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ABSTRACT

Nursing educators and administrators are concerned about medication errors made by students which jeopardize patient safety. The inability to conceptualize and calculate medication dosages, often related to math anxiety, is implicated in such errors. A computer-assisted instruction (CAI) program is seen as a viable method of allowing students to learn mathematics in a non-threatening, self-paced environment, and this dissertation describes a project aiming to develop a quality CAI software product for beginning baccalaureate nursing students at San Jose State University (SJSU, California). Research methodology involved analyzing data from 196 student surveys and studying errors made by beginning nursing students in 422 dosage and solution exams, evaluating 6 currently available software programs in dosage and solution mathematics, selecting an authoring program and evaluation tools for the new CAI product, and developing and evaluating the prototype. It was discovered that the SJSU students made errors that followed trends mentioned in the literature--namely, not so often computational errors but conceptual ones, especially ones of conversion between measurement systems. The CAI program developed for this project eliminates many flaws discovered in other programs of its kind and meets the suggestions in the literature for decreasing errors and math anxiety. The research ultimately suggested that more related CAI tools be developed, that this particular one be evaluated by larger groups of students, and that research be conducted to evaluate its effectiveness. Appendices include: (1) a sample dosage and solution exam; (2) student data collection form; (3) Gagne problem-solving guide; (4) list of instructional and software design experts; (5) a software evaluation tool; (6) permission for tool use; (7) narrative survey tool; (8) instructional task analysis; (9) instructions for the CAI program installation; (10) student suggestions for the CAI program; (11) dosage and solution software list; (12) sample computer screens; (13) summary of evaluator comments; (14) evaluations from software professionals; and (15) the panel of nursing experts. (Contains 87 references.) (Author/BEW)

A COMPUTER-ASSISTED INSTRUCTIONAL SOFTWARE PROGRAM IN MATHEMATICAL PROBLEM-SOLVING SKILLS FOR MEDICATION ADMINISTRATION FOR BEGINNING BACCALAUREATE NURSING STUDENTS AT SAN JOSE STATE UNIVERSITY

by

Sharon C. Wahl

A Major Applied Research Project Report
presented in partial fulfillment of the
requirements for the degree of
Doctor of Education

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Abstract of a Major Applied Research Project Presented to Nova University in Partial Fulfillment of the Requirements for the Degree of Doctor of Education

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Nursing educators and administrators are concerned about the medication errors made by students and staff nurses which jeopardize patient safety. The inability to conceptualize and calculate medication dosages, often related to math anxiety, are implicated in the medication errors. A computer-assisted instruction (CAI) program is seen as a viable method to allow students to learn the mathematics in a non-threatening, self-paced environment. The purpose of this Major Applied Research Project was to discover major flaws in current CAI programs and to produce a quality CAI software program for beginning baccalaureate nursing students at San Jose State University.

The research methodology was developmental, consisting of several interrelated steps. Gagne's Nine Events of Instruction provided the main conceptual framework and instructional design guidelines. The steps consisted of the following: (1) analyzing data from 196 student surveys and

evaluating the errors made by beginning nursing students in 422 dosage and solution exams; (2) critically evaluating six currently available software programs in dosage and solution mathematics; (3) selecting an authoring program and evaluation tools; (4) developing a prototype CAI program which emphasized mathematical problem-solving, using "Course Builder" an authoring program for the Macintosh computer; and (6) evaluating the prototype program based on French and Stimmel's software evaluation tool, utilizing student volunteers and nursing and non-nursing experts. The results from the evaluations showed high rankings in most areas.

Conclusions include the following: (1) the types of problems and errors made by SJSU nursing students follow the trend identified in the literature; (2) the problem-solving approach used for the CAI program developed for this project meets the suggestions in the literature on decreasing medication errors and math anxiety; (3) a CAI program can be a cost-effective means of providing basic instruction in dosage and solution mathematics for all students, but especially for disadvantaged students; and (4) the prototype program eliminates many flaws discovered in other contemporary dosage and solution CAI programs, addresses errors committed by students in solving problems, decreases math and computer anxiety by means of a user-friendly, conversational approach, and is understandable by persons with a wide variety of language competencies.

It was recommended that (1) more CAI programs be developed by SJSU nursing faculty to provide individualized instruction for students in an economically constrained educational environment, (2) the CAI program developed for this project be evaluated by larger groups of students, (3) research be conducted to evaluate the effectiveness of the CAI program on diminishing conceptual errors, (4) Gagne's Nine Events of Instruction be used as a guide for software development and French and Stimmel's tool for software evaluation, and (5) administrators of nursing education programs provide monetary resources for software development.

The CAI program, "Mastering Medication Math", will incorporate reviewers suggestions and will be implemented in the SJSU nursing program in the Fall term of 1992. It will be distributed to other California State University and California Community College nursing programs.

This project will contribute to educational improvement by facilitating the acquisition of mathematical concepts necessary for safe medication administration in a non-threatening, self-paced manner which will accommodate a variety of learning styles appropriate to a multi-ethnic student population, and will allow faculty to focus on teaching nursing behaviors in lieu of remediation. The publication of the software will contribute prestige to the Nursing Department as well as the University. It is anticipated that nursing programs in other geographic areas will find the program useful.

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Chapter 1

INTRODUCTION

Students entering baccalaureate nursing programs arrive with varying mathematical skills. Many American students, planning to go into careers that are perceived as not requiring mathematics, take only the basic math courses required for high school graduation. Math anxiety is frequently cited by educators as a major reason for math avoidance (AAUW Educational Foundation, 1992). Bander and Betz (1981:313) indicate that "Math anxiety has been postulated to be especially problematic for females since performance in the math/science domain has typically been considered the province of males, and females may be socialized to believe themselves incompetent in mathematics." In some cases, girls are discouraged from taking additional math by parents, teachers or advisors, even though they may have shown excellent aptitude during elementary and junior high school (Burton,1984). However, both basic calculation and mathematical problem-solving ability is necessary for the modern nurse when giving medications. Fulton and O'Neill (1989:344) note, "It would seem that nursing students, who are more than 90% female, carry with them a number of social and cultural predeterminants that impair their computational abilities in mathematics."

Many nursing educators and administrators are extremely concerned about the number of medication errors made by student and registered nurses. These errors can endanger patient well-being and even survival (Bindler and Bayne, 1991; Worrell and Hodson, 1989). Both lack of basic calculation skills and the inability to conceptualize (set up) the problem have been linked to medication errors (Blais and Bath, 1992). Since responsibility for medication administration will continue to rest with the nurse, the ability to calculate dosages and solutions accurately and rapidly is crucial.

Faculty in the nursing department at San Jose State University are troubled about math deficiencies in nursing students. This concern is evident in the students as well. On orientation day, just the mention that passing a dosage and solution exam is required to complete the first nursing semester causes an anxiety pallor on the faces of newly admitted nursing students.

The literature suggests that teaching Posology (the study of dosage calculations) can be accomplished effectively by use of computer-assisted-instruction (Hamby, 1986; LaMancusa and Louis, 1985). Computer-assisted-instruction (CAI) allows students to learn at their own pace, decreases the fear/embarrassment of making mistakes since the computer is non judgmental, and saves faculty time for teaching other critical nursing content.

Background and Significance

San Jose State University is the oldest of the nineteen campuses of the California State University (CSU) System. According to A Master Plan of Higher Education in California (1960-1975), the CSU system assures students a place in college if they are in the top one-third of California high school graduates. Of the other two participants, the University of California (UC) system and the Community Colleges, the former admits the top one-eighth and the latter all adults motivated to pursue a college degree (Ckerlund, 1992).

San Jose State University is a multi-disciplinary urban educational center of approximately 30,000 students and 5000 faculty/staff located a few blocks from the newly-renovated downtown San Jose, California. The University is accessible by bus, commuter train, light rail, and car via four major freeways which circle the entire Bay area. While most students live within a ten mile radius, including a few on-campus dormitories and nearby apartments, a number commute from the South County, from Monterey and Santa Cruz on the ocean, down the Peninsula from as far as San Francisco, and from the East Bay as far north as Oakland.

While some say that San Jose has not yet established an identity apart from being "fifty miles south of San Francisco," it does project a very strong multicultural image with a minority population soon to exceed the white majority. This multicultural diversity is reflected in the student body at San Jose State University (SJSU). In a recent memo to faculty, Academic Vice President (AVP) Arlene Okerlund reported that as a result of intensive minority recruitment and retention, the Fall 1991 enrollment of 30,061 students was comprised of 49.8% White, 22.3% Asian, 6.4% Mexican American, 2.7% Other Hispanic, 4% Black, 4.2% Filipino, 0.5% Pacific Islander, 1.3% American Indian/Alaskan, and 8% Unknown (Okerlund, 1992). These figures represent between thirty to forty-five percent increases in "underrepresented" students with a six and one-half percent decrease in the previous white majority.

According to The Office of Institutional Research at San Jose State University, Fall 1991 data revealed the following demographics for the 1074 nursing majors (the 5th highest enrolled major in the University):

<u>Gender</u>

Female	995	(92.6%)
Male	79	(7.4%)

<u>Age</u>

18-24	580	54.0%
25-34	283	26.3%
35-59	211	19.6%
60+	1	00.1%

<u>Ethnicity</u>

American Indian/Alaskan	9	00.8%
Black	41	03.8%
Hispanic	78	07.3%
Asian/Pacific islander	216	20.1%
Filipino	186	17.3%
White	479	44.6%
Unknown	65	06.1%

Thus, the students in the undergraduate Baccalaureate of Science in Nursing (BSN) degree fall into similar ethnic patterns with the exception of a much larger Filipino population. Also notable is the increasingly large numbers of Southeastern Asian students, many of whom have not yet acquired sufficient skill in reading and/or speaking English.

The Department of Nursing's ongoing population of approximately 900 students includes registered nurses and other health professionals working toward the BSN who are part of the Advanced-Placement program and those in the Master's program but excludes Freshman not yet eligible to begin nursing coursework. Between sixty and eighty students are admitted each semester to the nursing major at a Sophomore level, having completed physical, biological, and behavioral science prerequisites at a community college or university. Students who transfer from a California Community College at a sophomore level are not required to take the SAT for university admission. Only admitting grade-point average is taken into consideration.

Economic woes are rampant in many state colleges and universities across the United States (National Education Association, 1992). When members of the California legislature began working on the budget for 1992-1993, legislators were confronted with projections from the Office Of Finance which predicted a devastating financial deficit for the state. The recession with its concurrent unemployment was blamed for the declining revenues. To make matters worse, the legislators and governor are restrained by allocated funds which dedicate a specific portion of the budget to designated programs. For example, Proposition 98 guarantees that public schools, K through 14, receive a specified percentage of the budget. Unfortunately, the CSU system receives its support from the general fund, that portion of the budget subject to the discretionary allocations of the state government. Current subjective indicators point to proposed cuts from eight to twenty-five percent for all CSU campuses.

This projected loss of financial support will alter teaching methods and available classes as well limiting the number of new students. A proposed forty percent fee increase may freeze out the middle class allowing only those wealthy enough to pay their way or poor enough to qualify for loans and scholarships. Ironically, Okerlund (1992) notes that after much effort by the UC and CSU systems to increase enrollments, "the 1989 CSU Growth Plan for 1990-2005 has been replaced with 'No vacancy' signs in 1992." While some have suggested revising the criteria for admission to include a higher high school GPA or more math and science from high school, this is still being rejected by higher education administrators who are reluctant to deny education to any of the future workforce. However, sceptics note that the proposed downsizing from 30,000 students to 16,000 will, of necessity, result in some kind of admission criteria changes (Parsons, 1992). Increasing faculty work loads will be evident as many instructors and support staff are laid off to bring the campus within budgetary restraints.

Given the dire financial deprivation resulting in decreased resources and increased faculty workloads and the multicultural student population, finding cost-effective means of producing quality learning is essential. CAI may be one such means.

In 1987, after several years of faculty planning, the Department of Nursing at San Jose State University created a student computer lab, in conjunction with the Nursing Learning Resource Center (NLRC), and purchased hardware and some software financed by several grants. The purpose, then, was to promote computer literacy and to enhance instruction. While there may or may not have been foresight about the University's current situation, the effect could be to provide cost-effective solutions to teaching problems created by diminishing human resources. Niemiec, Sikorski, and Walberg (1989) identified that use of CAI may be as much as three times more cost-effective than tutoring and is more cost-effective than two other strategies used to improve student achievement: increasing classroom time and reducing class size, two means not viable with budget reductions.

When software was first being purchased by a computer task force, faculty had asked that a computer program be considered that would teach dosage and solution mathematics. Clinical instructors were well aware of their students' inadequate math skills. Despite having completed the prerequisites of basic math and an intermediate algebra examination (ELM), many of the nursing students lack the problem-solving skills necessary to pass an examination (Appendix A) in dosage and solution mathematics without extensive time in and out of class in remedial and tutorial work. Even if students pass the test in the first nursing semester (and a number have to repeat the test two or three times), most have forgotten the procedures by subsequent semesters, again requiring faculty time to bring the students up to a safe functioning level. For faculty to have to spend time in dosage and solution math remediation takes teaching time away from the nursing content to be mastered that semester, thus diluting the quality of instruction. Not to provide that extra tutoring is to put patients at risk for medication errors. This problem continues to engage faculty at all levels of progression in the nursing program.

Another phenomenon noted was that the students who appeared to need help the most, especially the disadvantaged, i.e., foreign-born with limited language skills or minorities from less-than-quality educational backgrounds, were not seeking tutoring when it was available thus perpetuating failure. Minority Retention Coordinator, Kathy Abriam-Yago (1992), who is responsible for counseling all students who are not succeeding academically and for providing support for minority and foreign-born nursing students, validates these faculty perceptions. She states the reason most students give for not seeking tutoring is not enough time. However, she notes that some students report feeling embarrassed or having fear of being singled out. Given the importance of not losing face, especially among the Asian students, she believes the latter might be the more legitimate reason.

To solve student and faculty problems, a quality CAI program teaching Posology appeared to be the ideal solution. However, that original faculty request has not been fulfilled because after reviewing a number of programs that promised to meet the need, those programs available manifested a number of major defects, e.g., poor quality/design, too expensive, or too long. The alternative of faculty authoring a program was explored. This was later recommended as a desirable option.

Statement of the Problem

A cost-effective means of providing individualized instruction in mathematical problem-solving leading to accuracy in calculating dosages and solutions which reduces math anxiety and which frees up faculty time to teach other essential nursing content is not currently available for the beginning nursing students at San Jose State University.

Several CAI programs promoted as teaching college level mathematical concepts for medication administration, both for basic math remediation and for dosages and solutions, are available. However, these programs have a number of identifiable flaws that compromise their usefulness. The most glaring flaws include the following:

(1) Several programs are very long, requiring many disks making them too expensive and too time-consuming;

(2) The better designed programs are done in a game format, but do not cover enough content to be either time-or cost-effective;

(3) The available programs teach generally accepted mathematical principles, but do not focus on correcting common student errors that inhibit accuracy in calculations, nor do they teach concepts of problem-solving.

If baccalaureate nursing students are not proficient in the mathematical problem-solving skills necessary to accurately calculate medication dosage and solutions, they are at greater risk for committing medication errors and causing harm to patients entrusted to their care. Since math anxiety, known to inhibit learning, is common among this population of students, computer-assisted instruction is needed that can provide a non-threatening, enjoyable way of involving students in the learning process.

Conceptual Framework

The conceptual framework for this study and for the design of the computer software program was Gagne's Nine Events of Instruction (Gagne & Briggs, 1979) with a particular focus on the problem-solving outcome category. Gagne's theory was selected as the conceptual model since it appeared to be the most compatible with the type of program envisaged and because other CAI developers had documented it as a valuable guide for instructional design.

Gagne, Wager, and Rojas (1981:17) adapt Gagne's theory for use in designing CAI. They note, "one of the first steps in designing CAI, so as to take advantage of principles of learning derived from theory and research, is to categorize the type of learning outcome." The learning outcomes are listed as (1) verbal information; (2) intellectual skills with five subsets of discrimination, rule, concrete concept, defined concept, rule, and problem-solving; (3) cognitive strategies; (4) motor skills; and (5) attitudes. The problem-solving subset of intellectual skills was selected as the desired outcome for this project, though other areas were included as well (Appendix C). Once the learning outcome has been selected, learning is then supported by incorporating the steps Gagne calls the Nine Events of Instruction (Gagne and Briggs, 1979). Each of these identifies an internal learning process and the related external instructional event which is used to implement the internal process. The nine events which guided the design of the CAI program were (1) Alertness (internal learning process) and Gaining attention (external instructional event), (2) Expectancy and Informing learner of lesson objective, (3) Retrieval to working memory and Stimulating recall of prior learning, (4) Selective perception and Presenting stimuli with distinctive features, (5) Semantic encoding and Guiding learning, (6) Retrieval and responding and Eliciting performance, (7) Reinforcement and Providing informative feedback, (8) Cueing retrieval and Assessing performance, and (9) Generalization and Enhancing retention and learning transfer (Gagne, Wager, and Rojas, 1981:20).

In addition to Gagne's learning theory, which guided the design and provided the developer with a useful framework for evaluating the program, Adult Learning Principles incorporated in a CAI evaluation tool by French and Stimmel (French, 1986) comprised the second portion of the framework. These principles and the tool presented by French and Stimmel formed the basis for evaluation of the program by students and experts.

Purpose of the Study

The purpose of this Major Applied Research Project was to discover major flaws in current CAI programs and to design and produce a computer instructional program for SJSU nursing students that would assist beginning baccalaureate nursing students to learn the mathematical problem-solving skills needed to analyze and calculate answers to dosage and solution problems encountered when administering medications. The design of this CAI program in dosage and solution mathematics would demonstrate substantial improvements over currently existing software of the same genre and would incorporate student suggestions.

Major Issues

The issues surrounding the development of this project relate to math anxiety, especially in female students; the value of CAI as a teaching strategy; the concern of nursing administrators and educators regarding nurses' (student and practicing) medication errors; the feasibility of educators creating their own learning software; evaluation of currently available software in dosage and solution mathematics; the conceptual learning model to be used in developing the software program under consideration; and the method of evaluation of the prototype and final program. These issues are addressed in the literature review and discussed throughout the study.

Research Questions

From the foregoing discussion of the problem, background and significance, and issues surrounding the problem, the following research questions were raised:

1. What major problems are faced in teaching the problem-solving skills necessary for calculating dosages and solutions for medication administration?

2. What conceptual and computational skills do SJSU nursing students need to accurately calculate dosages and solutions?

3. What specific errors do SJSU nursing students commonly make when they attempt to solve dosage and solution problems?

4. What factors in teaching mathematical concepts promote math anxiety?

5. What strategies can be used in the design of a computer educational program to specifically decrease math anxiety?

6. Can an inexpensive CAI program, for the Macintosh, be developed that incorporates recommended quality

instructional design and addresses specific learning errors and student needs to promote accuracy in mathematical problem-solving?

7. Is the guide for planning and authoring CAI, developed by Gagne, Wager, and Rojas (1981), useful for instructional design of a medication math CAI program?

Definition of Terms

Computer-assisted Instruction (CAI): "CAI is any instance in which instructional content or activities are delivered via computer. As such, CAI is an educational medium with its own unique set of strengths and limitations." (Hannafin and Peck, 1988:5).

Conversion: Method used in dosage and solution mathematics to bring values from differing measurement systems (apothecary, metric, household) into the same system.

Basic Formula: Easy to recall formula used to calculate drug dosages (Kee and Marshall, 1992)

$$\frac{D(\text{desired or ordered dose})}{H(\text{dosage on hand})} \times V(\text{vehicle-tablet or liquid}) = X(\text{to give})$$

Dimensional Analysis: Also called factor analysis, uses three factors to calculate dosages, i.e., form of dosage, conversion factor, and drug order (Kee and Marshall, 1992)

$$V = \frac{V\ (\text{vehicle}) \times C\ (H) \times D\ (\text{desired})}{\underset{(\text{Drug label})}{H\ (\text{on hand})} \times \underset{(\text{Conversion factor})}{C\ (D)} \times \underset{(\text{Drug Order})}{1}}$$

Fractional Equation: A form of ratio and proportion that is set up as an equation (Kee and Marshall, 1992)

$$\frac{H}{V} = \frac{D}{X}$$

Ratio and Proportion: The oldest method that sets up the drug calculation as a relationship between two different elements (such as milligrams to capsules) or measurement systems (apothecary to metric) using a set of two equal ratios. The ratio and proportion method multiplies the means (middles) and extremes (ends) of the proportion to solve for the unknown (Erickson and Todd, 1991).

H (on hand) : V (vehicle) :: D (desired dose) : X (amount to give)

MEANS

EXTREMES

Assumptions

It is assumed that the data provided by students as to their needs in a dosage and solution program reflect their best self-knowledge, and that evaluations provided on the prototype program are honest and reflect the reviewers' personal opinions. It is further assumed that the models used for guiding development of the CAI program are appropriate for this particular situation.

Limitations

The literature does not specifically identify types of errors made by nursing students in the process of conceptualizing and calculating answers to dosage and solutions problems. Since the data on errors are based on analysis of student exams at San Jose State University, the program may not be useful for other nursing students in other settings, especially those not as culturally diverse.

An additional limitation concerns the student evaluators. Since the evaluators were volunteers from two different semester levels in the SJSU nursing program, they may not have provided the most objective responses and, therefore, may have biased the results.

Chapter 1 has provided an overview of this Major Applied Research Project including the reasons underlying the decision to do such a project, the purpose of the project, the research questions that were addressed, and the conceptual framework. Chapter 2 contains the rationale: an extensive review of the current literature related to the problem identified.

Chapter 2

REVIEW OF THE LITERATURE

The following issues have been identified as having a significant bearing on the project:

1. math anxiety, especially in female students;
2. the concern of nursing administrators and educators regarding nurses' medication errors;
3. the value of CAI as a teaching strategy;
4. the feasibility of educators creating their own learning software;
5. the conceptual learning model to be used in developing the software program;
6. the method of evaluation of the prototype and final program.

The discussion of relevant literature will be organized around each of these issues.

Math Anxiety

> We are all too familiar with the flushed and fidgety student who is frustrated daily by the tortuous rigors of a mathematics class. . . . this student cannot seem to do anything right. Even simple calculations are incorrect; everything becomes a jumble; her mind goes blank, and she is convinced that there is absolutely no way she can pass this mathematics test!

This is Skiba's (1990:188) introduction to a discussion on math anxiety. She notes that, in her experience as a mathematics tutor, female students' intense fear of incompetence, seemingly more severe than boys of the same age, controls their thinking processes and ability to operationalize mathematical skills. Skiba (1990:189) continues by observing that "most students who suffer from math anxiety have difficulty remembering or understanding the steps involved in problem-solving and calculating." Her recommendations include helping students confront the fear, starting with problems that are easily solved, building self-confidence and competence, and teaching a more logical approach. She also supports CAI as a useful method to supplement instruction.

Williams (1988:96) suggests that math anxiety is generated by teachers and teaching. She defines math anxiety as "both an emotional and a cognitive dread of mathematics" and notes that a fatalistic negative attitude toward math, frequently acquired from parents and teachers, becomes a self-fulfilling prophesy resulting in math avoidance. She cites a number of studies which show a consistent negative relationship between math anxiety and math achievement. Williams (1988) gleaned from the literature specific causes of math anxiety:

1. poor math teaching, especially failure to diagnose student learning problems (#1 cause);
2. an unfortunate experience with a math teacher;
3. not teaching to student learning styles;
4. teachers not liking math and not using creative teaching strategies; and
5. memorization being promoted while understanding and

reasoning are not.

Williams (1988) suggestions for interventions to reduce math anxiety expand on Skiba's:

1. improve training of math teachers--develop math educational specialists who love the topic;
2. accommodate various learning styles;
3. make math relevant;
4. provide positive math experiences--assign some problems any student can solve;
5. use games that require original thinking;
6. have teachers model problem-solving and logical thinking, including making/correcting errors; and
7. create a risk-free positive classroom environment.

Williams (1988:101) sums up her ideas with a wonderful analogy paraphrased from a Chinese proverb:

> Tell me mathematics and I will forget; show me mathematics and I may remember; involve me in a tension-free atmosphere in small group work and with manipulative aids in mathematics and I will understand. If I understand mathematics, I will be less likely to have math anxiety, and if I become a teacher of mathematics I can thus begin a cycle that will produce less math anxious students for generations to come.

Lester and Hand (1989) studied sixteen male and twenty-one female undergraduate students and found that age, locus of control, or anxiety about learning math did not relate to exam performance. However, they did discover that evaluation anxiety made a difference. Students who were highly anxious about the exam did perform worse. They also commented about self-fulfilling prophesy. Goolsby, et al.(1988) studied students who were taking a remedial math program because their math scores were inadequate to qualify for university admission. They found that confidence in one's ability to learn mathematics, which correlated highly with a math anxiety score, contributed significantly to prediction of performance in a first quarter developmental math course. They recommended a less threatening math classroom environment, individualized instruction, and a focus on both the affective and cognitive domains in teaching math.

While some of the literature notes that female math anxiety is decreasing (Holden, 1987; AAUW, 1992), and other studies find no significant difference between males and females in their degree of math anxiety (Widmer and Chavez, 1982; Bander and Betz, 1981), studies still show that the myth of mathematics being a male-dominated profession tends to discourage females from taking advanced math and decreases their self-confidence in this subject (AAUW, 1992; Bleyer, Pedersen, and Elmore, 1981; Burton, 1984; Tracy and Davis, 1990). Burton (1984) documents that black female students do not take as much math as white males. Tracy and Davis (1990) suggest that even though females are making significant contributions in the math field, their names remain unknown while the popular media continues to focus on lack of mathematical achievement in females. They suggest making young women aware of strong female role models in mathematics.

While the literature is mixed regarding gender-specific math anxiety, fear of math and lack of confidence in one's competence does continue to be a problem which often results in math avoidance. The interventions recommended encourage positive classroom experiences and increasing competence by teaching problem-solving rather than just memorization. A computer-assisted instructional program is one such intervention.

Medication Errors

Many nursing educators and researchers have expressed concern about the obvious deficiency of math skills in nursing students and registered nurses (Bayne and Bindler, 1988; Bindler and Bayne, 1984; Bindler and Bayne, 1991; Blais and Bath, 1992; Chenger, et al, 1989; Dexter and Applegate, 1980; Eaton, 1991; Hamby, 1986; Ptaszynski and Silver, 1981; Worrell and Hodson, 1989). Bayne and Brindler (1988:258) pointed out that although most nursing programs require that students pass a medication calculation test, ". . .it is often possible for students to miss medication calculation questions on tests and still pass the courses where this content is tested. This skill is frequently not tested further in work settings." When they tested 62 practicing registered nurses, scores ranged from 20 to 100 percent, but only 35 percent earned 90 percent which is considered mastery. In a later study of 110 registered nurses, Bindler and Bayne (1991) discovered that medication calculation skills had worsened. Now, only 19 percent attained a score of 90 percent and 43.6 percent were below 70 percent. Another significant finding from this study, Bindler and Bayne (1991:222) indicated that "nurses had a significantly higher error rate (48.4 percent vs. 21.6 percent) when more than one calculation was required in a problem."

Worrell and Hodson (1989) assessed 223 baccalaureate, associate, and diploma nursing programs regarding medication math deficiencies. Forty-one percent of the respondents reported that between 11 and 30 percent of their students had math deficits while an additional 41 percent reported more than 31 percent of the students were deficient. The authors noted that faculty tutors provided remediation in 78 percent of the programs; however, "the potentially more cost-effective computer-assisted instruction (CAI) and graduate student tutoring were seldom used" (Worrell and Hodson, 1989:30). Another finding concerned the large variety of methods the different respondents used to set up the problem. They felt that these inconsistencies would be detrimental for students being tutored by several different faculty.

Blais and Bath (1992:12) suggest that dosage errors occur not because of computational errors, but rather from either conceptual errors or lack of knowledge of converting between measurement systems. They state, "some students cannot conceptualize the problem to set up the computations. Others conceptualize the problem incorrectly and cannot give the appropriate form of medication dosage." They found that out of 66 junior level baccalaureate nursing students, 89 percent did not receive a passing score of 90 percent and 68 percent of the errors were conceptual. The authors recommend that students be taught problem-solving in order to be able to conceptualize the problem correctly (Blais and Bath, 1992). Chenger, et.al.(1989) found that only 54 percent of 210 freshman and 145 senior nursing students achieved mastery (90 percent) on a 35 question math test, and the problem-solving section presented the greatest difficulty.

Eaton (1989:342) speaks for many nursing educators when she notes

> Despite new instructional approaches such as dimensional analysis (called "distractional analysis" by some seasoned faculty members), students lack basic math concepts. They fail to recognize incorrect (unrealistic and unsafe) answers that shine up at them from their calculators. Many students, especially female students, have negative attitudes toward mathematics and little confidence in their ability to solve problems.

She challenges faculty who enjoy math to help students problem-solve and to produce modules using actual clinical situations that allow students to work at their own pace.

The Value of CAI as a Teaching Strategy

Many educators and educational researchers are standing firmly behind the contention that computers are *the* instructional tool of the future. Glatthorn (1987:329) states, ". . . we should be past the point of asking whether the computer is an effective instructional medium. We need instead to increase our efforts to determine how it can be best used." Wills and Lewis (1988:xi) note that the microcomputer is no longer just a subject of study in itself, but rather has become a major player in the teaching-learning process. "The microcomputer, from its humble beginnings a few short years ago as a processor and screen for programming hobbyists, has rapidly expanded into the learning environment as a fully-fledged part of the information technology revolution, accompanied by a range of devices and software that are now considered essential." Supporters of this position hold that computers will become the dominant educational delivery system (Bork, 1987; Wills and Lewis, 1988; Terry, 1984). "Computers can be programmed to draw pictures, compose music, or simulate situations that might be too expensive or dangerous to experience in real life" (Terry, 1984:1).

Nursing educator proponents of CAI herald the use of computer simulations of such dangerous situations to teach nursing students safe practice without jeopardizing actual patients (Lassan, 1989; Mirin, 1981). Terry (1984) further asserts that computer use in education can foster learning goals such as student-directed inquiry and mathematical and scientific conceptualization, thus promoting the remediation of low ability or unmotivated students. Bork (1987), while noting that the book is still the predominant learning medium, its preeminent position is being challenged by the computer. Ravitch (1987), questioning why the computer is succeeding as a star instructional tool where film, radio, and television failed, concludes that its distinct advantages lie in the potential for individualized and interactive instruction. The film or radio continue whether or not the audience is paying attention, but the computer demands the user's full participation. Ravitch (1987:28) notes that the electronic (e.g., computer) classroom is soon to arrive and states, "the most obvious benefit of the electronic classroom is that it achieves what progressive educators could only dream of: a union of work and play." Some investigators have noted one objection to computers is that they are too much fun and detract from the work of learning (O'Shea and Self, 1983).

The efficacy of the computer as an educational tool has been amply documented by numerous studies that show that outcomes from CAI are as good as or superior to traditional methods. Glatthorn (1987) notes that in a recent review of research on CAI, student achievement was as good as or superior to conventional instruction, there is a 32 percent savings in time using the computer, and student attitudes are generally positive. Research in the nursing literature reveals similar findings (Amber, 1985; Belfry and Winne, 1988; Day and Payne, 1987; Gaston, 1988; Mahr and Kadner, 1984; Murphy, 1984; Neil, 1985; Newbern, 1985; and Thompson, 1984).

Pogue (1988) notes that learning theory supports the value of computer education in its ability to provide interaction and individualization of instruction. Quinn (1986:34) concurs by pointing out that "the interactive mode allows the student to actually converse with the computer to increase understanding of material presented elsewhere." Bork (1987) observes that computer learning supports both field-dependent and field-independent learning styles since it lends itself to in-class demonstrations and large group problem-solving; two or three students working cooperatively with one computer in the lab; or the individual student who prefers interactive, self-paced learning without working with others.

Despite support for CAI, many educators caution would-be users. Glatthorn (1987) identifies three major concerns: excessive use may limit experiential learning, may limit the role of emotions in learning, and may narrow the image-making capacity of the learners. He comments that the most impact is on low ability students. In some areas, however, limiting emotion might have a positive outcome. For example, when nursing students are trying to deal with math, the emotion-limiting function of the computer could be advantageous since their severe anxiety often interferes with learning and performance. O'Shea and Self (1983:218) note areas of difficulty with computers in education: reactions of people involved, poorly designed materials, cost and reliability, and inadequate evaluation, i.e., "was what was done worth doing." It has also been noted that students may be turned off to computer education because of the time and inconvenience to access the computer: written material can be taken home and studied on one's own schedule, but one has to go to the computer (Wahl, 1990).

Ravitch (1987) expresses concern that the new technologies devalue the printed word. She cites the example of children's preference for Nintendo over reading a book. She observes that "sometimes print materials actually have more drama and immediacy than visual materials" (p. 31). Pogue (1988) has concerns that the trend in computers in nursing education is more focused on the technology of computers than on the educational objectives for using computers. This is borne out by the excitement generated by the new interactive video disk software as instructors are awed by the visual effects without consideration of how to integrate these programs into the curriculum. However, deTornyay and Thompson (1988:210) put some of the objections into perspective:

> Certainly computers should not be used for everything, anymore than lectures should be used for everything. Only in variety can different types of content be effectively transmitted and needs of each student met. The task is to determine what portions of the educational process can be best handled by the computer and what is best done by the teacher. Once this is recognized, the activities of each should complement rather than compete with one another.

Ravitch (1987) also supports the concept of computer instruction complementing rather than competing with teachers.

Gerheim (1990) points out that the use of CAI has become very popular in nursing schools, and Hebda (1988) indicates that nearly one-half of the National League for Nursing approved baccalaureate programs use CAI. Ninety-two percent of this group opted for commercially developed programs, whereas thirty-nine percent of the schools produced their own local software.

CAI has been documented to be very useful in facilitating learning and retention of skills which require repetitive practice, such as basic math skills (Ediger, 1989-1990; Roblyer, Castine, and King, 1988). More importantly, a number of researchers are touting the ability of the computer to teach critical thinking and problem-solving, intellectual skills very important to conceptualizing mathematical concepts (Akbari-Zarin and Gray, 1990; Blubaugh, 1989-1990; Ganguli, 1990). Others challenge the notion that computer education uses only behavioral learning theories and stultifies innovation. Benedict and Coffield (1990) and Ferguson (1992) assert that the visual multimedia effect of computer programs using graphics and animations encourages use of the right cerebral hemisphere which promotes creativity.

Several investigators have evaluated the use of CAI for teaching medication dosage calculations; results showed positive achievement in most cases (Hamby, 1986; LaMancusa and Louis, 1985; McColgan,1984; Reynolds and Pontious, 1986). Reynolds and Pontious (1986) tested 143 nursing students on dosage and solution competencies comparing those who used computer practice problems and those who used other learning activities. The number of students who passed the test in the computer group was much greater than the group who used other means. The findings were highly significant.

Reynolds and Pontious (1986) point out that with budgetary constraints, cost and time-effective instructional methods are badly needed. "Computers can allow for more effective use of instructional time so that faculty can devote more instructional time to teaching decision-making and innovative nursing implications in clinical situations" (Reynolds and Pontious, 1986:164). Adams and Duffield (1991) evaluated the effectiveness of drill and practice for developing and maintaining dosage calculation skills. Although they did not use computer instruction, they recommended using CAI because the repeated drills resulted in an improvement of students' skills. The authors believed that "computer technology offers one strategy to achieve and maintain the goal of proficiency" (Adams and Duffield, 1991:216).

Thus, while using computers as teachers is not appropriate in all learning situations, this innovative technology can be beneficial in providing cost-and time-effective individualized instruction to students in a variety of content areas. In most cases, the research shows its greatest value to be as a supplement to classroom instruction, though CAI is finding a valuable place in providing remediation for students in skills such as mathematics. The computer's use as a teacher of critical thinking and problem-solving has just recently begun to generate research interest.

Educators Creating Their Own Software

Bork (1987:17) suggests that "people whose primary mode of interaction with pupils is through the presentation mode or through textbooks are seldom the best choices for preparing computer-based learning material." But he also observes that programmers and instructional designers may not be well grounded in how people learn. He notes that what works in a classroom may not translate to a viable, attention-sustaining CAI program, and what may be fun for kids is either too cute for adult learners or does not cover enough content to be time effective.

Monahan (1987:33) notes that "the time and training required for professional software development prevents most teachers from participating . . . ," but he indicates that there are now many effective authoring tools available to assist amateur developers. He goes on to promote the benefits for both faculty and students, even if programs are not commercially distributed. Students benefit from knowing their teachers' talents extend beyond the classroom, and teachers find that teaching of problem-solving is enhanced, as well as the ability to critically evaluate software. According to Gerheim (1990), instructors want to author their own courseware because of dissatisfaction with the quality of available software or because courseware does not match content. Also Farabaugh (1990) identifies that much commercial courseware currently on the the market for nursing students is no better than using a textbook--that commercial and amateur developers have not utilized basic learning theory resulting in bored students who do not satisfactorily achieve learning outcomes. Van Dongen (1985:22) asserts that "the CAI author should be knowledgeable in the areas of learning theory, instructional design, and computer science or should have the assistance of someone who is." She advocates a team approach to CAI development to share talents and the workload.

So, while faculty software developers need to be cautious, if learning theory and instructional design principles are incorporated, quality programs can result that are course specific and benefit both faculty and students. Of course, having access to a professional software developer is the ideal situation.

Conceptual Learning Models for Software Development

A number of software authors offer conceptual models for guiding software development. French (1986) offers a model based on nine principles taken from three educational learning domains: Stimulus-Response Principles that correspond to the Psychomotor Domain; Knowledge Acquisition, or the Conceptual Domain; and Motivation and Personality Principles, or student attitudes and differences domain. Kozma (1987) looks at Cognitive Psychology; Jonassen and Hannum (1987) recommend research-based principles; Van Dongen (1985) provides guidelines based on non-specified learning principles; Gerheim (1990) suggests an approach which supports the instructional strategy of the lesson; and Farabaugh (1990) promotes use of behavioral principles.

Gagne, Wager, and Rojas (1981) utilize Gagne's categories of learning outcomes: verbal information, intellectual skills, cognitive strategies, motor skills, and attitudes. They point out, "each of these categories has at least one critical attribute that distinguishes it from the others, and that makes it possible for the designer of instruction to determine into which category a given learning task fits" (p. 17). They go on to define these categories, then note that once learning outcomes have been decided upon, Gagne's nine "events of instruction" become the focus. The tools provided are complex, but invaluable, for the potential CAI designer/author. Each outcome category becomes a heading with each of the nine events of instruction as subsets; offering a procedure for presenting a lesson related to each event completes the section. The end result are five tables replete with detailed information and examples. This instrument is effective in assuring the software under development adheres to well-accepted learning principles. Other authors have utilized Gagne's model for their own software development (Hazen, 1985; Smaldino and Thompson, 1990).

Evaluating Computer-assisted Instruction (CAI)

A number of educators, especially those committed to integrating CAI into their particular educational programs, have proposed various methods of evaluating educational software (Billings, 1984; Billings, 1988; Bolwell, 1988; Callison and Haycock, 1988; French, 1986; Hudgings and Meehan, 1984; Poppen and Poppen, 1988; Shuell and Schueckler, 1989). Several suggested using learning theory and principles. Others were more global in their methods.

Poppen and Poppen (1988) advise using behavioral principles to evaluate software and to make recommendations to software developers. "In order to improve the quality of educational software, it would be advantageous to employ research findings of learning psychology in the development of software programs" (p. 37). They identified fourteen criteria which included such behavioral elements as assessment of learners, chaining, feedback, and reinforcement which were used to evaluate six children's educational programs. They conclude that their tool was effective in identifying the deficiencies in these programs.

French (1986) advanced the learning theory concept as criteria for evaluating CAI and designed a tool based on nine selected learning principles:

1. reducing conflict and frustration;
2. repetition of concepts with appropriate variations;
3. positive reinforcement: reward correct responses;
4. active student participation;
5. organization of material;
6. learning with understanding;
7. feedback: the key to successful learning;
8. allowance for individual differences; and
9. motivation and personal values of the students (pp. 33-36)

Under each heading, French listed several items which clarified the criterion, thus producing a tool with twenty-nine items to be evaluated on a poor-good-excellent range. At the end of the tool, a summary comment on each criterion was requested. She provided validity and reliability studies which supported the quality of this tool. She concludes this tool would be useful for developing as well as evaluating software.

Shuell and Schueckler (1989:136) state, "yet, it is not enough for instructional software to run properly; it must also teach effectively. . . Software designed for classroom instruction should be consistent with current knowledge about effective teaching and learning." For the basis of their evaluation criteria, they used Rosenshine and Steven's six functions performed by effective teachers: (1) review of work and reteaching as necessary, (2) presenting material including structured overview, (3) guided practice with understanding checks, (4) correction and feedback, (5) independent practice, and (6) systematic review. Anticipatory set and closure were also considered. The resultant software evaluation form documented nineteen items to be considered on a 1 to 6, low to high scale. They intended their form to be used primarily for software developers; however, the use of these items can also be effective in evaluating software for purchase.

Bolwell (1988:511) notes that "nurse educators historically have expertise in evaluating instructional materials." She points out they would look at accuracy and currency of content, amount of information, target audience, and effectiveness as a medium for achieving outcomes. Additionally, she believes that educators also incorporate values, biases, and philosophies of teaching into their selection criteria. But despite this expertise, she proposes that judging the suitability of instructional materials delivered via the computer require further expertise. While she offers no specific evaluation tool, she does select attributes that should be present when making software purchase decisions: utilizing the computer's ability to calculate, store, and give rapid feedback; being cost-effective; using varied and frequent interactions with the learning; and enhancing learning with graphics, animation, and sound. Bolwell also promotes a broad evaluation strategy when summing up her conclusions with, "The best indication of a well-designed CAI program is observed when a student is enthusiastically involved in the interactive learning environment" (p. 513).

Hudgings and Meehan (1984) discuss a proposed tool, under development at the time the article was written, which they believe would provide a systematic, descriptive method "to provide support for a decision regarding the appropriateness of this software for a particular nursing curriculum" (p.36). The tool would incorporate a hierarchal series of questions going from general to specific in several categories: (1) "identification"- general data about software, its publisher, cost, etc.; (2) "system requirements"- necessary hardware; (3) "documentation" - supplementary materials needed; (4) "technical operations" performance of software and availability of help; (5) "instructional features' - educational strategies; (6) "content" - actual program text, accuracy and appropriateness; (7) "summary" - overall assessment of strengths/limitations of program; and (8) "decision-making" - identifying specific uses in the curriculum (pp. 36-37). The authors did not share a finished tool and none was located in subsequent literature searches.

Callison and Haycock (1988) describe a process they developed and tested which involved students (grades three through twelve) in evaluating educational software. The questions asked focused on perceived difficulty or easiness of content, ability to move through the program, graphics, length, and enjoyment. They emphasized that the student must be allowed adequate time to do the program at his/her own pace. The intent of their questions seemed to support Bolwell's (1988) contention that the best program is one which totally absorbs the student.

Billings (1984, 1988) wrote two different articles about evaluating CAI: one for nursing faculty (1984) and the second (1988) geared toward critical care nursing educators. In both of these, she uses a two-step approach. For faculty (1984), she focuses on CAI needing to be consistent with social, professional, and educational values, and with facilitating learning through responsiveness to the user audience; for critical care educators, she advises software evaluators to consider "not only the operation of the lesson, but also the instruction embedded in the lesson" (1988:118). She recommends an overview of content and ease of use and then, a more in depth look at screen design and method of instruction. She provides a detailed tool covering instructional strategy, instructional specifications, content, teaching-learning principles, lesson design, screen design, lesson operation, documentation, and cost and purchase agreement.

Thus, a variety of approaches to evaluating instructional software exist, each with its own strengths and limitations as well as usefulness to the evaluator. While the ideas and recommendations discovered from the review of CAI evaluation literature were considered when designing the computer program, previous experience using French's tool, the adult learning focus, the clarity of language used, and its ability to interface with Gagne's learning theory, made the French tool the evaluation tool of choice for this project.

<u>Summary of the Literature Review</u>

The literature reviewed documents that math anxiety persists as a problem, especially for female students, despite gains made in math education, and that math anxiety does inhibit learning and retention. A supportive learning environment, individualized instruction, and teaching understanding and problem-solving to restore confidence and competence are recommended strategies to resolve math anxiety.

The nursing literature points to a continued decrease in medication calculation abilities with a subsequent increase in serious medication errors. Deficiencies in conceptualization and problem-solving are identified as more significant than calculation deficits in contributing to errors made.

Both the strengths and limitations of CAI as a teaching tool are proposed, but most of the literature notes the inevitability of this new technology invading most learning environments. The use of CAI is supported as a viable means to cost-and time-effectively teach both computational and problem-solving/critical thinking skills in a self-paced manner and non-threatening environment.

While faculty software developers are cautioned to either have good instructional design and computer skills or team up with experts who do, the benefits to both students and faculty are noted.

Finally, the literature identifies several conceptual frameworks for novice developers and a number of tools to use for both formative and summative evaluation of the product.

In chapter 3, the methodology and procedures that were used to carry out the project are discussed.

Chapter 3

METHODOLOGY AND PROCEDURES

The problem-solving methodology used for this MARP was developmental. The goal of the project was to provide the nursing students at SJSU with an educational software program that will instruct beginning students in the mathematical problem-solving skills needed to analyze and accurately calculate answers to dosage and solution problems encountered when administering medications. This program would demonstrate substantial improvement over currently existing software of the same genre.

When the original need for this project was identified, processes were initiated for collecting certain types of data anticipated to be needed for the project. After administration of the dosage and solution exam, students were asked to complete a simple survey (Appendix B) asking them what information would be useful for them in a dosage and solution computer program. These were collected and held for future analysis. In addition, all available completed exams were saved so that the methods used by the students to solve the problems as well as types of errors made could also be analyzed at a later date. Since the investigator was responsible for counseling students who failed the exam, careful notes were kept which identified problems students had which resulted in the incorrect answer. Students' actual verbalizations about why they made the errors were anonymously recorded with the idea that they could be incorporated into the computer design to make it more real.

Other indirectly related activities that had been completed prior to the initiation of this project included (1) surveying faculty as to their priorities for computer educational software; (2) conducting a small research study comparing achievement for students who studied giving intravenous medications by use of a written module vs. using a computer program; and (3) obtaining a grant to purchase CAI software for the nursing program and evaluating more than 30 programs on various nursing topics, including general mathematics and dosage and solution programs.

Armed with this background information, the following steps were taken to complete the project:

1. A convenience sample of all nursing students at SJSU enrolled in the beginning nursing skills course during the Spring term of 1990, the Fall term of 1991, and the Spring term of 1991 were asked to complete a survey after they had taken the mandatory Dosage and Solution Exam. Of the total of 186 enrolled students, 169 surveys were completed, a return of ninety-one percent. These surveys were analyzed, identifying students' perceptions of what information was needed to correct their deficits. Data were grouped according to content area, e.g., basic arithmetic, conversions, problem set-up. Illuminating anecdotal comments were recorded.

2. Dosage and solution exams were available from the

Fall semester of 1989 through the Fall semester of 1991 which yielded a total of 422 completed exams. Each exam was analyzed to identify methods used by students to solve the problems, e.g., dimensional analysis, ratio and proportion, fractional equation, or basic formula; the types of problems most frequently missed, e.g., one-step, complex, or solution; and the specific type of error, e.g., set-up or calculation.

3. The literature was reviewed and evaluated regarding the identified issues, such as medication errors, math phobia (anxiety), use of CAI in teaching, software development, and software evaluation.

4. Available software programs in dosage and solution mathematics were evaluated to identify strengths and weakness in design and operation. The flaws thus discovered were corrected, where applicable, in the design of the program developed for this MARP.

5. Individuals who were known to the SJSU campus and nursing department as experts in the field of educational software development and instructional design and who were available to meet with the investigator were consulted for assistance in designing the proposed program and selecting an authoring program. The six experts (Appendix D) who were available provided very concrete advise and specific suggestions as well as offering to act as reviewers of the prototype program.

6. Skills needed to complete the project were evaluated and contracts initiated with professionals needed to fill in

the developer's missing skills, i.e., a programmer to assist in implementing the authoring system and a graphics artist for the drawings and animations in the program. It had been noted in the literature that a team is often needed to develop quality software.

7. An authoring program for the Apple Macintosh computer was selected: "Course Builder" from TeleRobotics International, Inc in Knoxville, Tennessee. This program has several advantages that made it desirable: (a) It is a very sophisticated and complex program with many options for the author; (b) It uses a visual language (Icons) for all features and does not require writing in a programming language; (c) It is designed to run either on the Macintosh or on IBM and compatibles by use of the Window 3.1 operating system (CBT Directions, 1992:19); and (d) The Department of Instructional Technology at SJSU has a site license for "Course Builder," thus providing this program at no cost to SJSU faculty authors.

8. The conceptual model for instructional design was selected. Gagne's learning theory, utilizing the nine events of instruction, appeared to be the most compatible with the type of program (problem-solving) to be developed. The Gagne theory had been documented by other CAI developers as very useful for courseware development (Hazen, 1985; Smaldino and Thompson, 1990). An article by Gagne, Wager, and Rojas (1981) provided an essential guide for the instructional design.

9. A method of evaluation was determined to ensure that the CAI program would meet its proposed goals. French and Stimmel's (1986) "Criteria to Evaluate CAI Software Using Principles of Learning Theory" tool was selected as the evaluation tool of choice since it incorporated both Gagne's Events of Instruction and Adult Learning Principles. Also the language used is easy to understand for non-computer people and students for whom English is a second language (Appendix E). Permission for use was requested and granted by the author (Appendix F). A second tool, a narrative survey to discover particular strengths and limitations of the program prior to revision, was created by the developer (Appendix G).

10. Volunteer evaluators were requested from the nursing student body. In addition to the instructional experts consulted previously, nursing faculty were asked to be evaluators based upon their involvement with teaching dosage and solution math and their experience with evaluating CAI. Two nursing textbook editors were also asked to evaluate the program from a commercial and cost perspective.

11. Based on recommended CAI developmental procedures (Hannafin and Peck, 1988; Rojas, 1992), educational goals and an instructional task analysis were completed (Appendix H).

12. Working with a programmer and graphics artist, the first portion of the program was completed. This first section encompassed the process to be followed for subsequent lessons.

13. The prototype, or Beta Test program as it is called

in computer jargon, was distributed to faculty and computer professional evaluators with instructions for installing the program (Appendix I) and with the two evaluation forms to be completed and returned to the developer.

14. Based on the recommendation of Alicia Rojas (1992), an expert in computer software development as well as co-author of the instructional design model being used, the developer stayed in the same room with the each student evaluator, unobtrusively observing the evaluator's reaction to the program and any problems experienced. Student evaluators were given time alone to complete the evaluation forms.

For the purposes of this MARP, the project was completed at the finish of the Beta Testing and analysis of the evaluations. The next three steps will be implemented in 1992-1993.

15. Based on feedback from evaluators, the original first sections of the program will be revised and the balance of the program completed. The pretest/posttest disk will be completed.

16. The final copy of the program will be resubmitted to the original eight professional evaluators. Student evaluators will be the beginning nursing classes of the Fall term of 1992 and the Spring term of 1993 for whom "Mastering Medication Math" will be a required assignment.

17. Final revisions will be implemented and the program readied for distribution.

Chapter 3 has provided an outline of the procedures used to determine the type of computer educational program that would meet the project goals and the specific steps taken to create and evaluate the final product. In Chapter 4, the actual results of each of these steps are described and the research questions are answered.

Chapter 4

PRESENTATION OF RESULTS

The following are the research questions addressed by this Major Applied Research Project:

1. What major problems are faced in teaching the problem-solving skills necessary for calculating dosages and solutions for medication administration?

2. What conceptual and computational skills do SJSU nursing students need to accurately calculate dosages and solutions?

3. What specific errors do SJSU nursing students commonly make when they attempt to solve dosage and solution problems?

4. What factors in teaching mathematical concepts promote math anxiety?

5. What strategies can be used in the design of a computer educational program to specifically decrease math anxiety?

6. Can an inexpensive CAI program, for the Macintosh, be developed that incorporates recommended quality instructional design and addresses specific learning errors and student needs to promote accuracy in mathematical problem-solving?

7. Is the guide for planning and authoring CAI, developed by Gagne, Wager, and Rojas (1981), useful for instructional design of a medication math CAI program?

These seven questions were answered as each step outlined in Chapter 3 was implemented. The development of the final product, the computer program, was dependent on that series of steps, the results of each step providing the foundation for the next. The first two steps in the process were the analyses of data gleaned from the student survey and from the dosage and solution tests, which answered research questions 2 and 3.

Student Surveys and Analysis of Dosage and Solution Exams

In a survey given to SJSU nursing students shortly after completing the dosage and solution exam, students were asked what they would like included in a computer program on dosage and solution math. This survey elicited a total of 440 responses from 169 students. From the narrative comments, 18 categories were identified which pointed out students' areas of concern, i.e., those areas they found most problematic. The categories included medical terms and abbreviations, basic math, fractions, decimals, conversions, solution problems, formulas and set-up, examples, word problems, understanding the problem, many opportunities for practice, variation in kinds of problems, teaching only one method, the apothecary system, rounding numbers, step-by-step solving of problems with rationale, ratio and proportion method, and dimensional analysis method. One student stated, "Solution problems are a MUST!" The majority of the students surveyed agreed since "solution problem" was identified by 123, or 72.8 percent of the 169 respondents. This was followed by "conversions" at 43.2 percent, or 73 respondents and "medical terms and abbreviations" at 41.4 percent, or 70 respondents. Table 1 displays the list of suggestions with the number of students selecting each one.

In addition to the identification of specific content the students saw as desirable in a CAI program for dosage and solution math, students provided a number of comments and observations which contributed additional information that could be included in the program. These are noted in the students' own words in Appendix J.

Dosage and Solution examinations were available for six semesters from Spring 1989 through Fall 1991. The analysis of the 422 exams yielded data about the methods used by students to solve the problems, the types of problems missed, and specific errors which contributed to an incorrect answer. In addition, the percentage of students who achieved mastery, a score of at least 90 percent, were identified, as well as those who failed the exam with a score of less than 73 percent.

Percentages of Mastery and Failure

Of the 422 students taking the Dosage and Solution Exam between Spring 1989 and Fall 1991, 82, or 24 percent achieved mastery with scores of 90 percent or better, and 19.2 percent failed the exam with scores of less than 73 percent. Of the 19.2 percent, 35 percent of those students were not successful when they took the exam a second time and were

Table 1

Number of Students Requesting Specific Content Areas to be Included in a Dosage and Solution Program

Identified Content Areas	Number of Students
Solution Problems	123
Conversions	73
Medical Terms/Abbreviations	70
Fractions	30
Set-up/Formulas	29
Teach One Method	21
Lots of Practice Problems	21
Show Step-by-step Solution/Rationale	17
Ratio & Proportion Method	14
Decimals	12
Give Examples	8
Basic Math	5
How to Read/Understand Problem	5
Provide Real Situations	4
Variations in Kinds of Problems	2
Rounding	2
Dimensional Analysis Method	2
Apothecary System	2
Totals	440

required to repeat the entire course. Most, 95 percent, were successful on the third try.

Methods Used to Solve Dosage and Solution Problems

As noted under "Definitions" in Chapter 1, the four methods commonly taught to solve dosage and solution problems include the Basic Formula, Dimensional Analysis, Fractional Equation, and Ratio and Proportion. The results of the analysis of the 422 exams showed that the majority of the students used the Fractional Equation method, 49 percent, with the second most common being the Basic Formula preferred by 33.8 percent. Ratio and Proportion got 8 percent while Dimensional Analysis showed only 7 percent. A fifth category, labeled Other, included those students who did not use any known formula or had combined two or more of the standard methods in a unique way. A number of the students (23 percent) used more than one formula and a few tried out all possible methods, usually not successfully. Table 2 shows the methods used and the numbers of students using each.

Types of Problems Incorrectly Solved

The problems were divided into three groups: One-step, Complex, and Solution problems. One step problems are relatively easy and require only one step or conversion to solve for the unknown, e.g., Ordered dosage: Elixir of Terpin Hydrate 0.05 mg. On hand: Elixir of Terpin Hydrate 15 mg per ml. How many mls will you give? Complex problems are more difficult requiring more than one set of calculations in

Table 2

The Number and Percentage of Nursing Students Using Each Category of Problem-Solving Method

Category of Method	No.	%
Fractional Equation	206	49.3
Basic Formula	146	33.8
Ratio & Proportion	38	8.6
Dimensional Analysis	30	7.2
Other	15	3.1
Totals	435	100.0

order to discover the correct dosage, e.g., Ordered: Tetracycline 30 mg per kg over 24 hours in 4 equal doses. If patient weighs 132 pounds, how much will she receive for the first dose? Finally, solution problems require making a dilute solution from either a stronger solution or from dry weight powder or tablets, e.g., Prepare a 5 percent solution using 30 milliliters of vinegar.

Analyzing 1100 problems missed, it was found that 29.3 percent of the problems missed were one-step, 38.4 percent were complex and 33.3 percent were solution problems. Table 3 displays these data. It should be noted that the exams were composed of 54 percent one-step problems, 32.9 percent

Table 3

Percentage of Types of Problems Solved Incorrectly Related to the Percentage of Each Type of Problem in the Exam

Type	% of Problems on Exam	% Solved Incorrectly
One-Step	54.0	29.3
Complex	32.9	38.4
Solution	13.1	33.3
Totals	100.0	100.0

complex, and 13.1 percent solution. This relationship indicates that a relatively larger number of solution problems were missed.

Types of Errors

The types of errors made by students when they attempted to solve the problems provided important information for the CAI program. Out of the 1544 errors identified, the most commonly-occuring type of error occurred when the student was conceptualizing, or setting-up the problem. Table 4 summarizes all noted errors and the number of times they were committed.

Set-up errors (46.6 percent) included not putting the numbers in the correct position in the formula; doing only

Table 4

Types of Errors Made When Solving Problems by Number and Percentage of Total Errors

Nature of Error	No.	%
Incorrect Set-Up of Problem	720	46.6
Abbreviations/Symbols	142	9.2
Problem Misread/Misunderstood	122	7.9
Rounding Error	110	7.1
Incorrect Equivalency	100	6.5
Incorrect/No Conversion	98	6.4
Used Non-significant Data	78	5.0
Calculation Errors	58	3.8
Changing Numbers in the Problem	54	3.5
Misplaced Decimal	44	2.8
Incorrect Labeling	18	1.2
Totals	1544	100.0

one step when two or more were called for; and not appearing to have a clue as to where to put the numbers in the formula. Appendix K has copies of actual student work showing a correct set-up of the problem and illustrations of student confusion regarding how to set up the problem.

The second most commonly-occurring error pointed out a lack of understanding of medical terminology, abbreviations, and symbols used to express numerical values (9.2 percent). For example, iss means 1 1/2 but was frequently interpreted to mean 1/2 or left blank. Students had been exposed to this information prior to the exam.

The next most common error occurred when students either did not read the problem correctly or did not understand what was being asked (7.9 percent). For example, a problem asking them to calculate the amount of medication needed for an entire day was only done for one dose.

Not knowing how to round off a number to the nearest tenth of a whole number accounted for 7 percent of the errors. Rounding errors occurred in two different ways: (1) very small numbers were rounded during the calculation resulting in a small but significant difference in the final answer, and (2) final answers were not rounded correctly. For example, one student gave 1.0235 of a capsule.

The next two errors are related since they deal with converting numerical values from one system to another so that all values are in the same system. Either the equivalency was not right, e.g., 80 micrograms = 800 milligrams (6.5 percent), or the student did not perform a conversion (6.4 percent).

While this category could have been included in the group of reading the problem incorrectly, using non-significant data in the calculations (5 percent) was seen often enough to warrant a category of its own. This error occurred when the student tried to put data in the formula which were extraneous to the solution and indicated an inability to discriminate the significant from the unnecessary.

Calculation errors only occurred 3.8 percent of the time. These broke down into two groups: (1) basic arithmetic errors which constituted 55 percent of the calculation errors, and (2) problems changing fractions to decimals, 45 percent. For example, several students converted the fraction 1/60 to the decimal 0.6.

A similar set of errors occurred when students changed the numbers in the problems (3.5 percent). This manifested in several different ways. Numbers were changed when transferred from the written problem to the formula, e.g. 50 milligrams became 5 milligrams; numbers were changed during the steps of solving the problem; and numbers were transposed or inverted. One phenomena happened a number of times. The problem stated that the dosage on hand was grains 1/120 and the dosage to be given was 1/400. These numbers were changed to 1/120 and 1/140 or to 1/200 and 1/400.

Misplaced decimal was seen 2.8 percent of the time. Usually the student moved the decimal when transferring the numbers from the problem to the formula, in the process of solving for the unknown, or when writing down the final answer. The most common error was adding or subtracting zeros after the decimal, e.g., 0.1 became 0.01 or 0.005 became 0.05.

Finally, the last notable type error of incorrect labeling was found in 1.2 percent. This included mislabeling the values in the formula so that there was confusion about the unknown or an intermediate answer was labeled as the final answer so that the last step was not completed.

The information acquired from the compilation and analysis of the responses to student survey and the dosage and solution exams provided content and design resources for a later step, the development of the program. The next step evaluated the literature to find guidance for the software program development and evaluation and to answer research questions 1, 4, and 5.

Results of the Literature Evaluation

The literature provided a data base from which several research questions could be answered and furnished additional guidelines and information to be used in the development of the computer program. French and Stimmel's software evaluation tool and Gagne, Wager, and Rojas's software development guide were discovered during the literature review.

Research question 1. "What major problems are faced in teaching the problem-solving skill necessary for calculation dosages and solutions for medication administration?" was answered by studying the economic constraints placed on the universities and the lack of time for nursing faculty to devote to this topic. In addition, faculty tutoring time was not cost-effective. Other concerns unearthed by the literature included math anxiety and how lack of individualized teaching diminished student learning in mathematical skills, especially for the disadvantaged and immigrant. The computer was seen as a cost-effective method to provide anxiety-reducing, self-paced instruction in medication mathematics.

Research questions 4 and 5, "What factors in teaching mathematical concepts promote math anxiety?" and "What strategies can be used in the design of a computer educational program to specifically decrease math anxiety?" lead to an abundance of answers and suggestions. Math anxiety was believed to be caused by negative attitudes of parents, peers, and teachers towards math, especially for young women. Poor teaching strategies, emphasis on memorizing rather than understanding, lack of individualized help, and lack of success early in the math learning experience were also seen as contributing to math anxiety and avoidance. The suggestions made to reduce math anxiety included helping students confront the fear by acknowledging it and then building self-confidence by teaching problem-solving instead of memorization, giving the student more control over the learning, using creative strategies like manipulative aids and games, and providing positive classroom experiences by teachers who love math and encourage risk-taking. These important ideas and suggestions which resulted from the literature review were carried into the planning for the CAI program. However, in order to learn more about developing a program, the next step in the procedures was implemented, i.e., to evaluate available medication math software and discover their strengths and flaws.

Evaluation of Available Dosage and Solution Software

A list of drug dosage programs can be found Appendix L. However, according to Bolwell (1991), a number of the programs reviewed in her 1988 nursing software directory are no longer available, e.g., "Basic Math and Dosage Calculations," Mosby, 1987; "Computing Dosages,", Evergreen Enterprises, 1984; "Drug Calculations," Computer Educational Resources, 1986; "Mathematics of Nursing Pharmacology," Elsevier Science, 1987; and "Drug Dosage Calculations and Administration," Medi-Sim, 1985. These were not included in the evaluation of viable programs. Two other programs are also not included: "Calculate with Care," Lippincott, 1985, which came in a $500 package of thirteen disks which was determined to be too long for use in the SJSU nursing program; and "Logical Nursing Mathematics," Delmar, 1987, which was an adjunct to the textbook the company required to be purchased to get the computer program. Other than advertising brochures, no other published reviews were available on the programs evaluated.

"Calculation of Drug Dosages," T.J. Designs, 1981, Apple or IBM, $99.95, is one of the oldest programs still available and has been used for several research projects. Although the program does propose to help students identify areas for study, it apparently was designed originally for testing rather than for instruction. However, the function of identifying areas for further study did not appear valid. When the reviewer missed one problem out of ten, it gave the following message: "You seem to have forgotten how to add fractions." No information was provided on how many questions were in each set, no running or total score was provided, no feedback or correct data was provided when a problem was deemed wrong, and no definition of terms or what symbols were supposed to mean (the symbols used were not standard). This program included three sections covering conversions, basic math, and calculation problems, but the problems were much too simple and did not facilitate problem-solving. Finally, when this program asked the learner to enter a name, if only the first name was entered, another screen came up correcting the user with curt instructions to enter both names. Thus the learner starts the program with negative feedback.

The next three programs were produced in the last two years by CES (Computerized Educational Systems), an educational software company which is a division of Florida Hospital Association Management Corporation and has developed some quality, albeit expensive, programs for nursing. Even though these programs were technically superior to other programs of this genre, overall CES software provided examples of instructional design and classroom strategies which did not translate well into cost and time-efficient, adult-learning models.

"Miniums, Mililiters, and Gtts," CES, 1990, $250, had three sections-Metric, Apothecary, and Household, and was designed in a game format, which was the major problem with the program. It was too slow and became boring moving through the rooms of the hospital game board while calculating the dosages to be administered. In addition, instructions were not always clear, the problems were too simple to promote problem-solving beyond how to use the cursor to get from one room to the next. The entire program was based on a format of answering questions and receiving feedback as to error made when incorrect. Beginning instructions were very good, the color graphics were initially interesting, but provided no variety. When electing to return to the menu, the program returned the reviewer to the A >, thus requiring an extended boot-up to resume.

"Math General Hospital," CES, 1990, $250, focused on the basic math skills needed to work dosage and solution problems, but did not go beyond that. While it used a game concept, the student was not required to move around a board but rather just answered questions directly. However, it was necessary to keep picking answers until the correct one was selected, and with each incorrect answer, the student was asked if a review of the math involved in working the problem was desired. This repetition grew tiring and took too much time. Record-keeping was also flawed. When the reviewer missed most of the correct answers, attempting to move through the program more rapidly, the program informed the reviewer that she knew how to do the problems in that section. If one wanted to go to another section, going back to the menu was not an option. One had to exit the program and then wait while the IBM examined all of its circuits and checked for viruses. Then it was necessary to sit through the opening credits before accessing the menu again. One pleasing aspect was the sidebar which included a list of function keys, indicated the section currently being accessed, and kept a running total of the number of correct and incorrect answers.

"Starship Healthwise," CES, 1991, $250, was the most effective of the group, but also focused on the three areas of Apothecary, Metric, and Household conversions, and did so by means of a question/answer format. The graphics were excellent and the approach interesting. The screen looked like a StarTrek computer screen and indicated the user must be able to calculate conversions to give medications in numerous galaxies. However, the instructions were given in "starship language" which would be difficult for non StarTrek fans and especially for students with English as a second language. This program moved faster, but the learner had to get fifteen problems correct before moving to the next section, so it was difficult to assess time required for completion. Also the symbols were difficult to read which could result in incorrect answers thereby frustrating the learner and extending the time to complete the program.

The programs available were too long, or too expensive, or technically flawed in various ways, or repetitious and boring, or did not cover enough content. The approach to the tutorial process appeared to be from an assumption of what students need to learn. In none of the programs did there appear to be any attempt to identify and correct specific errors, teach an approach to solving the problem, or teach how to set up the problem which the literature notes is the major concern in medication errors.

The results of the evaluation of these currently top-of-the-line dosage and solution programs provided a clear view of specific flaws to be avoided in developing the CAI program for this MARP. The results of this step were carried forth to subsequent steps. Next, direct preparation for beginning the actual developmental process was begun as experts were consulted.

Preparations for Authoring CAI

Consulting experts in software and instructional design resulted in acquiring the use of the authoring program, "Course Builder", on the SJSU site license making the program, documentation, and software support available. According to the documentation, an educator could develop software by just using the provided tutorial. However, this developer has used "simple documentation" provided by software programmers on previous occasions and being wary of such claims, contracted with a programmer and computer graphics artist. This resulted in lessened frustration, but the documentation on how to implement this very sophisticated authorware was very minimal. The end result was much mutual problem-solving and a steep learning-curve for both the developer and programmer.

Before the program was started, the educational goal and instructional task analysis for the CAI program were developed using recommendations from the literature. The educational goal was to teach problem-solving skills enabling any nursing student to conceptualize and calculate with ninety percent accuracy the mathematics applicable to any type of dosage and solution problem encountered in the administration of medications. The instructional task analysis became the framework for the ensuing computer program. The full outline of the instructional task analysis is located in Appendix H. Following the completion of these crucial activities, the next step was to design and "write" the program using the authoring system provided by "Course Builder."

Authoring the Program

All of the analysis of previous examinations, student surveys, the literature, other medication CAI programs, and consultation with experts in the field culminated in the development of a CAI program which embodied a new approach to teaching medication math via computer. The focus was to make the learner as comfortable as possible by simulating a conversation with guides, Martha, Mark, and Molly. While the program aimed to encourage maximum student interaction, it also attempted to give ideas and hints that could be used to promote problem-solving and critical thinking. Appendix M. shows printouts of several of the actual screens as illustration.

Gagne's Nine Events of Instruction

The conceptual framework of Gagne's Problem-solving Learning Outcome with the subset of the Nine Events of Instruction was utilized throughout the development of the program. The following demonstrates the results of applying this framework. The prototype program was evaluated by the developer addressing each of Gagne's Nine Events.

1. Internal Learning Process: Alertness

   External Instructional Event: Gaining Attention

The learners attention was secured by the first screens showing large moving (animated) "M"s which introduced the program as the Three M Program: Mastering Medication Math. Following that was a visual and verbal introduction to the four people who would be the student's guide through the program. Martha, Mark, Molly, and Missy spoke directly to the student thus engaging his/her attention. Music and/or voice could have been used in the introductory screens, but were decided against since the program will be one of many in a multi-user lab. Throughout the program, one of the four guides is always conversing or interacting with the student in order to maintain attention.

2. Internal Learning Process: Expectancy

External Instructional Event: Informing learner of lesson objective

Right after the introduction, the guide, Martha, informs the learner of the educational goal and what he/she can expect to achieve upon completion of the program. It is the developer's experience that students do not read objectives when they are listed in the beginning, so in this respect the program deviated from Gagne by mentioning the objective that they had accomplished in a conversational tone at the end of each lesson. At the end of the complete section, all objectives are mentioned, again in ordinary conversation by several of the guides. This approach was used to promote a friendly, non-threatening environment in order to reduce anxiety.

3. Internal Learning Process: Retrieval to working memory

External Instructional Event: Stimulating recall of prior learning

Learners are asked to recall certain rules and processes acquired through previous nursing and math coursework, e.g., abbreviations and basic mathematical rules. Also, after information is presented or they are reminded of certain information, learners are asked to recall from previous lessons and respond to questions using previous information. As other lessons are completed for the balance of the program, learners will be asked to recall more higher order concepts with less help, thus promoting critical thinking.

4. Internal Learning Process: Selective perception

External Instructional Event: Presenting stimuli with distinctive features

Visual graphics of actual measurement containers such as syringes, medication bottles, medicine cups will be used (in the completed program) for association with the reality of what the dosages that are being calculated will look like. This will assist them in meeting the "reasonableness" objective. For problem-solving, students will have the option of reviewing additional information on a topic, be given a bibliography for further reference, and told where to access lists of information, such as symbols and abbreviations in the accompanying manual.

5. Internal Learning Process: Semantic encoding

External Instructional Event: Guiding Learning

Learners are guided logically and sequentially through the steps of solving one problem with side trips to caution them against potential errors that have been made by other students, such as inadvertently changing the fraction 1/120 to 1/200. New terms, concepts, and language are tied to familiar language and ideas to assist encoding. Learners are asked to respond to questions, point out errors, select the best options which stimulate their thinking processes and engage them actively in the learning process.

6. <u>Internal Learning Process: Retrieval and responding</u>

<u>External Instructional Event: Eliciting performance</u>

This overlaps with the previous event. In addition to the above, learners are asked to solve problems as well as respond to specific questions.

7. <u>Internal Learning Process: Reinforcement</u>

<u>External Instructional Event: Providing informative feedback</u>

Each time there is any activity requiring the student to respond to a question or solve a problem, positive feedback with reinforcement as to why the the answer is appropriate is given with each correct answer. If the answer is incorrect, gentle negative feedback is given followed by suggestions as to why the incorrect answer might have been selected and a thorough explanation of why the answer was wrong and how to do the problem correctly. Appendix M has printouts of several of the feedback screens. Positive feedback is also woven in subtly by calling the student a problem-solver and noting how well they are progressing through the program.

8. <u>Internal Learning Process: Cueing retrieval</u>

<u>External Instructional Event: Assessing performance</u>

Performance is assessed frequently throughout the lessons; in the completed program there will be many problems to work and with correct answers so learners can both practice and assess their own performance. The terminal activity of the program will be to take a post test and pass it with ninety percent accuracy--mastery.

9. Internal Learning Process:Generalizing

External Instructional Event: Enhancing retention and learning transfer

Retention was enhanced by encouraging learners to repeat lessons that are problematic and by providing many practice problems which are sufficiently varied in type and complexity. The feedback on the practice problems demonstrated how the problem is solved in a step-by-step fashion. Transfer of learning will be assisted by a final activity in the last lesson asking learners to design a dosage or solution problem of their own, write a test question for it, provide four answer options, and give possible explanations for the incorrect answers and rationale for the correct answer.

The preceding self-evaluation of the prototype medication math CAI program documents the value of the Gagne, Wager, and Rojas (1981) tool as a useful guide for instructional design; therefore research question # 7 has been answered affirmatively.

In addition to using Gagne's framework, the suggestions made by the students in the survey were incorporated into the prototype and will be further expanded in the complete program. For example, medical terms and abbreviations comprised one lesson, a list is in the manual, and will be repeated in future lessons. Other ways the students concerns were addressed: Discussions of the process of solving solution problems (which was the concern of 30.5 percent of the students), the easiest formula to use, and several different types of problems with the answers worked out in a step-by-step process will be in the next lesson developed. This will build on the previous lessons and incorporate other concerns such as conversions, fractions, decimals, and conceptualization and set-up of the problems.

Once the prototype program was completed, it was then ready for the evaluators. The process of "running it through its paces," or Beta Testing as computer programers call evaluation, was the next step.

Evaluation of the Program

Profile of the Program Reviewers

Thirteen reviewers participated in the evaluation of the prototype. Eight of the reviewers were the experts who were willing and available when the prototype was ready for review and the other five were students who volunteered when requested at the end of the semester. An additional five students had volunteered, but were not available at evaluation time.

The student volunteers covered a wide range of ages, progression in the nursing program, familiarity with computers, degree of math and/or computer phobia, and ethnic background. Following are the demographics of the participating students:

Age- Range was 19 to 46 with a mean of 32.5

Gender- Four female and one male

Ethnicity- Two students were Anglo-American, one

Iranian-American, one Mexican-American, and one a Chinese exchange student. The Chinese student has only been in the U.S for one year and has taken only one class in English. The Mexican-American student is bilingual with Spanish as her primary language.

Semester in Nursing Program- Two students had just completed the beginning semester (Semester 3), one student had completed Semester 4, one student just graduated but had served as a student tutor for the dosage and solution math, and one student was in the Masters program.

Familiar with Computers- None of the students were familiar with the Macintosh computer. Two students had not used computers at all and were nervous about the experience, the other three had IBM computers in their homes, two used the computer for word processing only, but the third was very competent in many aspects of computing. All of the students expressed comfort with using the Macintosh with only minimal introduction and assistance by the developer.

Degree of Math Anxiety- Three of the students confessed to anxiety about math. One reported previous failures in math classes and negative classroom experiences. Two of the students felt competent and comfortable with the mathematical concepts necessary for dosage and solution math. One remarked that he was glad that the program was teaching ratio and proportion; he had changed to that method and found it much easier.

The eight nursing and non-nursing reviewers, solicited to participate in the evaluation as experts, were available and willingly offered time and ideas. The profile of the experts was as follows. The group consisted of six women and two men. All are professionals in their respective fields and have worked with computers for some time.

Five of the reviewers are nurses and four of these are SJSU faculty who have taught dosage and solution math to beginning students; one had authored a software program on calculating intravenous medication dosages. One nurse faculty also is the Director of Student Retention and advises and tutors disadvantaged students. The fourth nurse is a software developer and routinely evaluates hundreds of nursing educational software programs.

One other SJSU faculty member is not a nurse but is chairperson of the Department of Instructional Design and teaches classes in software development. The two other reviewers who were neither nurses or faculty were experts in computer programming. One is currently in postgraduate work in instructional design and just learning the Macintosh; the other is a lawyer as well as an expert in computer programming for the Macintosh and in Beta Testing commercial software.

Evaluation Results

The results from the evaluations showed very high rankings in most areas on the French tool and many suggestions and comments on the narrative tool. Table 5 shows the frequency rankings on each of the criteria identified by

Table 5

Evaluation of Software Program Using
French and Stimmel Criteria

Evaluation Criteria	Excellent	Good	Poor	Not Applicable
1. REDUCING CONFLICT AND FRUSTRATION				
a. Printed information on use of program understandable?	5	6	0	2
b. CAI material inviting to use?	8	5	0	0
c. Directions clear?	7	6	0	0
d. Inform viewer how to correct if a wrong key is pressed?	6	4	2	1
e. Does program run smoothly?	8	5	0	0
f. Does program arrangement encourage positive feeling toward CAI?	12	0	0	1

Table 5 (Cont.)

Evaluation Criteria	Excellent	Good	Poor	Not Applicable
2. REPETITION OF CONCEPTS USING VARIATIONS IN TECHNIQUE				
a. Key concepts covered more than 1 time?	8	5	0	0
b. Repeat portions thru menu option?	10	3	0	0
3. POSITIVE REINFORCEMENT				
a. Receive positive encouragement throughout program?	11	2	0	0
b. Program react quickly to response?	8	5	0	0
c. Clues to help learner discover correct answers?	9	3	0	0
4. ACTIVE STUDENT PARTICIPATION				
a. Program provide exit options?	7	4	1	1
b. Program allow sufficient student interaction?	4	9	0	0
c. Delay between responses & student feedback short?	8	4	1	0

Table 5 (cont.)

Evaluation Criteria	Excellent	Good	Poor	Not Applicable
5. ORGANIZATION OF KNOWLEDGE				
a. Lessons presented in logical sequence	11	2	0	0
b. Interrelationship between units?	10	3	0	0
c. Units have sequence & coherence?	9	4	0	0
d. Content meet specified learning objectives?	11	2	0	0
e. CAI appropriate for this material?	12	1	0	0
6. LEARNING WITH UNDERSTANDING				
a. Content relevant for target population?	10	2	0	0
b. Adaptable to various levels of learning?	4	6	1	2
7. COGNITIVE FEEDBACK				
a. Incorrect responses given feedback why wrong or hints to get correct?	10	3	0	0
b. Sufficient practice opportunities to learn specific information?	4	6	2	1

Table 5 (Cont.)

Evaluation Criteria	Excellent	Good	Poor	Not Applicable
8. INDIVIDUAL DIFFERENCES				
a. Menu allow sequence options?	8	4	0	1
b. Menu allow choice of topics?	9	4	0	0
9. MOTIVATION				
a. Encouragement even when mistakes?	8	4	0	0
b. Program encourage frequent interaction?	6	6	0	1
c. Program personalize information?	0	0	0	13

French.

The areas that received less excellent, more good, and some poor ratings included "Inform viewer how to correct if a wrong key is pressed?", "Program provide exit options," "Delay between responses and student feedback short," "Adaptable to various levels of learning," and "Sufficient practice opportunities to learn specific information." Other items that showed less excellent and more good were "Program allow sufficient student interaction" and "Printed info on use of program understandable."

The reasons for the lower rankings in the specified areas were clarified through the narrative comments and verbal discussions the evaluators offered the developer. In fact, all of the reviewers, with one exception, were verbally very enthusiastic about the program and wanted to share their evaluations with the developer in person.

The narrative comments provided excellent specific feedback for the developer, with validation of the strengths of the program and many suggestions for improvement. Appendix N has a summary of all comments under each heading and Appendix O contains two outstanding evaluations that went well beyond what had been requested. The evaluators agreed to the inclusion of comments on their letterhead; both are computer software professionals.

Two editors with major book companies who had asked to participate in the evaluation had not returned the evaluations in time to be included in this report.

The strongly positive evaluations of the prototype indicate that that a quality product is in process and that the goals set forth are being met. This then addresses the sixth research question "Can an inexpensive CAI program for the Macintosh be developed that incorporates recommended quality instructional design and addresses specific learning errors and student needs to promote accuracy in mathematical problem-solving?" While the cost of the program is yet to be determined, the evaluation results do support that student needs are being met and the quality is mostly excellent.

Pre-and Post-Test

The fifty questions to be included in the pre-and post-test have been piloted on three semesters of beginning nursing students and, based on computer analysis, have documented validity and reliability. The questions were also submitted to a panel of nursing experts at SJSU who also verified the validity and reliability of the questions (Appendix P).

Summary of Results

The results of this complex and multi-step project show that each step of the procedure section has been carried out, with an exception noted below. The analysis of the student surveys and the dosage and solution examinations furnished information which was then used in subsequent steps. This also was the case with the evaluation of the literature and consultations with experts in the field of computer program design. The prototype of the computer program "Mastering

Medication Math" was completed and submitted to student and expert evaluators. The results of the evaluations were strongly positive and provided excellent suggestions for revision.

However, the last three steps of the procedure that indicated that the program would be revised, resubmitted to evaluators, and readied for distribution were not completed. The inexperience of the developer and the complexity of the authoring program coupled with minimal documentation for assistance contributed to the necessity to revise the completion schedule. All of the expert evaluators and two student evaluators who were unable to participate in the Beta testing have offered to review the final copy. After this final evaluation, the program will undergo any additional revisions and will be implemented in the Fall 1992 semester at San Jose State University.

This chapter has contained a step-by-step discussion of the results following the procedures previously identified and has provided an answer to each of the research questions. Chapter 5 will explore these results offering conclusions, recommendations, strategies for implementation and dissemination, and implications for educational improvement.

Chapter 5

DISCUSSION, CONCLUSIONS, RECOMMENDATIONS, AND STRATEGIES FOR IMPLEMENTATION AND DISSEMINATION

Discussion

In Chapter 4 the results of this project were presented based on the steps outlined in Chapter 3. The research questions were also answered. This chapter contains the discussion and interpretation of the results, conclusions and recommendations drawn from the results, and strategies to be used for implementation and dissemination of the final product.

The final product, the prototype of the CAI software program, "Mastering Medication Math", was dependent upon the integration of the results of each of the procedural steps. The first two steps consisted of the results from the student surveys and the analysis of past dosage and solution examinations.

In the survey, students were asked to list what they would like included in a dosage and solution CAI program. Eighteen different areas were identified but only three areas were mentioned by students in large enough percentages to be of value. These included solution problems with more than seventy-two percent, conversions with forty-three percent, and medical terms and abbreviations with slightly more than forty-one percent. None of the literature found made reference to asking students their concerns, rather, most of the investigators relied upon the opinions of the dosage and solution instructors (Worrell and Hodson, 1989; Eaton, 1989).

Two relationships were noted between the students' concerns and data yielded by the analysis of the dosage and solution examinations:

(1) The students' priority concern was solution problems and the exam analysis showed that a disproportionately large percentage of the solution problems were missed by these students. The solution problems only accounted for thirteen percent of the problems but constituted thirty-three percent of the errors.

(2) Based on the literature (Bayne and Brindler, 1988; Dexter and Applegate, 1980; Eaton, 1989; Hambly, 1986; Ptaszynski and Silver, 1981, Worrell and Hodson, 1989), it was expected that students would say that some aspect of basic arithmetic was a major problem, e.g., basic math, decimals, Roman numerals, or fractions. However, only fractions was high on the list, ranking fourth. And more surprising, a number of students indicated that setting up the problem (conceptualizing) was their major concern. This was determined by the exam analysis to be the largest single error found.

Even though many of the different responses came from small percentages of the total respondents, all ideas and suggestions were taken into consideration when the program was being developed. Only the basic arithmetic concepts and Roman numerals were not incorporated since this content is a prerequisite for admission to the nursing major. Texts which handled these areas were recommended.

The analysis of the dosage and solution examinations yielded data that, in some areas, was consistent with the findings from the literature. The students who achieved mastery, twenty-four percent, fell into the ranges described by Brindler and Bayne (1991) and Worrell and Hodson (1989), were well above the eleven percent reported by Blais and Bath (1992), but were considerably below the fifty-four percent noted by Chenger, et al. (1989). The only study that reported the low end, Bindler and Bayne (1991), found that more than forty-three percent were below seventy percent as compared to the SJSU nursing students with nineteen percent below seventy-three percent. There were no comparative studies for how many times students had to retake the test to pass at the minimum, i.e., seventy-three percent.

No studies were found that identified the methods used for solving the dosage and solution problems. Since the data for this study were taken from six sequential semesters during which three different instructors taught the dosage and solution math class, the results probably reflected the individual instructor's preference. In addition, some of the students reported that they learned dimensional analysis in a chemistry class. While no formal evaluation was done on the relationship between the method used and success on the exam, it was informally noted that students who used the more difficult dimensional analysis either were very competent or appeared to have no idea where to put the numbers in that formula. It was noted that twenty-seven percent of the students who used the basic formula, the second most preferred method for all problems, did not know how to set up solution problems in that method. The most successful students appeared to use more than one formula, selecting the one that appeared most appropriate to the problem under consideration. It was surprising that forty-nine percent of the students used the fractional method since a number of students voiced concerns about working with fractions. More errors were noted with the fractional method than with other methods.

The decision to use ratio and proportion in the program was based on the idea that the students will use the method that is taught. The ease with which students were able to use the ratio and proportion method when reviewing the prototype CAI program added a measure of validity to the decision. Also, this judgement was borne out by several of the evaluators who commented positively on the use of ratio and proportion in the program. The program does include some optional sections showing problems being solved using the fractional equation method and the basic formula. The literature is silent on the best method to use, although Eaton (1989:342) did call dimensional analysis "distractional analysis."

The types of problems incorrectly solved by SJSU nursing students were consistent, in part, with the findings of

Bindler and Bayne (1991) since they noted that the error rate was twice as high when more than one calculation was required and by Chenger, et al. (1989) who pointed out that problem-solving presented the most difficulty. This would seem to relate to the findings of this study that complex problems which constituted thirty-three percent of the problems on the exam accounted for thirty-eight percent of the errors. No mention was made by the other investigators about solution problems so it is not known if these problems were included in Brindler and Bayne's or Chenger's subgroups. From the results of this study, if the numbers of errors made in solving complex problems and solution problems were to be combined, the total would be seventy-one percent of the errors, a much larger percentage than the forty-eight percent noted by Bindler & Bayne (1991).

Regarding the nature of the errors committed by SJSU nursing students, the literature referred only to calculation or conceptualization errors and did not break the errors into subcategories. It is important to note that in this study, incorrect set-up of the problem constituted more than forty-six percent of the errors identified, with the next closest type of error being abbreviations and symbols at only nine percent. This finding is certainly consistent with Blais and Bath (1992) who found that sixty-eight percent of their subjects' errors were conceptual (set-up). However, Blais and Bath did not elaborate on what was meant by conceptual errors other than to differentiate them from computational errors. In this study, errors that were placed in subgroups other than conceptual might have been subsumed in Blais and Bath's conceptual category.

It does seem surprising that differentiating conceptual from computational has just recently come to the attention of nursing educators. Perhaps the permissive use of calculators has diminished the obvious calculation errors and allowed the more subtle conceptual errors to come to the forefront. One plaintive comment from a student found on the survey may exemplify this new concern: "When using a calculator would be helpful to learn which of the denomenator or numerator to use first in the calculator [sic]." This student seems to be expressing a common dilemma of how to set up the problem in order to know how to enter the numbers correctly into the calculator.

The considerable amount of information gained from identifying the kinds of errors committed provided a whole data base from which to draw when developing the CAI program. Since this information was not found in the literature, the use of these special data, furnished first hand from students, can give a richness to the program because each of these errors was considered important enough to be addressed at some point in the learning process.

As noted in the results section, suggestions from the literature on managing math anxiety, on the use of an instructional task analysis, and on authoring and evaluating computer software were incorporated into the design of the program. It would have been useful to have had published evaluations on available dosage and solution math CAI programs, but since none existed, this activity was completed as part of this project. Such hands-on analysis of other programs had an inestimable value in the amount of practical information acquired, mostly on what to avoid. The flaws so noted were assiduously avoided, even though different flaws were pointed out by the prototype program evaluators.

The use of Gagne's conceptual framework for the instructional design of the CAI program was extremely useful. At each stage of development, a pause to reflect on how the particular instructional event was implemented kept the program on track. While Alicia Rojas, co-author of the article used as a guideline (Gagne, Wager, and Rojas, 1981), was the harshest critic of the prototype program, she provided exceptionally valuable feedback which focused on subtleties of the model.

The development of the prototype program was much more difficult and time-consuming than anticipated. "Course Builder" is a very complex and sophisticated authoring program but the documentation and support are very limited. The manual accompanying the authoring program reported, in somewhat glowing terms, the ease with which any educator with familiarity with the computer could use this program "to create your own educational programs by just following the simple tutorial and copying the examples provided" (Appleton, 1987:4). Unfortunately, while the tutorial and examples were simple, a program that covers any topic adequately is not. The written documentation was inadequate, and campus support was not available. The only person who knew how to use "Course Builder" had left the university the previous semester. Finally, trying to explain a problem to the person on the other end of the help line in Tennessee proved to be a frustrating and unsuccessful communication experience. The end result was that the prototype program was painstakingly put together by the developer and programmer reading the manual out loud over and over, trying out different processes until something worked. Each time a process worked like the manual said it should, each step taken was carefully noted on a file card so that it could be repeated when needed. Thus the development time was greatly expanded over original projections.

The time and attention to detail during the development process was rewarded by the strongly positive reviews by the evaluators. However, a number of flaws were brought out by the reviewers, most of which were already known by the developer. Two major flaws noted by several were the inability to move back to a previous screen and, if the wrong menu item was selected, the inability to get back to the menu without going through the unwanted section. Since these were complex branching processes which had to be deduced from trial and error, it had been decided to get the program out to the reviewers without any more delay and to correct those flaws during the revisions. That the reviewers found and reported problems known to exist validated the quality and reliability of the reviewers. Other suggestions that were very useful included (1) decrease didactic presentations and increase student participation,(2) provide more practice problems (also already planned for the completed program), and (3) increase the amount of graphics. One astute evaluator diplomatically suggested an editor to cut down on wordiness.

Conclusions

The conclusions drawn from the results of this project were the following:

1. Nursing students are quite insightful in identifying problem areas and what would meet their needs in a dosage and solution program.

2. The types of problems and general kinds of errors made by SJSU nursing students follow the trend identified in the literature, even though subcategories of errors found by this study do not appear in the literature at this time.

3. The overall problem-solving approach taken by the CAI program developed for this project is supported by the literature on decreasing medication errors and math anxiety.

4. A CAI program can be a cost-effective means of providing basic instruction and remediation in dosage and solution mathematics for all students. The program could be especially useful for disadvantaged students and those with limited English skills (Goodman, Blake, and Lott, 1990).

5. The reviews by students and experts document that

the prototype of the CAI program, "Mastering Medication Math," does eliminate the flaws discovered in other contemporary dosage and solution CAI programs; addresses errors committed by students in solving problems; decreases math and computer anxiety by means of a user-friendly, conversational approach; and is understandable by persons with a wide variety of language competencies.

6. It is possible for a teacher to develop software on a designated topic with the use of a programmer, but prospective authors should select authoring programs that have extensive documentation and local support.

Recommendations

The following recommendations are derived from the results and conclusions:

1. More CAI programs should be developed by SJSU nursing faculty to provide individualized instruction for students in an educational environment fraught with economic constraints and diminishing human resources. By developing quality programs, faculty provide role models for students in computer literacy and in science and math capabilities.

2. The CAI program developed for this project should be subjected to further evaluation by larger groups of students and be revised as needed.

3. Research should be carried out evaluate the effectiveness of the CAI program on diminishing errors, especially those of a conceptual nature.

4. Related research projects should be initiated to focus on the relationship between the type of method used to solve dosage and solution problems, e.g., ratio and proportion versus basic formula or dimensional analysis, and mastery on an examination.

5. Gagne's Nine Events of Instruction should be used as a guide for software development and French and Stimmel's tool be used for software evaluation.

6. It is strongly recommended that novice software authors receive training in the use of the selected authoring program before attempting to develop a program without the aid of professional developers. A team approach, as recommended in the literature, is the ideal method, if economic conditions support such activity.

7. Administrators of nursing education programs should set aside monetary resources for software development. The literature points out that after the initial cost of development, CAI is cost-effective. In the case of learning dosage and solution math, students will benefit from the consistent, non-threatening approach provided by computer instruction.

Strategies for Implementation and Dissemination

The full CAI program, "Mastering Medication Math," will incorporate reviewers' suggestions and will be completed with four more sections, to be implemented at SJSU no later than the third week of the Fall 1992 term. An instruction manual for using the program will also be available; a lab assistant will provide help for those students who are unfamiliar with the Macintosh computer. The Fall 1992 syllabus for the beginning nursing skills class incorporates the completion of the program by November as a required assignment. Nursing students will be allowed to complete the program singly or in pairs, and upon mastery of the content, as evidenced by achieving a pass rate of ninety percent or greater on the CAI posttest, students will be admitted to take the in-class examination necessary to progress in the program. This required exam will be given during the tenth week and, for retakes, again in the thirteenth week of the semester. Students will be allowed to use the CAI program as often as desired prior to the final in-class exam. Evaluation of the program will be requested by all students in that class.

In addition to being part of the software library in SJSU's Nursing Computer Lab, the program and manual will be made available, at no cost, to all California State University nursing programs and at reduced cost to all California Community College Nursing Programs. The program will be marketed commercially. The two Macintosh disks of the revised prototype program are included with this MARP in a pocket following the Appendices.

A faculty development program will be offered to teach potential software developers to use "Course Builder."

The information discovered from the analysis of the dosage and solution exams will be prepared for publication in a refereed nursing journal to expand the data base on that topic. The experiences of authoring a program will also be prepared for publication providing both warning and support for potential software authors.

Implications for Improvement of Educational Practice

This project will contribute to educational improvement by facilitating the acquisition of mathematical concepts necessary for safe medication administration in a non-threatening, self-paced manner which will accommodate a variety of learning styles appropriate to a multi-ethnic student population.

The resulting computer instructional program will contribute to San Jose State University by allowing faculty more time to focus on teaching emerging nursing behaviors in lieu of remediation. The publication of the software will contribute prestige to the nursing department as well as the university.

Not only will the proposed computer program assist student nurses in learning dosage and solution mathematics in a self-controlled, supportive environment but having the program developed by a previously math-phobic female instructor may serve as a role model to encourage more women to advance math skills.

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APPENDICES

APPENDIX A

SAMPLE DOSAGE AND SOLUTION EXAM

SAN JOSE STATE UNIVERSITY
Department of Nursing

N71 Spring 1990

DOSAGE AND SOLUTION EXAM

Name ______________________

SS # ________________________

DIRECTIONS:

1. Write your name and social security number on the appropriate lines above.

2. There are 15 problem sets worth a maximum of 50 points.

3. Read each question carefully.

4. Show all your calculations.

5. You may use calculators of any kind for this exam.

6. Round final answers only to the nearest TENTH.

7. Place your final answer in the "|______|" provided by each problem.

8. If you have any questions during the exam, raise your hand. Do not get up from your seat.

9. When you have finished, raise your hand and I will pick up your exam. Recheck your calculations and answers before turning in your test.

10. The space provided below is for your convenience and may be used for listing equivalents.

RELAX!! TAKE A DEEP BREATH AND BEGIN. GOOD LUCK!!

____________________ = ____________________

____________________ = ____________________

____________________ = ____________________

____________________ = ____________________

____________________ = ____________________

____________________ = ____________________

____________________ = ____________________

5. Ordered: Aminophyllin .2 gm. I.V. t.i.d.
On hand: Aminophyllin 250 mg. per 10cc.
How many ml. will you give?

6. Ordered: Phenobarbital gr. iss p.o. t.i.d.
On hand: Phenobarbital 60 mg tablets
How many tablets will you give for each dose?
How many tablets will you need for one day?

7. Ordered: Morphine gr. 1/10 and
Scopolamine gr. 1/400 IM.
On hand: Morphine gr. 1/4 per ml.
Scopolamine gr. 1/120 per ml.
How many ml. of Morphine will you give?
How many ml. of Scopolamine will you give?

8. Ordered: Prostigmine 0.05 mg. IM.
On hand: Prostigmine 2 mg. per ml.
How many minims will you give?

13. Ordered: Lanoxin 80 mcg I.M.
On hand: Lanoxin .5 mg per 2 ml
How many ml. will you give?

14. Ordered: Dilaudid gr 1/60 s.q. q4h. p.r.n.
On hand: Dilaudid 10 mg per cc.
How many minims will you give?

15. Prepare 1 quart of a 3% solution from 500 mg. tablets. How many grams of solute are needed? How many tablets?

APPENDIX B

STUDENT DATA COLLECTION FORM

SJSU SAN JOSE STATE UNIVERSITY

A campus of The California State University

School of the Applied Arts and Sciences • Department of Nursing
One Washington Square • San José, California 95192-0057 • 408/924-3130

February 27, 1990

Dear Semester Three Student,

I am developing a computer program to assist students in learning the math needed to administer medications safely. To design a program that will be useful, I need your help in determining what should be included. Please take a moment and jot dawn what you would like to have help with. For example: medical terms & abbreviations; working with fractions; working with decimals, using formulas for conversions; solution problems; etc. Please be as specific as you can.

Thanks so much for your help.

Sharon Wahl

Sharon Wahl

APPENDIX C

PROBLEM-SOLVING GUIDELINE FROM GAGNE

Outcome Category: Problem Solving

Event of Instruction	Procedure
1.Gaining Attention	Raise learner's curiosity. Present a hypothetical situation. Ask a rhetorical question.
2.Informing Learner of Lesson Objective	State in simple terms what the student is to accomplish one he or she has learned.
3.Stimulating Recall of Prior Learning	Have the learner recall the rules that are applicable. The learner will have to synthesize these rules.
4.Presenting Stimuli with Distinctive Features	The stimulus in the case of most problem-solving materials is information about an existing state of affairs. Learner is not given any direct learning guidance unless requested,tho may be informed of available options.
5.Guiding Learning 6.Eliciting Performance	The computer is best used to simulate responses to action choices supplied by the learner. The learner will input information into the computer and the computer will present a changed stimulus display.
7.Providing Informative Feedback	Feedback is provided by changing the stimulus in response to the learner's action. Can give verbal feedback as well.
8.Assessing Performance	Provide learner with a different situation that calls for another synthesis of the applicable rules. Judge ability to generalize new problem-solving skill.
9.Enhancing Retention and Learning Transfer	Have the learner generate other strategies for solving similar situations using other rules.

From: Gagne, Robert, Walter Wager, and Alicia Rojas. "Planning and Authoring Computer Assisted Instruction Lessons." Educational Technology, 21:17-26. September, 1981.

APPENDIX D

INSTRUCTIONAL/SOFTWARE DESIGN EXPERTS

INSTRUCTIONAL/SOFTWARE DESIGN EXPERTS

The following individuals were consultants and reviewers for the software development project, "Mastering Medication Math."

Christine Bolwell, R.N., M.S.N., Owner, Diskovery, Computer-Assisted Healthcare Education, Software Developer. Saratoga, CA.

George Cole, J.D., M.S. Computer Science, Self-employed as a Lawyer and Computer Software "Debugger". Menlo Park, CA.

Lewis DeZitti, B.A.in Education, Master's Candidate in Software Design. Stanford University, Stanford, CA.

Susan Murphy, R.N., Ph.D., Associate Professor, CAI Developer. San Jose State University, San Jose, CA.

Don Perrin, Ph.D., Director of Department of Instructional Resources, CAI and Multi-media Developer. San Jose State University, San Jose, CA.

Alicia Rojas, Ph.D., Associate Professor, Chair of Department of Instructional Design, Software Design. San Jose, CA.

APPENDIX E

FRENCH AND STIMMEL SOFTWARE EVALUATION TOOL

Directions: Review the program once for a general overview and then review it an additional time for a more detailed analysis. Place a check by the learning principle you observed while previewing a particular software program. Not all items may relate to a particular program. The more items checked "Excellent" or "Good," the more likely this software could help produce effective learning.

	Rating Scale			
	Excellent	Good	Poor	Not applicable
1. Reducing Conflict and Frustration				
a. Is printed information on how to use the program understandable?				
b. Does the CAI material seem inviting to use?				
c. Are directions clear?				
d. Does it inform the viewer how to correct a mistake if a wrong key is pressed?				
e. Does the program run smoothly?				
f. Does the program arrangement encourage positive feeling toward CAI?				
2. Repetition of Concepts Using Variations in Technique				
a. Are key concepts covered more than once?				
b. Can learners repeat portions through a menu option?				
c. If available, does the printed material reinforce program content?				
3. Positive Reinforcement				
a. Do learners receive positive encouragement throughout the program?				
b. Does the program react quickly to any response given?				
c. Are there clues to help the learner discover correct answers?				
4. Active Student Participation				
a. Does the program provide exit options for the user?				
b. Does the program allow for sufficient student interaction?				
c Is the delay between student responses and program feedback short?				
5. Organization of Knowledge				
a. Are lessons presented in logical sequence?				
b. Is there interrelationship between the units of the program?				
c. Do they have sequence and coherence?				
d. Does the content meet specific learning objectives?				
e. Is CAI an appropriate medium for this material?				
6. Learning with Understanding				
a. Is content relevant for target population?				
b. Is the program adaptable to various levels of learning abilities?				
7. Cognitive Feedback				
a. Are incorrect responses given feedback as to "why they were wrong" or "hints" to move them closer to a correct response?				
b. Do students have sufficient practice opportunities to learn specific information?				
8. Individual Differences				
a. Does a "menu" allow sequence options?				
b. Does the menu allow choice of topics?				
9. Motivation				
a. Does the learner get encouragement even when mistakes are made?				
b. Does the program encourage frequent interactions?				
c. Does the program personalize the information i.e. user's name incorporated into program?				

Summary Comments:

1. Reducing Conflict and Frustration ____________
2. Repetition of Concepts ____________
3. Positive Reinforcement ____________
4. Active Student Participation ____________
5. Organization of Knowledge ____________
6. Learning With Understanding ____________
7. Cognitive Feedback ____________
8. Individual Differences ____________
9. Motivation ____________

FIGURE 1. Criteria to evaluate CAI software using principles of learning theory developed by Deanne F. French, RN, MSN, PhD, and Theron Stimmel, PhD, Social Psychologist.

APPENDIX F

PERMISSION FOR TOOL USE

Department of
Health Administration

SWT

April 9, 1992

Sharon Wahl
1301 Mills Street #4
Menlow Park, California 94025

To Whom It May Concern:

Sharon Wahl has my permission to use the "Evaluating CAI" instrument.

Sincerely,

Deanne French,
Professor

DF:mrr

Southwest Texas State University
601 University Drive cos, Texas 78666-4616

APPENDIX G

NARRATIVE SURVEY TOOL

3M PROGRAM

Reviewers Evaluation Form

June 1992

1. What did you like most about this program?

2. What did you like least?

3. How would you describe its strengths?

4. . . . its weaknesses?

5. Were there any areas in which you had problems? If yes, describe please.

6. Please share your suggestions for improvement.

7. What should be included in a manual that would assist users?

8. Please comment on the level of the language used? If English is your second language, could you understand what was being said?

9. If you are not familiar with the Macintosh Computer, what instructions would have been useful to you?

APPENDIX H

INSTRUCTIONAL TASK ANALYSIS

EDUCATIONAL GOAL AND INSTRUCTIONAL TASK ANALYSIS
USED IN CAI PROGRAM DESIGN

Educational Goal

To teach problem-solving skills enabling any nursing student to conceptualize and calculate with 90 percent accuracy the mathematics applicable to any type of dosage and solution problem encountered in the administration of medications.

Instructional Task Analysis

I. Read and Understand the Problem

A. Define terms

1. Apothecary System

2. Metric System

B. Decode abbreviations and symbols

1. Abbreviation examples:gr = grain; mg = milligram

2. Symbol examples: ss = 1/2

II. Select Data Needed to Solve the Problem

A. Identify what is known

B. Identify what is unknown

C. Eliminate extraneous, unnecessary data

III. Identify What System Data Is In

A. Apothecary

B. Metric

C. Household

D. Why more than one system is in use

IV. Convert Significant Data to Either Apothecary or Metric So All Data Is In Same System

A. Most appropriate conversion equation for specific problem

B. Rationale for the direction of conversion

V. Identify Methods to Solve Conversion and Dosage Problems

A. Kinds of problem-solving methods

1. Basic Formula
2. Dimensional Analysis
3. Fractional Equation
4. Ratio and Proportion

B. Define terms including means and extremes

VI. Solve For Conversion of Data to One System

A. Select unknown for conversions based on decision of direction of conversion: M > A, or A > M

B. Set up problem placing known and unknown data in correct positions in means and extremes formula

C. Using algebraic methods, solve for the unknown

VII. Solve Dosage Problem for Unknown

A. Using answer from conversion, set up problem in means and extremes format

B. Place known and unknown data in correct positions in formula

C. Label each piece of data correctly

D. Using algebraic methods, find numerical value for correctly labeled unknown

VIII. Round Off Final Answer to Nearest Tenth

A. Identify rules for rounding

1. > 5 round up
2. < 5 drop
3. = 5, leave as is
4. Exceptions to rule, such as very small numbers

B. Apply rounding rules

IX. Evaluate Answer For Reasonableness

A. Reread problem and compare answer to what is being asked for

B. Review work to make sure didn't invert or alter any of the numbers from problem to formula

C. Proof answer by evaluating

1. Using known data, see if answer is near to reasonable value, i.e., if dilution is a solution, having less than started with is not reasonable
2. Analyze if dosage is "givable", i.e. how can .00025 of a tablet be given?

X. Complete Process By Implementing Answer

A. If in clinical setting, obtain med and give

B. If taking test, enter answer in specified place without altering any of the numbers.

XI. Using The Foregoing Problem-solving Process, Apply Concepts to Different Types of Problems

A. Solution problems

B. Complex, multi-step problems

APPENDIX I

INSTRUCTIONS FOR CAI PROGRAM INSTALLATION

INSTRUCTIONS FOR INSTALLING THE 3M PROGRAM

To use this program you will need to have a Mac Plus or better with either an internal or external hard disk.

Because this program is larger than will fit on one 800k disk, this review copy is on two disks. For the program to run correctly, please follow the instructions exactly to install it on your hard disk.

(1) Insert Disk #1 "3M Start' in your disk drive. When the icon appears, open it by double-clicking, then click and hold the folder labeled "3M Program" and drag it to the desk top of your hard disk. **(Do not copy the disk to your hard disk!)** Send the folder back to the floppy disk by clicking on the box in the upper left corner. Eject Disk #1 by dragging it to the "trash" icon in the bottom right corner.

(2) Insert Disk #2 "Continue" in your disk drive. When the icon appears, open Disk 2 by double-clicking, take the "hat" icon called "Continue" and drag it to the "3M Program" folder which you already put on the desktop of your hard disk. It will copy into that folder and should no longer be visible. Eject Disk #2 the same way as Disk #1.

(3) Open the folder "3MProgram" by double-clicking on it. Then double-click on the "hat" icon called "3M Start" and you are on your way!

Call Sharon (415) 321-4199 if any problems.

APPENDIX J

STUDENT SUGGESTIONS FOR CAI PROGRAM

STUDENT SUGGESTIONS FOR THE CAI PROGRAM
(In students'own words)

"Lots of conversion problems where you have to convert a few different times. Explain--give solutions to problems written out step by step. Medical abbreviations and terms!"

"Solution problems are a MUST!"

"The <u>pronunciation</u> of certain medical terms. Exposure to a variety of medications and their values, i.e., grams, ml, etc. set up into word problems for dosage and solution questions."

"I think a computer program would be a fun way to learn the math needed for dosage and solutions. A well rounded program should have . . . terms, abbreviations, basic math skills, formulas, & problems. The program should have levels so you can get in & out of the sections you need the most."

"For the main formulas, set up one formula, one way to make the conversion, and keep it thru out all the problems. This way, I think, we will know how to set up <u>any</u> problem, we will just need to figure out which #s go where. Does this make any sense? I hope so . . ."

"A program concerning the math solution problems would be helpful. I had a great deal of difficulty doing these, even with the help of the Norville book. Designing the program that broke the problem down to great detail & why that was done would be great. Medical terms would be good to have incorporated too. With this new language, I have problems."

"More exposure through a computer program would definitely have assissted me in preparing for the dosage & solution exam!"

"An understanding of formulas is insightful--just memorizing a particular formula didn't give correlation to medications & orders."

"A lot of mixed questions--by staying with the same type of question each time we don't have to figure out what to do. A lot of conversions--very important. Teach only <u>1</u> way of processing the questions and use that throughout the computer program, in-class teaching, and the tutoring sessions. It's very confusing when so many different ways are taught and none in-depth enough to learn."

"Help with solution problems: knowing & understanding how to read the problem."

"First of all the mathamatics involve in this area of nursing is important. In teaching how do the problems I would stress that any step done, would not be skip. One should not assume the student knows how or where a number came from. I think, there should be more time devoted in learning how to do the problem step by step. The book was not well develop. It not very clear in it's procedures. Also the tension of passing & failing should not be so stressed. Anxiety build up in students, making their porformance not as good."

"Solution problems--setting up the ratio to obtain answer when you have different unknowns and knowns."

"<u>Solution problems</u> - I read that a nurse did the wrong % of an injection, and killed the little boy while in his mother's arms. This is so terrible! Working with decimals is difficult - perhaps you can show an easier way to not make errors."

"I feel that the most important examples that you could put on this computer program would be to give all the different ways possible to do a problem so, that each person can work the problems through successfully."

"Give terminologies and abbreviations in medicine orders just as the way physicians usually give to nurses. That would help us get used to the 2 - ways communication. I'm self-directed."

"Solutions seem to give me the most challenge so that would help me personally. I believe that computer assisted learning can be of great help, as it is an additional method to help stimulate learning, other than the 'old, stale' methods."

"When using a calculator would be helpful to learn which of the denomenator or numerator to use first in calculator."

"Using ratio/prop. instead of formulas and more time on solution probs."

"I am 6 units short of having a minor in math but I still had trouble with solutions. Norville didn't have enough problems to solve. I think that abbreviations and medical terms would also be helpful."

APPENDIX K

SAMPLES OF PROBLEM SET-UP BY STUDENTS

11. Robaxin 20 units IM has been ordered for Gracie Allen. The vial is labeled: 1 ml = 100 units. How many minims will you give Gracie?

D = 20 u

H = 100 u / 1 ml

? minims

100 u : 1 ml :: 20 u : x ml

100 x = 20

x = .20 ml

11. 3 minims

1 ml = 15 minims

0.20 ml = x minims

$\frac{1}{15} = \frac{0.20}{x}$

x = 3 minims

7. Mrs. Smith is going to surgery. Her preop order reads: Give Scopolamine gr. 1/400 sub q at 0800. The vial you have on hand is Scopolamine gr. 1/120 per ml. How many ml will you give?

   a. 0.4 ml
   b. 3.3 ml
   c. 0.5 ml
   d. 0.3 ml

4

10. Robaxin 20 units IM has been ordered for Gracie Allen. The vial is labeled: 1 ml = 100 units. How many minims will you give Gracie?

10. ______

APPENDIX L

DOSAGE AND SOLUTION SOFTWARE LIST

CAI DOSAGE AND SOLUTION CALCULATION SOFTWARE AVAILABLE

Basic Math and Dosage Calculations. Computer Software. St. Louis: Mosby, 1987. (Apple & IBM; 2 disks; $25)

Calculate with Care. Computer Software. Philadelphia: Lippincott, 1984.(Apple & IBM; 13 disks; $495)

Computing Dosages. Computer Software. Spring Lake, MI: Evergreen Enterprises, 1984.(Apple; 5 disks; $200)

DoseCalc. Computer Software. Philadelphia: Saunders, 1984. (Apple & IBM; 12 disks; $495)

Drug Calculations. Computer Software. Denton, TX: Computer Educational Resources, 1986.(Apple; 5 disks; $450)

Drug Dosage Calculations and Administration. Computer Software. Edwardsville, KS: Medi-Sim, 1985.(Apple & IBM; 4 disks; $720)

Logical Nursing Mathematics: Computer-Assisted instruction. Computer Software. Albany, NY: Delmar, 1987.(Apple; 1 disk; Free with textbook)

Mathematics of Nursing Pharmacology. Computer Software. New York: Elsevier Science, 1987. (Apple & IBM; 10 disks; $850)

Starship Healthwise. Computer Software. Orlando, FL: CES, 1990.(IBM; 1 disk; $250)

Math General Hospital. Computer Software. Orlando, FL: CES, 1990.(IBM; 1 disk; $250)

Minims, Milliliters and Drops: The Game. Computer Software. Orlando, FL: CES, 1990.(IBM; 1 disk; $250)

APPENDIX M

SAMPLE SCREENS FORM "MASTERING MEDICATION MATH"

SAMPLE SCREENS FORM THE CAI PROGRAM

"MASTERING MEDICATION MATH"

The following screens are randomly selected sample screens from the program. They do not follow sequentially except in the case of the pages where two screens are on one page. The last page shows one of the sections in Course Builder design format.

The 3 M's Present

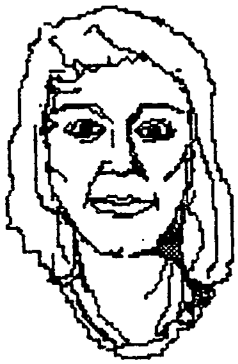
Mastering Medication Math

by

Sharon C. Wahl, R.N., Ed.D.

Supported by a Grant
from San Jose State University

Graphics & Programming
by
Larry E. Wahl



Hello, Martha here!

Now you are ready to begin the program, but first I want to tell you what you will be doing and give you some instructions about using the program.

This program will help you learn the problem-solving skills you will need to solve most of the dosage and solution problems that you will encounter when giving medications to your patients.

The fractional method is very similar to ratio and proportion; the values are just put in fraction form.

Starting with the ratio and proportion:

H : V :: D : X

We make it into a fraction by taking the letter in the first position and make it the numerator, and the letter in the second position and make it the denominator, then substitute = for ::, like this:

$$\frac{H}{V} = \frac{D}{X} \quad \text{or} \quad \frac{10\text{mg}}{1\text{cc}} = \frac{7.5\text{mg}}{x\text{ cc}}$$

New Screen

$$\frac{10\text{mg}}{1\text{cc}} = \frac{7.5\text{mg}}{x\text{ cc}}$$

Cross multiplication is then carried out, resulting in:

(10mg)(x cc) = (7.5mg)(1cc)

Dividing both sides by 10 to clear the x:

x = 7.5/10

x = .75 cc

NO-NO! If you got 0.133 mg for your answer, you must have reversed the numbers and divided 8 by 60.

7.5 mg is the correct answer.

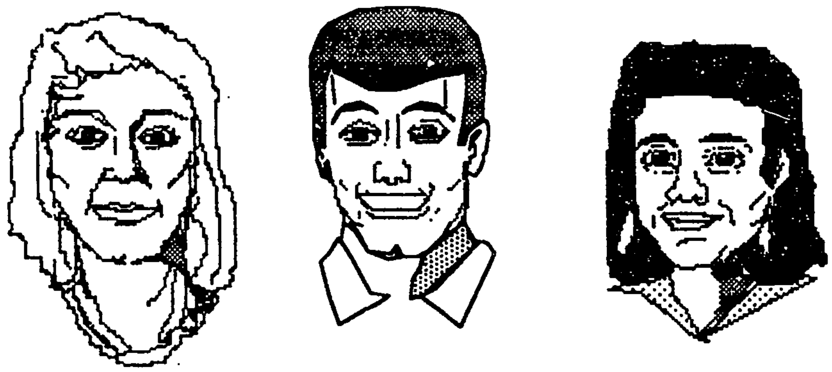
Here is how I worked the problem:

$(1)(x) = (60)(1/8)$

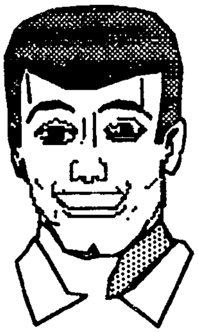
$x = (60/1)(1/8)$

$x = 60/8$ ...and by dividing 60 by 8, I get..

$x = 7.5$ mg



We are Martha, Mark, and Molly, your guides as you learn and master medication math through this tutorial program.



Now this gets to be more fun. Here comes our problem again (do you know it by heart, yet?!) and some things for you to do...

After you push the continue button.

Next screen

MOVE ON

> Mr. Jones is to receive 1/8 gr of Morphine Sulfate I.M. q 4 h prn. The vial on hand reads:
> Morphine Sulfate 10 mg per cc. How many cc's will you give for one dose?

Here are some actual conversion equivalencies between the two systems:

A. 1/60 gr = 1 mg

B. 1/6 gr = 10 mg

C. 1 gr = 60 mg

Please click on the conversion equation that would be the most useful in solving THIS problem.

Then click MOVE ON when you are finished.

A B

c d

1 gr : 60 mg :: 1/8 gr : X mg

The Means

Means = "middle" and is represented in the diagram by A and B. This data will always be in different measures, types, or identities.

Next Screen

C a b D

1 gr : 60 mg :: 1/8 gr : X mg

The Extremes

Extremes = "ends" and is represented in the diagram by C and D. This data will always be in different measures, types, or identities.

Hi again!

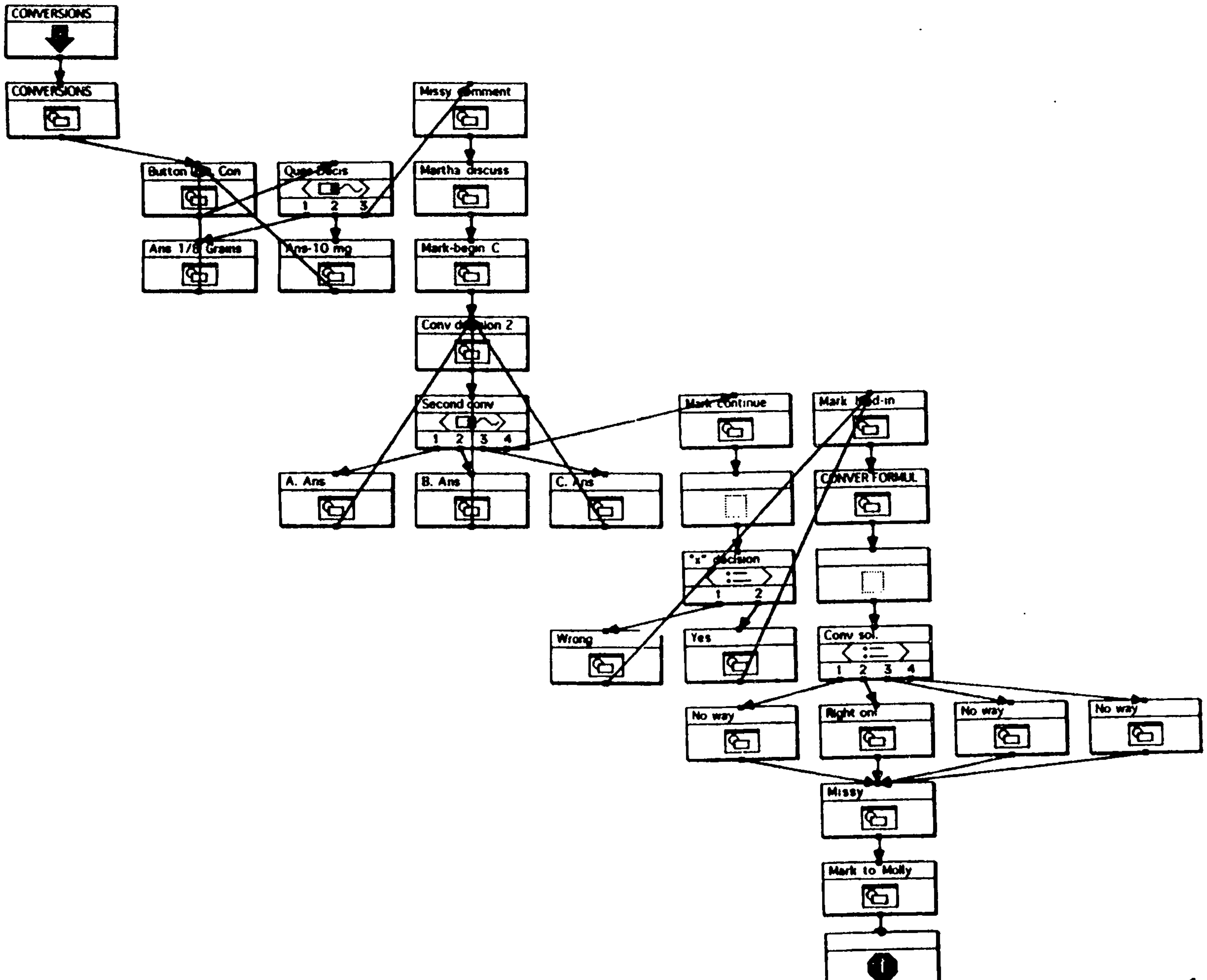
Mark did such a good job in the last section, my work will be much easier. Actually, I'm going to have you do most of it!

Now that you have converted the numbers into one system, our next step will be to answer the last question in the problem: "How many ccs will you give?"

Wonderful! You are absolutely correct.

And Mark will be so pleased--either you already knew how to do this..., or he actually taught you how to do it!

Press continue to compare your method of calculation with mine.



BEST COPY AVAILABLE

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APPENDIX N

SUMMARY OF EVALUATOR COMMENTS

EVALUATORS' NARRATIVE COMMENTS

1. What did you like most about this program?

*Ease of use & simplicity of language regarding the mathematics which is too often dense &/or too abstract.

*User friendly--fun--humor

*Selection of ratio & proportion as problem-solving format--final section on "reasonableness".

*Logical, sequential, and non-threatening.

*Directions are clear--opportunity to practice--presentation of rationales--great menu--good positive feedback when get right answer.

*The idea of having 3 people presenting & interacting with the students.

*Very user-friendly--great graphics--excellent design & presentation.

*I felt more comfortable using the computer than learning from an instructor.

*Liked the "student" giving her mistakes which was a good way to help users avoid them.

*Its simplicity and ease of use, and using the ratio & proportion method. I just changed to that (R & P) from the others we were taught-it's easier to use and less mistakes.

*Easy to follow each step of the way.

*Ability to make mistakes and not have the program grind to a halt. [Especially useful in 'testing' when I'm trying to break the program and/or whip through again to a point to review a different reaction.]

2. What did you like least?

*Nothing

*Couldn't go back to previous screen.

*Couldn't back-up when I didn't read something correctly.

*Some of the narrative was too long between instructions and examples.

*Some of the fonts used were hard to read.

*Lack of examples

*Too much reading in spots--conflicting/confusing terms.

*None

*Nothing

*Kind of slow-moving switching between areas

*Not having the equation in sight to practice with.

*Inability to back up one step to review the just-made mistake and now, smarter, 'do it right'.

3. How would you describe its strengths?

*Its relaxed pace and clarity of language reduced anxiety and, in my case, stimulated my interest in solving the problems.

*Great math content--reinforcement very positive--can stop & return easily.

*Logical step-by-step--presents then explains concepts.

*Examples were realistic--allowed student to choose method compatible to his/her thinking process.

*Friendly program--discussion of rationale--opportunity to practice--items are isolated when presented to viewer--rationale when pick a wrong answer--good positive feedback.

*Interaction with students.

*Definitely decreases anxiety.

*It is easy to use.

*Flow from basic abbreviations to final solution--immediate feedback--ability to leave and return--info on proofing.

*Ease of use--good graphic presentation of formulas, etc.

*Very strong--good design

*Explanation of conversion from system to system.

4. . . . its weaknesses?

*More "advanced" students might find it too basic possibly for them (though possibly not--I'm not in the profession, myself).

*Nothing important.

*"Click on 2 dosages that are in 2 different systems" comes before the explanation of what systems of measure are. Didn't like changing from clicking on "ok" to hitting carriage return.

*May be too simplistic for some students but will meet the "C" average students' needs.

*Lack of examples.

*Font hard to read in some of the presentations of the problem.

*Could include more graphics to explain and clarify. Could have more interactivity.

*None

*In several areas "data" used singularly--need to check.

*Small amount of problems with which to work.

*Could use more problems.

*The lack of any real explanation of the differences between methods. I think I'm too close to the problem, actually; they all boiled down to a functional equivalent, with minor arithmetical/positioning approaches, and the explanations didn't distinguish them enough.

5. Were there any areas in which you had problems? If yes, describe please.

*None other than being a non-medical person.

*When to be clicking and returning.

*Rounding section--wasn't sure if the tutorial was teaching basic rounding or rounding special for med math--was a little confusing.

*Print screen came up continuously and had to be cancelled. (Note: this problem was found early and other reviewers received corrected disks.)

*I couldn't back-up to read again some screens.

*No

*Keeping track and sorting the variety of terms. Pick a set and stick with it.

*I had a problem using method--I used my own way to get answers.

*No

*None

*When I began to do practice problems, I went blank, especially because I couldn't remember equations.

*No ability to back-up when you make a mistake--can't review your error.

6. Please share your suggestions for improvement.

*Measurement section--use unit name not "unit".

*Go beyond verbal information learning--more examples.

*More diagrams & use of bullets.

*Edit now. Add graphics & interactivity later.

*Please offer more examples

*Basic concept is great. I'm sure you could go on forever.

*Have the different areas flow from one to another instead of returning to main menu.

*Just add somewhere near practice problems equations for "security blanket".

See extensive list of suggestions in Appendix O

7. What should be included in a manual that would assist users?

*Is a manual necessary?

*Just as noted in program: bibs and references.

*Conversion charts, formulas, practice problems with answers, more examples of "reasonableness".

*Should also have problem printed in manual so students can see if they pushed "continue' too fast and need to review.

*Exercises and case studies.

*How to troubleshoot problems--have more practice problems.

*I'm not fond of having an essential part of the program on paper that can get lost or misplaced.

*The program was already clear.

*How to put in computer for us dumb dodo's!

*Abbreviations, formulas, conversion charts, etc.

*Nothing I can think of.

*Manual? (a) Put in some screen shots (especially of clicking on the 'Continue' and 'Move On' buttons). (b) Be sure to indicate how to move on after selecting a radio button, or testing some of the 'side loops'. (c) Why not a simple flow chart showing how you can step 'aside' on the path and return again? (d) 'Rosetta stone' of conversions. (e) A 'problems and answers' test set for self-testing. (f) Graphics showing how to install the program.

8. Please comment on the level of the language used? If English is your second language, could you understand what was being said?

*Language level was just fine. Don't change it.

*(Happy face drawn) Yes!! (*ESL student*)

*In some sections it was a little wordy--I circled some phrases on the back of page which need work.

*OK

*Yes (*ESL reviewer*)

*Very good for all students, especially ESL.

*Readability index is probably more than 5th grade. Editing will easily fix.

*The level of the language used was general. I could understand most of the sentences. (*ESL student with only six months study of English*)

*Easily understood--I would think even for ESLs.

*OK
*Appeared designed for younger students or those not familiar with English.

*Pretty simple. You probably need to review it carefully to make sure it isn't patronizing. Get a teenager or six to review it for that, since they're the most sensitive.

9. If you are not familiar with the Macintosh Computer, what instructions would have been useful to you?

*Basic Macintosh usage or ability should be given to all students.

*"Basic" menu which has been included.

*"Click OK after you have completed your answer."

*"Look above at the bar at the top of the screen for ...".

*I know the Mac.

*All were great!

*I was already familiar with the Macintosh computer.

*No problem.

*How to access the calculator.

*Um, I plead knowledge, which means this is difficult.

APPENDIX O

EVALUATIONS FROM SOFTWARE PROFESSIONALS

DISKOVERY
Computer-Assisted Healthcare Education
13740 Harleigh Ct., Saratoga, CA 95070
(408) 741-0156 Fax: (408) 741-5987
CHRISTINE BOLWELL, RN, MSN

Sharon

This is a very well done CAI program!!!!

You definitely achieved the goal of presenting the information to a student while removing any anxiety!! I especially liked the strategy of having helping, interested people involved with the learning. You might want to give a bit more of an introduction to all three. It's nice to know them as personalities and what their roles will be. You need not be as descriptive with each as you were with Martha, but you might say something like Mark will be your guide....... and ???? will share with your the medication errors she has made. With your description of Martha, I could hear her speaking in my head. Nice friendly touch. Later, you may want to add, in some places, a narrator who speaks the text that appears on the screen.

Is there any reason why you used all CAPS on the pull down menu? It's much easier to read upper and lower case.

You could use an editor to shorten and clarify some sentences. This could easily be done without compromising the beautiful conversationality of the program.

Guess you already know about the boxes in which 1/8 gr looks like 1/0 gr.

Nice symbols for ounce and minim. How did you accomplish that feat?

I like being able to select answers and get feedback more than once and I like being able to move on when I want to move on - whether I have selected all the answers correctly or not.

When explaining where the pieces fit in the formula, you might want to show haw the formula is developing rather than just using words to describe its development.

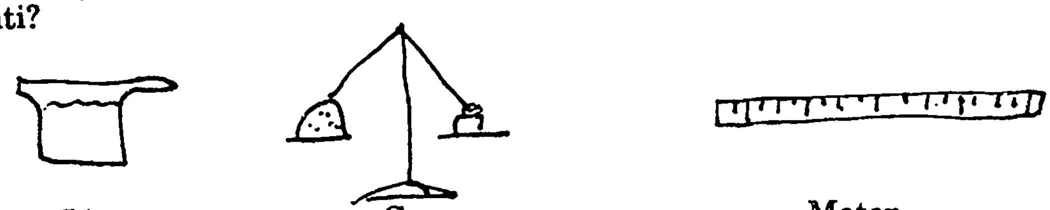
Is datum a common term today or do you say "data are" when using data as plural?

Nice graphics!!

You might want to have each of the three systems of measurement appear on the screen one at a time so that when complete they appear as a bulleted list:

- metric
- apothecaries
- household

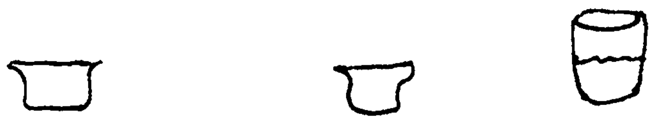
To clarify, how about a graphic showing the difference between kilo and centi?



Liter Gm Meter

How could you graphically show that grain is small compared to ounce and dram and that a minim is smaller than fluid ounce and quart.

You might want to show



1 pint = 500cc = 1/2 liter

Graphics such as these are good for the visual learner, are faster to understand that reading text and comprehending the meaning of the text, and may serve as a mnemonic device that stays in long-term memory.

Nice method for presenting the formula - one piece at a time - both piece of formula and explanation. Here is another place you could use a narrator's voice.

You might want to increase the readability of the summary. Instead of the lay out with text on the diagonal, it would be easier to read if you present each accomplishment one at a time with a bullet so it ends up as a bulleted list.

Please consider the number of different terms you have present as values in the equation/formula.

Ratio	Proportion		
Have	Desire		
Means	Extremes		
On hand	Vehicle	Desired dose	Amount to give

I got confused - you should think about using just one set to maintain consistency and reduce confusion. Just give the brain one memorable set to hang on to that will always apply. I could never solve another problem if I couldn't remember ratio and proportion.

Just before "Now we can give Mr. Jones 0.75cc morphine sulfate, label has a typo.

I would recommend finding a way to give students even more involvement. There is still a lot of page turning. You could do more exercises like the ones where students identify problems - such as identifying the mistranscribed number. Or, instead of telling something, have them select. Turn statements into questions or selections. This tends to engage them mentally - you insist that they think rather than just read and comprehend, or worse, read and memorize, or skip.

Sharon, I must say this is an excellent job. I like your design and your presentation very much!!!

Please do consider an editor - I never let anything out without my editor doing some pretty thorough cleaning up. I can never see where I could have said something better until after the editor cleans it up.

The addition of graphics and increased interactivity should be fun - after you get the first version Out-The-Door!

Thanks for asking me to participate in your review. I would like to tell others about its availability when you are ready.

Sincerely

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Software Evaluation & Feedback: Additional Notes and Comments

(1) The 'continue' buttons should be drop-shadowed, to indicate that they are the default option which will be activated by hitting the "enter" key, to meet the Macintosh User Interface standard.

(2) On a very large screen, the 'continue' buttons drop to the far right corner. It took me about a minute to find out how to get going on the first screen, because the button wasn't very visible, and there was no cue (like "click on the 'continue' button") in the typed text indicated how to get moving.

(3) On startup, you can print a blank screen....

(4) There's no ability to back up. If you've just made a mistake, and been told about it, you can't go back to the question, pick the right answer, and thus get immediate feedback. By the time you 'cycle round' again through quitting, etc. you can lose track of the error and correction.

(5) In "Methods", when asked the name, one little typo is the equivalent of a mistake. "Ratios and proportions" is just as wrong as "cgfjads;fjdsf;lkds".

(6) The "Move On" boxes are not the most obvious icon for a clickable item; on the other hand, they do give good feedback (by blinking) that they've been activated.

(7) In "Conversion", you should probably eliminate the phrase "most useful" method, since later on you admit that circumstance and choice can make other methods more useful in other situations. Perhaps you could use the phrase "easiest to use for this problem"?

Also, you might have a couple of examples showing why or when one method may or may not be easier to use, with an explanation: e.g. "1/6 of 60" means fractions are easier, because you can simple 'cancel out' the sixes, leaving a final answer of '10', but ".2 of 428" means decimal is easier, because you can 'cancel out' the 2 with a division, rather than dividing from '1/5'.

(Then Missie might point out that no one needs to know the 'fast way' or the 'neat trick' as long as the right answer is reached; tortoise beats hare every time!)

(8) Somewhat more personal grumph: why is the "left side easier for solving"? What is really easier is isolating the "x" to one extreme or the other:

"x = 1/6 * 432 / 754.3" is equivalent to "1/6 * 432 / 754.3 = x"

and for some folks, it's easier to think from the x to the operation, and for others, from the operations to the x.

Because there are such differences in how people think about math, but math teachers keep insisting that the way that they are the most comfortable with is the only 'right' or the 'best' way, math

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education turns off so many people. Your program is trying to solve that problem, or at least help with it — please don't get caught in that same trap!

(9) Why is the menu choice "Close" functional? If you "Close", you then have to figure out how to "really quit" – and you haven't anything else to do.

I'm glad you solved the "Print Dialog" problem.

APPENDIX P

PANEL OF NURSING EXPERTS

NURSING EXPERTS FOR TEST REVIEW

The following faculty in the Department of Nursing at San Jose State University participated in the evaluation of the Pretest-Posttest designed for the educational software program, "Mastering Medication Math."

Kathy Abriam-Yago, R.N., M.S.N., Ph.Dc.	Assistant Professor
Carol Michnowicz, R.N., M.S.N.	Lecturer
Suzanne Malloy, R.N., M.S.N., Ed.Dc.	Assistant Professor
Virgil Parsons, R.N., DSN.	Professor
Mary Reeve, R.N., Ed.D	Associate Professor

BIOGRAPHICAL SKETCH OF STUDENT

Sharon C. Wahl began life in Portland, Oregon, on November 4, 1937, the second child of Betty and Ted Johnson. She attended a variety of elementary and secondary schools in the Pacific Northwest and Alaska, graduating from high school in Crescent City, California in 1955. Her academic credentials consisted of a Baccalaureate in Nursing from the University of Portland, Portland, Oregon in 1959; a Master of Science in Nursing Education, with a minor in anthropology, from the University of Oregon Health Sciences Center, Portland, Oregon in 1973; and predoctoral studies in economics, mathematics, statistics, and computer science at Portland State University, Portland, Oregon 1979-1980.

Sharon entered the Nova University Ed.D program in 1985 with a specialization in Higher Education. Her practicum research included the areas of computer-assisted instruction, learning styles, marketing education, and articulation of community colleges and universities.

Her professional nursing career included thirteen years in various positions at St. Vincents Hospital and Medical Center in Portland, Oregon, ending with Head Nurse of the Cardiovascular/Neurological Intensive Care Unit; eight years as Assistant Professor of Medical-Surgical Nursing at the University of Oregon Health Science Center, Portland, Oregon; two years as a nursing administrator at Mills Hospital, San Mateo, California; and ten years as Instructor and Assistant

Professor of Nursing at San Jose State University, San Jose, California. She also holds a lifetime community college teaching credential. In addition to her teaching responsibilities, she maintains professional currency by carrying a small caseload of home health care clients; participates as an officer in professional organizations; works with community health-promoting organizations and was recently elected President-Elect for the Santa Clara County (California) American Lung Association; gives workshops on health-promoting behaviors to community and professional groups; and has published several articles and book chapters.

As a student in the Programs for Higher Education at Nova University, I do give permission to Nova University to distribute copies of this Major Applied Research Project on request from interested parties. It is my understanding that Nova University will not charge for this dissemination other than to cover the costs of duplicating, handling, and mailing of the materials.

8/1/92 (date) — Sharon C. Wahl

I certify that I have read and am willing to sponsor this Major Applied Research Project submitted by Sharon C. Wahl. In my opinion it conforms to acceptable standards and is fully adequate in scope and quality as a Major Applied Research Project for the degree of Doctor of Education at Nova University.

8/9/92 (date) — Frederick C. Kintzer, EdD
MARP Advisor

I certify that I have read this Major Applied Research Project and in my opinion it conforms to acceptable standards for a Major Applied Research Project for the degree of Doctor of Education at Nova University.

8/13/92 (date) — Mauro Chavez, Ed.D
Local Committee Member

This Major Applied Research Project was submitted to the Central Staff of the Programs for Higher Education of Nova University and is acceptable as partial fulfillment of the requirements for the degree of Doctor of Education.

8/20/92 (date) — Martin B. Parks, Ph.D
Central Staff Committee Member