XL=85
5030 FOR Y=0 TO 10:SET(XL,Y):SET(XL+42,Y):NEXT Y
5040 FOR Y=11 TO 26:FOR X=XL TO XL+42
5050 SET(X,Y):NEXT X:NEXT Y
5060 FOR J=0 TO 3:Y=27+J
5070 FOR X=XL+ABS(4*J-1) TO XL+42-ABS(4*J-1)
5080 SET (X,Y):NEXT X:NEXT J
5090 FOR Y=31 TO 36:SET(XL+15,Y):SET(XL+26,Y):NEXT Y
5100 Y=37:FOR X=XL+15 TO XL+26:SET(X,Y):NEXT X
5110 FOR Y=38 TO 47:FOR X=XL+19 TO XL+22:SET(X,Y):NEXT
X:NEXT Y
5112 X=XL+20 'LOCATE DROP FALL LINE
5114 RETURN
5115 REM DRIP GRAPHICS SUBROUNTINE
5160 FOR J=0 TO 6
5170 Y=31+J:SET(X,Y):SET(X+1,Y)
5180 Y=Y-1:IF Y<32 THEN 5190 ELSE RESET(X,Y):RESET(X+1,Y)
5190 NEXT J
5999 RETURN
6000 REM POSITIVE REINFORCER SUBROUTINE
6005 CLS
6010 ON RND(10) GOTO
6030,6040,6050,6060,6070,6080,6090,6100,6110,6120
6030 P$="THAT'S RIGHT!":GOTO 6990
6040 P$="GOOD FOR YOU, "+N$:GOTO 6990
6050 P$="GOOD JOB, "+N$:GOTO 6990
6060 P$="RIGHT ON, "+N$:GOTO 6990
6070 P$="CORRECT":GOTO 6990
6080 P$="VERY GOOD, "+N$:GOTO 6990
6090 P$=N$+", YOU'RE A GENIUS!":GOTO 6990
6100 P$="FANTASTIC!":GOTO 6990
6110 P$="GOOD":GOTO 6990
6120 P$="TERRIFIC!":GOTO 6990
6990 PRINT @ 394, P$
6999 RETURN
7000 REM NEGATIVE REINFORCER SUBROUTINE
7010 ON RND(7) GOTO 7030,7040,7050,7060,7070,7080,7090
7030 A$="SORRY, BUT THAT'S NOT RIGHT.":GOTO 7990
7040 A$="WRONG - - - TOO BAD.":GOTO 7990
7050 A$="TOO BAD; THAT'S INCORRECT, "+N$:GOTO7990
7060 A$="SORRY; THAT ANSWER IS INCORRECT, "+N$:GOTO7990
7070 A$="NOPE; THAT'S NOT RIGHT.":GOTO7990
```

```
7080 A$="SORRY; THAT'S NOT CORRECT.":GOTO7990
7090 A$="OOPS - - - THAT'S NOT RIGHT!":GOTO7990
7990 PRINT:PRINT:PRINT A$
7999 RETURN
8000 REM PAUSE SUBROUTINE
8010 PRINT @ 960,"PRESS THE WHITE <ENTER> KEY TO
CONTINUE.";
8020 W$=INKEY$:IF W$="" THEN 8020
8030 RETURN
9000 REM GRAPHICS POSITIVE REINFORCEMENT SUBROUTINE
9005 CLS
9010 ON RND(3) GOTO 9020,9030,9040
9020 PG$="THAT'S RIGHT, "+N$:GOTO 9900
9030 PG$="CORRECT.  GOOD FOR YOU.":GOTO 9900
9040 PG$="VERY GOOD.  YOU TIMED THAT JUST RIGHT!":GOTO 9900
9900 PRINT @ 394, PG$
9910 GOSUB 8000  'PAUSE SUBROUTINE
9999 GOTO 4500  'END GRAPHICS POSITIIVE REINFORCEMENT
SUBROUTINE
10000 REM GRAPHICS NEGATIVE REINFORCEMENT SUBROUTINE
10010 ON RND(3) GOTO 10020,10030,10040
10020 NG$="NOT CLOSE ENOUGH.  TRY AGAIN.          " :GOTO
10050
10030 NG$="MISSED IT!  TIME IT AGAIN.           ":GOTO
10050
10040 NG$="TOO BAD.  GIVE IT ANOTHER TRY.        ":GOTO
10050
10050 GOSUB 10100
10060 GOTO 10140
10100 'BLANK GRAPHICS TEXT SUBRT
10110 FOR I=0 TO 960 STEP 64
10120  PRINT@I,STRING$(40," ");
10130 NEXT I
10132 RETURN
10140 PRINT@256,NG$;
10150 GOSUB 8000 'TO PAUSE
10154 GOSUB10100 'CLEAR TEXT
10160 GOSUB4118  'GRAPHICS CONTROL SUBRT.
10999 RETURN   'END GRAPHICS NEGATIVE REINFORCEMENT
SUBROUTINE
```

APPENDIX C

SAMPLE RUN OF COMPUTER PROGRAM

APPENDIX C

SAMPLE RUN OF COMPUTER PROGRAM

```
          CALCULATION AND REGULATION
             OF INTRAVENOUS FLOW

        AUTHOR:  DONNA E. LARSON, R.N.


      COPYRIGHT (C) 1979 BY DONNA LARSON
```

Screen 1. Title page.

```
YOUR CLIENT IS TO RECEIVE  1000  CC OF INTRAVENOUS
FLUID IN  12  HOURS.  HOW MANY CC SHOULD BE
INFUSED EACH HOUR (TO THE NEAREST WHOLE NUMBER)?


JUST TYPE THE NUMBER OF CC PER HOUR YOU'VE
CALCULATED.  THEN PRESS THE WHITE <ENTER> KEY.
?_
```

Screen 2. Presentation of a randomly generated problem.

```
SORRY, SUSAN

TAKE A LOOK AT THE FORMULA:

TOTAL VOLUME TO BE INFUSED
--------------------------  =  CC PER HOUR
        TOTAL TIME

PRESS THE WHITE <ENTER> KEY TO CONTINUE.
```

Screen 3. Student response was incorrect. The first incorrect response results in presentation of formula.

```
SORRY, BUT THAT'S NOT RIGHT.

HERE'S HOW TO WORK IT OUT:

 1000  CC
---------- =  83.3  CC PER HOUR  =  83  CC PER HOUR
 12  HOURS

PRESS THE WHITE <ENTER> KEY TO CONTINUE.
```

Screen 4. The student's second try was incorrect. Formula again presented, but this time with the values substituted and the calculation worked out.

```
YOU'VE DETERMINED THAT YOUR CLIENT SHOULD RECEIVE
 83  CC PER HOUR IN ORDER TO INFUSE  1000  CC IN
 12  HOURS.


YOU NOW NEED TO CALCULATE HOW MANY CC SHOULD INFUSE
EACH MINUTE.


WHEN YOU HAVE THIS FIGURED OUT, TYPE IN THE NUMBER
OF CC PER MINUTE (TO THE NEAREST WHOLE NUMBER).
THEN PRESS THE WHITE <ENTER> KEY.?_
```

Screen 5. The next step is presented to the student.

```
CLOSE, BUT NOT CLOSE ENOUGH


TO HELP YOU OUT, HERE'S THE FORMULA


NUMBER OF CC PER HOUR
--------------------- = NUMBER OF CC PER MINUTE
     60 MINUTES



PRESS THE WHITE <ENTER> KEY TO CONTINUE.
```

Screen 6. The student's response was incorrect; the formula is presented.

YOU'VE CALCULATED THAT YOUR CLIENT SHOULD RECEIVE 1 CC PER MINUTE. THE NEXT STEP IS TO DETERMINE HOW MANY DROPS PER MINUTE SHOULD INFUSE.

OF COURSE, THIS FINAL CALCULATION WILL DEPEND UPON THE 'DROP FACTOR' OF YOUR EQUIPMENT.

PRESS THE WHITE <ENTER> KEY TO CONTINUE.

Screen 7. The student responded correctly after the previous prompt. This is the next segment.

THE 'DROP FACTOR' OF THE EQUIPMENT YOU'RE USING TODAY IS 20 DROPS PER CC. (REMEMBER, YOU WANT TO INFUSE 1 CC PER MINUTE).

WHEN YOU'VE CALCULATED WHAT YOUR DROP RATE SHOULD BE, TYPE IN THE NUMBER OF DROPS PER MINUTE (TO THE NEAREST WHOLE NUMBER). THEN PRESS THE WHITE <ENTER> KEY.?_

Screen 8. The next segment, continued ...

```
 YOU HAVE DETERMINED THAT  28  DROPS SHOULD INFUSE
 EACH MINUTE IN ORDER TO INFUSE  1000  CC IN  12 HOURS.


 YOU WILL NOW TIME THE DROPS PER MINUTE FOR YOUR
 IV.  HAVE YOUR WATCH READY TO PLACE NEAR THE
 COMPUTER SCREEN.





 PRESS THE WHITE <ENTER> KEY TO CONTINUE.
```

Screen 9. The student calculated the drop rate correctly, and is now primed for the IV simulation.

```
 HERE IS A SIMULATION OF YOUR IV     #               #
 BOTTLE AND DRIP CHAMBER.            #               #
                                     #################
 COUNT THE NUMBER OF DROPS IN-       #################
 FUSING.  ADJUST THE RATE OF         #################
 FLOW TO MATCH THE CALCULATED        #################
 RATE OF  28  DROPS/MINUTE.          #################
                                     #################
 TO MAKE THE IV INFUSE FASTER,       #################
 PRESS THE <F> KEY.                    #############
                                         #########
 TO MAKE THE IV INFUSE SLOWER,             #####
 PRESS THE <S> KEY.                        # # #
                                           #####
 IF THE IV IS INFUSING AT THE                #
 CORRECT RATE, PRESS THE <C> KEY.            #
```

Screen 10. The graphical representation of an IV system; drops are falling through the drip chamber with real-time animation.

GOODBYE, SUSAN

Screen 11. Student elected to exit from the program after correctly regulating the IV flow rate.

APPENDIX D

OBSERVER AND PROCTOR INSTRUCTIONS

APPENDIX D

OBSERVER INSTRUCTIONS

1. The proctor will direct the student to one of the IV regulation stations (selected by lottery).
2. The student should go to the randomly flowing IV system and regulate it so that it delivers the calculated rate.
3. If the student has been unable to calculate the number of drops per minute, then direct that student to regulate the flowing IV so that it delivers 42 drops per minute.
4. When the student tells you that s/he has completed the IV regulation, collect the Posttest Evaluation Form from the student.
5. Time the flow rate yourself for a full 60 seconds.
6. Enter the number of drops that fell during the 60 second period on the space provided on the Posttest Evaluation Form.
7. The student may leave the testing area now. Direct the student to complete a follow-up questionnaire before exiting from the basement (questionnaires, recepticles, refreshments, and writing surfaces are located in the foyer area by the stairwell).
8. Readjust the IV so that it delivers a different rate for the next student.
9. Using the Calculation Key, determine the correctness of each of the 3 student calculation problem segments.
10. Using the criteria on the Observer Scoring Guide, determine the score for the student's calculation.
11. Enter this score for the calculation in the space provided on the Posttest Evaluation Form.
12. Using the criteria on the Observer Scoring Guide, determine the score for the student's regulation of the IV flow rate.
13. Enter this score for the regulation in the space provided on the Posttest Evaluation Form.

14. Place your initials in the space provided on the Posttest Evaluation Form.

15. Have each of the other observers check the accuracy of the Posttest Evaluation Forms you have judged.

16. Likewise, check the accuracy of each of the other observers' Posttest Evaluation Forms they have judged.

17. At the conclusion of the day's testing, submit all completed Posttest Evaluation Forms to Donna.

PROCTOR INSTRUCTIONS

1. As the students enter room 33, you are to give each of them one IV calculation problem (the sheets in the manilla folder). There are 12 different problems, all mixed together, so it doesn't matter in what order you distribute them to the students.

2. Students are to sit at the tables in room 33 and complete the calculation. No calculators, texts, notes, help from friends, etc. are to be used.

3. When each student finishes his/her calculation, s/he is to select by lottery (drawing a slip of paper from a container) which IV regulation testing station s/he is assigned to.

4. Each student is to replace the slip of paper after s/he has made his/her selection. In this way, the next student is assured of an equal chance of selecting any of the three testing stations.

5. When the station that a student has selected becomes "open", s/he may proceed directly to it. S/he should take the completed IV calculation problem with him/her to the regulation testing station.

6. If a student has been unable to complete the calculation, s/he should proceed to an IV regulation testing station anyway. He'll just be assigned a random drop rate to regulate --- no big problem!

Note: You may answer student questions about format and understanding of the problem (e.g. "Do I need to round to whole numbers?" (yes) or "What does D5W mean?" (go ahead and tell). However, don't answer questions on how to actually perform the calculations.

APPENDIX E

STUDENT CONSENT FORM

APPENDIX E

STUDENT CONSENT FORM

Dear Nursing II Student:

I would like your help in conducting a study of the effectiveness and efficiency of a computer simulation compared to a skills lab simulation for teaching you how to calculate and regulate intravenous (IV) flow rates. I am trying to find a way to teach this basic nursing skill that will be both effective for your learning and efficient in terms of your learning time, faculty teaching time, and cost.

All students will be assigned to either a control or experimental group, dependent upon your regular skills lab assignment. All students will attend the beginning portion of the regularly scheduled skills lab session on hanging and monitoring IV's. After initial instruction on how to calculate and regulate IV flow rates, the control and experimental groups will be treated differently.

Students in the control group will practice with the usual skills lab simulation. Students in the experimental group will practice with a computer simulation. A posttest will be administered by an independent observer when you feel "comfortable" with the skill, or when the time alotted for the lab session ends, whichever occurs first. The posttest will measure your ability to calculate and regulate an intravenous flow rate. Ten weeks later, a similar posttest will again be administered.

Your grade in Nursing II will _not_ in any way be affected by your performance in this study. All documents and evaluation forms will be numerically coded; you will _not_ be identified by name. All records of this experiment will remain in my personal possession and will not be used for any other purposes. The results will be shared with you after the conclusion of the study.

You are free to withdraw from the study at anytime, without penalty. Your signature below signifies that this study has been explained to you and that you understand the nature of the study and your participation in it.

I appreciate your cooperation very much. Please sign below to signify your free and informed consent.

Student Signature:	Thank you,
Date:	Donna Larson Associate Professor of Nursing

APPENDIX F

STUDENT DATA FORM

APPENDIX F

STUDENT DATA FORM

Code number:__________ Sex: Female ____

Age: _____ Male ______

Current GVSC G.P.A.:______ (numerical score, A=4.0)

If a transfer student, your G.P.A. from your previous college at the time of your transfer:______ (A=4.0)

What was your course grade or equivalency exam score for GVSC Math 110 (or the equivalent course)? ______ (A=4.0)

Previous experience: It is very important that you describe your previous experiences in the following areas:

1) Computer-assisted instruction (When? What subject was covered? How many hours have you spent at a computer terminal?):

2) Work with patients who received IV therapy (When? How many times? What was the nature of your involvement with the IV?):

APPENDIX G

STUDENT INFORMATION HANDOUTS

APPENDIX G

INSTRUCTIONS FOR STUDENTS IN THE COMPUTER GROUP

Schedule for February 2:

Code #'s 1-12:

9:00-9:20	Initial instructions (Skills Lab)
9:30-10:00	Computer instruction (224 Mac)
10:00-10:40	Posttesting (Basement LMH)
10:40-12:00	Skills Lab

Code #'s 13-25:

9:00-9:20	Initial instructions (Skills Lab)
9:20-9:50	Skills Lab
10:00-10:30	Computer instruction (224 Mac)
10:30-11:10	Posttesting (Basement LMH)
11:10-12:00	Skills Lab

Posttesting will take place in the basement of Lake Michigan Hall. The entrance to the basement testing area is opposite the SHS suite of offices; follow the signs.

It's important that the observers (judges) in the testing area not know whether you're in the Computer or Skills Lab group. Therefore, please remove your coats and outerwear in the special area indicated in the basement. Also, obviously, try not to say anything to the observers (judges) that would tell them which group you're in.

Another (delayed) posttest will be held during the Open Skills Lab times on April 13 (9-12) and April 14 (2-5). This delayed posttest will be in the same format and in the same testing area (basement of LMH) as the posttest you take today. Please don't forget to come to this later posttest, as it's very important to the study!

Feel free to practice as much as you wish with the computer program between now and the final posttest in April. Use the computer in Room 112 LMH (the School of Nursing "Computer Room"). The instructions for operating the computer and loading the program are on the desk alongside the computer. Just ask Maureen (the School of Nursing Secretary) or me to open the door for you (I'll be here every Monday in 172 LMH). If you need help in operating the computer, either I or Emily Bielak can help you out.

Everytime you practice with the computer program, keep track of the time you spend and how many problems you work through. Use the "Student Practice Report" to record this information. There is a supply of these records and also a recepticle for your filled in forms alongside the computer in the Computer Room. Please don't forget, as this is very important information for the study!

One last instruction . . . Please practice ONLY with the computer program. Do not use the Skills Lab equipment or problems during the time of this study (until mid-April). It's very important to the study that the two groups under investigation be kept "uncontaminated"!

Thanks for assisting in this study,

Donna Larson

INSTRUCTIONS FOR STUDENTS IN THE SKILLS LAB GROUP

Schedule for February 3:

Code #'s 26-38:

2:00-2:30	Initial instructions (Skills Lab)
2:30-3:00	IV instruction
3:00-3:30	Posttesting (Basement LMH)
3:30-5:00	Skills Lab

Code #'s 39-52:

2:00-2:30	Initial instructions (Skills Lab)
2:30-3:00	Skills Lab
3:00-3:30	IV instruction
3:30-4:00	Posttesting (Basement LMH)
4:00-5:00	Skills Lab

Posttesting will take place in the basement of Lake Michigan Hall. The entrance to the basement testing area is opposite the SHS suite of offices; follow the signs.

It's important that the observers (judges) in the testing area not know whether you're in the Computer or Skills Lab group. Therefore, try not to say anything to the observers (judges) that would tell them which group you're in.

Another (delayed) posttest will be held during the Open Skills Lab times on April 13 (9-12) and April 14 (2-5). This delayed posttest will be in the same format and in the same testing area (basement of LMH) as the posttest you take today. Please don't forget to come to this later posttest, as it's very important to the study!

Feel free to practice as much as you wish with the Skills Lab equipment and problems between now and the final posttest in April. If you need help, don't hesitate to ask any of the faculty (I'll be here on campus every Monday in 172 LMH).

Everytime you practice calculating or regulating IV's, keep track of the time you spend and how many problems you work through. Use the "Student Practice Report" to record this information. There is a supply of these records and also a recepticle for your filled in forms on the back counter here in the Skills Lab. Please don't forget, as this is very important information for the study!

One last instruction . . . Please practice ONLY with the Skills Lab equipment and problem sets. Do not use the computer program during the time of this study (until mid-April). It's very important to the study that the two groups under investigation be kept "uncontaminated"!

Thanks for assisting in this study,

Donna Larson

APPENDIX H

STUDENT PRACTICE REPORT

APPENDIX H

STUDENT PRACTICE REPORT

Code number: __________ Date: __________

Method: Computer/Skills Lab (circle one)

Instructions: Please complete the following information for each time you work through an IV calculation and regulation practice problem. This information is very important for the study, so please remember!

Note that this one report can be used to record multiple practice problems that you do during any one date. If you run out of room to record all your practicing, just use another report and submit both.

After you've finished practicing in any one date, please submit this form to Donna Larson's faculty mailbox (in the School of Nursing Office). Thank you.

Starting time: ________ Total time in minutes: ______

Ending time: __________

Learning scenario #1 completed? Yes/No (circle one)

If no, which part was completed?
Calculation/Regulation (circle one)

Starting time: ________ Total time in minutes: ______

Ending time: __________

Learning scenario #2 completed? Yes/No (circle one)

If no, which part was completed?
Calculation/Regulation (circle one)

APPENDIX I

SAMPLE IV PROBLEM CARD

APPENDIX I

IV RATE CALCULATION AND REGULATION PROBLEM

Your patient is to receive an intravenous infusion of 1000 cc of D5NS over the next 6 hours. The "drop factor" of the equipment you're using today is 15 gtts/cc.

How many cc's per hour should this patient receive? cc's per minute? Drops per minute?

All answers should be rounded to the nearest whole number.

When you've finished your calculation, regulate one of the IV systems to flow at your calculated rate.

- -

Solution:

1000 ÷ 6 = 166.6 = 167 cc/hour

167 ÷ 60 = 2.7 = 3 cc/minute

3 x 15 = 45 gtts/minute

APPENDIX J

POSTTEST EVALUATION FORMS

APPENDIX J

POSTTEST EVALUATION FORM

Code number: ____________

Calculate the following patient problem, without using notes, texts, calculators, colleagues, etc. Show all of your work. Circle and label your answers to all three (3) segments of the problem solution (drops per minute, cc's per hour, and cc's per minute). All answers should be rounded to the nearest whole number.

Your patient is to receive an intravenous infusion of 1000 cc of D5W over the next 6 hours. The "drop factor" of the equipment you're using today is 10 gtts/cc.

When you have finished the above calculation, regulate one of the IV systems in the testing area to correspond to your calculated rate. When you have the IV regulated, call an observer to evaluate your work. Hand in this form to the observer when she comes to check your IV regulation.

Thank you.

Observer: Record below the number of drops per minute this student's IV was flowing when she or he called you over to check it.

Drops per minute flowing: _____ Observer initials:

Calculation raw score: _____ Regulation raw score: ____

POSTTEST EVALUATION FORM

Code number: ____________

Calculate the following patient problem, without using notes, texts, calculators, colleagues, etc. Show all of your work. Circle and label your answers to all three (3) segments of the problem solution (drops per minute, cc's per hour, and cc's per minute). All answers should be rounded to the nearest whole number.

Your patient is to receive an intravenous infusion of 1000 cc of D5W over the next 6 hours. The "drop factor" the equipment you're using today is 15 gtts/cc.

When you have finished the above calculation, regulate one of the IV systems in the testing area to correspond to your calculated rate. When you have the IV regulated, call an observer to evaluate your work. Hand in this form to the observer when she comes to check your IV regulation.

Thank you.

Observer: Record below the number of drops per minute this student's IV was flowing when she or he called you over to check it.

Drops per minute flowing: _____ Observer initials:

Calculation raw score: _____ Regulation raw score: ____

POSTTEST EVALUATION FORM

Code number: ____________

Calculate the following patient problem, without using notes, texts, calculators, colleagues, etc. Show all of your work. Circle and label your answers to all three (3) segments of the problem solution (drops per minute, cc's per hour, and cc's per minute). All answers should be rounded to the nearest whole number.

Your patient is to receive an intravenous infusion of 1000 cc of D5W over the next 6 hours. The "drop factor" of the equipment you're using today is 20 gtts/cc.

When you have finished the above calculation, regulate one of the IV systems in the testing area to correspond to your calculated rate. When you have the IV regulated, call an observer to evaluate your work. Hand in this form to the observer when she comes to check your IV regulation.

Thank you.

Observer: Record below the number of drops per minute this student's IV was flowing when she or he called you over to check it.

Drops per minute flowing: _____ Observer initials:

Calculation raw score: _____ Regulation raw score: ____

POSTTEST EVALUATION FORM

Code number: ____________

Calculate the following patient problem, without using notes, texts, calculators, colleagues, etc. Show all of your work. Circle and label your answers to all three (3) segments of the problem solution (drops per minute, cc's per hour, and cc's per minute). All answers should be rounded to the nearest whole number.

Your patient is to receive an intravenous infusion of 1000 cc of D5W over the next 8 hours. The "drop factor" of the equipment you're using today is 10 gtts/cc.

When you have finished the above calculation, regulate one of the IV systems in the testing area to correspond to your calculated rate. When you have the IV regulated, call an observer to evaluate your work. Hand in this form to the observer when she comes to check your IV regulation.

Thank you.

Observer: Record below the number of drops per minute this student's IV was flowing when she or he called you over to check it.

Drops per minute flowing: _____ Observer initials:

Calculation raw score: _____ Regulation raw score: ____

POSTTEST EVALUATION FORM

Code number: ____________

Calculate the following patient problem, without using notes, texts, calculators, colleagues, etc. Show all of your work. Circle and label your answers to all three (3) segments of the problem solution (drops per minute, cc's per hour, and cc's per minute). All answers should be rounded to the nearest whole number.

Your patient is to receive an intravenous infusion of 1000 cc of D5W over the next 8 hours. The "drop factor" of the equipment you're using today is 15 gtts/cc.

When you have finished the above calculation, regulate one of the IV systems in the testing area to correspond to your calculated rate. When you have the IV regulated, call an observer to evaluate your work. Hand in this form to the observer when she comes to check your IV regulation.

Thank you.

Observer: Record below the number of drops per minute this student's IV was flowing when she or he called you over to check it.

Drops per minute flowing: _____ Observer initials:

Calculation raw score: _____ Regulation raw score: ____

POSTTEST EVALUATION FORM

Code number: ___________

Calculate the following patient problem, without using notes, texts, calculators, colleagues, etc. Show all of your work. Circle and label your answers to all three (3) segments of the problem solution (drops per minute, cc's per hour, and cc's per minute). All answers should be rounded to the nearest whole number.

Your patient is to receive an intravenous infusion of 1000 cc of D5W over the next 8 hours. The "drop factor" of the equipment you're using today is 20 gtts/cc.

When you have finished the above calculation, regulate one of the IV systems in the testing area to correspond to your calculated rate. When you have the IV regulated, call an observer to evaluate your work. Hand in this form to the observer when she comes to check your IV regulation.

Thank you.

Observer: Record below the number of drops per minute this student's IV was flowing when she or he called you over to check it.

Drops per minute flowing: _____ Observer initials:

Calculation raw score: _____ Regulation raw score: ____

POSTTEST EVALUATION FORM

Code number: ____________

Calculate the following patient problem, without using notes, texts, calculators, colleagues, etc. Show all of your work. Circle and label your answers to all three (3) segments of the problem solution (drops per minute, cc's per hour, and cc's per minute). All answers should be rounded to the nearest whole number.

Your patient is to receive an intravenous infusion of 1000 cc of D5W over the next 10 hours. The "drop factor" of the equipment you're using today is 10 gtts/cc.

When you have finished the above calculation, regulate one of the IV systems in the testing area to correspond to your calculated rate. When you have the IV regulated, call an observer to evaluate your work. Hand in this form to the observer when she comes to check your IV regulation.

Thank you.

Observer: Record below the number of drops per minute this student's IV was flowing when she or he called you over to check it.

Drops per minute flowing: _____ Observer initials:

Calculation raw score: _____ Regulation raw score: ____

POSTTEST EVALUATION FORM

Code number: ____________

Calculate the following patient problem, without using notes, texts, calculators, colleagues, etc. Show all of your work. Circle and label your answers to all three (3) segments of the problem solution (drops per minute, cc's per hour, and cc's per minute). All answers should be rounded to the nearest whole number.

Your patient is to receive an intravenous infusion of 1000 cc of D5W over the next 10 hours. The "drop factor" of the equipment you're using today is 15 gtts/cc.

When you have finished the above calculation, regulate one of the IV systems in the testing area to correspond to your calculated rate. When you have the IV regulated, call an observer to evaluate your work. Hand in this form to the observer when she comes to check your IV regulation.

Thank you.

Observer: Record below the number of drops per minute this student's IV was flowing when she or he called you over to check it.

Drops per minute flowing: _____ Observer initials:

Calculation raw score: _____ Regulation raw score: ____

POSTTEST EVALUATION FORM

Code number: ____________

Calculate the following patient problem, without using notes, texts, calculators, colleagues, etc. Show all of your work. Circle and label your answers to all three (3) segments of the problem solution (drops per minute, cc's per hour, and cc's per minute). All answers should be rounded to the nearest whole number.

Your patient is to receive an intravenous infusion of 1000 cc of D5W over the next 10 hours. The "drop factor" of the equipment you're using today is 20 gtts/cc.

When you have finished the above calculation, regulate one of the IV systems in the testing area to correspond to your calculated rate. When you have the IV regulated, call an observer to evaluate your work. Hand in this form to the observer when she comes to check your IV regulation.

Thank you.

Observer: Record below the number of drops per minute this student's IV was flowing when she or he called you over to check it.

Drops per minute flowing: _____ Observer initials:

Calculation raw score: _____ Regulation raw score: ____

POSTTEST EVALUATION FORM

Code number: ____________

Calculate the following patient problem, without using notes, texts, calculators, colleagues, etc. Show all of your work. Circle and label your answers to all three (3) segments of the problem solution (drops per minute, cc's per hour, and cc's per minute). All answers should be rounded to the nearest whole number.

Your patient is to receive an intravenous infusion of 1000 cc of D5W over the next 12 hours. The "drop factor" of the equipment you're using today is 10 gtts/cc.

When you have finished the above calculation, regulate one of the IV systems in the testing area to correspond to your calculated rate. When you have the IV regulated, call an observer to evaluate your work. Hand in this form to the observer when she comes to check your IV regulation.

Thank you.

Observer: Record below the number of drops per minute this student's IV was flowing when she or he called you over to check it.

Drops per minute flowing: _____ Observer initials:

Calculation raw score: _____ Regulation raw score: ____

POSTTEST EVALUATION FORM

Code number: ____________

Calculate the following patient problem, without using notes, texts, calculators, colleagues, etc. Show all of your work. Circle and label your answers to all three (3) segments of the problem solution (drops per minute, cc's per hour, and cc's per minute). All answers should be rounded to the nearest whole number.

Your patient is to receive an intravenous infusion of 1000 cc of D5W over the next 12 hours. The "drop factor" of the equipment you're using today is 15 gtts/cc.

When you have finished the above calculation, regulate one of the IV systems in the testing area to correspond to your calculated rate. When you have the IV regulated, call an observer to evaluate your work. Hand in this form to the observer when she comes to check your IV regulation.

Thank you.

Observer: Record below the number of drops per minute this student's IV was flowing when she or he called you over to check it.

Drops per minute flowing: _____ Observer initials:

Calculation raw score: _____ Regulation raw score: ____

POSTTEST EVALUATION FORM

Code number: ____________

Calculate the following patient problem, without using notes, texts, calculators, colleagues, etc. Show all of your work. Circle and label your answers to all three (3) segments of the problem solution (drops per minute, cc's per hour, and cc's per minute). All answers should be rounded to the nearest whole number.

Your patient is to receive an intravenous infusion of 1000 cc of D5W over the next 12 hours. The "drop factor" of the equipment you're using today is 20 gtts/cc.

When you have finished the above calculation, regulate one of the IV systems in the testing area to correspond to your calculated rate. When you have the IV regulated, call an observer to evaluate your work. Hand in this form to the observer when she comes to check your IV regulation.

Thank you.

<u>Observer:</u> Record below the number of drops per minute this student's IV was flowing when she or he called you over to check it.

Drops per minute flowing: _____ Observer initials:

Calculation raw score: _____ Regulation raw score: ____

APPENDIX K

CALCULATION SCORING KEY

APPENDIX K

CALCULATION SCORING KEY

<u>If 1000 cc in 12 hours:</u>

- 83 cc per hour
- 1 cc per minute
- If "drop factor" is 10:
  - 10 drops per minute
- If "drop factor" is 15:
  - 15 drops per minute
- If "drop factor" is 20:
  - 20 drops per minute

- -

<u>If 1000 cc in 10 hours:</u>

- 100 cc per hour
- 2 cc per minute
- If "drop factor" is 10:
  - 20 drops per minute
- If "drop factor" is 15:
  - 30 drops per minute
- If "drop factor" is 20:
  - 40 drops per minute

- -

<u>If 1000 cc in 8 hours:</u>

- 125 cc per hour
- 2 cc per minute
- If "drop factor" is 10:
  - 20 drops per minute
- If "drop factor" is 15:
  - 30 drops per minute
- If "drop factor" is 20:
  - 40 drops per minute

- -

<u>If 1000 cc in 6 hours:</u>

- 167 cc per hour
- 3 cc per minute
- If "drop factor" is 10:
  - 30 drops per minute
- If "drop factor" is 15:
  - 45 drops per minute
- If "drop factor" is 20:
  - 60 drops per minute

APPENDIX L

OBSERVER SCORING GUIDE

APPENDIX L

OBSERVER SCORING GUIDE

Scoring of Calculations

Criteria	Score
All 3 problem segments correct	3
2 problem segments correct	2
1 problem segment correct	1
No problem segments correct	0

Scoring of Regulations

Criteria	Score
Actual rate within 3 gtts of calculated rate	3
Actual rate within 4-6 gtts of calculated rate	2
Actual rate within 7-9 gtts of calculated rate	1
Actual rate 10 or more gtts from calculated rate	0

APPENDIX M

POSTTEST STUDENT REMINDER LETTER

GRAND VALLEY STATE COLLEGES

APPENDIX M

POSTTEST STUDENT REMINDER LETTER

Allendale, Michigan 49401 • 616/895-6611 • An Equal Opportunity/Affirmative Action Institution

April 6, 1981

Dear

I'm writing to remind you that the concluding phase of data collection for my research study will occur next week.

Several IV calculation and regulation stations will be set up in the basement of Lake Michigan Hall during both of the "Open Skills Lab Practice Sessions" on Monday, April 13, from 9 a.m. to noon, and on Tuesday, April 14, from 2 to 5 p.m. The procedure will be the same as in February.

Please go to the Lake Michigan Hall basement at your convenience on Monday or Tuesday, during the time scheduled for Skills Lab.

Thank you for your participation in this study; I greatly appreciate your continued cooperation. I'll be reporting the results to you during one of your nursing courses next year.

Sincerely,

Donna Larson
Associate Professor of Nursing

P.S. In case you've forgotten, your identification code number for this study is

APPENDIX N

FOLLOW-UP QUESTIONNAIRE

APPENDIX N

FOLLOW-UP QUESTIONNAIRE

This questionnaire was designed to provide feedback as to how you feel about using computer simulation or skills lab simulation for learning how to calculate and regulate IV flow rates.

Code number: __________

Did the simulation experiences help you with your first clinical experience with calculating and regulating IV flow rates?

Yes/No (circle one)

How?

Did you feel that you were adequately prepared for your first clinical experience with calculating and regulating IV flow rates?

Yes/No (circle one)

How?

What did you like most about the IV simulation you experienced?

What did you like the least?

What was the most difficult part of this learning experience for you?

What was the easiest?

What would you like to see done differently?

Comments?

APPENDIX O

CLINICAL I.V. EXPERIENCES RECORD

APPENDIX O

CLINICAL I.V. EXPERIENCES RECORD

Student name: ____________________

Clinical instructor: _____________

Clinical rotation: Pediatric/Medical-Surgical (circle one)

Rotation sequence: First/Second (circle one)

How many patients receiving I.V. therapy did the student directly care for during the time of this study?

How many times did the student calculate an I.V. flow rate during the time of this study?

How many times did the student regulate a flowing I.V. to match the rate he or she previously calculated?

Additional comments?

APPENDIX P

FACULTY TIME FORM

APPENDIX P

FACULTY TIME FORM

Name ________________________ Date ________

Method: Computer/Skills Lab (circle one)

Instructions: Please complete the following information for each time you have anything to do with teaching the calculation and regulation of IV flow rates (e.g. setting up or dismantling the lab equipment, answering student questions, checking accuracy, etc.).

These data are very important for the study, so please remember! Note that this one report can be used to record multiple encounters on any one date. After you've finished recording your "IV time" for any one date, please submit this form to Donna Larson's faculty mailbox.

Thanks.

Starting time: ________ Total time in minutes: ______

Ending time: __________

Nature of the "IV Encounter": (check one)

_____ supervising lab (regular assignment)

_____ answering student questions

_____ checking student accuracy

_____ setting up/dismantling lab equipment

_____ ordering, checking supplies

_____ other (please describe)

APPENDIX Q

PROGRAMMED INSTRUCTION MATH EXAM SERIES

APPENDIX Q

MEDICATION DOSAGE MATH EXAM #1

SHOW ALL STEPS TO YOUR WORK

Reduce to lowest terms.
Carry work out to nearest hundredth.

A. Basic Concepts

1. 66/11 x 7 1/3 =

2. 2 1/16 from 5 3/8 =

Change the following to decimals:

3. 295.8% =

4. 13/61 =

Change to percent:

5. 0.0125 =

6. 27/42 =

Express as Roman Numerals:

7. 7 =

8. 30 =

Express as Arabic Numerals:

9. XV =

10. $\frac{7/8}{1/2} = \frac{X}{400}$ X =

B. Equivalents and Abbreviations

1. 1500 milligrams = ---------- gram(s)

2. 0.003 grams = -------------- milligram(s)

3. 14 kilograms = ------------- pound(s)

4. 1 3/4 liters = ------------- milliliter(s)

5. 250 milliliters = ---------- glass(es)

6. 2 drams = ----------------- fluid ounce(s)

7. 4 milliliters = ----------- gram(s)

8. 2 fluid drams = ----------- minimum(s)

9. 4 gallons = --------------- quart(s)

10. 32 fluid ounces = ---------- pint(s)

11. 180 drops = --------------- teaspoon(s)

12. 4 fluid ounces = ---------- tablespoon(s)

13. 4 fluid ounces = ---------- glassful(s)

14. 1 fluid ounce = ----------- teaspoonful(s)

C. Conversion and Dosages

1. a) 35° C = ---------- $^{\circ}$ F

   b) 113° F = --------- $^{\circ}$ C.

2. A child is to receive a drug as 2 mg per kg of body weight. The child weighs 24 lbs. How many milligrams should be given?

3. The doctor has ordered gr. vi. The tablets on hand are labeled 0.2 Gm. You should give ------------- tablet(s).

4. The doctor has ordered 1.0 Gm. of an antibiotic. The vial contains 5 Gms. Directions accompanying the injectable powdered drug read: "Add 8.6 ml of diluent (each ml contains 500 mg)." After adding the diluent, give the client -------------- ml of the solution.

5. The clinic physician has ordered Gantrisin suspension 0.5 Gm q.i.d. to be given to an eight year old client. The bottle is labeled "sulfisoxazole (Gantrisin) suspension, 100 mg per ml". How many teaspoons (measuring) should be given in each dose?

   How many ounces will be needed to continue the medication for ten days?

D. Preparation of Solutions

1. You are to prepare 1000 ml of a 4% solution of vinegar.

   a) How much vinegar is needed?

   b) How much water should be added?

2. You are to prepare 400 cc of a 3% solution from tablets labeled 0.5 Gm solution. How many tablets will be used?

3. Prepare 500 cc of a 1 1/2% solution from a 3% stock solution.

   a) How much stock solution is needed?

   b) How much diluent is needed?

4. How much 100% iodine solution is needed to make 1 liter of 5% solution?

5. Prepare 2 liters of 1:1000 solution from 5 gr. tablets. How many tablets would you use?

MEDICATION DOSAGE MATH EXAM #2

1 Gm	= -------- mgm		1 oz	= -------- cc
1 tsp	= -------- cc		1 Gm	= -------- gr
1 ml	= -------- cc		1 Tbsp	= -------- cc
1 kilo	= -------- lb		1 cc	= -------- minims
			1 gr	= -------- mg

Directions:

1. Calculate dosage for single dose.
2. Show your mathematics.
3. Label your answer with correctly written unit of measure.
4. Answer must be measurable with equipment available on unit. (For example, there are no 1/3 markings on any syringe). The measurement should be converted to a measurable fraction.

Problems:

1. Order: 40 mg Nembutal
   0.3 mg Atropine IM on call

   Available medication: Nembutal 150 mg per ml
   Atropine 0.4 mg per ml

2. Order: Penicillin G Procaine 300,000 u IM q6h

   Medication available: 400,000 u/ml

3. Order: PenVee Suspension 400,000 u q6h p.o.

   Medication available: 300,000 u in 5 cc

4. Order: Tetracycline hydrochloride 200 mg IM

   Medication available: 100 mg/ml
   250 mg/ml
   500 mg/ml vials

5. Order: Morphine Sulfate 2.5 mg sub q

   Medication available: 10 mg/ml

6. Order: Potassium Chloride 4 mEq IV

   Medication available: 3 mEq/cc

7. Order: PenVee Suspension 250 mg p.o. q6h

   Medication available: 180 mg in 5 cc

8. Order: Kanamycin 15 mg IM q6h

   Medication available: 75 mg in 2 cc

9. Order: Ampicillin 150 mg p.o. q6h

   Medication available: 250 mg in 5 cc

10. IV Ordered:

    600 cc for 8 hr.
    How will you regulate this IV?

    cc per hour ________________

    gtts per minute ________________

    (Pediatric IV micro-drops = 60 per cc)

MEDICATION DOSAGE MATH EXAM #3

1. Give Ampicillin 200 mg q6h IM
   Have Ampicillin 250 mg/cc

2. Give Colymycin 10 mg q8h IM
   Have Colymycin 150 mg/2cc

3. Give Polycillin Suspension 75 mg q6h p.o.
   Have Polycillin 125 mg/5cc

4. Give Lanoxin 0.025 mg q 12h p.o.
   Have Lanoxin 0.05 mg/cc

5. Give Procaine Penicillin 250,000 u q12h IM
   Have Procaine Penicillin 300,000 u/cc

6. Give Keflin 40 mg q6h IM
   Have Keflin 75 mg/2cc

7. Give Nafcillin 120 mg q12h IM
   Have Nafcillin 250 mg/cc

8. Give Phenobarbital elixir gr 1/4 p.o.
   Have Phenobarbital elixir 16 mg/4cc

9. Give Scopolamine gr 1/300 IM
   Have Scopolamine 0.4mg/cc

10. Give Nembutal elixir 15 mg p.o. at 9 a.m.
    Have Nembutal elixir 20 mg/5ml

11. Give Nembutal gr 1/2 IM stat
    Have Nembutal 100 mg/2ml

12. Give Erythromycin Suspension 75 mg q6h p.o.
    Have Erythromycin Suspension 100 mg/2.5cc

MEDICATION DOSAGE MATH EXAM #4

1. Give Ilosone Liquid 200 mg q6h p.o.
   Have Ilosone Liquid 250 mg/5cc

2. Give Procaine Penicillin 200,000 u q12h IM
   Have Procaine Penicillin 300,000 u/cc

3. Give Geopen 5 Gm q6h IV
   Have Geopen 1 Gm/20ml

4. Give Garamycin in 40mg q6h IM
   Have Garamycin in 80mg/2cc

5. Give Keflex 75mg q6h p.o.
   Have Keflex 125mg/5cc

6. Give Keflin 60 mg q6h IM
   Have Keflin 75 mg/2cc

7. Give Diuril 200mg 2x weekly p.o.
   Have Diuril 250mg/5cc

8. Give Lanoxin 0.04 mg daily p.o.
   Have Lanoxin 0.05 mg/cc

9 Give Atropine gr 1/150 IM
  Have Atropine 0.4 mg/cc

10. Give Phenobarbital Elixir gr 1/8 q4h p.o.
    Have Phenobarbital Elixir 16mg/4cc

APPENDIX R

POST-STUDY QUESTIONNAIRE

APPENDIX R

POST-STUDY QUESTIONNAIRE

Code #: ____________

Did you take Math Exam #2 (the one with the IV calculation problem) before or after your first participation in the IV study?

Before / After (circle one)

Did you study for the final posttest of the IV study?

Yes / No (circle one)

If yes, please indicate what you studied from:

_____ Programmed Text
_____ Computer Program
_____ Skills Lab
_____ Notes from initial skills lab demo
_____ Other (please describe)

If you were in the COMPUTER GROUP:

Rank the following as to their helpfulness to you in learning how to calculate IV flow rates (place a 1 beside the most helpful, a 2 beside the next most helpful, and a 3 beside the least helpful):

_____ Programmed Text
_____ Computer Program
_____ Clinical Instructor(s)

Rank the following as to their helpfulness to you in learning how to regulate IV flow rates (use a 1 for the most helpful, a 2 for the next most helpful, and a 3 for the least helpful):

_____ Programmed Text
_____ Computer Program
_____ Clinical Instructor(s)

If you were in the SKILLS LAB GROUP:

Rank the following as to their helpfulness to you in learning how to calculate IV flow rates (use a 1 for the most helpful, a 2 for the next most helpful, and a 3 for the least helpful):

_____ Programmed Text
_____ Skills Lab
_____ Clinical Instructor(s)

Rank the following as to thir helpfulness to you in learning how to regulate IV flow rates (use a 1 for the most helpful, a 2 for the next most helpful, and a 3 for the least helpful):

_____ Programmed Text
_____ Skills Lab
_____ Clinical Instructor(s)

Please indicate which of these two methods you prefer to use when calculating IV flow rates:

_____ Method 1:

$$\frac{\text{Total volume}}{\text{Total hours}} = \text{Volume per hour}$$

$$\frac{\text{Volume per hour}}{60} = \text{Volume per minute}$$

Volume per minute x "drop factor" = Drops per minute

_____ Method 2:

$$\frac{\text{Total volume x "drop factor"}}{\text{Total minutes}} = \text{Drops per minute}$$

Thanks again!

APPENDIX S

STUDENT COMMENTS

APPENDIX S

COMMENTS FROM COMPUTER LEARNERS ON FOLLOW-UP QUESTIONNAIRE

DID THE SIMULATION EXPERIENCE HELP YOU WITH YOUR FIRST CLINICAL EXPERIENCE WITH CALCULATING AND REGULATING IV FLOW RATES? HOW?

"Yes. I felt I knew what I was doing before I had to perform."

"Yes. Helped me to regulate any IV flow."

"Yes. Gave me practice."

"No. No clinical experience with IV's."

"Yes. I knew how to do it when I got there."

"Yes."

"No. I have had no opportunity to work with IV's yet."

"Yes. It helped me regulate the number of drops/min on an IV before I actually had to do it in a clinical experience."

"No."

"Yes. Made me keep reviewing the process."

"Yes. It helped me in that it gave me experience doing calculations."

"No. I never had to calculate an IV in clinical, and all the ones I worked with were on IVAC's."

"No. I used an IVAC in regulating the IV flow rate. I did calculate the rate before hand but the simulation experience didn't help me there."

"No. I'd already done one before that."

"No. My first experience was with an IVAC machine. The simulation was not like an IVAC machine."

"No."

"Yes. I felt secure in that I was doing the rate correctly."

"No. We had already learned IV calculations for our medication passing test."

"No. Computers aren't anything like regulating a real IV. Nothing beats messing around with the IV itself."

"No."

"No. I had already had to calculate IV's in clinical areas before the simulation experience."

"Yes. Just in the repetition of the calculations."

"No. We used IVAC's."

DID YOU FEEL THAT YOU WERE ADEQUATELY PREPARED FOR YOUR FIRST CLINICAL EXPERIENCE WITH CALCULATING AND REGULATING IV FLOW RATES? HOW?

"Yes. I knew how to regulate it."

"No. Didn't know how to work IVAC machine."

"Yes. I knew how to calculate the IV flow rates which made me much more comfortable in my clinical experience."

"Yes. But no experience."

"Yes. By learning how to regulate one in the lab and by learning it for our med test."

"Yes. Computer gave many problems."

"Yes. I knew how to calculate how many gtts/min the client should receive."

"Yes."

"Yes."

"No. This IV test was the only experience with IV's at all before clinical. Had I had to do one, I don't feel I would have been able to do it with any speed, but I would have been able to get it close."

"Yes. The simulation experience did not help directly, but gave me an idea of what to expect with IV rates."

"No."

"Yes. I knew, from practice, the formula for IV rate regulation."

"No. My first were with IVAC's, and I didn't know anything about these."

"Yes. Plenty of time to practice had been provided before the clinical experience."

"Yes."

"Yes. I thought that I'd had adequate experience with IV calculations and that the simulation was a very helpful reminder of the procedure."

"Yes."

"N.O.N. applicable."

"Yes."

"Yes. But I was confident with regulating IV's merely because of the testing experience and using a real IV at that time!"

"Yes. Due to our math quiz which we had to pass with a 100%."

"Yes. Because the computer gave us so many practice problems."

WHAT DID YOU LIKE MOST ABOUT THE IV SIMULATION YOU EXPERIENCED?

"The number of practice problems."

"I didn't have to wait for an available instructor."

"Using the computers."

"It was different than most learning experiences -- gave you some independence in learning."

"Instant feedback."

"I learned how to do it adequately."

"Learning how to calculate the IV."

"Actually practicing with an IV."

"Working with the computer; I've never had that experience before."

"The computer helped in calculating IV's."

"Working with the computer; I'd never done it before."

"It was a new experience and challenging to see if the experience helped or hurt me. I feel the experience was not hurting my learning in any way except the feeling IV regulators."

"Using the computer was fun."

"Experience with the computer terminal was exciting."

"Playing with the computer."

"You could stop when you felt you had done enough, you weren't standing on your feet with the computers. There wasn't an instructor looking over your shoulder."

"I liked being able to get more experience on the computer."

"Increased comfort with IV regulation in clinical."

"I didn't really like the experience."

"It made calculations easier by getting immediate feedback on your answers."

"The number of practice problems."

"Regulating IV flow rates is a mechanical skill that needs to be practiced. Computers do not adequately give the mechanical practice. Math figures yes, but the mechanics no."

WHAT DID YOU LIKE THE LEAST?

"Walking over to the computer room."

"Walking over to the computer room (very cold)."

"Gave too much independence. Felt like I needed reassurance from someone besides computer."

"Machine (computer) malfunction."

"Going over to Mackinac to do it and running that dumb computer -- mine didn't work well."

"The confusion the first day."

"Not being able to practice regulating an IV on my own time."

"Being tested. Just took extra time."

"I think I would have preferred practicing with the real thing rather than the computer."

"Couldn't get exact rates."

"I don't think it gave me the feel for regulating rates. Pressing a button on the computer feels so much different than regulating a flow rate on an IV."

"The computer wouldn't work right."

"It was ultra easy to regulate the simulated IV, just punch a button."

"Didn't work with IV's enough."

"I don't feel that using the computer is a good representation of regulating IV's. Pushing buttons on a machine just doesn't seem the same to me as adjusting the flow regulator on real IV tubing."

"Computers aren't anything like the real thing."

"I felt that the timing procedure on the computer was not accurate enough for me to tell when I had the correct rate."

"Problems with calculators -- minor problems -- the feeling of unreality of the simulation. More like a space invader game than an IV."

"The computer program did not function correctly."

"Computers are not as hard to regulate as the real IV's."

"A computer is not like the real IV's and that regulation is what I needed to build confidence in doing."

"Computers aren't anything like the real thing."

"Walking to the computer in the cold."

WHAT WAS THE MOST DIFFICULT PART OF THIS LEARNING EXPERIENCE FOR YOU?

"Regulating the IV."

"Coming here and then going over to the computers."

"Overcoming stress at testing time."

"Regulating the IV."

"Trying to get the gtts/min within 3 gtts on the IV."

"Nothing really -- maybe doing the math in my head."

"Regulating."

"Setting the actual IV drop at proper rate."

"Learning to calculate IV rates."

"Remembering the formula."

"The book work, learning the formula."

"Setting the rate on an actual IV."

"Keeping record of the IV's I regulated and did calculations for."

"The formula."

"Performing the arithmetic."

"The second time around had more difficulty with the IV control lever."

"No real experience on the minute control of an IV."

"Walking to the computer center on the snowy day we had."

"I didn't like that we didn't get to fool around with real IV's to become used to them -- it was hard to do the testing area with a real IV at first!"

"Walking to computer room in 0 degree weather."

"The mechanical part."

WHAT WAS THE EASIEST?

"Learning how to calculate."

"Calculations."

"The computer."

"Calculations."

"Timing the actual IV's"

"Regulating on the computer."

"None of it was all that difficult."

"Calculating the rate."

"The simulation experience."

"Calculations were simple."

"Regulating them on the actual IV. It took alot of time because I didn't have the feel for it, but it wasn't difficult."

"Calculating rates."

"Calculating."

"Regulating the IV."

"Calculating how many gtts/min the IV would run."

"Working on the computer."

"Regulaing the IV."

"Calculations."

"Regulating the IV itself."

"The math calculations."

"The whole experience was easy."

"Math."

WHAT WOULD YOU LIKE TO SEE DONE DIFFERENTLY?

"Yes, don't turn instructors into computers. Your study was fine!"

"No, it was quite interesting on the computer, and you did get to practice in clinical."

"Different method selecting for testing sites so decrease delay. Machines in proper working order."

"Nothing. Just that the computer will be running okay. But that's not your fault!"

"Tell us at the beginning the IV is okay 3 gtts either way."

"Nothing."

"Not having to go across campus to the computers."

"Practice more with setting rates on real IV's."

"The whole class participating would be a change. I would like to see everyone experience the simulation in the beginning, but if wanting to, practice after on real IV's."

"The computers should be working accurately, otherwise it's really confusing to the student."

"Bring the computers over here!!"

"Computer combined with actual setting of IV drips on real IV's."

"For myself, I don't feel there was any benefit gained from using the computer due to the time it takes to get across campus. I could have been done in less time if I had stayed up in the lab."

"Use real IV's!"

"I would prefer not having to go across campus for the computer training."

"Starting IV's on faculty!!"

"Computers in this building."

"Use real IV's."

"Calculations can be learned by computer, but practice should be reserved for real IV's!"

"Learn on the real set-up."

COMMENTS?

"The computer did not give me the fine motor control to regulate IV's."

"I feel that the use of the computer did not provide any better means of learning the procedure than working with actual IV's."

"The simulation was a very unique experience. I enjoyed working at a terminal."

"I'd prefer 'hands-on' experience to working with a computer. I think you can more accurately get the feel for how to do it that way."

"I think this helped because I at least had some exposure to IV's before clinical, but I still would have liked more."

"I'm looking forward to seeing the results."

"Really good project."

COMMENTS FROM LABORATORY LEARNERS ON FOLLOW-UP QUESTIONNAIRE.

DID THE SIMULATION EXPERIENCES HELP YOU WITH YOUR FIRST CLINICAL EXPERIENCE WITH CALCULATING AND REGULATING IV FLOW RATES? HOW?

"Yes. It gave me practical experience."

"No. Worked with soluset so haven't had to calculate flow rates in clinical yet."

"Yes. I was acquainted with IV before I went into clinical."

"Yes. By setting up a testing situation there was pressure to perform and thus I listen and concentrate harder on learning and doing it right."

"Yes. By creating a situation under pressure to calculate an drop formula."

"No. Did not do this in med-surg."

"Yes. Found regulating IV's easy."

"Yes. Knew how to set up the equation."

"Yes. I knew how to calculate and check flow rates. I wasn't allowed to regulate it though."

"Yes. I never actually had to regulate IV flow rates in med-surg, but it did help me in the calculation of rates."

"Yes. Gave me expreience in regulating the IV, which takes time."

"Yes, it gave me practice with calculating the IV rate and regulating the IV."

"It would have, but I've never had a clinical experience calculating IV flow rates."

"Yes. Gave me practice so the equipment used was more familiar."

"Yes. I never knew how to regulate IV's, so by doing this I learned."

"Yes. Even when I had to calculate the drip rate very quickly (I was in a hurry) I was able to remember the right way to do it and was able to regulate the flow without problem."

"Yes. I did have an idea how to adjust drip rates on IV's."

"Yes."

"Yes."

"No."

"Yes. I knew how to calculate flow rate and regulate IV to proper drops/min."

"Yes. I enjoyed being in a study."

"Yes. It gave me more confidence."

"Yes. Knew how when I needed to do it in clinical."

"Yes. I felt more comfortable regulating an IV in clinical because I had practiced in lab."

DID YOU FEEL THAT YOU WERE ADEQUATELY PREPARED FOR YOUR FIRST CLINICAL EXPERIENCE WITH CALCULATING AND REGULATING IV FLOW RATES? HOW?

"Yes. Knowing that I did it properly in the lab gave me more confidence in clinical."

"Yes."

"Yes. I was familiar with it and had actually experienced it and calculated it using an IV."

"Yes."

"Yes. Practice in calculating gtts/min helped alot."

"No. Very ill prepared -- didn't have enough practice time."

"No. I wasn't aware of preparing the time left. I thought I had to divide it into the hours it was to hang (i.e. 12 hrs instead of time left)."

"Yes."

"No. IV flow rates were sometimes written differently than were for practice problems. So it was hard to figure them. All doctors wrote orders differently."

"Yes. I got plenty of practice in lab problems."

"No. Not enough problems."

"Yes."

"Yes. I knew I could do the calculations and I understood what I was doing and knew I could do the actual performance part since I had done it in the pre-test and got a feel for it."

"Yes. I knew how to calculate the drip rate. And had practiced regulating the IV."

"Yes."

"Yes. I think I would have been prepared with more practice if I had been called on to regulate rates."

"Yes. Because I knew how to calculate and check flow rates already set-up on IV's when my instructor expected me to do so."

"Yes. I knew how to do it."

"Yes. Had no trouble regulating IV's."

"Yes."

"Yes. I knew how to go about figuring the calculations."

"Yes. I felt confident of my ability from the instruction we had in class and from practicing the first day."

"Yes. But I should have practiced more."

"No."

"Yes. I felt more prepared than it I had not physically done it."

WHAT DID YOU LIKE THE MOST ABOUT THE IV SIMULATION YOU EXPERIENCED?

"Testing accurately after learning procedure."

"I liked being in a study."

"The experience that it gives you and being true to life (e.g. hospital like situation)."

"I liked the learning experience. I discovered I was handling the equipment wrong."

"It gave me some experience that I never received in med-surg."

"Able to practice on real IV."

"It gave me practice."

"I enjoyed the challenge of being able to see if I could get the IV drip set exactly."

"Actually regulating the drip."

"Calculation of the drip rate was presented in a way that made it easy to understand."

"It was a learn by doing experience, which really helps me learn."

"Gave me practice."

"That I got to practice by using the real IV equipment and not the computers!"

"Working with actual equipment."

"I liked working with the IV's."

"Increased practice."

"Refreshes my memory -- gave me the desire to be accurate."

"I liked being able to work with the real IV and get a feel for the regulator."

"Being in a study."

"The most was actually regulating the IV."

"Practice decreases stress in hospital setting.

Increased reinforcement to learning."

"Gave me the practice I needed. Practicing at your own pace is a nice learning atmosphere."

WHAT DID YOU LIKE THE LEAST?

"Waiting around to regulate the IV."

"Waiting in line to get to the IV."

"Wish more IV's around to practice on during practice session."

"I did not like trying to keep track of every IV problem I figured and every IV I adjusted."

"Waiting in line."

"Waiting in line for my turn at the IV."

"The waiting."

"Standing in that crampy little room."

"The first time doing it, I was nervous."

"Waiting for the IV to be free."

"It was time-consuming to count drops and very frustrating when you were only 1 or 2 off."

"I felt nervous at first -- like I was pressured for time."

"A little bit of a bother."

"Waiting in line."

"I felt like I was in a funeral parlor during the first practice session."

WHAT WAS THE MOST DIFFICULT PART OF THIS LEARNING EXPERIENCE FOR YOU?

"Calculations without calculator!"

"Memorizing and understanding the calculation."

"Remembering to round up after you get cc/hr."

"Nothing was real difficult."

"Calculating IV flow rates."

"Getting the exact gtts/min."

"Regulating the IV; it takes time to know how to finely regulate."

"Trying to correctly adjust IV's especially when it was a small number like 8 drops/min."

"Remembering where to round off the numbers."

"None was difficult."

"It was all pretty easy."

"Getting a feel for the IV equipment."

"It was difficult to remember how many times in the clinical setting I regulated an IV (there were so many other things to remember and keep track of)."

"Taking the time to regulate -- tedious."

"Actually doing the regulating."

"I found no part difficult (getting the drip exactly on was the hardest part of it all, I guess, if I must choose a part)."

"There wasn't anything that I considered difficult."

"Do not think any part was difficult."

"Not using a calculator."

"Time factor."

"Having patience to regulate a very slow rate."

"Frustration of not knowing about 3 drops on both ways and learning how to do calculation different way."

"Regulating flow in short amount of time."

"Regulating the IV."

"Adjusting the drips. It seems like it takes forever to get within 3 drops of the right amount."

WHAT WAS THE EASIEST?

"The math."

"The math calculation."

"Calculations."

"Calculations."

"Calculations."

"The IV simulation was not difficult and it was helpful."

"I felt the figuring of the rate was easiest."

"Calculating the drips."

"Calculating the rate."

"The calculations!"

"Calculating IV rate."

"Math calculations."

"Calculating."

"It was easy to participate in when it was during our lab period."

"Calculation."

"Regulating."

"Regulating the IV."

"Actually monitoring the drops from IV."

"Regulating the IV."

"Timing drop factors within 3 gtts."

WHAT WOULD YOU LIKE TO SEE DONE DIFFERENTLY?

"It was good."

"More supervised practice."

"I like the flexibility of coming in when you like."

"Not as much time between pretest and posttest."

"Don't need to spend so much time on calculations."

"Spend longer time practicing."

"Make it so we won't have to stand in line forever."

"Go in the room that empties instead of waiting for the number you pulled."

"More supervised practice time."

"Maybe more of these IV testings throughout the year."

"Teach how to regulate if IV gets ahead or behind."

"I would have liked further encouragement and no pressure as far as time was concerned."

"More time for practice in the lab."

COMMENTS?

"It was interesting to be in a study."

"I liked the way you conducted this study. I felt that you truly appreciated our participation, and I appreciate your politeness. Hope everything comes out well."

"I though it was a good learning experience. It gave me practice which is the easiest way for me to learn."