A study of the effects of computer assisted instruction prior to traditional instruction on retention and transfer of learning

by

Barbara Jo Crittenden

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CHAPTER I: INTRODUCTION

Integrating the computer into the educational system has been a slow process. Computers are becoming popular as educational tools, and many people are convinced that computer technology can be used to extend traditional education in a positive way. However, the potential for computer assisted instruction (CAI) has remained largely unexplored in classrooms across the United States; although, many schools districts have purchased computers for instructional use, most have only bought enough to put one or two in every classroom (Douglas & Bryant, 1985). Even those schools that have purchased large numbers of computers are using them for traditional activities that can be acomplished as well by other means.

History of Educational Computing

In the early 1960s, university educators harnessed mainframe computers for research and demonstration projects, and the basic methods and vocabulary of computer assisted instruction were developed at that time (Berg & Bramble, 1983). Attention was focused on the potential of the computer as an educational device, but cost and inaccessibility prevented widespread adoption (Berg & Bramble, 1983).

About 1977, microcomputers were introduced. They were both powerful and inexpensive, and public schools began to adopt them for educational use. Berg and Bramble (1983) have proposed three phases of educational computing: the "experimentation phase" of the 1960s, the "popularization phase" which began in 1977 with microcomputers, and the "transition phase" which should begin in the mid 1980s. These phases are situational; some schools are already moving into the transitional phase while other schools have only started into the popularization phase.

The popularization phase is characterized by schools purchasing computers, teachers receiving inservice education about computers, and low level educational use being made of computers. During the transitional phase of educational computing, it is predicted educators will have the opportunity to improve and transform public education through technology; this transformation will take place through less expensive and more powerful microcomputers, digitalized voice, high quality classroom management software, and more sophisticated instructional software. To be utilized to their full potential, the unique contributions of the computer to the instructional process must be discovered, documented, and implemented.

Current Uses of Computers in Education

The ways computers have been, and are being used, in the classroom can be illustrated by the types of software available. Currently, instructional computer software is most commonly classified as drill and practice, tutorial, problem solving, or simulation. When using drill and practice software, the student responds to a series of questions, immediate feedback appropriate to each response is given, and a summary of his/her performance is presented. Tutorial software presents instructional material, asks questions, and branches to new material or remediation depending on the student's responses to the questions.

Problem solving software allows the user to solve specific discipline-oriented problems, such as exercises, research problems, etc. (Hassett, 1984). It provides answers to problems and/or performs computations; for example, a computer program may be used to calculate t-scores on research data. Finally, simulation software places the student in a simulated realistic setting where he/she is confronted by situations that require active participation in initiating and carrying through a sequence of inquiries, decisions, and actions (McGuire, 1976). For instance, simulation programs may be used to teach a person to drive a car, to fly, or to perform various other psychomotor and academic skills.

Taxonomy of Educational Software

Two professors from Iowa State University, Drs. Thomas and Boysen, believe the traditional classification system for educational software, described above, has major deficiencies. For example, it does not provide guidance on how a particular application should be used in the educational setting, and the categories do not focus the teacher's attention on student weaknesses (Thomas & Boysen, 1984). Thomas and Boysen have proposed a taxonomy for classification of educational software that they believe focuses on the needs of the learner, provides guidance for the development of lessons and their instructional use, and facilitates the design and communication of research studies. The five categories Thomas and Boysen have proposed are presented below:

<u>Experiencing</u>--sets the cognitive or affective stage for future learning; precedes formal instruction and should serve as a foundation for it.

<u>Informing</u>--used by students to acquire information; supplements or replaces the textbook and lecture.

<u>Reinforcing</u>--used to strengthen specific learning objectives (e.g., drill and practice programs).

<u>Integrating</u>--provide opportunity to apply previous learning to new situations (e.g., simulation programs).

<u>Utilizing</u>--computer program used as a tool to perform a specific task.

Each category of Thomas's and Boysen's taxonomy represents a step in the learning process with experiencing being the first step and utilizing being the last (Thomas & Boysen, 1984). This classification places the focus on the learner. For example, if the learner uses the program prior to instruction to "set the stage" for learning, the program is said to be an experiencing program. If the learner uses the program to acquire the information, it is said to be an informing program. Informing and reinforcing applications are usually computer-directed, while experiencing, integrating, and utilizing applications are learner-directed. It is through learner-directed applications that the highest levels of learning and computer literacy are achieved, and the greatest degree of teacher competence and deepest philosophy of education are required

(Thomas & Boysen, 1984).

To date, most computer assisted instruction programs have focused on linear rote activities in the areas of mathematics and grammar, and drill and practice has been the prevailing methodology (Heermann, 1984). Computer programs that are narrowly focused on the knowledge level of Bloom's taxonomy of educational objectives (cognitive domain) incompletely exploit the power of computers; computer assisted instruction that is merely page turning misses the point--a book can accomplish the same thing more effectively at a lower cost (Heermann, 1984).

Effectiveness of the Computer as an Educational Tool

Many research studies have been conducted in an attempt to determine how effective the computer is as an educational tool. In a review of research conducted by Kysilka et al. (1975) regarding the effectiveness of computer assisted instruction, the conclusion was drawn that normal instruction supplemented by computer assisted instruction is more effective than normal instruction alone. Another study, by Thomas (1979), concluded that computer assisted instruction leads to achievement levels equal to or higher than traditional instruction, as well as to favorable attitudes, significant time savings, and comparable levels of retention and cost.

Numerous studies and their results can be cited. Magidson (1978) found that most studies of computer assisted instruction (CAI) generally conclude that an instructional program supplemented with CAI is at least as effective as, and frequently more effective than, a program utilizing only traditional instructional methods; this finding is supported by reviews by Vinsonhaler and instructional methods; this finding is supported by reviews by Vinsonhaler and Bass (1972), Edwards et al. (1975), Jamison, Suppes, and Wells (1974), and Hartley (1977), as reported by Shively (1984).

Much of the research on CAI has been conducted in elementary and secondary schools. Meta-analysis of the effectiveness of computer-based college teaching has demonstrated that, for the most part, the computer has made a small but significant contribution to the effectiveness of college teaching (Kulik, Kulik, & Cohen, 1980).

The quality of research studies in the field of instructional computing has been questioned. Factors cited as limiting studies include, lack of controlled scientific analysis and technical problems, use of inferior CAI programs in terms of instructional design, and the influence of the abilities and attitudes of teachers using CAI (Murphy, 1984). In addition, research has frequently grouped all types of CAI programs together. Many studies have not provided a clear description of the type of CAI program used in the study. Without this description and differentiation, it is difficult to determine what specific characteristics of computer use have been evaluated, and generalization of the results of these studies is difficult.

Technology versus Curriculum

Integration of the computer into education has been a slow process for many reasons. One major factor is that successful employment of a computer in education depends on many human variables, including the adequacy of software design, off-computer follow-up activities conducted by the teacher, consistency of course objectives with student interest, and the way in which the CAI experience is integrated with the student's overall instructional and socialization program (Shively, 1984). Another reason CAI has been slow to advance is that to date, there has been little evidence that large sums of money are to be made out of teaching, whether by human or machine (Shively, 1984).

Teachers are transferring their existing teaching techniques to the computer rather than using the computer to its full potential. Many of the CAI programs presently available are computerized versions of traditional instruction--they are not innovative, nor do they reflect high regard for high level learning strategies. Computer assisted education risks automating the most ineffectual assets of traditional education (Heermann, 1984).

At present, the dominant educational use of computers is to provide students with drill and practice. While computer hardware has improved in power, the curriculum material available on the computer has not matched pace with regard to quality; most learning materials available have not been produced by any careful process, and few have undergone careful evaluative study (Bork, 1984). The best computer assisted education programs engage the learner in real-world situations, encourage observation and reflection, and culminate in the application of learning to new situations (Heermann, 1984).

In many situations where computers are being used in the educational system today, the technology is driving the curriculum rather the the curriculum driving the technology. Many schools that are buying computers are not certain what to do with them; the ability of educators to exploit the computer has not kept pace with hardware developments (Aiken, 1980). Poor quality CAI programs may be used for lack of availability of better programs, and/or for lack of knowledge of more appropriate ways to utilize computers in education. Teachers may be given a computer to use, but not instructed in how to utilize it to its fullest potential. Although much of the current educational software is limited and of mediocre quality, these are not deficiencies of the technology, but only reflect initial development efforts (Podemski, 1984).

Research in the Field

Many studies have concluded that computer assisted instruction leads to achievement levels equal to or higher than traditional instruction, favorable attitudes, significant time savings, and comparable retention and cost (Thomas, 1979). However, most studies have compared traditional instruction to computer assisted instruction which closely emulates traditional instruction (Jamison, Suppes, & Wells, 1974). While research regarding CAI is not without flaws, the following conclusions can be drawn: 1) CAI is at least as effective as traditional instruction; and 2) no one mode (drill and practice, tutorial, simulation, or problem solving) has clear superiority over the others (Murphy, 1984).

Recently, research on computers in education has been criticized for stripping the medium down to its bare technology. This type of research assumes that there is some aspect of the medium of instruction that causes a positive or negative effect on the learner. It assumes that computers are introduced into the classroom in a highly structured fashion in order to facilitate the attainment of old objectives. It is naive, however, to assume that the medium, rather than some specific attribute or quality of it affects learning; when everything else in instruction is held constant, except the medium, not much of an effect can be observed (Salomon & Gardner, 1986). The best current evidence demonstrates that media are mere vehicles that deliver instruction but do not influence student achievement any more than the truck that delivers our groceries causes changes in our nutrition (Clark, 1983). In studies where different instructors teach control and experimental groups, larger differences are found than in studies in which a single teacher teaches both groups to control for instructor effects (Kulik, Kulik, & Cohen, 1980). There is reason to believe that this is due to the greater control of nonmedium variables (Clark, 1983).

Media are vehicles for instruction and do not directly influence learning, however, certain elements of different media may facilitate learning (Clark, 1983). Research on computer assisted instruction needs to be more explicit in terms of specifying the objectives of the use of the computer in the study and the instructional approach to its use in order to explain its effects. In other words, research must be very specific in describing what characteristics of computer use are being evaluated before the effects of this use can be explained in a meaningful way.

Purpose of this Study

Due to deficiencies currently existing in the uses being made of computers in education, poor quality educational software which does not maximize the educational potential of computers, and lack of empirical evidence that computers can make unique and beneficial contributions to learning, computers have been slow to become an integral part of education. In order for research to be conducted that will determine the actual effectiveness of computers in education, educational software must be developed that is based upon established principles of learning. Computers must be utilized for those things that can be accomplished better by computer than by other means, and the objectives for computer use must be clearly stated and measureable.

Often students are determined to have mastered a particular skill or bit of knowledge as evidenced by performance on classroom acitivities and yet are not able to correctly apply the knowledge or skill to a real-world situation. Computers may be able to aid in resolving this problem through appropriately designed programs. For example, computers may be able to provide simulations representative of real-world situations, thus, promoting the transfer of learning. Studies need to document empirical evidence of this benefit, if it exists.

This study investigated the effects of a computer assisted educational program designed to provide a unique experience for users. The study was based upon the belief that computers themselves do not affect learners in any direct way, rather, it is the way they are used in instruction that is important. The computer assisted instruction program used in the study provided a unique instructional environment in which students were given problems to solve in a discovery manner. The program was administered prior to traditional instruction to set the cognitive stage for later learning, and its effect upon retention and transfer of learning was measured.

The computer program used in this study was designed by this researcher specifically for the subjects in this study to provide a new learning experience for them. This study was not designed as a media comparison study; it did not involve two instructional groups receiving the same instruction, one via the computer and one via traditional instruction. Rather, the study was exploratory in nature, and attempted to identify some of the possible unique characteristics of the use of computers in education. Once these characteristics are identified, further studies may be conducted to determine which characteristics of computer use are crucial to its effects being positive. Once these characteristics have been described, guidelines for effective use of computers in education can be established.

Hypotheses

1. There will be no difference in performance on tests of short term retention between students who use the treatment CAI program prior to traditional instruction and students who receive no treatment prior to traditional instruction.

2. There will be no difference in performance on tests of near transfer between students who use the treatment CAI program prior to traditional instruction and students who receive no treatment prior to traditional instruction.

3. There will be no difference in performance on tests of far transfer between students who use the treatment CAI program prior to traditional instruction and students who receive no treatment prior to traditional instruction.

4. There will be no difference in performance on tests of long term retention between students who use the treatment CAI program prior to traditional instruction and students who receive no treatment prior to traditional instruction.

Overview of the Study

The subjects utilized in this study were students in an associate degree registered nursing program. There were several reasons for the study being conducted in a nursing program. First, this researcher has been involved in the field of nursing for approximately ten years, and in nursing education for the past four years, and therefore, has particular interest in the role of computer assisted instruction in nursing education. Also, the field of nursing education, and health care education in general, has rich possibilities for the computer.

Computers are capable of providing clinical simulations, which closely approximate the clinical experience, yet provide a controlled environment; hence, the learner has the opportunity to become a primary care provider who can incorporate previously learned concepts, procedures, and principles in a unique situation where error can occur without harm to clients (Yucha & Reigeluth, 1983). Simulations provide learning opportunities without being dependent on the accidents of nature and the flow of clinical problems available at the particular place and the specific moment in time when instruction is to be given or an assessment is to be made (McGuire, 1976). Computer simulations make it possible to focus on the elements of primary concern in a learning situation and to eliminate the irrelevant "noise" present in reality which complicates learning (McGuire, 1976).

Computer-based instruction can be used to individualize instruction, making education more meaningful and efficient for the variety of students in nursing. Another important reason for using computers in nursing education is to prepare students for future use of the computer as a tool in nursing as increasing numbers of health care facilities are utilizing computers in patient care management and in record keeping (Yucha & Reigeluth, 1983).

Although the potential applications of computers in health education is unlimited, both as a motivational device and as a device for allowing students to apply knowledge to hypothetical problems, computers as a basic tool for nursing education have been used very little (Yucha & Reigeluth, 1983). The implementation and utilization of computer assisted instruction in nursing education will involve planned institutional change (Murphy, 1984). Before this type of change will occur, empirical evidence of the unique contributions of computer applications to learning must be documented.

The learning concept utilized in this study was acid-base balance in the human body. In this researcher's involvement with nursing education over the past several years, it has been found that the concept of acid-base balance is particularly difficult for students to grasp, retain, and transfer to the clinical (real-patient) setting. This is likely due to the complexity of the subject, and the lack of a concrete representation of the concept. The CAI program utilized in the study was a microworld centered around the acid-base status of a vial of solution. The program consisted of simulated experiments in which the student manipulated the ingredients in a vial of solution, and discovered the effects of these manipulations upon the pH (acid-base status) of the solution.

This program allowed students to actually observe the pH of the simulated vial of solution change according to acid-base status. Of course, it is not possible for the student in the clinical setting with human patients to directly observe the patient's blood pH change according to the level of certain parameters. The program was designed to convert acid-base status in the human body to a more directly observable, more concrete and attainable concept by providing a model for the student. This type of activity could be accomplished by use of the computer better than by use of any other medium. By using the computer, the student was able to actually manipulate variables rather than simply observe the manipulations of another. Also, results of these manipulations could be observed quickly, and the manipulations were recorded on computer disk for future reference by the student. This activity could not be duplicated in the real-patient hospital setting, in a chemistry lab, on video cassette, or by other means.

The computer program was used prior to traditional classroom instruction on acid-base status in the human body. A control group and an experimental group were used, and a pretest was administered to all subjects prior to the experiment to measure knowledge of the material to be covered on acid-base balance. Following instruction, near transfer, far transfer, short-term retention, and long-term retention of learned concepts were measured.

Near transfer in this study was defined as transfer from one school-learned event to another school-learned event, and was evaluated by pencil and paper acid-base word problems. Far transfer referred to transfer from a school-learned event to a real-world situation, and was evaluated by asking the student to determine the acid-base status of clinical patients in the hospital setting from actual patient data. The far transfer situation closely simulated the actual working environment the nurse would experience following graduation from the nursing program. Short term retention was evaluated by a unit post-test given following instruction. Long term retention was evaluated by repeating an equivalent post-test six weeks after instruction.

Definition of Terms

Advance Organizer:	Information presented prior to instruction to activate existing cognitive structures in order to facilitate assimilation of new information.
Associate Degree Nursing Program:	Twenty-two month instructional program in nursing education. Upon successful graduation from the program, the student is eligible to take the Iowa Board of Nursing Licensure Exam for Registered Nurses.
Discovery Learning:	Instructional process that places responsibility for finding information or problem solutions on the learner. The learner must use investigative procedures to obtain information.
Experiencing Program:	Computer program used prior to traditional instruction to set the cognitive or affective stage for learning.
Far Transfer:	Ability to apply knowledge gained from a school-learned-event to a real-world (out of school) event. Refers to a situation where the stimulus for the transfer event is different from the

stimulus for original learning (Royer, 1979).

Long Term retention:	The ability to retain information in memory. Measured six weeks after instruction by written exam.
Meaningful Learning:	Process in which the learner relates new information to previously acquired knowledge (DuBois, Alverson, & Staley, 1979).
Microworld:	A computer-based interactive learning environment where learners can become active, constructing architects of their own learning (Papert, 1980). The user manipulates elements of the simulated environment, observes the results of these manipulations, and draws conclusions from these observations.
Near Transfer:	Ability to apply knowledge gained from one school-learned-event to another school-learned event. Refers to a situation where the stimulus for the transfer event is similar to the stimulus for original learning (Royer, 1979).
Short Term retention:	Ability to retain information in memory. Measured seventy-two hours after instruction by written exam.
Transfer of Learning:	Ability to apply knowledge to situations differing from those encountered during original learning (Royer, 1979).

Treatment: Use of an experimental computer program designed as a discovery learning microworld in which students experiment with the concept of acid-base status.

CHAPTER II: REVIEW OF LITERATURE

Computers are being used in education primarily in drill and practice or tutorial modes. Both of these activities can be provided quite easily without use of a computer, and they promote lower levels of learning--knowledge and comprehension as defined in Bloom's taxonomy. This study is directed at determining the effect of use of the computer in a well-planned, nontraditional approach on retention and transfer of learning.

The computer assisted instructional program utilized in this study was designed based upon the following ideas and learning strategies: 1) discovery learning; 2) meaningful learning; 3) transfer of learning; 4) microworlds; and 5) experiencing. Review of literature pertinent to each of these concepts is presented in the order above. Each is discussed as it relates to the treatment program used in this study.

Discovery Learning

Learning is a way of getting from a state of not knowing to a state of knowing (Strike, 1975). Discovery learning has an *independence condition*, that means it involves trying to find out something as though there were no one to find out from; finding out from someone else is <u>not</u> discovery learning (Strike, 1975). The discovery method of teaching calls on students to use investigative procedures to obtain information and make observations, then organize their procedures to obtain information and make observations, then organize their thoughts and make sense of them (Charles et al., 1978).

When the discovery approach to learning is used, it is important that the student is successful in discovering the solution to the problem. It is also important that the student verify the correctness of his/her discovery. In other words, the student discovers a proposition, hypothesizes this proposition, and independently obtains evidence to verify the truth of the proposition (DuBois, Alverson, & Staley,1979). In this type of setting, the teacher provides encouragement and helps students when they run up against obstacles they can not overcome (Charles et al., 1978).

Several studies have shown that performance on problems involving new rules is greater following discovery learning than following rule learning presentation (DuBois, Alverson, & Staley, 1979). The discovery learning environment should provide a situation in which students can tie new information to old. When the primary objective of instruction is that the learner be able to transfer skills from the classroom to the real-world setting, the discovery approach is advantageous. Discovery instruction aids in the transfer of learning because it gives the student opportunity to practice problem solving in a situation which is more representative of actual problem solving than is expository instruction (DuBois, Alverson, & Staley, 1979).

In a discovery learning environment, the student is very active in the learning process, as demonstrated by the above discussion of discovery learning. As research has evidenced, the more active a student is in the learning process, the more he/she learns (Yucha & Reigeluth, 1983). The more interconnections the learning has with a person's experience and the more active he/she has been in using the learning, the deeper the impact will be on his/her memory (Redman, 1976).

The discovery learning approach has been promoted by Papert and his associates at MIT, and seems to have considerable appeal for many educators involved in instructional computing (Roblyer, 1983). There seems to be two-part reasoning for this: 1) self-directed, exploratory learning is the only method which exploits the unique potential of microcomputers, and 2) these approaches will yield greater gains in the long run for students than will using computers for traditional learning methods (Roblyer, 1983).

The computer program utilized in the study places the student in a discovery learning environment. The student is given a problem to solve, is allowed to experiment within the computer environment to discover the solution to the problem, is asked to hypothesize the solution, and is required to test his or her hypothesis until satisfied it is correct. The program is layered in three sections, with the solution to one problem providing the basis for the solution to the next. The process of the solution to a problem building upon the solution of the previous problem, or prior knowledge, should promote the occurence of meaningful learning.

Meaningful Learning

David P. Ausubel is the educational psychologist most associated with the theory of meaningful learning. According to his theory, meaningful learning comes about when the learner relates new information to previously acquired knowledge (DuBois, Alverson, & Staley, 1979). The key prerequisite for meaningful learning is that the learner possesses relevant prior concepts

(Summers, 1982). People learn and remember what they have learned only to the extent that the new information to be learned relates to existing cognitive structures, or schemas (Owen, Blout, & Moscow, 1978).

For meaningful learning to occur, the information to be learned must be potentially meaningful, and the learner must approach the new information with the intention of relating it to his/her cognitive structure in a substantive and nonarbitrary manner (DuBois, Alverson, & Staley, 1979). Since it may be unlikely that learners possess ideally relevant concepts, it may be desirable to introduce these concepts prior to presentation of the learning task; these introduced subsumers could thus constitute efficient advanced organizers or anchoring foci for new material (Mouly, 1971).

Without relevant prior knowledge, students must simply memorize new concepts. Information which is simply memorized, is forgotten quickly and the student is unlikely to be able to apply the information to a new situation; individuals forget nonsense material and isolated facts (Redman, 1976). If the factors required for meaningful learning do not exist, rote learning occurs in which the material is said to "lack meaning" to the learner (DuBois, Alverson, & Staley, 1979). Meaningful learning is superior to rote learning because rote learning occurs without comprehension, therefore, the only performance supported by it is verbatim repetition, and information learned verbatim is forgotten quickly (DuBois, Alverson, & Staley, 1979). Meaningful learning facilitates the learning of new related information and promotes retention and transfer of learning.

Transfer of Learning

A major goal of education is that students be able to successfully apply what they learn in the classroom to novel situations outside the classroom. To facilitate this, learning should go beyond memorizing or paraphrasing; teachers should teach for transfer (Wollman, 1983). Transfer of learning is defined as the ability to apply a particular skill, or bit of knowledge, to situations differing from those encountered during original learning (Royer, 1979).

Theories on transfer of learning have been around for many years. The predominant learning theory at the foundation of education up until the early 20th century had at its core a concept of transfer called the "doctrine of formal discipline" (DuBois, Alverson, & Staley, 1979). According to the doctrine of formal discipline, the mind was a muscle which could be improved and strengthened through exercises such as reciting passages in Greek and Latin; it was believed that the improvement in the mental faculties by these exercises would transfer to all types of situations experienced in life (DuBois, Alverson, & Staley, 1979).

Theories on transfer of learning have been refined since early times. The theory of formal discipline has now been rejected as an explanation for transfer of learning because studies have shown that students of equal initial mental ability taking so-called "formal" and "non-formal" discipline courses made about the same gains on mental tests given at the end of their course work (Craig, 1961). It is now believed that transfer of learning is of a much less general nature than held in the doctrine of formal discipline. In the first decade of this century, E. L. Thorndike conducted research demonstrating that transfer effects among educational tasks are quite specific and depend upon the presence of similar elements in both tasks.

A number of distinctions in types of transfer have been made; a few which are pertinent to this study will be discussed here. A number of years ago Gagne made a distinction between lateral and vertical transfer of learning. Vertical transfer occurs when a learned capability at one level facilitates the learning of a skill at the next higher level (DuBois, Alverson, & Staley 1979). Lateral transfer of learning occurs when a learned capability generalizes to a broad set of situations at roughly the same level of complexity (Royer, 1979).

Another distinction that has been made by many authors is between near and far transfer. Near transfer refers to a situation where the stimulus for the transfer event is very similar to the stimulus for the original learning while far transfer refers to a situation in which the stimulus for the transfer event is somewhat different from the stimulus for the original learning (Royer, 1979). Royer (1979) gives the following examples of near and far transfer: near transfer--original learning involved adding two digit numbers, transfer assessed by adding three digit numbers; far transfer--original learning involved number problems, transfer assessed by substituting addition word problems.

In this study, near transfer referred to transfer of learning from one school-learned-event to another school-learned-event. Specifically, transfer from numerical acid-base problems to acid-base word problems. Far transfer referred to transfer from a school-learned-event to a real-world (out of school) event. Specifically, transfer from numerical acid-base problems to actual hospital patient acid-base problems. See Figure 1 for sample transfer items.

Cognitive theories on transfer of learning suggest that the likelihood of transfer is dependent upon the likelihood of encountering similar elements in the learning environment and the transfer environment (Royer, 1979). This would suggest that a learning environment that increased the likelihood of encountering real-world characteristics would promote transfer. In a study conducted by Huckabay, Anderson, Holm, and Lee (1979) support was found for this theory of transfer of learning which proposes that when students are provided with the opportunity to learn in environments that are similar to actual situations and when they master the content presented, they will be able to transfer and apply theoretical knowledge to real-world situations.

If a main goal of education is that students not only acquire knowledge about a specific subject matter, but also be able to apply or transfer what they have learned to actual situations, then teaching strategies that employ computer assisted instructional programs designed according to established principles of learning will enable students to learn and transfer what they have learned to real-world situations (Huckabay et al., 1979). Therefore, the CAI program utilized in this study was designed to provide a learning environment through simulation which contains parameters similar to the ones most likely to be encountered later in actual situations. The simulation contains real-world characteristics; this simulated "world" may be referred to as a microworld.

Microworlds

In his book Mindstorms, Papert promotes two important principles of learning. He states that if one wishes to learn something new, he or she should first, relate what is new to be learned to something already known, and second, he or she should take what is new and make something with it, play with it, build with it--make it his/her own (Papert, 1980). He promotes a particular environment in which students can relate what is new to what is already known, and make the new idea their own--a microworld.

A microworld is a simulated world in which the student has direct access to the fundamental aspects of what they are to learn about. A microworld is a "place" where certain kinds of thinking can hatch and grow--an incubator so to speak (Papert, 1980). A microworld is designed to eliminate roadblocks to learning; it should be interactive, elements are manipulated by the learner, providing an environment for active learning. In a microworld, the learner can invent their own assumptions about the microworld and its laws; these environments allow the student to discover facts, make propositional generalizations, and learn skills (Papert, 1980).

The primary learning experience in a microworld is not memorizing facts or practicing skills, it is getting to know a new concept through manipulation of variables, and observation of the results of these manipulations. Papert's microworlds allow self-directed, exploratory learning which exploits the unique potential of microcomputers. The characteristics of a microworld described by Papert are very similar to the principles of discovery learning, transfer of learning, and meaningful learning discussed earlier.

The computer program used in this study fits the definition of a microworld. It provides a discovery environment in which students are able to manipulate variables within a controlled setting, and observe the results of these manipulations. In this manner, users are able to form hypotheses, discover facts, and make generalizations.

Experiencing

As presented earlier in this paper, Drs. Thomas and Boysen, from Iowa State University, have described a taxonomy of computer instruction in which CAI programs are classified according to the state of the student at the time of learning, with respect to the knowledge, skill, or attitude being acquired. The specific mode pertinent to this study is the experiencing mode.

Programs used in the experiencing mode are used prior to formal instruction to set the cognitive or affective stage for learning. These programs serve as a foundation for formal instruction. Experiencing programs are learner-directed, and it is through learner-directed applications that the highest levels of learning are achieved (Thomas & Boysen 1984). The experiencing domain of Thomas's and Boysen's taxonomy is closely related to the theory of advance organizers. Advance organizers are defined as appropriately relevant introductory materials introduced in advance of learning to provide ideational scaffolding for the stable incorporation and retention of more detailed material that follows (Mayer, 1979). An advance organizer generally has the following characteristics: 1) short set of verbal or visual information; 2) presented prior to learning a larger body of information; 3) contains no specific content from the to-be-learned information; 4) provides a means of generating the logical relationships among the elements in the to-be-learned information; 5) influences the learner's encoding process by providing a new general organization or activating an existing general organization (Mayer, 1979).

The effectiveness of advance organizers has been questioned. Based on review of 32 studies, 12 of which reported that advance organizers facilitated learning and 20 of which reported that they did not, Barnes and Clawson (1975) concluded that "advance organizers, as presently constructed, do not facilitate learning." In a rebuttal to Barnes and Clawson's article, Ausubel (1978) stated the studies reviewed failed to analyze both the learner's relevant subsumers already present and the proper level of item difficulty for test questions. Mayer (1979) identified major limitations to the Barnes and Clawson review, and concluded that there are definable situations in which convincing evidence for the effects of advance oganizers has been established; when used in appropriate situations and when evaluated adequately, advance organizers do appear to influence the outcome of learning.

Computers may be an appropriate vehicle for providing advance organizers through use of computer assisted instructional programs in the experiencing mode as described by Thomas and Boysen (1984). The success of experiential programs depends on two important conditions: 1) the students relate to the programs, and 2) the programs relate to important intellectual structures or attitudes (Thomas & Boysen, 1984). Experiencing programs provide students with a model that can be manipulated prior to instruction to lay the foundation for learning.

Summary

The primary goal of education is for students to be able to retain information and apply the information to novel situations outside of the classroom. The process of applying information to novel situations is referred to as transfer of learning. Distinctions have been made between the ability to transfer learning from school-learned-event to school-learned-event or near transfer, and transfer of learning from school-learned-event to real-world (out of school) events or far transfer. The probability that a student will be able to transfer learning can be increased by providing an appropriate learning environment.

Research summarized in this chapter identified the advantages of discovery learning and meaningful learning in the promotion of retention and transfer of information. Discovery learning is learning through the use of investigative procedures. Discovery instruction aids in the transfer of learning because it gives the student opportunity to practice problem solving in a situation representative of actual problem solving. The discovery learning environment should provide a situation in which meaningful learning can occur. Meaningful learning occurs when the student is able to link new information to be learned to prior existing knowledge. For this to occur, the student must possess relevant prior concepts.

To ensure that the learner possesses relevant prior concepts, advance organizers may be provided. Advance organizers are appropriately relevant introductory materials introduced in advance of learning to set the cognitive stage for learning. Computers may be appropriate vehicles for the presentation of advance organizers. When computer assisted instructional programs are presented in advance of formal instruction to set the cognitive or affective stage for learning, they are classified as experiencing mode programs according to the taxonomy of educational software identified by Thomas and Boysen (1984).

These learning concepts, discovery learning, meaningful learning, transfer of learning, advance organizers, and experiencing mode programs, can all be pulled together within the concept of a microworld. Microworlds are simulated environments in which the student has direct access to aspects of what they are to learn about. The student is able to manipulate variables within the parameters of the simulation, observe the results of these manipulations, form hypotheses, discover facts, and make generalizations from the information gained. In this manner, the student learns in a meaningful way, in a discovery environment which is similar to the natural process of problem solving.

The research reviewed in this chapter and summarized above, provides the foundation upon which this study is based. The treatment used in this study is a computer based microworld program which was administered prior to the formal presentation of learning material to ensure that students had relevant prior knowledge in order to promote meaningful learning, and therefore, retention and transfer of learning.

CHAPTER III: RESEARCH METHOD

This chapter contains a description of the treatment CAI program used in the study, the study population, the data analysis measures, and the steps taken in carrying out the research project. The CAI program and its use in the study are explained in detail, followed by presentation of the characteristics of the population. The description of the population is presented in order for the reader to assess the generalizability of the research findings. Next, the questions addressed by the study are presented, a detailed account of the steps taken to collect and analyze data is given, and limitations of the study are discussed.

Description of the Treatment

The CAI program used in this study provided a discovery environment in which students were provided with variables to manipulate and problems to solve. Users conducted "experiments" to form hypotheses regarding the solutions to these problems. The computer activity was conducted prior to traditional instruction to provide a meaningful foundation upon which learning could be based.

The program established a simulation of a lab in which students conducted experiments. They were presented with a simulation of a vial of solution, and were given three pieces of information about this solution. They were told the pH of the solution, and that the solution contained two primary ingredients; one ingredient was an acid, and the other was a base. They were told the normal levels of the acid and the base, and were allowed to experiment with the levels of these two ingredients. Students were given problems to solve through their manipulations of the ingredients and were able to observe the effects of these manipulations on the pH of the solution. Figure 2 presents a diagramatic representation of the flow of this program.

In discovering the solutions to the computer-microworld problems, users should have formulated the following basic concepts:

1) If the amount of acid in a solution is increased, all else being equal, the pH of the solution will become acidic.
2) If the amount of acid in a solution is decreased, all else being equal, the pH of the solution will become alkaline.
3) If the amount of base in a solution is increased, all else being equal, the pH of the solution will become alkaline.
4) If the amount of base in a solution is decreased, all else being equal, the pH of the solution will become acidic.
5) The normal level of an ingredient within the solution falls within a range, rather than being a specific amount.
6) Compensation for acidic or alkaline pH can be accomplished by increasing the level of the ingredient with the opposite pH.

Classroom instruction which followed use of this program by the experimental group focused on acid-base balance in the human body.

Introduction/Instructions

↓

Questions Regarding the Acid Ingredient

↓

Experimentation/Problem Solving

↓

Formation of Hypotheses

↓

Testing of Hypotheses

↓

Questions Regarding the Alkaline Ingredient

↓

Experimentation/Problem Solving

↓

Formation of Hypotheses

↓

Testing of Hypotheses

↓

Questions Regarding Compensation

↓

Experimentation/Problem Solving

↓

Formation of Hypotheses

↓

Testing of Hypotheses

Figure 2. Diagramatic representation of the treatment program flow

Variables manipulated in the CAI program were not identical to the variables students were taught to analyze in determining acid-base status in the human body. However, the concepts described above constitute relevant prior knowledge upon which to base meaningful learning.

The program used in this study was defined as a microworld. It was designed to provide opportunity for students to manipulate variables in a discovery environment to set the stage for information to be presented in class following its use. In this manner, it provided for the development of relevant prior knowledge upon which meaningful learning could occur. It was used in an experiencing mode prior to instruction.

Description of the Population

Subjects for this study consisted of students enrolled in the second year of the Associate Degree Nursing (RN) Program at Southwestern Community College (SWCC) in Creston, Iowa. All subjects had completed a Licensed Practical Nursing (LPN) Program, and had taken and passed the LPN licensure exam. Work experience in the field of nursing ranged from 0 (zero) to 20 years.

There were twenty-six subjects in the study; these 26 students comprised the entire ADN student population at SWCC. They ranged in age from 19 to 60 years. The population consisted of 25 females and 1 male. Southwestern Community College is situated in a rural Iowa town; students lived within approximately 50 miles of Creston. Very few of the students had ever used a computer prior to this experience.

Questions Addressed by the Study

The study addressed the following questions: 1) Will there be a difference in performance on tests of short term retention between students who used the treatment CAI program prior to traditional instruction and students who received no treatment prior to traditional instruction? 2) Will there be a difference in performance on tests of near transfer between students who used the treatment CAI program prior to traditional instruction and students who received no treatment prior to traditional instruction? 3) Will there be a difference in performance on tests of far transfer between students who used the treatment CAI program prior to traditional instruction and students who received no treatment prior to traditional instruction? 4) Will there be a difference in performance on tests of long term retention between students who used the treatment CAI program prior to traditional instruction and students who received no treatment prior to traditional instruction? For the purposes of this study, these questions were stated as null hypotheses as presented in Chapter 1.

Research Procedures

This study used an experimental design; experimental designs involve comparisons between and among groups to which subjects have been randomly assigned (Mason & Bramble, 1978). Random assignment was used to establish equivalency between the two groups in the study. Since human subjects were used for study purposes, the human subjects committee at Iowa State University was consulted. A copy of the human subjects form approved by the committee can be found in Appendix A.

Each subject in the study signed a consent form. This document gave an explanation of the procedures to be followed in the study, their purposes, an offer to answer any inquiries concerning the procedures, and instruction that the student was free to withdraw from the study at any time without prejudice to him or her on this account. A copy of the informed consent form can be found in Appendix B.

A pretest-posttest control-group design was used. This design is represented as follows (Mason & Bramble, 1978):

R O X O

R O   O

Due to the threat of sensitization of the subjects to the treatment by the pretest, a posttest-only control-group design may be preferred. However, the possibility of study contamination by subjects who already knew the concept to be taught outweighed the threat of sensitization by the pretest. This is due to the fact that the work experience backgrounds of the subjects prior to the start of the ADN program was widely varied; some subjects could have worked in a situation where they were exposed to the concept of acid-base balance on a significant level. These individuals could have scored higher on the post-test due to experience rather than due to the treatment.

All students were given a paper and pencil pretest to assess their knowledge of the concept of acid-base balance in the human body. See Appendix C for a copy of the pretest. Scores on the pretest ranged from 30% to 58%. A nurse who was knowledgeable of 58% of the information on the topic of acid-base balance in the human body would not be considered prepared to function adequately in the hospital setting. All subjects were included in the study on the basis of this information. Students were then randomly assigned to one of two groups, the experimental treatment group or the control group.

The treatment group used the experimental CAI program prior to traditional instruction. Students were monitored by this researcher during the computer activity. A number of observations of the experimental group subjects during use of the experimental CAI program were made. The only assistance given to students during use of the program consisted of instructions on use of the computer. The program was booted and loaded for them, and they were given assistance if they experienced difficulty in operation of the computer or the program. Otherwise, they were left to discover the answers to the questions posed in the program on their own. See Appendix D for a copy of the study guide given to students in the experimental group. This study guide presents the problems students were asked to solve through use of the CAI discovery program.

As was discussed in Chapter II of this report, the CAI program was designed as a discovery learning experience. Students had to use their problem solving skills to discover answers to questions posed in the program. Wide variance in problem solving approaches were observed.

In the computer simulation, students were given a normal level of an ingredient in a solution and asked to conduct experiments to determine at what level of this ingredient the pH of the solution became acid and alkaline. Some students proceeded in a very organized fashion, raising the value by one until the pH changed, then lowering the value by one until the pH changed in the opposite direction. Other students made a large jump in either direction, then "backed-up" to find the point at which the change occurred. Other students tried numbers/values in a random fashion.

Following experimentation, the values tried by each student were read back to the student by the computer. During this process, one student exclaimed, "Look, I was trying to find the point at which the pH turned acid, and I just kept going in the wrong direction!" Some students remarked that the CAI program was "easy to work with and fun," while others experienced frustration. Students spent approximately 45 minutes to an hour using the CAI program. All students did find the correct answers to all questions involved with the program during this time.

The control group received only traditional instruction. Both the experimental and control groups received instruction by the same instructor at the same time. The only known difference in the experiences of the groups was the use of the experimental computer program (treatment) prior to traditional instruction by the experimental group.

Following instruction, all subjects completed tests of short-term retention, near transfer, and far transfer. The short-term retention test was designed to examine the subject's knowledge of the concept of acid-base balance in the human body. This test contained 50 items, and was equivalent to the pretest; in fact, it was identical to the pretest with the exception of the acid-base number problems (questions 36 through 50) in which different numbers were substituted for the problems on the retention test. See Appendix E for a copy of the short-term retention test.

The near transfer test was designed to measure the subjects' ability to transfer knowledge from the school centered learning environment to another school centered event. It consisted of ten acid-base word problems. See Appendix F for a copy of the near transfer items.

The far transfer test was designed to measure the subjects' ability to transfer knowledge from the school centered learning environment to the real-world (hospital) setting. Students were taken to the hospital. They were each given a worksheet/test to complete, and assigned five patient's charts to evaluate. Students were asked to assess and analyze the acid-base status of each of the five patients. They had to determine what assessment data were pertinent, and interpret the data accurately. This activity is representative of the expectations of the actual working environment these students will enter upon graduation. See Appendix G for a copy of the far transfer worksheet.

Six weeks following instruction students were given a long term retention test. This test was identical to the short term retention test in order to eliminate questions of the equivalency of the two tests, and to facilitate comparison of scores from the pretest to the short term retention test to the long term retention test.

An attempt was made to ensure the validity of this study. Methods used to control threats to the validity of this study are discussed below.

This researcher administered all pertinent instruction, and administered and scored all tests associated with the study. Therefore, the study was controlled for instrumentation. The study was not effected by selection. Subjects were randomly assigned to the control group and the experimental group, and the scores of the two groups on the pretest were not significantly different.

Student scores on the pretest ranged from 15 to 29 out of 50 possible. The mean score of the control group was 22.692 and the mean score of the experimental group was 22.769. A t-score was calculated on this data to compare the results of these two groups on the pretest. The calculated t-score was -0.048. With $p < .05$, and 24 degrees of freedom, a critical value of ±2.064 was identified. The t-value of -0.048 falls within the range of ±2.064. Therefore, a statistically significant difference between the two groups on the pretest was not found. See Table 1 for details of the comparison.

Table 1. T-test for pretest samples

	Control Group	Experimental Group	T	DF
N	13	13		
Mean	22.692	22.769	-0.048	24

Experimental mortality did not present a problem as all subjects remained in the study for the duration. The study lasted eight weeks, and utilized a control group, therefore, it should have been controlled for threat of maturation.

The study was controlled for reactive effects of experimental arrangements because subjects were observed in both the standard classroom testing situation and in the real-world hospital setting. Also, since the completion of this study, this researcher has been notified by other nursing instructors that students continue to demonstrate ability to solve patient acid-base status problems confronted in the hospital setting.

Subjects were not selected on the basis of suseptibility to the experimental treatment or on the basis of extreme scores on the pretest, in fact, the entire population of students was involved and assignment to groups was made in random fashion. Also, multiple treatment interference should not have occurred as only one treatment was used.

The test items used in this study were taken from various nursing test references. All were written by experts in the field, and answers to these questions were documented in the textbook utilized by the subjects in this study, and in the lecture notes of this researcher. Test items were not formally evaluated for reliability or validity, but were reviewed by content experts prior to being selected for use.

In summary, a pretest-posttest control-group experimental design was used for this study. The internal validity of this design is high (Mason & Bramble, 1978). The question of sensitization of subjects to the post-test by taking the pretest may be asked, indicating that there could have been interaction of testing and the treatment. However, the pretest was indicated due to the widely variable backgrounds of the subjects involved. If this threat to validity were in fact a problem, it would influence generalization (external validity), rather than internal validity. Internal validity was maintained, and internal validity is the crucial question without which the results of the study would not be useful (Mason & Bramble, 1978).

Tests of Significance

Nondirectional null hypotheses were used in this study. T-tests were calculated to determine if statistically significant differences existed between the experimental group and the control group on the tests of retention and transfer. Level of significance was set at .05. Because the hypotheses were nondirectional, the alpha was split between the two tails of the sampling distribution. With a total study population of 26, and therefore, 24 degrees of freedom, in a two-tailed test, the critical value used for this study was ±2.064 according to the t-table in Mason and Bramble (1978).

Limitations of the Study

The population utilized in this study consisted of community college registered nursing students in a rural Iowa setting. The number of subjects was limited by the size of the population--26 total subjects. Subjects ranged in age from 19 to 60, and previous computer experience ranged from no exposure to computers to programming in the language BASIC. Therefore, generalization of the study results to larger populations will have to be made with regard to the population description.

Summary

The CAI program used in this study provided a discovery environment in which students were able to manipulate variables in order to solve problems. The problems presented in the program centered around the acid-base status (pH) of a simulated vial of solution. The program involved the presentation of problems, experimentation by the student, formulation of hypotheses, and testing of these hypotheses.

The subjects in the study were 26 registered nursing students in the Associate Degree Nursing program at Southwestern Community College in Creston, Iowa. The study used a pretest-posttest control-group design, and addressed whether there was a difference between the performance of the control group and the performance of the experimental group in terms of retention and transfer of learning. The two groups were determined equal at the outset of the study in terms of knowledge of the topic of acid-base status.

This chapter provided a description of the treatment CAI program used in the study, the study population, the data analysis measures, and the steps taken in carrying out the research project. Limitations of the study were also presented.

CHAPTER IV: FINDINGS

The findings of this study will be presented and discussed as they relate to the hypotheses of the study presented in Chapter 1. Each of the four hypotheses is presented and relevant findings discussed. The final section of the chapter provides a summary of the study results.

Hypothesis 1

Hypothesis 1 was stated as follows: There will be no difference in performance on tests of short term retention between students who use the treatment CAI program prior to traditional instruction and students who receive no treatment prior to traditional instruction.

Scores on the short term retention test ranged from 32 to 48 out of 50 possible. The mean score for the control group was 39.000 and the mean score for the experimental group was 40.769. Therefore, the experimental group scored 1.769 points higher on the average than the students in the control group.

A t-score was calculated on these data to determine if a statistically significant difference between the scores of the two groups existed. A t-value of −1.006 was calculated. With $p < .05$ and 24 degrees of freedom, a critical value of ±2.064 was identified. The t-value of −1.006 is within the range of ±2.064. Thus, while the students who used the experimental computer program scored an average of 1.769 points higher than those who did not use the program, this was not a statistically significant difference. See Table 2 for the details of this comparison.

Table 2. T-test for short term retention test samples

	Control Group	Experimental Group	T	DF
N	13	13		
Mean	39.000	40.769	-1.006	24

Hypothesis 2

Hypothesis 2 was stated as follows: There will be no difference in performance on tests near transfer between students who use the treatment CAI program prior to traditional instruction and students who receive no treatment prior to traditional instruction.

Scores on the near transfer test ranged from 1 to 10 out of a total of 10 possible. The mean score for the control group was 8.462 and the mean score for the experimental group was 8.615. Therefore, the experimental group scored 0.153 points higher on the average than the students in the control group.

With $p < .05$ and 24 degrees of freedom, a critical value of ±2.064 was identified. The calculated t-value of -0.185 falls within the range of ±2.064. Consequently, while the students who used the experimental computer program scored slightly higher (0.153 points) on the average than those who did not use the program, this was not a statistically significant difference. See Table 3 for the details of this comparison.

Table 3. T-test for near transfer test samples

	Control Group	Experimental Group	T	DF
N	13	13		
Mean	8.462	8.615	-.185	24

Student scores on the near transfer test are presented in Table 4. Each subject's score is presented followed by a frequency distribution of scores. As may be noted from the score distribution, one student in the experimental group scored only 1 point while all other students in this group scored between 8 and 10. This score was not typical of this student. The student scored 36 out of 50 on the short term retention test, 12.5 out of 15 on the far transfer test, and 31 out of 50 on the long term retention test. For interest, a t-value was calculated on the near transfer data with this score thrown out. A t-value of -1.401 was calculated. With $p < 0.5$ and 23 degrees of freedom, a critical value

Table 4. Summary of near transfer test data

	Control Group	Experimental Group
Size of Sample	13	13
Scores		
Subject #1	7	9
Subject #2	10	9
Subject #3	10	10
Subject #4	10	10
Subject #5	10	8
Subject #6	7	9
Subject #7	5	10
Subject #8	10	9
Subject #9	10	1
Subject #10	7	9
Subject #11	8	9
Subject #12	6	10
Subject #13	10	9
Score	Frequency	Frequency
10	7	4
9	0	7
8	1	1
7	3	0
6	1	0
5	1	0
4	0	0
3	0	0
2	0	0
1	0	1

of ± 2.069 was identified. The t-value of -1.401 falls within the range of ±2.069. The results of this comparison are presented in Table 5. The means of the two groups varied from 8.462 for the control group to 9.250 for the experimental group with the one atypical value thrown out, however, this difference still was not statistically significant.

Table 5. T-test for near transfer test--atypical score removed

	Control Group	Experimental Group	T	DF
N	13	12		
Mean	8.462	9.250	-1.401	23

A contingency table was established for crosstabular analysis of this data, and is presented in Table 6. As can be determined from the table, 92.3% of the experimental group scored between 8 and 10 out of a total possible on the near transfer test of 10, while only 61.5% of the control group scored in this same range. Also, 38.5% of the control group scored between 5 and 7 while no one in the experimental group scored in this range. In addition, 7.7% of the experimental group scored between 1 and 4 while no one in the control group scored in this range. As can be seen from this data, a higher percent of the experimental group scored in the range of 8 to 10 than did the control group. Also, 96% of the total population scored 5 or above, while one student scored only 1 point on the test.

Table 6. Contingency table--near transfer data

	Score range 1 - 4	5 - 7	8 - 10	Total
Control group	0 (0%)	5 (38.5%)	8 (61.5%)	13 100%
Experimental group	1 (7.7%)	0 (0%)	12 (92.3%)	13 100%

Hypothesis 3

Hypothesis 3 was stated as follows: There will be no difference in performance on tests far transfer between students who use the treatment CAI program prior to traditional instruction and students who receive no treatment prior to traditional instruction.

Student scores on the far transfer test ranged from 11.5 to 15 out of a total of 15 possible. The mean score for the control group was 13.808 and the mean score for the experimental group was 13.885; the experimental group scored 0.077 points higher on the average than the students in the control group.

A t-value of -0.184 was calculated on these data. With $\underline{p} < .05$ and 24 degrees of freedom, a critical value of ±2.064 was identified. While the students who used the experimental computer program scored slightly higher (0.077 points) on the average than those who did not use the program, this was not a statistically significant difference. See Table 7 for the details of this comparison.

Table 7. T-test for far transfer test samples

	Control Group	Experimental Group	T	DF
N	13	13		
Mean	13.808	13.885	-.184	24

Hypothesis 4

Hypothesis 4 was stated as follows: There will be no difference in performance on tests of long term retention between students who use the treatment CAI program prior to traditional instruction and students who receive no treatment prior to traditional instruction.

Control group scores ranged from 20 to 44 out of a total of 50 possible on the long term retention test. Experimental group scores ranged from 31 to 45 out of a total of 50 possible. The mean score for the control group was 33.846 and the mean score for the experimental group was 36.769. Therefore, the experimental group scored 2.923 points higher on the average than the students in the control group.

A t-value of -1.319 was calculated on these data. With $p < .05$ and 24 degrees of freedom, a critical value of ±2.064 was identified. Thus, while the students who used the experimental computer program scored an average of 2.923 points higher than those who did not use the program, this was not a statistically significant difference. See Table 8 for the details of this comparison.

Table 8. T-test for long term retention test samples

	Control Group	Experimental Group	T	DF
N	13	13		
Mean	33.846	36.769	-1.319	24

Long Term Transfer

Student scores on the near and far transfer tests administered within four days following instruction were relatively high. Therefore, for interest of analysis, two questions were added to the near transfer test and it was repeated six weeks following instruction at the time of the long term retention test. See Appendix H for a copy of the long term transfer test.

Scores on this test ranged from 0 to 11 out of a total of 12 possible in both the control and the experimental groups. The mean score for the control group was 7.962 and the mean score for the experimental group was 8.346. Therefore, the experimental group who used the experiencing computer program prior to traditional instruction scored 0.384 points higher on the average than the students in the control group who did not use the experimental computer program.

A t-score was calculated on these data to determine if a statistically significant difference between the scores of the two groups existed. A t-value of -0.316 was calculated. With $p < .05$ and 24 degrees of freedom, a critical value of ±2.064 was identified. The t-value of -0.316 falls within the range of ±2.064. With the addition of two questions to the near transfer test, and the elapse of six weeks between administrations, student's scores were not as high. None of the students scored 100% on the test. However, no significant difference between the groups was found. The details of this comparison are presented in Table 9.

Table 9. T-test for long term transfer test samples

	Control Group	Experimental Group	T	DF
N	13	13		
Mean	7.962	8.346	-0.316	24

Summary

Each of the hypotheses established for this study have been addressed, and results of the statistical analysis measures employed have been presented. While the subjects in the experimental group scored higher than the subjects in the control group on all tests used in the study, these positive effects were not found to be statistically significant. Therefore, the four null hypotheses stated in this study were accepted.

On the test of short term retention the mean score for the experimental group was 40.769 while the mean score for the control group was 39.000. This indicated that the subjects in the experimental group scored an average of 1.769 points higher than the subjects in the control group. However, the t-score calculated on the sample data was not statistically significant. Consequently, a statistically significant difference in performance on tests of short term retention between students who used the treatment CAI program prior to traditional instruction and students who received no treatment prior to traditional instruction was not found.

While all subjects in this study scored in the upper 40% of the score range on the short term retention test, students were not chosed for this study on the basis of extreme scores. Post-test scores for a group of nursing students in the second semester of their final year would be expected to be in the upper 40% of the scale. This is due to the fact that students in this program must maintain a C grade or above in each nursing course to be able to continue in the program. Students who would typically fall at the lower end of the grading scale have been dropped from the program. This policy is consistent throughout nursing education programs. Hence, this finding would not be atypical of nursing students in other programs throughout the states.

On the test of near transfer the mean score for the experimental group was 8.615 while the mean score for the control group was 8.462. This indicated that the subjects in the experimental group scored an average of 0.153 points higher than the subjects in the control group. The difference between the scores of the two groups on this test was very slight, and the t-score calculated on the sample data fell within the acceptable range. Therefore, a statistically significant difference in performance on tests of near transfer between students who used the treatment CAI program prior to traditional instruction and students who received no treatment prior to traditional instruction was not found.

On the test of far transfer the mean score for the experimental group was 13.885 while the mean score for the control group was 13.808. This indicated that the subjects in the experimental group scored an average of 0.077 points higher than the subjects in the control group. The difference between the scores of the two groups on this test was again very slight, and the t-score calculated on the sample data fell within the acceptable range. As a result, a statistically significant difference in performance on tests of far transfer between students who used the treatment CAI program prior to traditional instruction and students who received no treatment prior to traditional instruction was not found.

On the test of long term retention the mean score for the experimental group was 33.846 while the mean score for the control group was 36.769. This indicated that the subjects in the experimental group scored an average of 2.923 points higher than the subjects in the control group. While a positive effect of the experimental treatment can be noted, the t-score calculated on the sample data fell within the acceptable range. Therefore, a statistically significant difference in performance on tests of long term retention between students who used the treatment CAI program prior to traditional instruction and students who received no treatment prior to traditional instruction was not found.

The control group and the experimental group were considered equivalent at the outset of this study. Their scores on the pretest were nearly identical, and no statistically significant difference existed. Their experiences through the duration of this study were controlled, and the only known difference between the groups was the use of the experimental CAI program by the experimental group. Yet, members of the experimental group scored higher on each test administered following instruction. The differences between the two groups increased in favor of the experimental group on the tests administered six weeks following instruction. For example, there was only a 1.769 point difference between the groups on the test of short term retention, while this difference increased to 2.923 on the test of long term retention. Therefore, while a small positive influence of the treatment was demonstrated, a statistically significant difference between the two groups was not found on any of the evaluation measures employed.

CHAPTER V: SUMMARY, CONCLUSIONS, AND IMPLICATIONS

As stated in the definition of the problem, integration of the computer into the educational system has been a slow process. This is due in part to deficiences in educational software, and lack of empirical evidence that computers can be used in ways that create unique positive contributions to learning. As each new medium of communication is introduced, it begins its life by first adopting the contents and formats of the media it is likely to replace or modify (Saloman & Gardner, 1986). In order for computers to make a truely positive influence on education, and to be heralded as a powerful educational tool, unique uses of the computer must be documented. Studies must be conducted which document computer treatments that can be better implemented by use of the computer than by any other known means, and the positive results of these uses must be verified.

This chapter presents a summary of the purpose of this study, a brief outline of the research design features, a list of the major findings, an outline of the conclusions relative to these findings, and discussion of the implications of the study. The information presented in this chapter provides a brief summarization of the study, and suggestions for further research.

Purpose of the Study

The purpose of this study was to investigate the effects of a computer assisted educational program designed to provide a unique experience for learners on retention and transfer of learning. The study was based upon the belief that computers themselves do not affect learners in any direct way, rather, it is the way they are used in instruction that is important.

The treatment administered in this study via the experimental CAI program could not have been administered in as efficient a manner, if at all, by other means. The treatment program provided a simulation experience in which subjects were able to conduct lab experiments to discover the solutions to problems. The program was designed upon the principles of discovery learning, meaningful learning, and transfer of learning. These principles were combined in a microworld program which was presented in the experiencing mode. In other words, it was administered prior to traditional instruction to set the cognitive stage for later learning.

Study Design

A pretest-posttest control-group design was used. The population consisted of twenty-six registered nursing students enrolled in community college Associate Degree Nursing program in rural southwest Iowa. Subjects were randomly assigned to the control group and the experimental group. All subjects were given a pretest to determine that they did not already possess the information to be learned in the study. The CAI program was administered to the experimental group prior to traditional instruction. This program did not present the information to be later covered in the classroom setting, rather, it provided information which was not content specific to the new information to be learned. Following this activity, both groups received traditional instruction on the subject of acid-base balance in the human body. The concepts formed during use of the treatment program were to provide students with relevant prior knowledge needed to learn the new concept, not to present the information itself. The study was not to simply compare the results of presenting the same information via the computer as without the computer; instead, it was to study the effects of using the computer in a unique manner to prepare the subject for learning later information.

Major Findings

Based upon pretest scores, the subjects in this study were considered to be equivalent in terms of knowledge of the concept of acid-base balance in the human body prior to the study. Though subjects were determined to be equivalent prior to the study, subjects in the experimental group scored higher on all measures employed following the experiment. The experimental group scored higher on the test of short term transfer, slightly higher on the test of near transfer, slightly higher on the test of far transfer, and higher on the test of long term transfer. Table 10 presents a comparison of the mean scores of the control group and the experimental group on all measures employed.

Table 10. Comparison of mean scores on tests used in the study

Test	Control Group Mean Score	Experimental Group Mean Score	Mean Score Difference
Pretest	22.692	22.769	0.077
Short Term Retention	39.000	40.769	1.769
Near Transfer	8.462	8.615	0.153
Far Transfer	13.808	13.885	0.077
Long Term Retention	33.846	36.769	2.923

While the mean score for the experimental group is higher in each instance, the calculated t-score for each test comparing the scores of the two groups did not demonstrate a statistically significant difference between the two groups on any of the measures. The study involved a small sample size (13 in each group and a total study population of 26), therefore, while a statistically significant difference between groups was not demonstrated, a positive trend was identified. If this study were repeated with a larger population, the differences between groups could be more definitive. As a result of these findings, the null hypotheses of the study were accepted. There was no statistically significant difference between students who used the treatment CAI program prior to traditional instruction and students who received no treatment prior to traditional instruction on measures of short term retention, near transfer, far transfer, or long term retention.

Conclusions

The following conclusions can be drawn on the basis of the results of this study. Computers can be utilized as vehicles for presentation of advance organizers. They can be utilized to present information in a unique manner which could not be accomplished as effectively or as efficiently by other means. The treatment CAI program in this study used a discovery approach. It required use of investigative problem solving skills. The student was able to manipulate variables, observe the results of these manipulations, form hypotheses, and make generalizations from the information gained. Instructional activities of this nature exploit some of the unique potential of computers; it is this type of innovative approach to integration of the computer into curriculum that will contribute to the transformation of education through technology in the "transitional phase" of educational computing proposed by Berg and Bramble (1983) and discussed in Chapter 1 of this paper.

When used for activities of the nature described here, small positive effects can be observed on measures of retention and transfer of learning. It may also be concluded on the basis of this study that these positive effects are increased as time elapses between instruction and testing measures. Six weeks following instruction the difference in the mean score on the retention test increased from 1.769 to 2.923 in favor of the experimental group. Also, the difference in the mean score on the transfer test administered at that time increased from 0.153 to 0.384 in favor of the experimental group.

Though these effects may not individually be statistically significant as demonstrated on t-test comparison, the fact that the experimental group demonstrated small positive effects on all tests administered following treatment represents a consistency in effect significant enough to warrant future investigation. In addition, these results may be significant to students. The population studied in this project consisted of registered nursing students near the completion of their education. These students are highly motivated to succeed. Success for them means maintaining an adequate grade point average during school, and ability to pass a state licensure exam. If given the option to use a computer program prior to instruction that could improve their long term retention of subject matter by approximately 6%, or improve their test score by approximately 3 points, a student might conclude that use of the program would be of value to them.

Implications

The independent variable in this study, the experimental CAI program, possessed a whole complex of attributes. In fact, it involved a whole new instructional environment/microworld designed by this researcher specifically for the subjects in the study. The study compared the use of the program/treatment versus no treatment. Studies of this nature must be conducted to determine if positive outcomes result from this type of activity, then each attribute of the treatment must be evaluated to determine what specific variables within the treatment make a difference. This can be done through the process of eliminating variables to determine which are crucial to the positive influences of the computer activity.

This study provides evidence of a positive influence of the use of CAI on retention and transfer of learning. The positive effects of the experimental treatment on retention of learning appeared to increase as time elapsed following instruction. It would be interesting to continue to make periodic measurements to determine if this positive effect continues and/or increases further as additional time elapses. With small sample size, such as in this study, only large differences in the means of the two groups will produce statistical significance, while with large samples, small differences between means will produce significant t-values. Similar studies should be conducted with larger populations containing more equal distribution of males and females, learners ranging in ability from low to high, and with populations of less variable age range.

Each individual brings unique characteristics to any learning encounter. Individuals mold their own experiences by the traits and goals they bring to the encounter, the way they apprehend the technology and the situation and the choices they make; these differences in individuals influence the way learners are affected by the experience, particularly when given interactive opportunities with computers (Saloman & Gardner, 1986). Studies to determine the influence of individual differences between learners on the results of this study could be conducted. Some of the individual differences which could be studied include: preferred learning style, hemisphericity, and attitude towards computers.

Computers themselves do not affect learners in any direct way, it is the way they are used in instruction that is important. Strict attention must be given to the type of instructional applications being made with computers. Educational software must be built upon established principles of learning, and the objectives for computer use must be clearly stated and measureable. Integration of the computer into curriculum must be a well-planned process, and teachers must be provided with first-hand computer experience. It is not realistic to expect teachers to make unique valuable educational applications of the computer without instruction, guidance, and planning.

Future studies must be specific in describing the objectives of the specific use of the computer being made in the study, and in explaining the instructional approach to its use. Studies must differentiate between types of CAI to aid in determination of what characteristics of computer use are being evaluated. Research must be explicit in describing what characteristics of computer use are being evaluated before the effects of this use can be explained in a meaningful way, and before appropriate generalizations can be made.

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APPENDIX A. HUMAN SUBJECTS FORM

INFORMATION ON THE USE OF HUMAN SUBJECTS IN RESEARCH
IOWA STATE UNIVERSITY
(Please follow the accompanying instructions for completing this form.)

1. Title of project (please type): Effects of Computer Assisted Instruction Used in an Experiencing Mode Prior to Traditional Instruction On Retention and Transfer of Information

2. I agree to provide the proper surveillance of this project to insure that the rights and welfare of the human subjects are properly protected. Additions to or changes in procedures affecting the subjects after the project has been approved will be submitted to the committee for review.

Barbara Jo Crittenden	12/14/85	
Typed Named of Principal Investigator	Date	Signature of Principal Investigator

R.R. #2 Box 166-a Creston, Ia.	(515) 782-7081 or 782-8878
Home ~~Campus~~ Address	~~Campus~~ Telephone

3. Signatures of others (if any) | Date | Relationship to Principal Investigator

Major Professor

4. ATTACH an additional page(s) (A) describing your proposed research and (B) the subjects to be used, (C) indicating any risks or discomforts to the subjects and (D) covering any topics checked below. CHECK all boxes applicable.

- [ ] Medical clearance necessary before subjects can participate
- [ ] Samples (blood, tissue, etc.) from subjects
- [ ] Administration of substances (foods, drugs, etc.) to subjects
- [ ] Physical exercise or conditioning for subjects
- [ ] Deception of subjects
- [ ] Subjects under 14 years of age and(or) [ ] Subjects 14-17 years of age
- [ ] Subjects in institutions
- [ ] Research must be approved by another institution or agency

5. ATTACH an example of the material to be used to obtain informed consent and CHECK which type will be used.

- [x] Signed informed consent will be obtained.
- [ ] Modified informed consent will be obtained.

6.

	Month	Day	Year
Anticipated date on which subjects will be first contacted:	Jan.	10	86
Anticipated date for last contact with subjects:	May	7	86

7. If Applicable: Anticipated date on which audio or visual tapes will be erased and(or) identifiers will be removed from completed survey instruments:

May	7	86
Month	Day	Year

8. Major Chairperson | Date | Department or Administrative Unit

12/18/85 Prof Studies

9. University Committee on the Use of Human Subjects in Research:

- [x] Project Approved
- [ ] Project not approved
- [ ] No action required

George G. Karas	1/6/86	
Name of Committee Chairperson	Date	Signature of Committee Chairperson

APPENDIX B. CONSENT FORM

CONSENT FORM

I, ______________________________, a student in the RN 275 Comprehensive Nursing Course have been informed that during the unit of instruction on acid-base balance in the human body, as part of the Comprehensive Nursing Course, students will be divided into two groups at random. The students in one group will use a computer assisted instruction program prior to traditional instruction on the topic of acid-base balance. The other group will receive only traditional instruction on the topic of acid-base balance. The only difference in the way the two groups will be instructed is the use of the computer assisted instruction program by one group.

I understand that I will be randomly assigned to one of the two groups. I will take a pretest, and two post-tests; the performance of the students in the two groups will be compared to determine if there is any significant difference in the performance of the two groups on these tests. Being involved in this activity will in no way increase the ordinary risks of daily living, and the study will determine if there are any significant benefits to use of the computer assisted instructional program.

I have been informed that this study is being conducted in order for the researcher to fulfill advanced degee requirements at Iowa State University. I grant permission to include my scores on the tests associated with this study in the data analysis measures. I have been informed that my name will not appear in any printed reports associated with this study, and that every effort will be made to keep my personal data confidential. Furthermore, I understand that I am free to withdraw my consent for inclusion of my scores in data analysis associated with this project, or to discontinue participation in the computer activity associated with this project at any time during the course of the project without prejudice against me on this account.

______________________________ ______________________

Signature Date

Any inquires regarding this project should be directed to:

Barb Crittenden
Southwestern Community College
1501 W. Townline
Creston, Iowa 50801
(515) 782-7081

APPENDIX C. PRETEST

PRETEST

Acid-Base Balance in the Human Body
Southwestern Community College: Nursing Education

This is a test to determine your current level of understanding of acid-base balance in the human body. The results of this test will not be used to determine your grade for this unit, they will provide a means of comparing your knowledge of this topic before instruction to your knowledge of this topic following instruction. Read each question carefully. There is only one best answer for each question.

Questions 1 - 3 are true-false. Read each statement carefully, indicate on the line to the left of the statement a 'T' if the statement is true or an 'F' if the statement if not true.

1. ______ Arterial blood is neutral--it is neither acidic nor alkaline.

2. ______ Hyperventilation causes a decrease in the carbonic acid level in the blood.

3. ______ A major goal of therapy for a patient with respiratory acidosis is to slow the rate and depth of breathing.

Questions 4 - 34 are multiple choice. Choose the one best answer for each question. Circle your answer.

4. The largest buffer system in the body is the:

   A. bicarbonate-carbonic acid system.
   B. phosphate system.
   C. plasma protein system.
   D. ammonia system.

5. When an increase in body acid is balanced by a proportionate increase in base, the pH returns to normal. This process is called:

   A. assimilation
   B. accommodation
   C. compensation
   D. congruency

6. The only way to confirm the presence of an acid base disturbance is by:

   A. leukocyte differential analysis.
   B. arterial blood gas analysis.
   C. a complete blood count.
   D. autopsy.

7. Mr. DeNapoli is to have a specimen taken for blood gas analysis. The nurse should:

   A. mix the obtained specimen with an equal amount of air.
   B. administer heparin to the patient immediately before obtaining the sample.
   C. apply a face mask with 40% oxygen prior to obtaining the sample.
   D. apply firm pressure to the puncture site after obtaining the specimen.

8. An elevated pH along with a decreased pCO_2 is indicative of:

   A. metabolic acidosis
   B. metabolic alkalosis
   C. respiratory acidosis
   D. respiratory alkalosis

9. Ms. Donnelly is brought into the emergency room in severe shock after being shot in the thigh. The disturbance she will exhibit is:

   A. metabolic acidosis
   B. metabolic alkalosis
   C. respiratory acidosis
   D. respiratory alkalosis

10. Which of the following patients is at risk for developing metabolic alkalosis? One who:

   A. is a diabetic and has omitted several doses of insulin.
   B. is undergoing gastrointestinal suctioning.
   C. has overdoses on aspirin.
   D. has diarrhea.

11. Mrs. Daniels is pregnant with her first child and has started labor. She has had no preparation and is extremely frightened. She is a risk to develop:

    A. metabolic acidosis
    B. metabolic alkalosis
    C. respiratory acidosis
    D. respiratory alkalosis

12. Which of the following blood buffers is regulated by both the kidneys and the lungs?

    A. bicarbonate
    B. protein
    C. phosphate
    D. hemoglobin

Isaac is 63 years old and has been admitted to the hospital with a diagnosis of diabetes mellitus. On admission, the nurse observes rapid respirations, confusion, and signs of dehydration.

13. Considering Isaac's diagnosis and symptoms, he is most prone to which of the following acid-base disturbances?

    A. metabolic acidosis
    B. metabolic alkalosis
    C. respiratory acidosis
    D. respiratory alkalosis

14. A manifestation <u>not</u> associated with altered acid-base balance would be:

    A. bradycardia
    B. hypertension
    C. lethargy
    D. tachypnea

15. In terms of a cellular buffering response, the nurse should expect that the major electrolyte disturbance would be:

   A. hyperkalemia
   B. hypernatremia
   C. hypocalcemia
   D. hypokalemia

Judy is a 55 year old woman with a ten year history of chronic obstructive pulmonary disease. She came to the emergency room with symptoms of severe headache and blurred vision. Her respirations on admission were 60 per minute and shallow in nature.

16. Considering Judy's diagnosis of COPD, she is most likely to manifest what acid-base imbalance?

   A. metabolic acidosis
   B. metabolic alkalosis
   C. respiratory acidosis
   D. respiratory alkalosis

17. The nurse would initially instruct Judy to:

   A. breathe deeper and alter her rate to 30 breaths per minute.
   B. hold ber breath for 30 seconds, every 5 minutes.
   C. hypoventilate by increasing the rate of her respirations.
   D. maintain shallow lung expansion.

18. Judy needs supplemental oxygen via nasal cannula because of an associated hypoxemia. The nurse should adjust the liter flow to:

   A. 2 to 3 liters/minute
   B. 4 to 5 liters/minute
   C. 6 to 7 liters/minute
   D. 8 to 9 liters/minute

19. Chemoreceptors in the carotid bodies in the neck and aortic arch influence respiration because they are sensitive to blood levels of:

   A. oxygen
   B. uric acid
   C. bicarbonates
   D. carbon dioxide

20. During respirations, the exchange of oxygen and carbon dioxide in the alveoli occurs by the process of:

A. osmosis
B. dialysis
C. filtration
D. diffusion

21. The nurse studies the blood pH of one of her patients. The pH is within normal range when the ratio of HCO_3 to CO_2 is approximately:

A. 1 to 1
B. 5 to 1
C. 10 to 1
D. 20 to 1

22. Which one of the following blood findings should the nurse judge as typical for a patient who has metabolic acidosis?

A. an increased bicarbonate content
B. a decreased bicarbonate content
C. an increased carbon dioxide content
D. a decreased carbon dioxide content

23. The body's normal buffering system, which maintains an acid-base balance, is geared toward either taking up or releasing the ion:

A. sodium
B. oxygen
C. hydrogen
D. potassuim

24. The normal range for the pH of arterial blood is between:

A. 7.12 and 7.22
B. 7.22 and 7.32
C. 7.38 and 7.42
D. 7.42 and 7.52

25. Respiratory acidosis can be caused by:

    1. chronic obstructive pulmonary disease
    2. vomiting
    3. pregnancy
    4. hypoventilation

    A. 1
    B. 1, 3
    C. 1, 4
    D. 1, 2, 4

26. Saliva is a nearly neutral solution. This means that it has a pH of:

    A. 4
    B. 7
    C. 9
    D. 12

27. Which of the following act as buffering systems in the blood?

    A. carbonic acid-sodium bicarbonate
    B. phosphates
    C. proteins
    D. A, B
    E. A, B, C

28. Which of the following statements concerning pCO_2 are correct?

    A. decreased ventilation results in increased pCO2.
    B. the higher the pCO2 the lower the pH.
    C. pCO2 is controlled by the lungs.
    D. all of the above.

29. Which of the following statements concerning HCO_3 are correct?

    A. may be considered acid
    B. is controlled by the kidneys
    C. may be considered base
    D. A, B
    E. B, C

30. Which of the following are signs of metabolic acidosis?

   A. hyperreflexia, paresthesias, and tetany.
   B. giddiness, irregular respiratory pattern, and moist, cool skin.
   C. muscle weakness and numbness and tingling in the extremities.
   D. lethargy, disorientation, and increased rate and depth of respirations.

31. Ms. Modigan is hyperventilating. She is likely to develop:

1.	tetany	A.	1, 2, 3
2.	convulsions	B.	1, 2, 4
3.	increased pH	C.	1, 2, 3, 5
4.	decreased pH	D.	1, 2, 4, 5
5.	pCO_2 decreased		

Questions 32 - 35 relate to the following arterial blood findings:

pH 7.20
pCO_2 40 mm Hg.
HCO_3 13.5 mEq per liter

Indicate as the correct answer the letter:
A if the statement is supported by laboratory findings.
B if the statement is not supported by laboratory findings.
C if the statement is neither suported nor contradicted by laboratory findings.

32. ______ The pCO_2 is lower than normal.

33. ______ The HCO_3 is lower than normal.

34. ______ The patient is in great need of oxygen.

35. ______ The patient is in a state of metabolic acidosis.

Questions 36 - 50 are arterial blood gas problems. Evaluate each set of lab values. On the line to the right of the values indicate whether the values indicate the acid-base status is: normal, metabolic acidosis, metabolic alkalosis, respiratory acidosis, or respiratory alkalosis. Also, indicate whether the situation is compensated or uncompensated.

36. pH 7.20 ______________________________
pC02 65
HC03 24

37. pH 7.60 ______________________________
pC02 40
HC03 39

38. pH 7.50 ______________________________
pC02 40
HC03 42

39. pH 7.55 ______________________________
pC02 25
HC03 24

40. pH 7.40 ______________________________
pC02 70
HC03 41

41. pH 7.38 ______________________________
pC02 23
HC03 13

42. pH 7.49 ______________________________
pC02 40
HC03 27

43. pH 7.30 ______________________________
pC02 39
HC03 17

44. pH 7.24 ____________________
pCO2 38
HCO3 15

45. pH 7.25 ____________________
pCO2 48
HCO3 24

46. pH 7.47 ____________________
pCO2 25
HCO3 25

47. pH 7.46 ____________________
pCO2 40
HCO3 36

48. pH 7.42 ____________________
pCO2 50
HCO3 30

49. pH 7.38 ____________________
pCO2 31
HCO3 19

50. pH 7.60 ____________________
pCO2 23
HCO3 24

APPENDIX D. STUDY GUIDE

STUDY GUIDE: ACID-BASE MICROWORLD

After using this microworld program the student will be able to:

1. Given a simulated solution, explain the effect of adding acid to a solution on the pH of the solution.

2. Given a simulated solution, explain the effect of adding alkali to the solution on the pH of the solution.

3. Given the name of an ingredient in a solution, explain the concept of "normal range" of that ingredient.

4. Given the level of acid and base in a solution, predict whether the pH of the solution will be acid, alkaline, or neutral/normal.

5. Define the term compensation in relation to acid-base status.

6. Given two ingredients, one acid and one base, summarize the process of compensation to neutralize the pH.

Instructions for program use:

1. Boot the Apple Logo II disk.
2. Remove the Apple Logo II disk, and place the program disk in drive 1.
3. Type the following command: SETPREFIX "/CRITT/
4. Press return.
5. Type LOAD "MICROWORLD
6. Press return.
7. Type START.HERE
8. Press return. The program will begin following this step. Follow the directions on the screen.

Study Guide Questions:

Section 1 (ASO2):

1. What is the normal range for ASO2?

2. At what level of AS02 does the pH of the solution become acid?

3. At what level of AS02 does the pH of the solution become alkaline?

After testing your responses to these questions on the computer, you may wish to alter your responses above.

Section 2 (BD03):

1. What is the normal range of BD03?

2. At what level of BD03 does the pH of the solution become acid?

3. At what level of BD03 does the pH of the solution become alkaline?

After testing your responses to these questions on the computer, you may wish to alter your responses above.

Section 3 (Compensation):

1. If the amount of AS02 in the solution is elevated and the pH of the solution is acid, what would you need to do to the level of BD03 in order to bring the pH of the solution back to normal?

2. If the amount of ASO2 in the solution is decreased and the pH of the solution is alkaline, what would you need to do to the level of BDO3 in order to bring the pH of the solution back to normal?

3. If the amount of BDO3 in the solution is increased and the pH of the solution is alkaline, what would you need to do to the level of ASO2 in order to bring the pH of the solution back to normal?

4. If the amount of BDO3 in the solution is decreased and the pH of the solution is acid, what would you need to do to the level of ASO2 in order to bring the pH of the solution back to normal?

To test your answers to these four questions on the computer, follow these examples:

If you answered question number one that you would decrease the level of BDO3 to compensate for a high level of ASO2, you would try a high level of acid and a low level of base and observe the results. For example, you might type: ACID 60 "BASE 12.

If you answered question number one that you would increase the level of BDO3 to compensate for a high level of ASO2, you would try a high level of acid and a high level of base and observe the results. For example, you might type: ACID 60 "BASE 42.

You must use <u>this exact format for testing answers</u>:
'ACID' 'amount' '"BASE' 'amount'

Do this for each question. After testing your responses to these questions on the computer, you may wish to change your answers accordingly.

APPENDIX E. SHORT TERM RETENTION TEST

SHORT TERM RETENTION TEST

Acid-Base Balance in the Human Body
Southwestern Community College: Nursing Education

Read each question carefully. There is only one best answer for each question.

Questions 1 - 3 are true-false. Read each statement carefully, indicate on the line to the left of the statement a 'T' if the statement is true or an 'F' if the statement if not true.

1. ______ Arterial blood is neutral--it is neither acidic nor alkaline.

2. ______ Hyperventilation causes a decrease in the carbonic acid level in the blood.

3. ______ A major goal of therapy for a patient with respiratory acidosis is to slow the rate and depth of breathing.

Questions 4 - 34 are multiple choice. Choose the one best answer for each question. Circle your answer.

4. The largest buffer system in the body is the:

   A. bicarbonate-carbonic acid system.
   B. phosphate system.
   C. plasma protein system.
   D. ammonia system.

5. When an increase in body acid is balanced by a proportionate increase in base, the pH returns to normal. This process is called:

   A. assimilation
   B. accommodation
   C. compensation
   D. congruency

6. The only way to confirm the presence of an acid base disturbance is by:

   A. leukocyte differential analysis.
   B. arterial blood gas analysis.
   C. a complete blood count.
   D. autopsy.

7. Mr. DeNapoli is to have a specimen taken for blood gas analysis. The nurse should:

   A. mix the obtained specimen with an equal amount of air.
   B. administer heparin to the patient immediately before obtaining the sample.
   C. apply a face mask with 40% oxygen prior to obtaining the sample.
   D. apply firm pressure to the puncture site after obtaining the specimen.

8. An elevated pH along with a decreased pCO_2 is indicative of:

   A. metabolic acidosis
   B. metabolic alkalosis
   C. respiratory acidosis
   D. respiratory alkalosis

9. Ms. Donnelly is brought into the emergency room in severe shock after being shot in the thigh. The disturbance she will exhibit is:

   A. metabolic acidosis
   B. metabolic alkalosis
   C. respiratory acidosis
   D. respiratory alkalosis

10. Which of the following patients is at risk for developing metabolic alkalosis? One who:

    A. is a diabetic and has omitted several doses of insulin.
    B. is undergoing gastrointestinal suctioning.
    C. has overdoses on aspirin.
    D. has diarrhea.

11. Mrs. Daniels is pregnant with her first child and has started labor. She has had no preparation and is extremely frightened. She is a risk to develop:

    A. metabolic acidosis
    B. metabolic alkalosis
    C. respiratory acidosis
    D. respiratory alkalosis

12. Which of the following blood buffers is regulated by both the kidneys and the lungs?

    A. bicarbonate
    B. protein
    C. phosphate
    D. hemoglobin

Isaac is 63 years old and has been admitted to the hospital with a diagnosis of diabetes mellitus. On admission, the nurse observes rapid respirations, confusion, and signs of dehydration.

13. Considering Isaac's diagnosis and symptoms, he is most prone to which of the following acid-base disturbances?

    A. metabolic acidosis
    B. metabolic alkalosis
    C. respiratory acidosis
    D. respiratory alkalosis

14. A manifestation <u>not</u> associated with altered acid-base balance would be:

    A. bradycardia
    B. hypertension
    C. lethargy
    D. tachypnea

15. In terms of a cellular buffering response, the nurse should expect that the major electrolyte disturbance would be:

   A. hyperkalemia
   B. hypernatremia
   C. hypocalcemia
   D. hypokalemia

Judy is a 55 year old woman with a ten year history of chronic obstructive pulmonary disease. She came to the emergency room with symptoms of severe headache and blurred vision. Her respirations on admission were 60 per minute and shallow in nature.

16. Considering Judy's diagnosis of COPD, she is most likely to manifest what acid-base imbalance?

   A. metabolic acidosis
   B. metabolic alkalosis
   C. respiratory acidosis
   D. respiratory alkalosis

17. The nurse would initially instruct Judy to:

   A. breathe deeper and alter her rate to 30 breaths per minute.
   B. hold ber breath for 30 seconds, every 5 minutes.
   C. hypoventilate by increasing the rate of her respirations.
   D. maintain shallow lung expansion.

18. Judy needs supplemental oxygen via nasal cannula because of an associated hypoxemia. The nurse should adjust the liter flow to:

   A. 2 to 3 liters/minute
   B. 4 to 5 liters/minute
   C. 6 to 7 liters/minute
   D. 8 to 9 liters/minute

19. Chemoreceptors in the carotid bodies in the neck and aortic arch influence respiration because they are sensitive to blood levels of:

   A. oxygen
   B. uric acid
   C. bicarbonates
   D. carbon dioxide

20. During respirations, the exchange of oxygen and carbon dioxide in the alveoli occurs by the process of:

A. osmosis
B. dialysis
C. filtration
D. diffusion

21. The nurse studies the blood pH of one of her patients. The pH is within normal range when the ratio of HCO_3 to CO_2 is approximately:

A. 1 to 1
B. 5 to 1
C. 10 to 1
D. 20 to 1

22. Which one of the following blood findings should the nurse judge as typical for a patient who has metabolic acidosis?

A. an increased bicarbonate content
B. a decreased bicarbonate content
C. an increased carbon dioxide content
D. a decreased carbon dioxide content

23. The body's normal buffering system, which maintains an acid-base balance, is geared toward either taking up or releasing the ion:

A. sodium
B. oxygen
C. hydrogen
D. potassuim

24. The normal range for the pH of arterial blood is between:

A. 7.12 and 7.22
B. 7.22 and 7.32
C. 7.38 and 7.42
D. 7.42 and 7.52

25. Respiratory acidosis can be caused by:

    1. chronic obstructive pulmonary disease
    2. vomiting
    3. pregnancy
    4. hypoventilation

    A. 1
    B. 1, 3
    C. 1, 4
    D. 1, 2, 4

26. Saliva is a nearly neutral solution. This means that it has a pH of:

    A. 4
    B. 7
    C. 9
    D. 12

27. Which of the following act as buffering systems in the blood?

    A. carbonic acid-sodium bicarbonate
    B. phosphates
    C. proteins
    D. A, B
    E. A, B, C

28. Which of the following statements concerning pCO2 are correct?

    A. decreased ventilation results in increased pCO2.
    B. the higher the pCO2 the lower the pH.
    C. pCO2 is controlled by the lungs.
    D. all of the above.

29. Which of the following statements concerning HCO3 are correct?

    A. may be considered acid
    B. is controlled by the kidneys
    C. may be considered base
    D. A, B
    E. B, C

30. Which of the following are signs of metabolic acidosis?

A. hyperreflexia, paresthesias, and tetany.
B. giddiness, irregular respiratory pattern, and moist, cool skin.
C. muscle weakness and numbness and tingling in the extremities.
D. lethargy, disorientation, and increased rate and depth of respirations.

31. Ms. Modigan is hyperventilating. She is likely to develop:

1.	tetany	A.	1, 2, 3
2.	convulsions	B.	1, 2, 4
3.	increased pH	C.	1, 2, 3, 5
4.	decreased pH	D.	1, 2, 4, 5
5.	pCO_2 decreased		

Questions 32 - 35 relate to the following arterial blood findings:

pH 7.20
pCO_2 40 mm Hg.
HCO_3 13.5 mEq per liter

Indicate as the correct answer the letter:
A if the statement is supported by laboratory findings.
B if the statement is not supported by laboratory findings.
C if the statement is neither suported nor contradicted by laboratory findings.

32. ______ The pCO_2 is lower than normal.

33. ______ The HCO_3 is lower than normal.

34. ______ The patient is in great need of oxygen.

35. ______ The patient is in a state of metabolic acidosis.

Questions 36 - 50 are arterial blood gas problems. Evaluate each set of lab values. On the line to the right of the values indicate whether the values indicate the acid-base status is: normal, metabolic acidosis, metabolic alkalosis, respiratory acidosis, or respiratory alkalosis. Also, indicate whether the situation is compensated or uncompensated.

36. pH 7.29 ______________________________
    pCO2 62
    HCO3 24

37. pH 7.49 ______________________________
    pCO2 24
    HCO3 17

38. pH 7.51 ______________________________
    pCO2 40
    HCO3 41

39. pH 7.38 ______________________________
    pCO2 48
    HCO3 34

40. pH 7.32 ______________________________
    pCO2 40
    HCO3 11

41. pH 7.34 ______________________________
    pCO2 32
    HCO3 14

42. pH 7.41 ______________________________
    pCO2 40
    HCO3 24

43. pH 7.30 ______________________________
    pCO2 62
    HCO3 24

44. pH 7.40 ______________________
pCO2 62
HCO3 41

45. pH 7.50 ______________________
pCO2 23
HCO3 17

46. pH 7.25 ______________________
pCO2 60
HCO3 17

47. pH 7.30 ______________________
pCO2 40
HCO3 17

48. pH 7.55 ______________________
pCO2 40
HCO3 32

49. pH 7.50 ______________________
pCO2 50
HCO3 32

50. pH 7.60 ______________________
pCO2 19
HCO3 25

APPENDIX F. NEAR TRANSFER TEST

NEAR TRANSFER TEST

1. A 17-year-old diabetic entered the emergency room with Kussmaul breathing and irregular pulse of 88. Arterial blood gases were drawn with the following results--pH 7.05, pCO_2 12 mm Hg, HCO_3 5 mEq/L. The patient's blood pressure is 110/70.

   What is your interpretation of the acid-base status of this patient?

2. A 66-year-old woman with a history of chronic obstructive pulmonary disease entered the emergency room in obvious pulmonary edema. Room air blood gases were drawn with the following results--pH 7.10, pCO_2 25 mm Hg, HCO_3 8 mEq/L. The patient has a respiratory rate of 32 and a pulse of 100.

   What is your interpretation of the acid-base status of this patient?

3. A 17-year-old girl with severe kyphoscoliosis entered the hospital with pneumonia. Room air blood gases are--pH 7.53, pCO_2 31 mm Hg, HCO_3 25 mEq/L. The Doctor orders oxygen at a rate of 3 liters per minute.

   What is your interpretation of the acid-base status of this patient?

4. A 47-year-old man collapsed on the street and was brought to the emergency room. On admission he was blue, had no palpable pulse, and was making agonal respiratory movements. The patient was successfully resuscitated, and the following blood gases were drawn: pH 7.51, pCO_2 35 mm Hg, HCO_3, 27 mEq/L. The patient has a B/P of 124/88, pulse of 64, and respirations of 64.

   What is your interpretation of the acid-base status of this patient?

5. A 54-year-old woman with a 10-year history of heart failure was taking diuretics regularly. She had a chest cold the last week and experienced progressive shortness of breath. Room air blood gases: pH 7.54, pCO_2 26 mm Hg, HCO_3 22 mEq/L, pO_2 48 mm Hg. Oxygen therapy is ordered.

   What is your interpretation of the acid-base status of this patient?

6. A 47-year-old man without previous illness entered the coronary care unit with an ECG diagnosis of "inferior wall infarct" and severe chest pain. He had received morphine 1/4 grain in the emergency room. The cardiac monitor shows numerous PVC's. Room air blood gases are-- pH 7.51, pCO_2 29 mm Hg, HCO_3 23 mEq/L.

   What is your interpretation of the acid-base status of this patient?

7. A 9-year-old boy with a history of allergic asthma is admitted to the emergency room. He had been placed on penicillin, plus oral bronchodilators, for one week. His mother stated he had not slept in two nights. The child was sitting and was using all accessory muscles to breathe. The wheezes can be heard from across the room. Room air blood gases are: pH 7.46, pCO_2 25 mm Hg, HCO_3 15 mEq/L. The child's respiratory rate is 32.

   What is your interpretation of the acid-base status of this patient?

8. A 24-year-old woman entered the emergency room with a broken ankle. She appeared somewhat disoriented and confused. Room air blood gases were: pH 7.55, pCO_2 27 mm Hg, HCO_3 23 mEq/L. There is little evidence of tissue hypoxia. The patient is in pain and is considerably anxious.

   What is your interpretation of the acid-base status of this patient?

9. A 67-year-old woman was admitted for uncontrolled rectal bleeding of several days duration. Room air blood gases are: pH 7.48, pCO2 28 mm Hg, HCO3 21 mEq/L. Hemoglobin content is 6 gm %, pulse rate is 100, blood pressure is 100/55.

   What is your interpretation of the acid-base status of this patient?

10. A 76-year-old man with a long history of symptomatic chronic obstructive pulmonary disease entered the hospital with basilar pneumonia. Room air blood gases are: pH 7.25, pCO2 49 mm Hg, HCO3 40 mEq/L, pO2 38 mm Hg. He is placed on a nasal cannula at 2 L/minute flow. Vital signs are: B/P 160/98, P 78, R 20.

    What is your interpretation of the acid-base status of this patient?

APPENDIX G. FAR TRANSFER WORKSHEET

FAR TRANSFER WORKSHEET

For each of the five patients assigned, complete the following information.

History: (diagnosis, age, etc.)	Assessment Data: (lab work, resp. status, etc.)	Acid-Base Status

1. Patient Initials:

2. Patient Initials:

3. Patient Initials:

4. Patient Initials:

5. Patient Initials:

APPENDIX H. LONG TERM TRANSFER TEST

LONG TERM TRANSFER TEST

1. A 17-year-old diabetic entered the emergency room with Kussmaul breathing and irregular pulse of 88. Arterial blood gases were drawn with the following results--pH 7.05, $pCO2$ 12 mm Hg, $HCO3$ 5 mEq/L. The patient's blood pressure is 110/70.

   What is your interpretation of the acid-base status of this patient?

2. A 66-year-old woman with a history of chronic obstructive pulmonary disease entered the emergency room in obvious pulmonary edema. Room air blood gases were drawn with the following results--pH 7.10, $pCO2$ 25 mm Hg, $HCO3$ 8 mEq/L. The patient has a respiratory rate of 32 and a pulse of 100.

   What is your interpretation of the acid-base status of this patient?

3. A 17-year-old girl with severe kyphoscoliosis entered the hospital with pneumonia. Room air blood gases are--pH 7.53, $pCO2$ 31 mm Hg, $HCO3$ 25 mEq/L. The Doctor orders oxygen at a rate of 3 liters per minute.

   What is your interpretation of the acid-base status of this patient?

4. A 47-year-old man collapsed on the street and was brought to the emergency room. On admission he was blue, had no palpable pulse, and was making agonal respiratory movements. The patient was successfully resuscitated, and the following blood gases were drawn: pH 7.51, $pCO2$ 35 mm Hg, $HCO3$, 27 mEq/L. The patient has a B/P of 124/88, pulse of 64, and respirations of 64.

   What is your interpretation of the acid-base status of this patient?

5. A 54-year-old woman with a 10-year history of heart failure was taking diuretics regularly. She had a chest cold the last week and experienced progressive shortness of breath. Room air blood gases: pH 7.54, pCO_2 26 mm Hg, HCO_3 22 mEq/L, pO_2 48 mm Hg. Oxygen therapy is ordered.

   What is your interpretation of the acid-base status of this patient?

6. A 47-year-old man without previous illness entered the coronary care unit with an ECG diagnosis of "inferior wall infarct" and severe chest pain. He had received morphine 1/4 grain in the emergency room. The cardiac monitor shows numerous PVC's. Room air blood gases are-- pH 7.51, pCO_2 29 mm Hg, HCO_3 23 mEq/L.

   What is your interpretation of the acid-base status of this patient?

7. A 9-year-old boy with a history of allergic asthma is admitted to the emergency room. He had been placed on penicillin, plus oral bronchodilators, for one week. His mother stated he had not slept in two nights. The child was sitting and was using all accessory muscles to breathe. The wheezes can be heard from across the room. Room air blood gases are: pH 7.46, pCO_2 25 mm Hg, HCO_3 15 mEq/L. The child's respiratory rate is 32.

   What is your interpretation of the acid-base status of this patient?

8. A 24-year-old woman entered the emergency room with a broken ankle. She appeared somewhat disoriented and confused. Room air blood gases were: pH 7.55, pCO_2 27 mm Hg, HCO_3 23 mEq/L. There is little evidence of tissue hypoxia. The patient is in pain and is considerably anxious.

   What is your interpretation of the acid-base status of this patient?

9. A 67-year-old woman was admitted for uncontrolled rectal bleeding of several days duration. Room air blood gases are: pH 7.48, pCO_2 28 mm Hg, HCO_3 21 mEq/L. Hemoglobin content is 6 gm %, pulse rate is 100, blood pressure is 100/55.

   What is your interpretation of the acid-base status of this patient?

10. A 76-year-old man with a long history of symptomatic chronic obstructive pulmonary disease entered the hospital with basilar pneumonia. Room air blood gases are: pH 7.25, pCO_2 49 mm Hg, HCO_3 40 mEq/L, pO_2 38 mm Hg. He is placed on a nasal cannula at 2 L/minute flow. Vital signs are: B/P 160/98, P 78, R 20.

    What is your interpretation of the acid-base status of this patient?

11. Mr. Jones, a 76-year-old man with history of heart disease, enters the emergency room with complaint of chest pain. Mr. Jones has a cardiac and respiratory arrest while in the ER.

    What would you anticipate to be the acid-base status of Mr. Jones following the arrest?

    List a set of arterial blood gas findings that would demonstrate this imbalance.

12. Sarah Smith, a 6-year-old patient has had diarrhea for the past several days. Her stools have been liquid and foul smelling.

    What acid-base disturbance would Sarah be likely to develop? Why?

    List a set of arterial blood gas findings that would demonstrate this imbalance.