6-1976

Computer Simulation as a Medium for Teaching Inventory Management in Food Systems Administration

Joyce Willene Fleming West
University of Tennessee, Knoxville

To the Graduate Council:

I am submitting herewith a dissertation written by Joyce Willene Fleming West entitled "Computer Simulation as a Medium for Teaching Inventory Management in Food Systems Administration." I have examined the final electronic copy of this dissertation for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Doctor of Philosophy, with a major in Human Ecology.

Betty L. Beach, Major Professor

We have read this dissertation and recommend its acceptance:

Mary Jo Hitchcock, Grayce Goertz, Ohmer Milton, Ada Marie Campbell

Accepted for the Council:

Carolyn R. Hodges

Vice Provost and Dean of the Graduate School

(Original signatures are on file with official student records.)

To the Graduate Council:

I am submitting herewith a dissertation written by Joyce Willene Fleming West entitled "Computer Simulation as a Medium for Teaching Inventory Management in Food Systems Administration." I recommend that it be accepted in partial fulfillment of the requirements for the degree of Doctor of Philosophy, with a major in Home Economics.

Betty L. Beach

Betty L. Beach, Major Professor

We have read this dissertation and recommend its acceptance:

Mary Jo Hitchcock

Grayce E. Goertz

Ada Marie Campbell

Accepted for the Council:

____

Vice Chancellor

Graduate Studies and Research

COMPUTER SIMULATION AS A MEDIUM FOR TEACHING INVENTORY MANAGEMENT IN FOOD SYSTEMS ADMINISTRATION

A Dissertation

Presented for the

Doctor of Philosophy

Degree

The University of Tennessee, Knoxville

Joyce Willene Fleming West

June 1976

ACKNOWLEDGMENTS

The author is indebted to Dr. Betty L. Beach, director of the University of Tennessee, Knoxville, Coordinated Undergraduate Program, for her hours of giving endless information, suggestions and encouragement.

Appreciation also is expressed to Dr. Alan Lasater, University of Tennessee, Knoxville, statistician, concerning the use and interpretation of the statistical tests and the results; to Dr. M. Eileen Matthews, University of Wisconsin, for permission to use the inventory management computer simulation models; to Mrs. Judy Mellor, University of Tennessee, Knoxville, computer consultant, for aid in the conversion of the Job Control Language of the computer simulation models and for aid in placing the data in the computer for statistical analysis; to Dr. Grayce Goertz, Dr. Ohmer Milton, Dr. Ada Marie Campbell and Dr. Mary Jo Hitchcock, graduate committee members for their help and suggestions.

This research was supported with an Allied Health Advanced Traineeship for Administrative Dietetics, an NIH Special Improvement Grant for the Coordinated Undergraduate Program in Dietetics, and the University of Tennessee, Knoxville, Computer Center.

The undertaking and completion of this degree and dissertation would not have occurred if not for the encouragement and understanding of the author's parents, Mr. and Mrs. John L. Fleming and husband, Mr. Benny West.

ABSTRACT

A conceptual framework was developed incorporating computer simulation as an instructional medium for teaching conceptual thinking and techniques for decision making and problem solving needed for inventory management. With this framework as a guide, an individualized instruction unit was designed and implemented for teaching cognitive learning.

Fifty-two food systems administration students at the University of Tennessee, Knoxville, evaluated the effectiveness of the individualized study unit (experimental method) as opposed to the traditional lecture (control) method in teaching inventory management principles. A pretest was administered to each student in selected junior and senior courses prior to the teaching unit. A posttest was given three weeks after the pretest and following the teaching unit; then again, as a retention test, five weeks later. The student's prior exposure to inventory management principles, evaluation of teaching method and amount of time spent in the learning process were analyzed in relation to test scores.

Test scores indicated that the vertical transfer of cognitive knowledge from the recall level to the problem solving level for inventory management principles was evident for students using the experimental method. These scores also showed that students in the senior course utilized the experimental method more effectively for achieving cognitive learning than did students in the junior courses. Posttest scores compared to retention test scores showed that the

experimental method did influence student retention for the recall of inventory management principles as well as for the application of these principles towards solving a problem. The student's prior exposure to inventory management principles, evaluation of teaching method and time spent in the learning process did not affect cognitive learning or retention of knowledge for the principles.

This study does show that the individualized instruction unit with computer simulation could be used for teaching conceptual thinking and techniques for decision making and problem solving needed for inventory management.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER I

INTRODUCTION

Administrators and administrative dietitians recognize a need for on-the-job dietitians to have greater expertise in conceptual thinking and decision making and a better understanding of inventory management concepts and use of the computer as a management decision making tool. Blaker (1969) reported at the Food Service Systems Management Education Council that many on-the-job dietitians were weak in the ability to do conceptual thinking and were unfamiliar with the tools for problem solving, analysis and evaluation.

The use of computer simulation in the classroom could provide such a tool for student dietitians to gain experience in these areas before leaving the academic situation. This tool could offer the student dietitian direct decision making experiences through the replication of a real situation and the manipulation of influencing variables within this situation (Braun, 1970; This, 1970).

Since one of the purposes for using simulation is to involve the student more in the actual teaching/learning experiences, the concept of individualized instruction and mastery learning (Milton, 1972) can be used. Mastery learning procedures provide a method for teaching the techniques and for the development of experiences in concept attainment, decision making and problem solving (Block, 1971).

I. IDENTIFICATION OF PROBLEM

Learning to control and manage the physical inventory of a food service at an optimal level to achieve minimum costs is a major part of an undergraduate food systems administration training program. In inventory management, the fixed-order-period and fixed-order-quantity theories are used to create and control food service inventories (Andrews, 1969; Nagy, 1967). It is one of the few areas for which computer simulation models have been developed. Two of four inventory models as developed by Matthews and David (1971) for research purposes have been converted to teaching models to simulate these two basic inventory systems. The incorporation of these models into a teaching/learning situation would provide the student with experiences in the use of the computer as a decision making tool, with opportunities to have problem solving experiences and with experiences in applying inventory management principles.

During 1974, the Food Science, Nutrition and Food Systems Administration Department at the University of Tennessee, Knoxville, incorporated, as part of the Coordinated Undergraduate Program in Dietetics, computer simulation into several courses to provide student experiences in applying cognitive learning to decision making and problem solving. Limited research had been done regarding the use of computer simulation in the application of concepts which later must be organized and reorganized to solve a problem.

A professional need also existed for a conceptual framework incorporating computer simulation as an instructional technique for teaching conceptual thinking, decision making and problem solving.

II. PURPOSE OF STUDY

The purpose of this study was to develop a conceptual framework for teaching inventory management principles to food systems administration students. A methodology based on the conceptual framework was designed and implemented to study the feasibility of using computer simulation as an aid to teaching cognitive learning.

Instruments were developed to evaluate student attitude to the teaching procedure and to assess the amount of time used by students participating in the study.

CHAPTER II

REVIEW OF LITERATURE

Computer simulation is one form of simulation available to education for use in teaching decision making. Industry has used computer simulation extensively over the past few years as a decision making tool, especially in the area of inventory control and inventory management. Other forms of simulation used by education for problem solving experiences have been role-playing, case studies, mock-up diagram and replicas, in-basket techniques, interviews and, more recently, simulation games (This, 1970).

I. COMPUTER SIMULATION

Computer simulation may be defined as the development of a mathematical model for a real situation. A set of influencing variables is identified to describe the state of the system at a given point in time together with other input data required to generate the behavior of the system during a time interval. Experiments then are performed through manipulation of numbers or symbols representing the variables in relation to time. The results are values of the variables that describe the state of the system at the end of the simulated time interval. This process is repeated until the desired length of time has been represented.

When the desired length of time is simulated, the resultant values are evaluated in relation to the original problem being studied.

The original variables then are changed in accordance to decisions made as a result of the evaluation and the entire process is repeated until a satisfactory solution is obtained. These techniques of analysis, manipulation of variables and replication tend to promote thinking on a broad scale rather than on a narrow scale (Sarthory and Wade, 1971; Meier et al., 1969).

Use of Simulation in Teaching

Bandeen and Upton (1972) developed a computer simulation model representing the dietary department of a 1,000 bed hospital. The model emphasized student understanding of how the computer could relieve the dietitian from repetitive paperwork, giving time for other duties. A total of 47 undergraduate dietetic students at the University of Guelph in 1970 and 1971 used the models. Given a fixed alternative questionnaire the students were asked to rate the unit. Eighty percent of the students considered the unit successful in the area of realism, presentation, recipe coding and student involvement. A longer teaching unit was indicated for use at a higher level than that chosen for the study.

A review of the literature offers little conclusive evidence about the learning effects of computer simulations. This is due in part to the relative newness of the method, to the inherent difficulty of controlling variables necessary to compare simulation with other teaching methods (Boocock, 1971) and to the lack of good measuring instruments for the specifics of what the simulation was supposed to teach and the selection or design of tests to measure these criteria accurately.

The available research evidence does point to several learning effects attributable to the use of simulation. Heinkel (1970) reported a study conducted in two randomly selected junior college political science classes to evaluate the effect of a simulation game on cognitive learning and to determine attitudinal changes that could be attributed to participation in the simulated situation. Simulation was used in one class of 35 students while the other class of 32 students was used as a control. A pretest was given prior to the simulation unit and a posttest was given immediately afterwards followed by a delayed posttest at the end of the semester. Cognitive learning between students in the two groups was similar in that a statistically significant difference did not occur. Within the limits of the study analyses showed the simulation produced desirable attitudes and resulted in polarization of positive feelings toward the government.

A simulation game depicting a community's response to a natural disaster was played by 256 players (Inbar, 1970). The participants' reactions were determined and analyzed by means of the matched pairs and chi-square tests. Results were statistically significant at the 5% level indicating that the simulation game was a powerful motivational device and had teaching potential.

Stuck and Manatt (1970) in a teaching training program compared the traditional teaching method to a technique which combined simulated materials and the audio-tutorial method of instruction. Two hundred nineteen students were randomly placed in either the traditional lecture method group or the experimental audio-tutorial group. Pretests and posttests were administered to all students to determine the learning growth of the student and three weeks later a retention test was given. The students also were asked to keep accurate logs of the time spent on the experiment, in class or outside of class. The experimental group had a significantly larger growth in learning differences over time than did the traditional group. The traditional group spent 38.44% more time on the unit than did the experimental group.

According to Boocock (1966) and Anderson et al. (1964), retention of factual material from the use of simulation was equal to that from other teaching methods, such as lectures.

Advantages for Instructional Use

When it is not possible to bring reality into the classroom, simulation may be used to replicate a situation (This, 1970; Braun, 1970). This replication of an actual situation, as closely as possible, results in transfer of knowledge and skills (This, 1970). Computer simulation offers an opportunity to enrich the student's direct learning experiences when equipment or procedures are unavailable because of expense or complexity (Braun, 1970). It also offers an immediate feedback to decision making on reality based problems (Meckley, 1970; This, 1970; Heinkel, 1970).

Disadvantages for Instructional Use

Effective utilization of computer simulation is dependent upon the quality or reality of the materials and the capability of the instructor to devise and use them (Sarthory and Wade, 1971; Nee, 1971; This, 1970). The transfer of knowledge from the simulated situation to on-the-job situations is not guaranteed (Sarthory and Wade, 1971).

The technique is expensive and time consuming. Cost in time and in computer investment are important considerations when using computer simulation. These costs involve those for computer time, those in time for the instructor to develop the teaching materials and use them effectively and those in time for the student while using the materials (Braun, 1970; Nee, 1971; This, 1970).

The student's initial attitude and degree of anxiety toward the activities involved with simulation can affect their overall performance (McKenney and Dill, 1966; Baldwin, 1969). Early dissatisfaction with the teaching procedures using a form of simulation can lead to reduced efforts from the students in learning the inherent concepts.

Use of Computer Simulations for Research Purposes

Computer simulations for research purposes have proven to be effective in the study of the behavior of food service systems. Beach and Ostenso (1969) developed a computer simulation model showing the relationship of service times to number of customers served within a given period of time. The input variables were arrival and movement of customers, customer delay decision time, percentage of customers selecting a specific entree and entree service time. The model could be used in menu planning to predetermine cafeteria or tray assembly work load and the optimal combination of entree serving times required to control the operation period needed to handle a given number of customers.

Four inventory management models were developed by Matthews and David (1971) to represent the two basic inventory systems, the fixed-order-period and the fixed-order-quantity. Each system also has a model for the variable census with unequal probability for selection of each item and for the deterministic census. These simulations were used to see the effect of manipulation of program variables during the simulation time period on cost of daily issues, total cost of items used, average carrying and ordering costs for each item, the sum of all items used, total cost of both the food and the inventory used, storage requirements on a daily basis and financial investment in inventory.

The cafeteria line model devised by Beach and Ostenso (1969) and the inventory management models devised by Matthews and David (1971) have been converted into teaching models. Other computer simulations for food service operations also have potential for teaching models but need to be converted for this purpose. Knickrehm (1966) investigated the use of simulation as a tool in studying the dining room capacity of a food service. The effect of varying the arrangement of table and total seating capacity and the effect of changes in operating procedures on the dining room seating capacity can be observed without interrupting customer service.

Use of simulation as a technique in determining the effect of changes in layouts or operating procedures on the time customers spend in a cafeteria service line, the rate of flow of customers and the utilization of facilities was studied in another computer model by Knickrehm et al. (1963). This model could also simulate the relationship of the three variables to the counter length, number of personnel serving at various stations and menu combinations.

A general purpose cafeteria simulator was developed by Ostenso et al. (1965) to provide a method of determining the effect of varying the parameters of the systems components on the effectiveness of the total system. An artificial history of the estimated performance of a cafeteria for a given period of operation is obtained in the computer printout.

Decisions as to the optimal combination of customers, service times, facilities and operational rules may be based on derived data.

Calder (1967) developed a computer simulation model of cafeteria systems to evaluate the effectiveness of the system in terms of customer waiting and service times, facility capacity and utilization for straight-line, by-pass, and random-path cafeteria systems.

II. INVENTORY MANAGEMENT PRINCIPLES

Because of the large amount of invested capital and the many costs associated with the maintenance of an adequate supply of food, the control of the inventory is considered one area which contributes to the success or failure of the food service system. Management desires that a food inventory system supply the required amount of food for the preparation of the menu items as demanded by the patients or customers (Matthews and David, 1971); purchase supplies at a minimum cost (Andrews, 1969); prevent production schedule interruptions caused by shortages of materials; minimize losses due to theft, obsolescence and spoilage; and keep investments in inventory at a minimum point consistent with production requirements.

The attainment of these objectives depends on the constant identification and control of acquisition costs, possession costs and fixed costs. These are associated costs. The first two are incurred in the ordering of the inventory and in the holding of the inventory in storage, respectively. Fixed costs have no effect on the order quantity but are a basis upon which the other costs are built (Durben, 1970; Nagy, 1967). The total cost of an inventory consists of the sum of the three above costs.

General Areas of Inventory Control

Controlling and maintaining an adequate inventory at a maximum level with a minimum of associated costs consists of three basic areas. These areas are ordering the products required for use in the system, receiving items into the system, and issuing items within the system (Matthews and David, 1971). Ordering involves establishing methods to determine how much to purchase, when to order and which items are most expensive and need greatest control. Receiving involves the establishment of procedures to determine quality checks for ordered foods and to maintain this quality during storage. Excesses in inventory and out-of-stock situations can be avoided or minimized when control is maintained in the ordering and receiving process resulting in an economic relationship between acquisition and possession costs.

Issuing includes the procedures for maintaining control over the issued quantity of items within the food service. This area includes control through use of perpetual records and physical counts of the items to reduce costs due to pilferage and spoilage.

Fixed-Order-Quantity and Fixed-Order-Period Inventory Systems

Food service inventories provide data for forecasting probability of future demands and for determining probability distribution of demand varying with time including demand during lead time (Starr and Miller, 1962). Using these data the decision maker develops a repetitive and/or continuous decision process that will control fluctuations in demand. This can be done by varying the frequency with which orders are placed or by varying the amount ordered. These two possibilities form the fixed-order-quantity and fixed-order-period systems, respectively. A lead time and safety stock are necessary for both systems.

The time which lapses between the time the order is placed and the time that it is actually received and added to inventory is called the "lead time" (Durben, 1970). The safety stock is a fixed quantity of stock needed for protection against running out of stock (Andrews, 1969; Wight, 1970) between order periods due to abnormal conditions occurring among the supply and demand for food items. The lead time and safety stock are expressed in terms of the inventory level at which an order should be placed. This level is referred to as "reorder point" or "order point."

To maintain a high level of service when there is an uncertain demand, the reorder point should not fall to the forecasted average usage before reordering. The reorder point is a reorder signal in time to replace the items and still meet the needs or expected demands during the next lead time.

<u>The fixed-order-quantity system</u>. The optimum order size for the fixed-order-quantity system can be determined by using the economic order quantity formula. This system has a fixed order size and lets the frequency of ordering be determined by the fluctuations in demands (Bierman et al., 1969; Starr and Miller, 1962). The system operates

by determining the amount of stock needed to offset demand during lead time and the requirement for safety stock. When this level is reached the order is placed immediately. The major disadvantage of the fixed-order-quantity system is that it requires perpetual inventory procedures. A formula which could be used to determine the order point in this system is

$$L + SS = I + O$$

where

L = usage for lead time

SS = safety stock

I = inventory level

O = outstanding orders.

The fixed-order-period system. In the fixed-order-period system the size of the order varies with fluctuations in demand. The order period is determined by analytical forecasting with the amounts reviewed at intervals equal to the order period. The amount ordered is determined by analysis of fluctuations in demand for the order period and amounts needed during lead time and for safety stock. This system has the advantage over the fixed-order-quantity system in that periodic reviews of the inventory situation are required making it convenient for use in food services. A formula representing the quantity to order at a fixed time is

$$Q = (M + L + SS) - (I + O)$$

where

Q = quantity to order

M = maximum forecast usage for order period

L = usage in lead time

SS = safety stock

I = inventory on hand

O = outstanding orders

Use of Computer Simulation to Control Inventories

Inventory control was one of the first areas in business to be examined mathematically with computer simulation (Meier et al., 1969). Through the use of simulated inventory amounts and simulated assumptions, interactions among various inventory factors can be tested and evaluated (Meier et al., 1969; Vance, 1968). These factors can include reorder point, lead time, cost of being out of stock, demands, economic order quantities, unit costs, forecasted needs and estimated carrying costs.

Every inventory simulation has a built-in time period in which the program goes through the written sequences. These program sequences generate information based on current demands and forecasts which are either placed in the program or selected by random probabilities built into the program. Issues and receipts may be generated by the program or be based on actual inventory data. These two sources determine the inventory on hand, on order or out of stock. The data are manipulated by the program for the given time period. The results are information that describes the simulated situation at the end of the time period. After the last step is completed, a summary printout is made.

The printout is evaluated to see the effect of changes in variables on meeting objectives of the inventory system. Additional runs are made, if necessary, until management feels that the primary objectives are achieved.

Vance (1968) reported the use of computer simulation at the Atomic Energy Commission in Richland, Washington. This facility established an Integrated Stores Inventory (ISI) system after using simulation to determine demand, reorder points, economic order quantities, safety stock for critical items and order lead times.

III. MASTERY LEARNING

Using computer simulation to teach inventory management principles involves the student more in the actual teaching/learning experience. Since the concept of individualized instruction and mastery learning both stress student involvement in the learning process, this philosophy of education can provide the procedures for incorporating computer simulation as a medium for teaching inventory management principles.

Concept of Mastery Learning

The concept of mastery learning proposes that 95% of all students can master what they are taught and also suggests procedures whereby each student's instruction and learning can be managed within the context of ordinary group-based classroom instruction to promote the fullest academic development (Bloom, 1971). The procedures include carefully defining course objectives in behavioral terms and arranging them in a number of smaller learning units based on the desired cognitive, affective or psychomotor learning experience (Bloom, 1971; Kibler et al., 1970; Mager, 1962). These objectives are evaluated through a series of feedback/corrective devices consisting of student self-scored formative tests and usually an instructor-scored summative test. These devices help the student and instructor recognize when a student has attained the desired outcome (Francis, 1972; Airasian, 1971; Bloom, 1971). If the desired mastery is not attained the student can use supplementary materials to overcome any unit learning problem before instruction continues. Throughout the study the student participates in one or more methods for teaching the unit's concepts. Some of these teaching methods could be small group problem solving sessions, individual tutoring and use of audio-tutorial learning materials including computer simulation.

Carroll (1971) theorized that the degree to which a student learns depends upon aptitude for that subject, quality of instruction, perseverance of the student, time allowed for the subject and the student's ability to understand. According to Bloom (1971), a high relationship exists between the student's aptitude and achievement if the students are normally distributed as to aptitude and uniform instruction is received. When the students receive the best quality of instruction based on their needs and all the learning time needed, the majority can master a subject if aptitude is normally distributed. In the mastery concept there is no relationship between aptitude and achievement.

Self-directed individualized instruction enables the student to go at his own pace through a course at a speed suited to individual ability and available time and then to proceed to new material after demonstrating mastery of a unit (Keller, 1968). Ullery (1971) stated that a student enters an individualized instruction program at a level corresponding to previous experience and knowledge, and is guided to learning experiences through behavioral objectives mutually agreed upon with the instructor and as a result experiences success in learning.

Development of Materials

A systems approach model for the design and management of individualized instruction has been devised and described by Tuckman and Edwards (1971). This model can be applied to the overall process of developing instructional materials as well as to the materials used to convey an individualized unit of concepts. The three phases of analysis, synthesis and operation make up the model, followed by the activity of feedback and iteration.

The analysis phase or first step in preparing materials and planning a program for individualized instruction for mastery involves the determination of behavioral objectives. These statements describe the observable kinds of useful performance expected from the student after completion of a specific learning experience. Each objective also identifies the specific conditions under which the student is expected to demonstrate performance capability and gives the criteria used for judging the performance (Morrison, 1970; Kibler et al., 1970; Mager, 1962). Behavioral objectives are arranged or sequenced in a learning unit from the simplest to the more complex orders of cognitive, affective or psychomotor domains (Tennyson and Merrill, 1971; Kibler et al., 1970).

Evaluation of Materials

In the synthesis phase of instructional development two types of evaluation are used: formative and summative (Francis, 1972; Tuckman and Edwards, 1971). Formative evaluation may be further divided as individual and materials evaluation. Individual formative evaluation is the frequent monitoring of each student's performance with resultant feedback information, so that decisions can be made about further progress in the learning sequence (Tuckman and Edwards, 1971). Materials formative evaluation is a process used to evaluate the behavioral objectives and the improvement of sequencing learning experiences to meet the objectives. Summative evaluation is the overall evaluation of the learning experience relying on tests or other assessment procedures (Francis, 1972; Tuckman and Edwards, 1971) to provide the "final" grade.

Implementation of the Materials

One common method for implementation of an individualized program is to provide the learning sequences in the form of modules or mini-courses. Modules are short, self-contained, independent units of instruction built around a few well defined objectives. Each module consists of materials and instructions needed to accomplish these objectives through sequencing learning activities based on acceptable modes of learning. The major components are a statement of purpose, a diagnostic pretest, necessary equipment, the program, related experiences, evaluative posttest and an assessment of the module (Murray, 1971). The modular approach offers many advantages to the student, such as personal involvement in the learning experience, reduction of failing experiences and the ability to skip material already familiar to him (Creager and Murray, 1971).

Prior to beginning any new teaching/learning experience, the concepts found within the area being studied should be identified. Such a conceptual framework presenting computer simulation as a tool for gaining experience in concept attainment, decision making and problem solving was not available and needed to be devised.

CHAPTER III

CONCEPTUAL FRAMEWORK

The ability of an organization to succeed in its environment and to adapt to change or even to capitalize on change is basically in the hands of management. Management is rewarded and evaluated in terms of decision making success (Miller and Starr, 1967). One of the main responsibilities and functions of the administrative dietitian is to make decisions. These decisions may be directed toward every conceivable physical and organizational area of the operation (West et al., 1966). One such area is the control and management of the food service inventory. Decisions here deal with financial planning and the purchasing and issuing of inventory for production and service. To be successful with these decisions the administrative dietitian needs to be constantly aware of inventory management concepts and with the procedures for decision making and problem solving.

The use of computer simulation models for teaching inventory management concepts can give student dietitians experience and practice, while still on the academic level, in conceptual thinking, decision making and problem solving which can be used later on the job.

I. COMPUTER SIMULATION FOR CONCEPTUAL LEARNING

Conceptual thinking is the understanding of a field's generalizations and being able to select and use the generalizations for thinking through and dealing with situations and problems (Kreutz, 1971). There are different levels of generalization. These levels proceed from a simple idea gained through memorizing, recall or observations to a level which describes complex relationships between concepts (Kreutz, 1971; Hoover, 1967).

Concept Attainment

The attainment of conceptual thinking begins with the students becoming aware of and using basic concepts to form generalizations. A concept is an idea which a person mentally forms in order to understand and cope with an experience (Tinsley and Sitton, 1967). Concepts are to generalizations as words are to sentences.

Instructors should give students learning opportunities which show, through varied experiences, numerous aspects of the concepts. The students should be allowed to form the idea, to expand and/or reorganize the idea, to identify ways in which the idea directs behavior and to understand the interactions and relationships between concepts.

The use of computer simulation can help in these areas. Structural relationships (Cherryholmes, 1966) between concepts within a problem can be discovered by students when given the activities of

1. designing a computer simulation before using it,
2. redesigning an existing computer simulation,
3. validating the theory embedded in a computer simulation by a variety of comparisons with the real-life referent system and
4. redesigning a computer simulation on the basis of the validation results.

The rapid manipulation of data describing the variables within an existing computer simulation situation (Bell and Linebarger, 1970) also provides the student with a tool for use in visualizing concept relationships readily and for making changes in these relationships.

Learning Hierarchies

Concept attainment is dependent upon the formation of objectives based upon student needs. These objectives can be written as behavioral objectives using the learning hierarchies of the cognitive, affective and psychomotor domains as guides.

The cognitive domain emphasizes the intellectual learning and problem solving tasks which range from simple recall of facts to placing previously learned ideas into new material and making new relationships (Kibler et al., 1974). The rapid manipulation of given data in a computer simulation enables the student to observe the effect of relationships between recalled or given data within a simulated situation.

The affective domain contains behaviors and attitudes which have some emotional overtones that encompass likes, dislikes, attitudes, values and beliefs (Kibler et al., 1974). Increased interest and change of attitude have most often been observed when computer simulation has been used. Boocock (1966), McClelland (1970), Heinkel (1970) and Inbar (1970) found, when using simulation, student interest and motivation increased and attitudes improved about the subject being simulated.

Simulation is also self revealing (Meckley, 1970). By using human and technical skills to solve the simulated problem, the student has the opportunity to observe personal understanding of simulated concepts and personal ability to make decisions based on the immediate feedback information from the simulation.

The psychomotor domain includes skills that require the identification and combination of stimulus-organism-response elements into coordinated patterns of activity as a result of practice repetitions and reenforcing feedback (Kibler et al., 1974). The use of computer simulation gives the student the opportunity to learn and further develop skills in key-punching, in actual use of the simulation, evaluation and analysis of results and in the processes of redesigning and constructing new simulations.

Transfer of Learning

Transfer of learning is the ability to apply learned information to situations different from that in which the material was first learned. In the learning situation the student needs to see the transfer potential of the material to make it useful (Kreutz, 1971). Subject matter content and instructional methods used should be so structured that the student gains knowledge and learns to use the subject matter in meeting situations and in solving problems. The instructor's time should be spent in guiding the student towards a broad application of this knowledge to varying situations.

The learning results are obtained by giving attention to vertical and lateral forms of transfer of knowledge. Vertical transfer involves the learning of generalizations or concepts at one level resulting in greater ease in learning more complex generalizations at the next level.

Lateral transfer is that type of transfer spreading over a broad set of situations at the same level of complexity.

Hoover (1967) identifies three vertical levels of concept development. These levels are the descriptive or first level, the second level where the student sees and states relationships and the third level where the student can justify, predict and interpret. Conceptual understanding ranges from an understanding of definitions and terminology to the more complex understanding of relationships among ideas. The cognitive process used at the various levels of concept development for teaching inventory management principles in Figure 1 is based on the hierarchy of the cognitive domain as developed by Bloom et al. (1956). The first level is knowledge of definitions or descriptions of inventory management theories. The second level includes more ideas than the first level by showing relationships among the various inventory management terms and theories. The third level includes the processes of analysis and evaluation of a problem where relationships among the inventory management principles occur and predictions based on these cause and effect relationships can be made. Computer simulation models for teaching inventory management principles can be used at the higher vertical levels of learning transfer.

Conceptual understanding at each level involves one or more of the following cognitive processes: knowledge, comprehension, application, analysis, synthesis and evaluation. The more complex cognitive processes are utilized in the third level by the student for making decisions and solving problems pertaining to inventory management.

LATERAL TRANSFER ⟶

VERTICAL TRANSFER ⟶

LEVEL I: Knowledge of Definitions and Terminology	
Discuss inventory management terminology, inventory management theories and formulas.	Answer questions on self scored test designed for knowledge recall.
	Apply knowledge in calculating and solving simple written problems based on this information.
LEVEL II: Knowledge of Relationships	
Discuss relationships between inventory management principles.	Solve written problems of varying degrees of complexity based on these relationships.
Apply these relationships to a specific problem.	Answer questions on self scored test designed for knowledge relationships.
LEVEL III: Analysis and Evaluation	
Analyze an inventory management problem.	Given a hypothetical case study involving more than one inventory management relationship which are not identified, analyze, identify and solve the problem using computer simulation models.
Recognize cause and effect relationships within a problem.	
Predict problem consequences of alternatives within these relationships	Write analysis and evaluation report.
Draw conclusions based upon evaluation and judgments to solve the problem	

Figure 1. Cognitive process used at various levels of concept development for teaching inventory management principles.

II. THE SYSTEMS APPROACH TO DECISION MAKING

The decision maker wishing to achieve some objective selects a plan from those which are available. This selection is based not only on an information feedback system which offers information as to the performance of previous decisions but also on an established system of standards and values which measure the performance of the alternative plans (Buffa, 1969; Miller and Starr, 1967). This selected plan, together with combinations of natural uncontrolled factors and actions from competitors will determine the extent to which the objectives are attained.

A system is a set of objects so related that a change in one will affect the whole (Buffa, 1969). An informational feedback system is one which has a portion of the output regularly introduced as input to influence and control future decisions. The input affects and/or is changed by organizational factors resulting in output. Output is evaluated in light of organizational objectives, standards and restraints (Vinacke, 1971; McMillan and Gonzalez, 1965). Modifications can be made in the output. The new information then is returned to the system as input.

David (1972) devised an informational feedback system for making decisions in food service organizations. Figure 2 gives a decision making model for inventory management based on the one by David (1972). Computer simulation is used to determine modifications and alterations for the system. The meal census and menu items are inputs which are affected by the available resources and organizational processes to

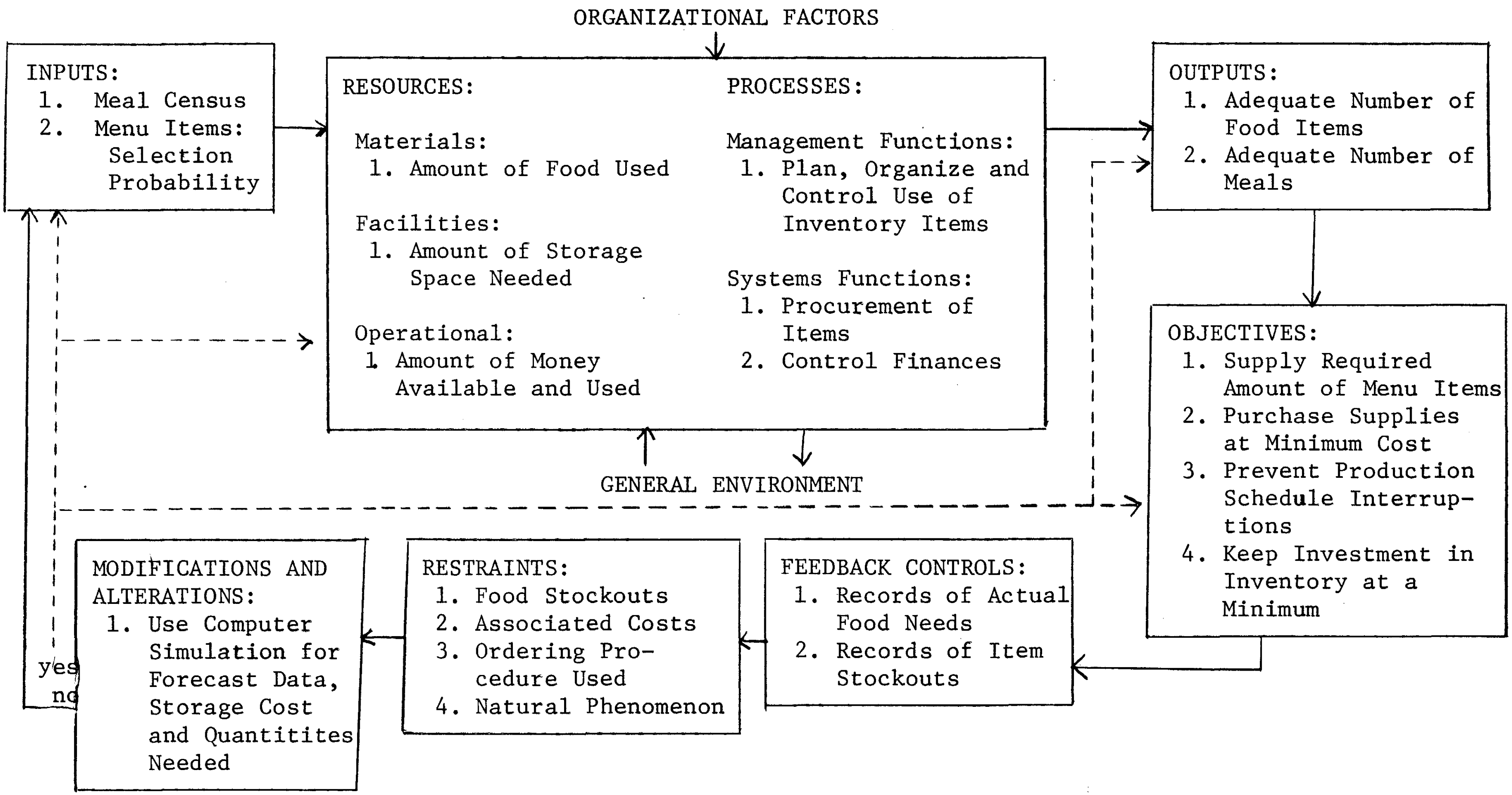


Figure 2. Decision making model for food service systems using inventory management computer simulation. Adapted from David, B. D. 1972, A model for decision making, Hospitals 46(15): 50.

produce the outputs, adequate number of food items and meals. These outputs are evaluated by comparing them to the food service objectives, feedback controls and any other restrictions found in the system.

An example of an informational feedback system might involve a comparison of the number of meals prepared with the actual number of meals needed. If these two are the same, the food service objectives would have been met and restrictions would have been overcome. No modification would be needed and the actual quantity required would become new input. If these two amounts are drastically different, the objectives would not have been achieved. A possible cause for this difference would be determined by a careful evaluation of actual food needs, food stockouts, order frequency of food items, ordering quantity, natural phenomena and other restrictions or restraints on the system. Changes would be made where needed such as in the quantity and type of food item ordered, or frequency for ordering food items. The new derived data would then become new input. The incorporation of these changes into the actual on-going facility would require a sufficient passage of time to reflect the influence of the decision. Other problems such as stockouts, over-stocking, increases in associated costs or overproduction of some food items could arise during this time.

The use of an inventory management computer simulation model of the facility would reduce the overall time needed to obtain satisfactory information about the system. Data collected or estimated based on facility restrictions could be placed in the simulation and manipulated. The results would be immediate and could be evaluated, changed, repunched and manipulated. This process could be continued until a set of satisfactory results was obtained. This set of modifications could then be placed in operation with a resultant decrease in associated problems. Figure 3 shows this overall process involved in the use of computer simulation models as an informational feedback system for decision making.

Matthews and David (1971) used computer simulation to determine the effect of varying number of entrees in a food system on financial investment in inventory and on needed storage space for the inventory. Four computer simulations for inventory management were designed. Data concerning the entrees were placed in the simulation programs.

Manipulation of the data resulted in information about the resources of food, space and money as well as information about the procurement process for food items used. Procurement alternatives were evaluated by simulation without waiting for actual time to pass to see the effect of the number of entrees used on the system. This quick means of evaluating results of modifications made within a system can facilitate planning as in the use of new operational procedures or the feasibility of introducing new recipes or new market forms of food into the operation and also in controlling the use of space and money within the operation. Therefore, the inventory management computer simulation models can provide a means of evaluating modifications of a food service system without waiting for long periods of time to pass before output can be evaluated. These models can be used to facilitate the planning of an informational feedback system within a food service.

Decision making in business may occur under several conditions. One of these is decision making under uncertainty (Miller and Starr, 1967). Maintaining food service inventories involves many decisions

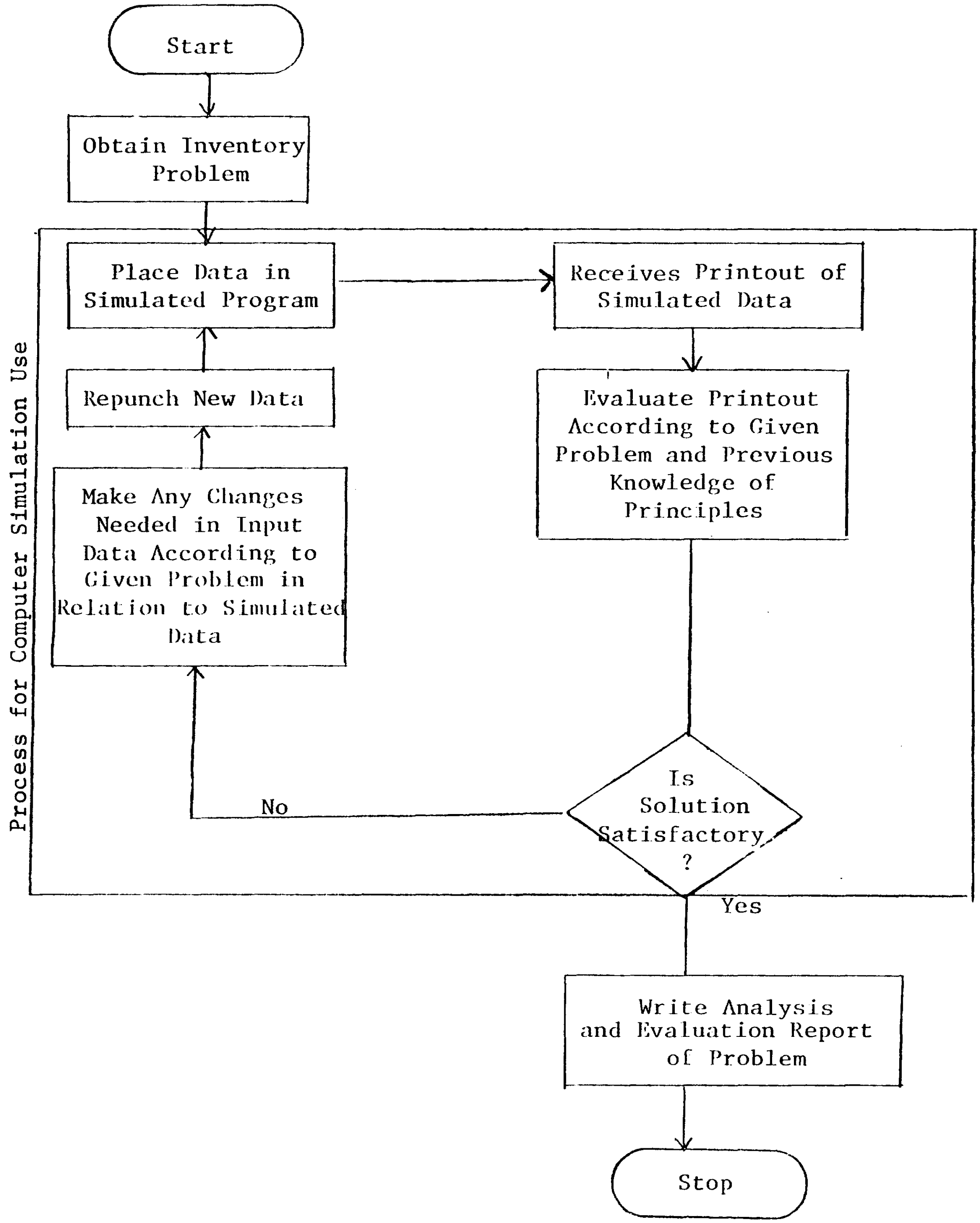


Figure 3. Process for computer simulation models used as an informational feedback system for decision making.

which have to be made under uncertainty because often the actual demand for food is not known and can only be forecasted based on previous records. A computer simulation model, such as that developed by Matthews and David (1971), could be used under conditions of uncertainty. When making reorder decisions under uncertainty, the attitude and state of mind of the decision maker should not be jeopardized (Miller and Starr, 1967). Computer simulation offers the decision maker the opportunity to manipulate data in a simulated situation or in an on-going operation occurring under uncertainty (Matthews and David, 1971; Vance, 1968). The resultant decisions can give the decision maker immediate feedback for better utilization of available inventory (Sarthory and Wade, 1971; Meckley, 1970; This, 1970).

In the classroom these computer simulations on inventory management can be used to give the student experience and practice in decision making and problem solving. The rapid manipulation of data used in varying combinations would give the student immediate feedback information on inventory management interrelationships among principles. The student would be able to analyze and compare data combinations, analyze and evaluate results and draw conclusions based on personal judgment and known principles.

III. COMPUTER SIMULATION FOR PROBLEM SOLVING

In a problem solving situation a person must overcome obstacles by using past experience to arrive at the goal or solution not previously known to that individual about the present situation (Vinacke, 1971). Many methods may be used to arrive at the desired solution. Computer simulation lends itself to the methods of trial and error and of analytic behavior.

In the trial and error process the student explores and manipulates data, chooses between alternatives, corrects those choices that are not successful and continues until the goal is reached. If this process becomes one of random repetition, it is considered a poor process for learning. This process is often used where no rule exists to facilitate a solution or is used to promote the discovery of clues to a principle when it exists (Vinacke, 1971).

Some tasks call for a gradual analysis of the problem and a step-by-step working through of the stages toward a solution. This is analytic behavior. This process involves a need for a major understanding of all primary steps, of concepts and of progress up to and through each successive stage. There is no general rule to be followed and efficiency depends more on mastery of steps than on a search for the direct route to the solution (Vinacke, 1971). The actual study of influencing factors and variables within a simulated situation prior to devising the simulation and then the actual construction of the simulation involve the processes of analytic behavior. The use of computer simulation by the student to manipulate alternative data to solve a problem can involve both the process of trial and error as well as analytic behavior.

A flow chart of the process used by students for solving an inventory management problem using computer simulation is found in Figure 4. This diagram shows how the learning experience guides the student through the analytic decision making process using Matthews' inventory management models. The entire procedure was based on the learning hierarchies in Figure 1, p. 25. Once the student has mastered the inventory management

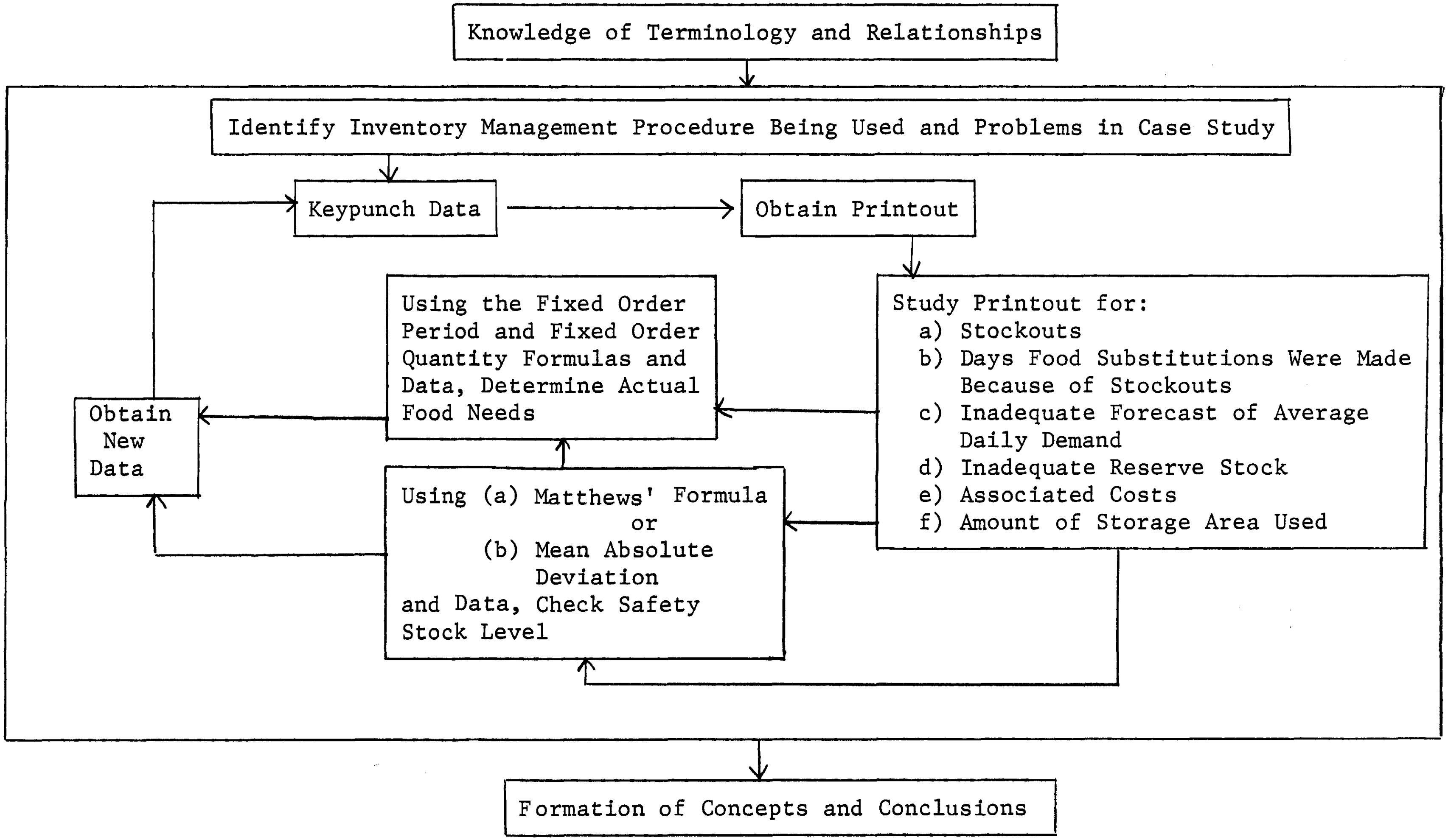


Figure 4. Analytic decision making process for solving inventory management problems using a computer simulation model.

terminology and relationships through discussion and solving simple written problems, application of these principles would be the next step. Computer simulation would give the student experience in the vertical transfer of learning from application to analysis to evaluation.

A hypothetical case or a problem from an on-going facility depicting one or more inventory management concepts could be given to the student. The student would identify the major principles which are being mishandled, punch the data and obtain a printout of the results based on the problem as manipulated by the computer simulation. The printout would be analyzed and evaluated by the student for stockouts, food substitutions, inadequate safety stocks, high or low associated costs or inadequate storage space. One or more alternative solutions, possibly using known formulas, could be derived. These solutions could be punched as new data, placed in the computer simulation, manipulated and printed out as a new set of results. This process would be continued until the student decides a satisfactory solution has been obtained. Care must be taken that the process does not become one of random repetition which could occur only if trial and error decisions are made. When inventory management principles are applied using the analytic process of understanding principle interrelationships, mastery can occur.

IV. SUMMARY

In concept attainment the student must discover relationships between or among various facts. The process of attainment involves the relating or classifying of facts according to one or more characteristics inherent in the studied subject matter. Bell and Linebarger (1970) contend that computer simulation gives the student the opportunity to visualize concept relationships through the manipulation of data. Computer simulation can be used as an instructional aid for the attainment of behavioral objectives based on the cognitive, affective and psychomotor hierarchies of learning and to achieve both vertical and lateral transfer of concepts.

In decision making the student is presented with data which call for a choice between alternatives, each of which can result in rewards of some form. Risks associated with each alternative may be known or assessed giving the student information about possible results based on the selected solution (Vinacke, 1971; Miller and Starr, 1967). Computer simulation allows the student to study the effects on a system of manipulated data over time, to practice decision making based on these data and to see feedback results without being personally harmed if a wrong decision is made (Sarthory and Wade, 1971; Meckley, 1970; This, 1970; Heinkel, 1970).

A professional need exists for more research and evaluation of the effectiveness of computer simulation models for teaching vertical transfer of knowledge at the cognitive learning levels. These levels would involve the simplest level of knowledge recall; then, progress to the second level where relationships among ideas would be made, compared and applied in solving a problem. The final level in this vertical learning would result in the student being able to analyze a specific situation, recognize cause-and-effect relationships and draw conclusions based upon evaluation and personal judgment of the involved principles. In the second and third levels the processes of trial and error or of analytic behavior would be used to solve the problem.

CHAPTER IV

METHODS AND PROCEDURES

With the conceptual framework serving as a guide, an individualized study unit was developed using computer simulation to teach inventory management principles to students enrolled in food systems administration courses at the University of Tennessee, Knoxville. Evaluation instruments were developed to measure cognitive learning and to obtain supporting profile data from each student.

The basic objectives of this study were:

1. To convert the FORTRAN IV Job Control Language of two inventory management computer simulation models for instructional use from that of the UNIVAC 1108 Computer located at the Computing Center, University of Wisconsin, Madison, to that of the IBM System/360 Model 65 Computer located at the Computing Center, University of Tennessee, Knoxville.

2. To develop an instructional module incorporating the computer simulation models for the fixed-order-period variable census inventory system and/or the fixed-order-quantity variable census inventory system for use by the students enrolled in food systems administration courses.

3. To evaluate the effect of the use of computer simulation on (a) the presence of cognitive learning for participating students concerning inventory management principles, (b) student attitude toward structural components of the teaching procedures, and (c) cost in time involved for the students and the instructor in preparing and using the module.

I. CONVERSION OF SIMULATION MODELS

Four inventory management computer simulation models developed by Matthews and David (1971) for research purposes were converted by Beach (1972) for teaching purposes to simulate two basic inventory systems, the fixed-order-period and the fixed-order-quantity. A model represents each system under a deterministic and a variable census with unequal probability for selection of each item. Since most food services have a variable census, these two models, fixed-order-period variable and fixed-order-quantity variable, were selected for use in this study.

Before the models could be used the FORTRAN IV Job Control Language for the UNIVAC 1108 computer at the University of Wisconsin, Madison, was changed to the FORTRAN IV Job Control Language for the IBM System/360 Model computer at the University of Tennessee, Knoxville. With the aid of a consultant from the University of Tennessee Computing Center, the Job Control Language was changed and a standard computer library routine was identified for selecting random numbers based on a normal distribution.

The converted programs were placed on offline disk for temporary computer storage. During the time planned for class use, the student had access to the program through assigned individual Job Control Language numbers.

II. DEVELOPMENT OF STUDY MODULE

An individualized instructional module on inventory management using the computer simulation models to solve a case study was the means developed for applying the principles. The student used this module in an individualized learning experience through the Audio-Visual Learning Center facilities in the College of Home Economics at the University of Tennessee, Knoxville. Copies of the module and cassette tape were stored in this center and available to the students as desired. The module consisted of a study guide booklet and a taped lecture on inventory management principles. The organization of this module for conceptual attainment as well as for lateral and vertical transfer of cognitive learning was based on Figure 1, p. 25, in the conceptual framework. Levels I and II in Figure 1 were incorporated into the study guide booklet and tape, while Level III was attained by use of the case study and the computer simulation models for decision making and problem solving.

Overall Study Guide Format

The concepts covered in the study guide booklet and in the taped lecture were inventory management systems and inventory control systems, economic order quantity theory, forecast error, reorder point, safety stock, and the fixed-order-period and fixed-order-quantity inventory purchasing theories. The student's progress through the study guide booklet of the module is depicted in the flow chart in Figure 5.

The study guide booklet contained behavioral objectives, a diagnostic pretest on forecasting techniques, formative tests for recall and/or application of each section's information and a case study for principle application using the computer simulation model.

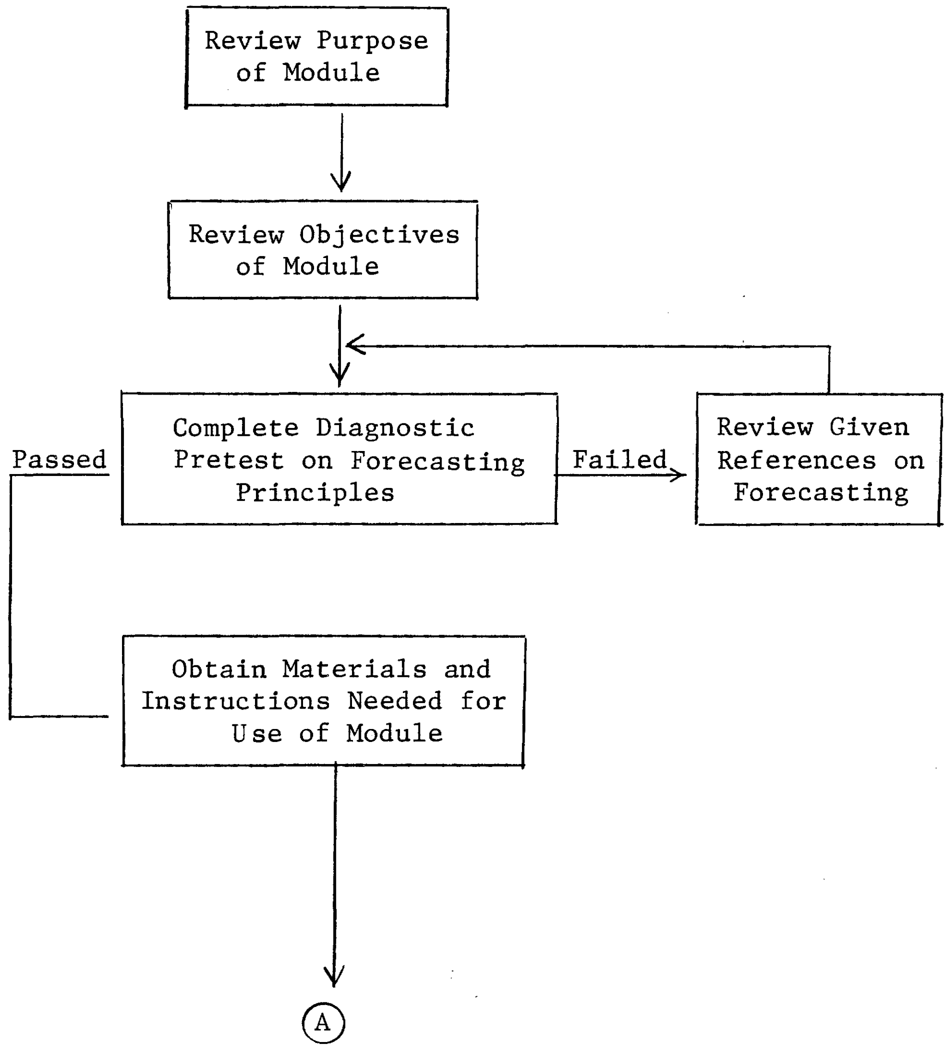


Figure 5. Procedure followed by students through the inventory management study guide booklet.

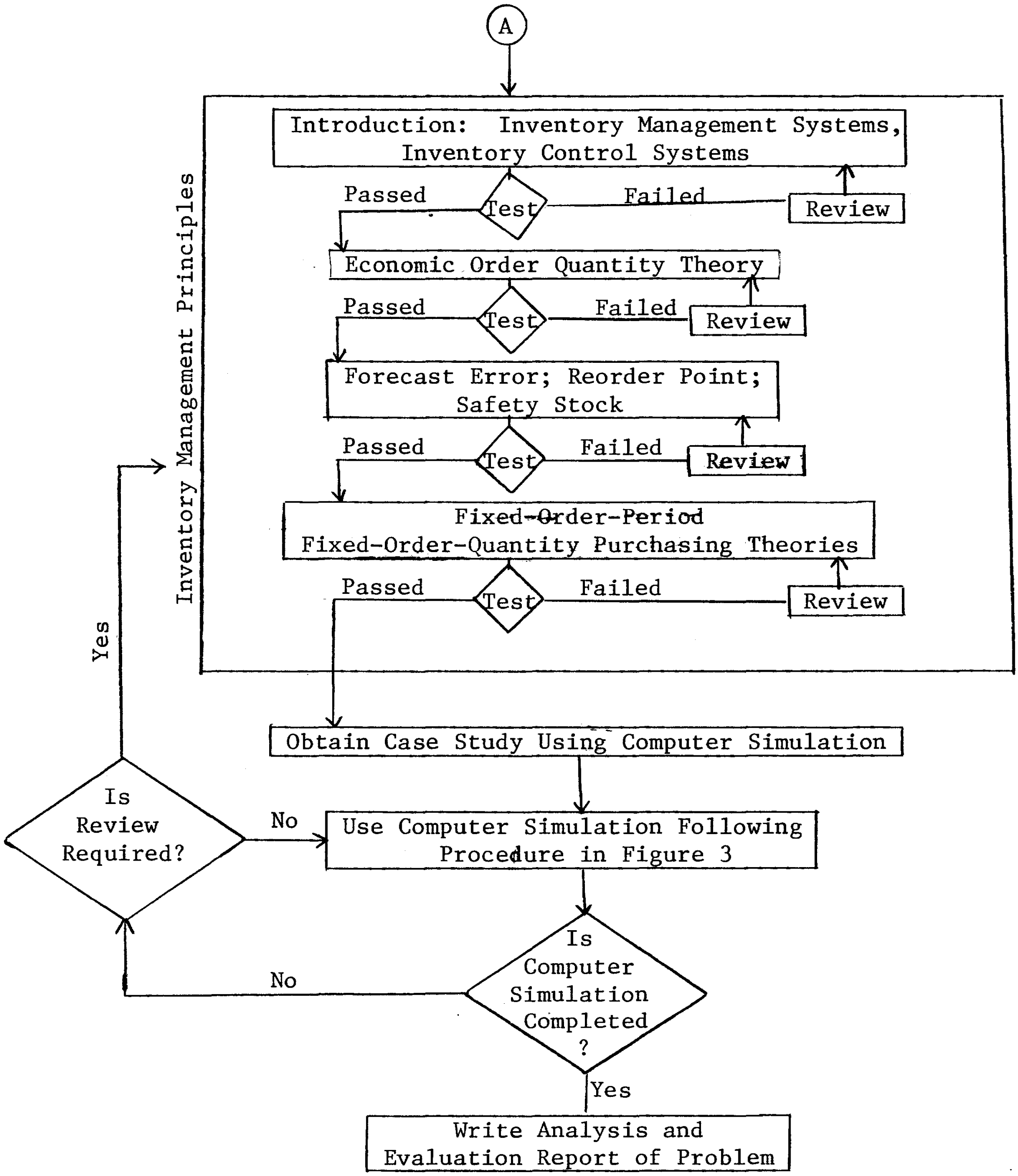


Figure 5 (continued)

Review of purpose and objective of module. The purpose of the module was to teach inventory management concepts to food systems administration students using computer simulation models as a medium for decision making and problem solving experiences.

The objectives of the module were based on the general concepts and were to

1. define the terminology pertaining to inventory management and inventory control systems,
2. describe the inventory management system in relation to forecast of demands, order points and order quantities or operating levels of the food service,
3. describe the inventory control system in relation to the demands, issues and purchase orders of the system,
4. differentiate between the inventory management system and inventory control system,
5. describe the economic order quantity theory in relation to the acquisition, possession and fixed costs of the inventory,
6. differentiate between the conditions needed for the theoretical economic order quantity and the actual conditions which occur within a food service,
7. differentiate between the fixed-order-period and the fixed-order-quantity systems for inventory management,
8. apply either the fixed-order-period or fixed-order-quantity systems to food service situations,
9. relate forecast error to the determination of order point and safety stock levels in an inventory and

10. apply the principles of inventory management to a hypothetical food service situation using computer simulation as a learning tool.

Complete diagnostic pretest on forecasting principles. After the student read the purpose and objectives of the inventory management module, a self-scored diagnostic pretest on forecasting techniques was taken. If all the questions on this pretest were answered correctly, the student progressed to the next section in the module. If the pretest was not passed at the 100% level, the student was instructed to read and study several given references; then, the pretest was taken again. This process was repeated until the student passed the pretest.

Use of module. In each section of the module the topic being discussed on the cassette tape also was presented in the booklet. A self-scored formative test was found after each section. If this test was passed, the student progressed to the next section. If this test was not passed, the student was instructed to study several given references and then go back to the beginning of that section. This process was continued until the student passed the test at the 100% level. The student progressed through the module at an individual rate of speed, taking each formative test when feeling confident that the material in that section was understood.

Use of computer simulation. After the cassette tape and module were completed to the student's satisfaction, a hypothetical case study (Appendix A) depicting several mishandled management principles was given to the student. The case study used was one developed at the University of Wisconsin by Beach (1972). The specific variables studied within the case study were (1) effect of an inadequate daily forecasted amount or average daily demand on overstocking of vegetables and (2) effect of inaccurate forecasting on ordering costs.

Limitations of the simulation model incorporated in the case study were

1. a lead time of one day,
2. orders placed every two days,
3. number of days simulated not to exceed 100 and
4. probability of selection of food items not to exceed 1.0.

The student used the computer simulation models to solve this problem following the procedures outlined in the conceptual framework and outlined in Figure 1, p. 25, Figure 3, p. 30, and Figure 4, p. 33. If further clarification of any principle was needed for solving the case study, the student could again review any section of the study guide booklet.

Write report. After reaching a satisfactory conclusion for the case study using the computer simulation model, the student wrote an analysis and evaluation of the problem. This report included a discussion of the student's approach for solving the problem, reasons for any decisions made while using the computer simulation models and the final solution to the problem.

III. EVALUATION OF STUDENT LEARNING

Selection of Subjects

Subjects were all the students enrolled in FSA 3110, Quantity Food Production, Procurement and Service and FSA 4130, Food Systems Administration fall quarter 1973 and winter quarter 1974.

Test Construction and Scoring

Two short-answer written objective tests (Appendix B) were developed, based on nine years of teaching experience of the author and using a procedure presented by Marshall and Hales (1972).

The questions on both the pretest and the posttest were worded differently but required the same answers. These questions were arranged in a different order on each test with a code assigned to each known only to the author (Appendix B). The questions also represented two cognitive learning levels, knowledge recall and application of knowledge for problem solving. The groups of questions representing these learning levels were called Division I (DIV I) and Division II (DIV II), respectively (Appendix B).

The tests were scored on a point basis with a total possible score of 96 points for each test. Each test was graded by a food systems administration graduate student not connected with the process of devising or administering the tests but knowledgeable in the inventory management principles. This student did not know to which student or to which group of tests each test belonged. Each test taken by each student was coded with a number that, along with the social security number provided by the student, later identified both the test and the student.

Administration of Tests and Module

All participating students were taught in the usual procedure in each class until the point in the course where the inventory management principles were to be included. A general lecture then was given by the author on the use of data processing in food service systems and on the use of computer simulations.

Students then were randomly placed in either the control group or the experimental group. Numbers were assigned to the students in each class. Using a random number chart, the author placed the students alternately in either the control or experimental group according to each assigned number. The experimental group was given class instruction in the use of the independent study module and individual instruction in key-punching for use with the computer simulation. The control group was taught in the traditional manner using the lecture method. This group did not receive special training.

All students in each group were given the pretest prior to beginning the inventory management unit. The posttest was given twice, once as a posttest three weeks following the pretest and teaching unit and again eight weeks later to as many of the same students as possible (Hastings, 1972; Heinkel, 1970; Stuck and Manatt, 1970). This later posttest will hereafter be designated as the retention test. Time sequences and experimental procedure followed by each group are depicted in Figure 6 with the methods used for achieving lateral and

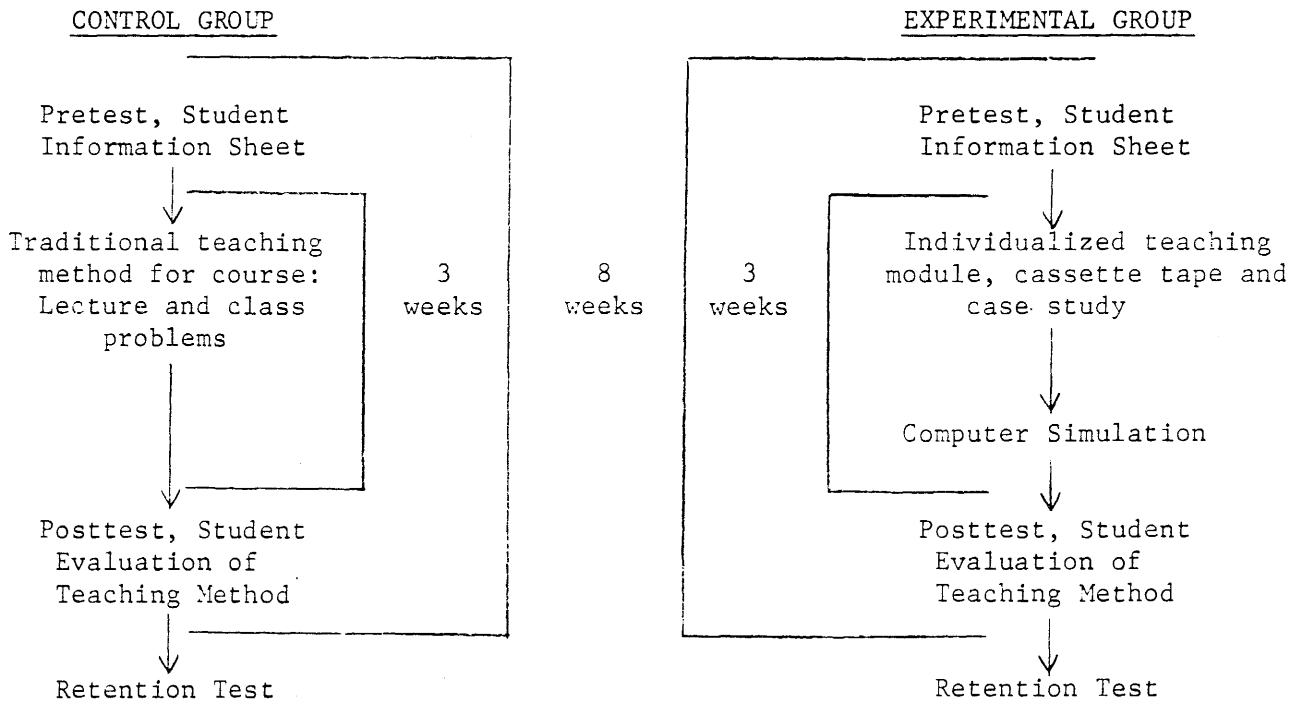


Figure 6. Time sequences and experimental procedure followed by students in the experimental and control groups.

vertical transfer of cognitive knowledge by each group depicted in Figure 7. These methods were based on the cognitive process described in Figure 1, p. 25, in the conceptual framework.

The time between tests was the same for both groups. A difference did exist between the two groups as to the use of this time. The lecture for the control group was given during one lecture period at the beginning of the unit. The posttest was given three weeks later. The only review of information available to these students was class notes and outside assignments. The experimental group had access to the inventory management module booklet and tape during the entire three weeks.

Followup contacts for taking the retention test were made by telephone and in person.

Collection of Supporting Data

The Student Information Sheet (Appendix C) was based on a similar sheet used by English (1974). In the present study this sheet was used to collect information from each student concerning classification, major, and prior contact with food service inventories. Each sheet was identified by the student's social security number and given prior to the teaching method along with the pretest.

The information was coded numerically with "0" representing no prior contact, "1" for work experience only, "2" for course work only and "3" for both work and courses.

To ascertain the student's opinion of the structural components of the teaching procedure, the Student Evaluation of Teaching Method

LATERAL TRANSFER

VERTICAL TRANSFER

Cognitive Levels	Instructional Methods: Control Group	Instructional Methods: Experimental Group
Knowledge of Terminology	Lecture and Outside Readings	Module: Study Guide Booklet, Cassette Tape, Outside Readings
Knowledge of Relationships		
Application of Knowledge	Class Problems, Problems on Posttest	Problems in Study Guide Booklet; Use of Computer Simulation
Analysis and Evaluation	Write Report	Write Report

Figure 7. Instructional methods used by experimental and control groups for achieving transfer of cognitive learning.

sheet (Appendix D) was given to each student at the end of the teaching unit (Heinkel, 1970; Bandeen and Upton, 1972; Hastings, 1972) along with the posttest. This sheet was divided into Section A and B. Section A contained questions concerning amount of student time spent in preparing for posttest. Section B was made of descriptive phrases for the structural components being evaluated. The sheet was identified by the student's social security number.

The seven areas covered by the sheet in Section B were structure of the tape, structure of module or lecture, extent of content coverage, stated objectives for inventory management, case study or class problem, instructor/student rapport, and overall reaction to teaching method used. Each area was covered by three descriptive phrases. The questions were answered by the student checking a phrase denoting their attitude toward the area being evaluated. Each part of the seven areas was given a numerical code by the author ranging from a -2 to a +2.

After completion of the teaching procedure each student was asked on Section A of the Student Evaluation of Teaching Method sheet to give an approximation of the time spent in the project. The students in the experimental group were asked to give the approximate length of time spent on the module and with the computer simulation model. The time spent on the module was also obtained from the sign-in sheets kept in the Audio-Visual Learning Center. The amount of computing time spent by the experimental group and the computing cost of this time was obtained for each student from the Computing Center. The data from the sign-in sheets and from the computer audit trails were compared to the approximate time given by each student. If a student did not give a time on Section A, the time used for statistical analysis was the time obtained by adding data from the sign-in sheet and audit trails together.

Statistical Analysis of Test Scores

The scores obtained from the pretests, posttests and retention tests were arranged into the three categories of test scores, question scores and division scores. The test scores were the numerical value obtained by summing the question scores earned by each student on each test. The question scores were the numerical values earned by each student on each question. A numerical value for each division was obtained for each student for each test by summing the earned value for each question within that division.

The term "difference" as used here and in the remainder of the discussion denotes the numerical value obtained when the test scores were subtracted from each other. The pretest and retention test scores were subtracted from the posttest scores to obtain the "difference" between the scores.

The Mann Whitney U-Test (Siegel, 1956) was used to study the effect of the teaching method on cognitive learning. A significantly greater increase in scores between the pretest and posttest in experimental versus control groups would indicate that the teaching method influenced cognitive learning. The following comparisons were made on the differences between the pretest and posttest (p-p) scores for all students in each class (Table 1):

TABLE 1

COMPARISONS MADE ON DIFFERENCES BETWEEN TEST (T), QUESTION (Q) AND DIVISION (DIV) SCORES FOR EXPERIMENTAL AND CONTROL GROUPS USING THE MANN WHITNEY U-TEST

	Control group											
	Fall 3110			Winter 3110			Fall & Winter 3110			Fall 4130		
	T	Q	DIV	T	Q	DIV	T	Q	DIV	T	Q	DIV
Experimental Group												
		p-p			p-p			p-p			p-p	
Fall 3110 p-p												
test (T)	X											
question (Q)		X										
division (DIV)			X									
Winter 3110 p-p												
test (T)				X								
question (Q)					X							
division (DIV)						X						
Fall & Winter 3110 p-p												
test (T)							X					
question (Q)								X				
division (DIV)									X			
Fall 4130 p-p												
test (T)										X		
question (Q)											X	
division (DIV)												X
		p-r			p-r			p-r			p-r	
Fall 3110 p-r												
test (T)	X											
question (Q)		X										
division (DIV)			X									
Winter 3110 p-r												
test (T)				X								
question (Q)					X							
division (DIV)						X						

TABLE 1 (continued)

	Control group											
	Fall 3110			Winter 3110			Fall & Winter 3110			Fall 4130		
	T	Q	DIV	T	Q	DIV	T	Q	DIV	T	Q	DIV
		p-r			p-r			p-r			p-r	
Fall & Winter 3110 p-r												
test (T)							X					
question (Q)								X				
division (DIV)									X			
Fall 4130 p-r												
test (T)										X		
question (Q)											X	
division (DIV)												X

p-p = posttest minus pretest scores.
p-r = posttest minus retention test scores.
X = comparisons made between score differences.

- experimental group test scores versus control group test scores,
- experimental group question scores versus control group question scores,
- experimental group division scores versus control group division scores.

The effect of teaching method on retention of learned subject matter was studied by testing differences between retention test scores and posttest scores for the two groups by the Mann Whitney U-Test. A significantly greater decrease in score for the control group than for the experimental group indicates greater retention in the experimental group. The same comparisons were made for the differences between the posttest and retention tests (p-r) scores as for the differences between pretest and posttest (p-p) scores (Table 1).

In order to have similar sizes in the FSA 3110 and FSA 4130 experimental and control groups, the fall quarter 1973 and the winter quarter 1974 FSA 3110 classes were used. Because two separate groups were being used at different times, the scores for the fall quarter FSA 3110 students were compared to those of the winter quarter FSA 3110 students. The Mann Whitney U-Test was used to study the effect of quarter in which material presentation was made on student cognitive learning and on retention of learned materials.

The following comparisons were made on differences between pretest and posttest scores for all FSA 3110 students to determine the effect of quarter on the presence of cognitive learning (Table 2):

- fall quarter control group test scores versus winter quarter control group test scores,
- fall quarter experimental group test scores versus winter quarter experimental group test scores,

TABLE 2

MANN WHITNEY U-TEST COMPARISONS MADE ON DIFFERENCES BETWEEN TEST (T), QUESTION (Q) AND DIVISION (DIV) SCORES FOR FSA 3110 EXPERIMENTAL AND CONTROL GROUPS

	Winter 3110					
	p-p			p-r		
	T	Q	DIV	T	Q	DIV
Fall 3110 p-p						
test (T)	X					
question (Q)		X				
division (DIV)			X			
Fall 3110 p-r						
test (T)				X		
question (Q)					X	
division (DIV)						X

p-p = posttest minus pretest scores.

p-r = posttest minus retention test scores.

X = comparisons made between score differences.

- fall quarter control group question scores versus winter quarter control group question scores,
- fall quarter experimental group question scores versus winter quarter experimental group question scores,
- fall quarter control group division scores versus winter quarter control group division scores,
- fall quarter experimental group division scores versus winter quarter experimental group division scores.

The same comparisons were made on differences between posttest and retention test (p-r) scores for all FSA 3110 students to determine the effect of quarter on the retention of learned materials.

The influence of teaching method on retention of subject matter was further evaluated by the Wilcoxon Matched Pairs statistical test (Siegel, 1956). Since each student taking the retention test had also taken the same test as the posttest, a matched pairs relationship existed. The actual test, question and division scores for each posttest were compared to the actual test, question and division scores for each retention test. The following comparisons were made for each course (Table 3):

- posttest scores versus retention test scores for the control group,
- posttest scores versus retention test scores for the experimental group,
- posttest question scores versus retention test question scores for the control group,
- posttest question scores versus retention test question scores for the experimental group,
- posttest division scores versus retention test division scores for the control group,
- posttest division scores versus retention test division scores for the experimental group.

TABLE 3

WILCOXON MATCHED PAIRS COMPARISONS MADE ON ACTUAL TEST (T), QUESTION (Q) AND DIVISION (DIV) SCORES FOR THE EXPERIMENTAL AND CONTROL GROUPS

	Fall and Winter 3110 ret			Fall 4130 ret		
	T	Q	DIV	T	Q	DIV
Fall and Winter						
3110 post						
test (T)	X					
question (Q)		X				
division (DIV)			X			
Fall						
4130						
test (T)				X		
question (Q)					X	
division (DIV)						X

post = posttest scores.

ret = retention test scores.

X = comparisons made between scores.

Computer programs for the Mann Whitney U-Test and for the Wilcoxon Matched Pairs were used for the statistical analyses. These programs were a part of the BMDP3S non-parametric statistic series from the Health Sciences Computing Facility, University of California, Los Angeles and are located in the computer library at the University of Tennessee, Knoxville.

Statistical Analysis of Test Scores in Relation to Supporting Data

Supporting data for the project were obtained through the Student Information Sheet (Appendix C) and the Student Evaluation of Teaching Method sheet (Appendix D). The information from these sheets concerning prior knowledge of inventory management principles and student's attitude toward structural components of teaching procedure was grouped on the basis of test score differences. The Chi-Square Test (Siegel, 1956) then was calculated to analyze the influence of the student's prior knowledge of subject matter and the student's attitude towards each of the structural components of the teaching procedure on cognitive learning and on subject matter retention. The Spearman Rank Correlation was used to analyze the relationship of student study time on cognitive learning and on subject matter retention.

A computer program for the Spearman Rank Correlation was used for the statistical analysis. This program was a part of the BMDP3S non-parametric series from the Health Sciences Computing Facility, University of California, Los Angeles and is located in the computer library at the University of Tennessee, Knoxville.

CHAPTER V

RESULTS AND DISCUSSION

Fifty-two food systems administration students participated in the project to determine the effectiveness of computer simulation in teaching inventory management concepts.

Objective measures included a pretest and a posttest (Appendix B). The pretest was administered to each student in the selected courses prior to the teaching unit on inventory management principles. The posttest was given three weeks after the pretest and following the teaching unit and again, as a retention test, eight weeks after the pretest. The written tests were scored on a 96-point scale by a food systems administration graduate student.

Supporting data were obtained by each student completing a Student Information Sheet (Appendix C) and a Student Evaluation of Teaching Method sheet (Appendix D). The student's prior knowledge of the inventory management principles, the student's attitude towards the teaching method being used and the amount of time the student spent in studying for the tests and in using the computer simulation were analyzed in relation to test scores.

I. EFFECT OF TEACHING METHOD ON SCORES

Actual scores for all students are in Tables 17, 18 and 19 in Appendix E. The overall low test scores can be attributed to a strict grading procedure followed by the graduate student who was grading the tests. All of the groups showed an expected increase in scores between the pretests and posttests and an expected decrease in scores between the posttests and retention tests.

The Mann Whitney U-Test values for p-p scores were higher ($P \leq 0.2$ for FSA 3110 winter quarter; $P \leq 0.01$ for FSA 4130) for the experimental group than for the control group (Table 4). This difference indicates that within the limits of this study the self instructional unit plus the computer simulation models did influence cognitive learning. No significant difference was found between the p-r scores for the experimental and control groups. This result suggests that the five week interval between the posttest and retention test was not long enough for significant loss of knowledge to occur. The information in Table 4 suggests that the FSA 4130 class utilized the experimental teaching method to a greater extent than the students in FSA 3110. Possibly the experimental teaching method and/or content was more difficult for the FSA 3110 students. The U-Test values for the probabilities shown in Table 4 are in Table 22 in Appendix F.

The U-Test values for the FSA 4130 p-p question scores were higher ($P \leq 0.01$ to $P \leq 0.05$) for the experimental group than for the control group for all questions except question 4 (Table 5). The lack of significance for this question suggests that the inventory management concept covered in question 4 either was difficult and not sufficiently explained in either teaching method or that the question itself was not discriminating enough. The experimental teaching method did produce higher cognitive learning values than the control method for some of the questions answered by the FSA 3110 classes but a

TABLE 4

PROBABILITY LEVELS FOR EFFECT OF TEACHING METHOD ON COGNITIVE LEARNING DETERMINED BY COMPARING DIFFERENCES BETWEEN TEST SCORES

	Control group							
	FSA 3110						FSA 4130	
	Fall		Winter		Fall & Winter		Fall	
	p-p	p-r	p-p	p-r	p-p	p-r	p-p	p-r
Experimental Group								
Fall FSA 3110								
p-p N = 10	n.s.							
p-r N = 9		n.s.						
Winter FSA 3110								
p-p N = 17			0.2					
p-r N = 11				n.s.				
Fall and Winter FSA 3110								
p-p N = 27					n.s.			
p-r N = 20						n.s.		
Fall FSA 4130								
p-p N = 25							0.01	
p-r N = 23								n.s.

Probabilities represent a one sided Mann Whitney U-test level of significance for the experimental group.

n.s. = no significance beyond the 0.2 level.
p-p = posttest minus pretest scores.
p-r = posttest minus retention test scores.
N = total sample for experimental plus control tests.

TABLE 5

PROBABILITY LEVELS FOR EFFECT OF TEACHING METHOD ON COGNITIVE LEARNING DETERMINED BY COMPARING DIFFERENCES BETWEEN QUESTION SCORES FOR EXPERIMENTAL AND CONTROL GROUPS

	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11
FSA 3110 Fall p-p N=10	n.s.	0.1	n.s.	n.s.	0.2	n.s.	0.1	n.s.	n.s.	0.2	0.2
FSA 3110 Fall p-r N= 9	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.
FSA 3110 Winter p-p N=17	0.2	n.s.	n.s.	0.2	n.s.	n.s.	0.2	n.s.	0.05	n.s.	n.s.
FSA 3110 Winter p-r N=11	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.
FSA 3110 Fall & Winter p-p N=27	n.s.	n.s.	n.s.	0.1	0.2	n.s.	0.05	n.s.	0.2	0.2	n.s.
FSA 3110 Fall & Winter p-r N=20	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	0.2
FSA 4130 Fall p-p N=25	0.01	0.01	0.05	n.s.	0.05	0.01	0.01	0.01	0.01	0.01	0.05
FSA 4130 Fall p-r N=23	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.

Probabilities represent a one sided Mann Whitney U-Test level of significance for the experimental group.

n.s. = no significance beyond the 0.2 level.
p-p = posttest minus pretest scores.
p-r = posttest minus retention test scores.
N = total sample for experimental plus control tests.

consistent pattern did not evolve. Again a significant difference was not found for the p-r question scores. The U-Test values for the probabilities shown in Table 5 are in Table 23, Appendix F.

When the division scores between the experimental and control groups were analyzed by means of the Mann Whitney U-Test (Table 6), a significant difference did not occur for DIV I for the FSA 3110 classes but was present for the FSA 4130 class ($P \leq 0.01$). This difference shows that higher p-p scores were found for the students in the experimental group than for the students in the control group and indicates that the teaching method influenced the recall of inventory management principles for FSA 4130.

For DIV II, significant differences occurred between the experimental and control groups for FSA 3110 p-p scores ($P \leq 0.05$ for winter, and $P \leq 0.1$ for fall and winter); and for the FSA 4130 p-p scores ($P \leq 0.01$). The differences represent higher U-Test values for the experimental group than for the control group and indicate that the experimental teaching method did influence the student's ability to apply inventory management concepts towards solving a problem. The U-Test values for the probabilities in Table 6 are in Table 24, Appendix F. A significant difference did not occur for any of the p-r division scores indicating that neither teaching method was more influential than the other on the retention of inventory management concepts.

II. EFFECT OF QUARTER ON SCORES

Significant differences for the U-Test values occurred for the winter quarter p-p test scores and division scores for both the

TABLE 6

PROBABILITY LEVELS FOR EFFECT OF TEACHING METHOD ON COGNITIVE LEARNING DETERMINED BY COMPARING DIFFERENCES BETWEEN DIVISION SCORES FOR EXPERIMENTAL AND CONTROL GROUPS

	Division I (DIV I) Probability level	Division II (DIV II) Probability level
FSA 3110 Fall p-p N = 10	n.s.	n.s.
FSA 3110 Fall p-r N = 9	n.s.	n.s.
FSA 3110 Winter p-p N = 17	n.s.	0.05
FSA 3110 Winter p-r N = 11	n.s.	n.s.
FSA 3110 Fall & Winter p-p N = 27	n.s.	0.1
FSA 3110 Fall & Winter p-r N = 20	n.s.	n.s.
FSA 4130 Fall p-p N = 25	0.01	0.01
FSA 4130 Fall p-r N = 23	n.s.	n.s.

Probability levels represent a one sided Mann Whitney U-Test level of significance for the experimental group.

n.s.= no significance beyond the 0.1 level.
p-p = posttest minus pretest scores.
p-r = posttest minus retention test scores.
N = total sample for experimental plus control groups.

experimental and the control teaching methods (Tables 7 and 8). The U-Test values for these probabilities are in Tables 25, 26 and 27, Appendix F. In Table 9 some of the p-p question scores also showed a significant difference for the winter quarter U-Test values for both teaching methods. These differences indicate that both teaching methods were received and utilized better for cognitive learning during the winter quarter than during the fall quarter.

The p-r test scores (Table 7) did not show any significant difference between quarters with only an occasional p-r question score (Table 9) showing a significant difference for the fall quarter experimental teaching method. The control group DIV I p-r scores (Table 8) were significant for the fall quarter while both the control and experimental groups were significant for the fall quarter DIV II p-r scores. These results indicate that both teaching methods aided the fall quarter students in the retention of the inventory management concepts while the same teaching methods did not affect the retention of knowledge for the winter quarter students. This inconsistency in the results could be attributed to the individual student's ability to control learning (Carroll, 1971).

Summary of Effects of Teaching Method and Quarter on Scores

Within the limitations of this study the individualized instructional module incorporating computer simulation models did produce some results when compared to the traditional lecture method. The conceptual attainment of inventory management principles and the application of the principles toward problem solving and decision

TABLE 7

PROBABILITY LEVELS FOR EFFECT OF QUARTER IN WHICH TEACHING METHOD WAS USED ON COGNITIVE LEARNING DETERMINED BY COMPARING DIFFERENCES BETWEEN TEST SCORES

	Control group		Experimental group	
	Winter 3110			
	p-p	p-r	p-p	p-r
Control Group				
Fall 3110 p-p N = 13	0.05			
Fall 3110 p-r N = 9		n.s.		
Experimental Group				
Fall 3110 p-p N = 14			0.05	
Fall 3110 p-r N = 11				n.s.

Probability levels represent a one sided Mann Whitney U-Test level of significance for the winter quarter.

n.s. = no significance beyond the 0.1 level.
p-p = posttest minus pretest scores.
p-r = posttest minus retention test scores.
N = total sample for both fall and winter quarters.

TABLE 8

PROBABILITY LEVELS FOR EFFECT OF QUARTER IN WHICH TEACHING METHOD WAS USED ON COGNITIVE LEARNING DETERMINED BY COMPARING DIFFERENCES BETWEEN DIVISION SCORES FOR FSA 3110 CLASSES

	Division I	Division II
Fall Con. vs Winter Con. p-p N = 13	0.01	0.01
Fall Exp. vs Winter Exp. p-p N = 14	0.05	0.01
Fall Con. vs Winter Con. p-r N = 9	0.01[F]	0.05[F]
Fall Exp. vs Winter Exp. p-r N = 11	n.s.	0.01[F]

Probabilities represent a one sided Mann Whitney U-Test level of significance for the winter quarter.

F = a one sided Mann Whitney U-Test level of significance for the fall quarter.
n.s. = no significance beyond the 0.01 level.
Con. = Control group.
Exp. = Experimental group.
p-p = posttest minus pretest scores.
p-r = posttest minus retention test scores.
N = total sample for both fall and winter groups.

TABLE 9

PROBABILITY LEVELS FOR EFFECT OF QUARTER IN WHICH TEACHING METHOD WAS USED ON COGNITIVE LEARNING DETERMINED BY COMPARING DIFFERENCES BETWEEN QUESTION SCORES FOR FSA 3110 CLASSES

	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11
Fall Con. vs Winter Con. p-p N=13	n.s.	0.05	0.1	n.s.	0.1	n.s.	0.05	0.05	n.s.	0.01	n.s.
Fall Con. vs Winter Con. p-r N= 9	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.
Fall Exp. vs Winter Exp. p-p N=14	0.1	n.s.	0.05	n.s.	0.1	0.01	0.1	0.05	0.01	0.05	n.s.
Fall Exp. vs Winter Exp. p-r N=11	n.s.	n.s.	n.s.	n.s.	0.05^{F}	n.s.	n.s.	n.s.	n.s.	0.01^{F}	0.01^{F}

Probabilities represent a one sided Mann Whitney U-Test level of significance for winter quarter. "F" represents a one sided U-Test level of significance for fall quarter.

n.s. = no significance beyond the 0.1 level.
Con. = Control group.
Exp. = Experimental group.
p-p = posttest minus pretest scores.
p-r = posttest minus retention test scores.
N = total sample for both fall and winter quarters.

making situations were evident primarily in the FSA 4130 class. Possible reasons for the greater effectiveness of the experimental method in FSA 4130 include either prior familiarity of this group with inventory management principles and with the teaching method which helped overcome the initial anxiety of a new experience or that the teaching method in its present form helped these students achieve the desired results.

Overall, the experimental groups had more significant results than did the control groups for Division II. This division was designed for answers requiring the upper level cognitive knowledge of application of lower level principles for solving problems. Indirectly the significant results for Division II shows that vertical transfer of cognitive learning was present and also that the techniques of decision making and problem solving were used by the students.

The lack of significant differences for more of the p-r scores suggests that either the teaching methods produced equally well or equally poor results in the retention of subject matter or possibly that the time interval between tests was not long enough for loss of knowledge to occur.

When the fall quarter FSA 3110 groups were compared to the winter quarter FSA 3110 groups, the winter quarter students achieved the better results. Statistical significance occurred for both the winter quarter control and experimental groups for test scores, question scores and division scores among the p-p tests. These results indicated that both teaching methods were better utilized by the winter quarter groups than by the fall quarter groups for achieving cognitive learning.

The author observed that the winter FSA 3110 class had the better overall positive attitude toward the project. Their test scores also were higher than those of the other groups. Since fall quarter was the first time the experimental teaching method had been used in food systems administration classes, these students possibly were anxious about the new experience, resulting in their overall negative attitude. These findings were in accord with McKenney and Dill (1966) and Baldwin (1969).

According to Carroll (1971) the degree of learning attained by a student is dependent upon aptitude for that subject, quality of instruction, perseverance of the student, time allowed for the subject and student's ability to understand. One or all of these factors could enable the student to control test scores regardless of teaching method used for presenting the material to be learned.

III. ANALYSIS OF SCORES USING THE WILCOXON MATCHED PAIRS

Since a student was expected to have a retention test score less than or equal to the posttest score, any retention score higher than the posttest score would not be a result of the teaching method used. These positive differences were selected for the "T" values. Any significance would be a result of the teaching method. The actual test scores for each student may be found in Table 17, Appendix E. The "T" values for each class are given in Table 28 in Appendix F.

A significant difference was not observed for the post- and retention test scores (Table 10). These results indicate that the teaching method did not influence the student's retention of subject matter as represented by the test scores.

A consistent pattern of significant differences did not occur

TABLE 10

PROBABILITY LEVELS FOR COMPARISONS OF ACTUAL SCORES FROM POSTTESTS WITH ACTUAL SCORES FROM RETENTION TESTS USING WILCOXON MATCHED PAIRS TEST

	FSA 4130		FSA 3110	
	Con N=12	Exp N=10	Con N=9	Exp N=11
Total	n.s.	n.s.	n.s.	n.s.
Q1	n.s.	0.01	n.s.	0.05
Q2	n.s.	0.01	n.s.	0.025
Q3	n.s.	0.025	n.s.	n.s.
Q4	n.s.	n.s.	n.s.	0.025
Q5	n.s.	n.s.	n.s.	n.s.
Q6	n.s.	n.s.	n.s.	0.05
Q7	n.s.	n.s.	n.s.	n.s.
Q8	0.025	n.s.	n.s.	n.s.
Q9	n.s.	n.s.	n.s.	n.s.
Q10	n.s.	0.05	n.s.	0.05
Q11	0.025	n.s.	n.s.	n.s.
DIV I	n.s.	0.01	0.01	n.s.
DIV II	n.s.	0.05	n.s.	0.025

Probabilities represent a one sided Wilcoxon Matched Pairs Test for the presence of subject matter retention.

n.s. = no significance beyond the 0.1 level.
Con = Control group.
Exp = Experimental group.
N = total number sample in that group.

for the question scores. Occasional significances did occur for some questions within both teaching method groups (Table 10). Both experimental groups had a significant difference for questions 1, 2 and 10, indicating that the experimental teaching method did affect the retention of learned material for these questions. Question 10 was the problem solving question which required the application of learned concepts for obtaining an answer.

The experimental teaching method produced significant results in both divisions for the FSA 4130 experimental group ($P \leq 0.01$ for DIV I and $P \leq 0.05$ for DIV II) and in DIV II for the FSA 3110 experimental group ($P \leq 0.025$). The FSA 3110 control group also had a one sided level of significance for DIV I ($P \leq 0.01$).

Within the limitations of this study the individualized teaching method incorporating computer simulation resulted in the student's retention of learned information being equivalent to if not greater than that for the students in the control group. The ability to apply learned knowledge towards solving a problem was needed for answering questions in DIV II. The traditional lecture method did produce results equivalent to if not greater than those in the experimental method for the recall of facts. Since both experimental groups showed significance in DIV II, indications were that retention of cognitive vertical transfer of learning from the lower level of knowledge recall to the higher level of knowledge application did occur as a result of the individualized instruction module using computer simulation for teaching inventory management principles. The use of computer simulation in an individualized learning situation did produce learning results "as good as" the traditional lecture method. These results were in agreement with those reported by Boocock (1971).

IV. RELATIONSHIP OF SUPPORTING DATA TO TEST SCORES

On the Student Information Sheet data were collected from each student concerning classification, major, prior food systems administration courses which included inventory management principles and prior contact with food service inventories. The information about the student's prior work experience and/or knowledge of inventory management principles was coded numerically with "0" representing no prior contact, "1" for work experience only, "2" for course work only and "3" for both work and courses.

Of the students participating in the study, 15 were juniors and 23 were seniors in the food systems administration major or coordinated undergraduate program in dietetics. The remaining students were 4 seniors with a major in nutrition, 9 graduate students and 1 special student majoring in food systems administration.

Of the 52 students only 2 had had no previous contact with inventory management principles in any way (Table 20, Appendix E). Thirty-two had had both course contact and work experience. The remaining 18 had had course work only.

To determine if a relationship existed between the student's prior contact with inventory management principles and the attainment of cognitive learning or the retention of learned materials, a Chi-Square test was used. The number of students in each coded-prior-contact category was compared to differences between posttest and pretest (p-p) scores only and also to the test scores only between the posttest and retention (p-r). No significant relationship was found between student's prior contact with inventory management principles and cognitive learning or retention of knowledge (Table 11).

The Student Evaluation of Teaching Method sheet was developed to learn the amount of time each student spent on the unit, to obtain information about the student's attitude towards the structure of the teaching materials, and to obtain information about the student's overall reaction to the teaching method being used. The actual data for each of these areas are in Table 21, Appendix E. A Chi-Square analysis (Table 12) was made to determine if a relationship existed between student evaluation of the structural components of the teaching method and cognitive learning or retention of knowledge. The pretest scores were subtracted from the posttest scores for each student. These differences (p-p) were compared to each of the seven structural components. The same comparisons were made using the differences between posttest and retention test (p-r) scores.

A statistical significance was found for the area of case study or class problem ($P \leq 0.1$) when compared to the p-p test scores. When the calculated Chi-Square values for the other areas within this analysis were compared to the Chi-Square value needed for statistical significance, the areas for structure of tape and for content of study guide, lecture or tape were close to the $P \leq 0.1$ level of significance. This result indicated that significance could be present between the student's attitude towards these two areas and possibly would show up when a larger sample size was used.

TABLE 11

RELATIONSHIP OF PREVIOUS KNOWLEDGE OF INVENTORY MANAGEMENT PRINCIPLES TO COGNITIVE LEARNING AND RETENTION OF COGNITIVE KNOWLEDGE

	df	Chi-Square	Probability
Posttest-Pretest p-p N = 52	2	.094	n.s.
Posttest-Retention Test p-r N = 42	2	2.28	n.s.

df = degrees of freedom.
N = total number of students completing Student Information Sheet and taking all tests.
n.s. = not significant beyond 0.1 level.

TABLE 12

RELATIONSHIP OF STUDENT EVALUATION OF TEACHING PROCEDURE TO COGNITIVE LEARNING AND RETENTION OF KNOWLEDGE DETERMINED BY DIFFERENCES BETWEEN TEST SCORES

	Cognitive Learning p-p				Retention of Knowledge p-r			
Structural Components	N	df	Chi-Square Value	Probability	N	df	Chi-Square Value	Probability
Structure of Tape	28	4	6.48	n.s.	21	4	6.36	n.s.
Structure of Study Guide or Lecture	38	3	2.69	n.s.	30	2	1.49	n.s.
Content of Study Guide, Lecture or Tape	37	3	4.53	n.s.	30	2	0.47	n.s.
Stated Objectives	37	2	2.38	n.s.	29	1	1.41	n.s.
Case Study or Class Problem	28	3	7.33	0.1	23	3	5.67	n.s.
Instructor/Student Rapport	36	2	0.21	n.s.	29	2	2.07	n.s.
Overall Reaction	36	2	1.64	n.s.	29	2	2.86	n.s.

p-p = posttest minus pretest scores.
p-r = posttest minus retention test scores.
N = total number of students completing the Student Evaluation of Teaching Method Sheet.
n.s. = value not significant beyond 0.1 level.

No significant relationship was found for the p-r test scores when compared to any one of the seven areas depicting the student's attitude toward the structural components of the teaching procedure. When the calculated Chi-Square value for the area of structure of tape was compared to the Chi-Square value needed for significance, a closeness was observed at the $P \leq 0.1$ level. This closeness suggests the possibility that significance could occur if a larger sample size were used.

To gain further insight into the student's attitude to structural components, the data were compiled as percentages and given in Table 13. The students in the experimental groups tended to agree that the tape and study guide booklet were too long but that the inventory management principles were adequately covered in a way that was easily understood.

Fifty-two percent of the experimental group considered the case study and computer simulation to be busy work. Incorporating the computer simulation into the activities in the study guide booklet along with more discussion concerning the use of computers in food systems inventories might overcome this feeling. Dividing the study guide booklet into several smaller units would shorten the amount of time required at one study session and allow for breaks in using the module. Several short units could encourage review of more difficult sections with minimum use of time.

Fifty-two percent of the students evaluating the teaching method considered the overall procedure "interesting" while 48% considered it to be a "waste of time." The vocal opinions of the FSA 3110 winter quarter experimental group were favorable to the project

TABLE 13

COMPILATION IN PERCENTAGES OF STUDENT ATTITUDES TO STRUCTURAL COMPONENTS OF TEACHING METHODS

Structural Components	Experimental N=26 %	Control N=13 %
1. Structure of Tape:		
Adequate length for content coverage; presented in an interesting manner.	36	0
Too long; presented in a boring manner.	52	0
Inadequate length for content coverage but presented in an interesting manner.	12	0
No reply.	0	0
2. Structure of Study Guide or Lecture:		
Materials and instructions presented in clear terms; adequate length; well organized.	48	54
Materials and instructions presented in vague terms; material not well organized.	32	31
Materials and instructions presented in vague terms but well organized; too long.	20	15
No reply.	0	0
3. Content of Study Guide, Lecture or Tape:		
Adequate coverage of topic; language was easily understood.	64	38
Inadequate coverage of topic; language was vague; hard to understand.	32	23
Inadequate coverage of topic but language was clear and easily understood.	4	38
No reply.	0	0

TABLE 13 (continued)

Structural Components	Experimental N=26 %	Control N=13 %
4. Stated Objectives for Inventory Management Unit:		
Clearly worded so that knew what was expected.	76	54
Objectives were not given.	8	15
Not clearly worded, did not know what was expected.	16	23
No reply.	0	8
5. Case Study or Class Problem:		
Instructions clearly presented; problem helped to explain inventory management principles.	24	23
Busywork; problem was of no value to understanding inventory management principles.	52	8
Instructions vaguely presented but problem helped to understand inventory management principles.	20	0
No reply.	0	69
6. Instructor/Student Rapport:		
Instructor was able, willing and available to answer questions.	84	77
Instructor was not available to answer questions.	16	0
Instructor was available but unable to answer questions.	0	8
No reply.	0	15
7. Overall Reaction to Teaching Method:		
Interesting	52	54
Waste of Time	48	15
Boring	0	23
No reply	0	8

with many students expressing further interest in the use of the individualized instruction and computer simulation as a means of teaching food systems principles. Many participants in the control group expressed a desire to complete the module and use the computer simulation. Three students in the winter quarter FSA 3110 control group actually studied the module study guide booklet and listened to the tape during the research period. The fall FSA 4130 group considered the research project as "another thing to do" for which they were not being graded. Later in the year several expressed the thought that they wished they had spent more time on the project.

To determine if a correlation existed between cognitive learning and estimated time spent on the learning process, a Spearman Rank Correlation analysis was made on data collected from Section A of the Student Evaluation of Teaching Method sheet. The difference between the pretest and posttest (p-p) scores only was compared with each student's estimated length of time spent in the learning process. The time spent was correlated also with the difference between the posttest and retention test (p-r) scores only. The results of these analyses are given in Table 14. The actual time spent is listed in Appendix E in Table 20.

No relationship existed between cognitive learning or retention of knowledge and estimated time spent on the learning process except in the FSA 4130 experimental p-p group. This group had a positive correlation value of 0.708 which was significant at the $P \leq 0.05$ level. A positive relationship indicated that as the amount of time spent by these students increased so did the cognitive learning of inventory management principles.

TABLE 14

CORRELATION BETWEEN STUDENT'S COGNITIVE LEARNING AND ESTIMATED TOTAL AMOUNT OF TIME SPENT ON LEARNING PROCESS

	Correlation Coefficient	Probability
FSA 3110 Fall and Winter Exp. p-p N=14	0.426	n.s.
FSA 3110 Fall and Winter Exp. p-r N=11	-0.099	n.s.
FSA 3110 Fall and Winter Con. p-p N=13	0.292	n.s.
FSA 3110 Fall and Winter Con. p-r N= 9	-0.298	n.s.
FSA 4130 Fall Exp. p-p N=12	0.708	0.05
FSA 4130 Fall Exp. p-r N=11	-0.597	n.s.

Correlation Coefficient represents a one sided level of significance for the rho (r_s) value.

Exp. = Experimental group.
Con. = Control group.
p-p = Posttest minus pretest scores.
p-r = Posttest minus retention test scores.
N = total number of students completing the student Evaluation of Teaching Method sheet for this area.

A total of 86.06 hours was spent by the FSA 4130 students on the experimental p-p groups while a total of 183.77 hours was spent by the FSA 3110 students. Stuck and Manatt (1970) reported that the audio-tutorial approach to teaching resulted in better learning in less time when compared to the lecture method. The students in FSA 4130 had received the traditional lecture method in inventory management principles in the FSA 3110 course as much as a year earlier. This previous exposure also enabled the students to recall the learned material in less time with better utilization.

Students in the experimental group as a whole in all courses spent more time (269.83 hours) on the unit than did those in the control group (48.44 hours). Much of this time was spent with the module and tape. Due to unfamiliarity with the teaching method and with the inventory management principles, much time was spent in repeating various sections. The students in the experimental group reported that the module was too long and required approximately four hours to complete with understanding. The taped lecture played straight through required a minimum of 45 minutes.

Because of the prior exposure to the FSA 3110 inventory management lecture, the FSA 4130 students were not required to spend class time on the project whereas the FSA 4130 students were required to spend one lecture period of class time. This fact accounts for the lack of estimated time data in Table 14 for the FSA 4130 control group.

The negative correlation coefficients for the p-r groups were a result of random variation affecting the small sample size being used. If a larger sample size had been used, these negative values might show a negative correlation between the retention of inventory management knowledge and estimated time spent on the learning process.

V. TIME AND COMPUTER COST FOR STUDY

The cost of computer time must be limited to conditions under which the computer is used. These conditions include size of school, type of school access to the computer, department money allocations for computer use, and amount of costs absorbed by the computer center. Only the CPU time is exact from computer to computer and can be used for cost comparisons from place to place. At the University of Tennessee, Knoxville, the computing center costs are listed on an audit trail which is sent monthly to each participating instructor. If the computer use cost is less than $2.00 per month, an audit trail is not sent to a department.

For teaching purposes, the University allocates a minimum charge of $1.00 per student per quarter for supplies and paper and charges $2.50 per hour for computing center consultant services.

To obtain an average cost of computer use under the University of Tennessee, Knoxville, conditions, the cost is divided by the total number of runs listed under "#jobs" on the audit trail. The students in the fall quarter classes had a total of 70 jobs at a cost of $105.9102. A total of $1.97 was used above the allotted $1.00 per student for supplies. The winter quarter students had a total of 149 jobs and a cost of $202.7093 or a total of $308.6195 for the two quarters. The average cost of computer use was $1.4092 per job.

Another cost incurred in the use of the simulation models was for the offline disks used for storing the program. This cost was $5.60 for the two quarters.

Construction of the study guide and lecture took the author approximately 57 hours to plan, devise and construct. Taping of the 45 minute lecture on the cassette tape took approximately 6 hours.

Individual instructor/student contact with the experimental groups was greater fall quarter than for the winter quarter due to the greater number of students participating in the project who needed individual keypunching instruction and to the students' unfamiliarity with the entire procedure.

CHAPTER VI

SUMMARY AND RECOMMENDATIONS

A conceptual framework for teaching inventory management principles using computer simulation as a teaching medium was developed. A methodology based on this framework was designed and implemented. The feasibility of using computer simulation models in an individualized instructional module for teaching the transfer of cognitive knowledge from the lower level of knowledge recall to the upper levels of decision making and problem solving was used. Inventory management principles were used in the module. The effectiveness of the module was evaluated through objective tests. The student's attitude towards the structural components of the teaching procedure, the student's prior knowledge of inventory principles and the amount of time spent by the student in studying and preparing for the posttests were evaluated through subjective questioning.

I. SUMMARY

Two short answer tests were administered to two groups of students, control and experimental, and analyzed using the Mann Whitney U-Test to determine if the experimental teaching method produced better cognitive learning results than did the control method. Differences between pretest and posttest (p-p) scores showed that cognitive learning attributable to the use of the module and computer simulation models did occur in FSA 4130 but that retention, as measured by posttest and retention test (p-r) scores, did not occur. Differences between p-p question scores and p-p cognitive level division scores detected learning on the upper cognitive level of problem solving due to the experimental teaching method but the experimental teaching method did not influence the retention of this information, as measured by p-r scores.

The Mann Whitney U-Test also was used to determine if the quarter in which the teaching method was used affected cognitive learning or knowledge retention. Better overall learning results occurred for both FSA 3110 p-p experimental and control groups during the winter quarter than for the fall quarter groups. This outcome might be attributed to the better overall observed attitude for winter quarter students for the project.

When comparing the actual posttest scores with the retention test scores using a Matched Pairs test, the experimental teaching method did influence the retention of the recall of inventory management principles as well as the application knowledge needed for solving a problem on inventory management.

Chi-Square tests between test score differences and the student's attitude towards the teaching procedure and between test score differences and the student's prior contact with inventory management principles were significant for the one area of case study or class problems for the p-p scores. These results as a whole indicate that within the limits of this study these two variables did not affect cognitive learning or retention of knowledge. Of the 52 students participating in the project only 2 had had no previous contact with inventory management principles. Fifty-two percent of the experimental group considered the individualized instructional module to be "interesting" while 48% considered it to be a "waste of time."

Students in the experimental group as a whole spent more time in the learning process than did students in the control group. When this amount of time was correlated to p-p and p-r test score differences, no relationship was found except for the FSA 4130 experimental p-p group. As the amount of time spent in the learning process increased for this group so did cognitive learning but not retention of knowledge for inventory management principles.

Construction of the individualized instructional module and cassette tape took the author approximately 57 hours. Students in the experimental group reported that the module was too long and took approximately four hours to complete with understanding. Once the module with computer simulation was constructed, only minimal time would be needed to keep it updated by incorporating new learning problems and case studies. The major cost incurred would be cost of new cassette tapes and computer time. The average cost of computer use was $1.4092 per run of computer program.

II. RECOMMENDATIONS

Further research in the use of these computer simulation models for teaching inventory management concepts is recommended. Comparisons could be made of the module as it now stands with modifications within its structure to determine a form which would achieve greater mastery of inventory management concepts. Comparisons among types of case studies used with the simulation could be made to determine a form which would be more effective in teaching problem solving experiences. Some of these could be instructor devised case studies versus actual inventory management problems from a food service facility.

Research concerning the amount of study time needed by the student to achieve mastery of inventory management concepts could be developed. The effectiveness of this self-instructional teaching method for later on-the-job transfer of inventory management concepts could be investigated.

If this study were repeated the author recommends that the researcher use more than one test grader to increase test score reliability. These graders also should be trained in the grading procedure used and in knowledge of inventory management concepts. The participating students should have prior knowledge of keypunching techniques to reduce researcher's time in individual instruction. The tests should be given to food systems administration students not participating in the study for validation of terminology and question answers. These tests also should consist of either multiple choice answers or answers requiring one word or one sentence for ease and objectivity in grading. The Student Evaluation of Teaching Method sheet should have many one idea descriptions for each structural component rather than long descriptive phrases, for obtaining a better overall concept of component effectiveness for mastery.

Proctors should be used for scoring the formative tests within the study guide booklet to assure student mastery of inventory management concepts.

This study indicates that either teaching method produced overall equal learning results for the FSA 3110 students with the experimental method having some influence on student's problem solving ability. The concepts of inventory management are difficult to master in any teaching/learning situation. This difficulty could be a cause for these results. Greater learning results from the experimental method were evident in the FSA 4130 class. These students had prior knowledge of the inventory management concepts and were better able to utilize this material with the computer simulation models for solving a problem.

Division of the inventory management module into smaller units with the computer simulation models used in each might help the FSA 3110 students master the concepts better. Use of the computer simulation models for solving inventory management problems after collecting the data within a facility would give the FSA 4130 students more experience in decision making and problem solving. These self instructional learning situations for teaching inventory management concepts could release the instructor from the classroom role of lecturer to the capacity of a supervisor of learning.

LIST OF REFERENCES

LIST OF REFERENCES

Airasian, P. W. 1971. The role of evaluation in mastery learning. In "Mastery Learning." Ed. Block, J. H. p. 77. Holt, Rinehart and Winston, Inc., New York, New York.

Anderson, L. F., Hermann, M. G., Robinson, J. A. and Snyder, R. C. 1964. A comparison of simulation, case studies, and problem papers in teaching decision making. Cooperative Research Project No. 1568. Northwestern University. Evanston, Illinois. Cooperative Research Program of the Office of Education, U. S. Department of Health, Education and Welfare.

Andrews, J. 1969. Inventory control in the dietary department. Hospitals 43: 96.

Baldwin, J. D. 1969. Influences detrimental to simulation gaming. The American Behavioral Science 12(6): 14.

Bandeen, V. E. and Upton, E. M. 1972. Computer simulation as a teaching technique in food service management. Journal of Canadian Dietetic Association 33(2): 94.

Beach, B. L. and Ostenso, G. L. 1969. Relationships of serving time to system capacity. Entree serving times. Journal of American Dietetic Association 54(4): 290.

Beach, B. L. 1972. Computer simulation instructional models for the food administration curriculum. Unpublished paper.

Bell, C. W. and Linebarger, R. N. 1970. Applications of computer modeling and simulation to science education. Simulation 15(4): 185.

Bierman, H., Bonini, C. P. and Hausman, W. H. 1969. Inventory control with reordering and uncertain demand. In "Quantitative Analysis for Business Decisions." 3rd ed. Richard D. Irwin, Inc.

Blaker, G. 1969. Implication of the trends in the food service industry. In the "Proceeding: the Fifth Conference of College and University Faculties of Institution Management." Nebraska Center for Continuing Education, University of Nebraska, 33rd and Holdredge Streets. Lincoln, Nebraska. March 19-22. 1969.

Block, J. H. 1971. Operating procedures for mastery learning. In "Mastery Learning." Ed. Block, J. H. p. 64. Holt, Rinehart and Winston, Inc. New York, New York.

Bloom, B. S. 1971. Mastery learning. In "Mastery Learning." Ed. Block, J. H. p. 47. Holt, Rinehart and Winston, Inc. New York, New York.

Bloom, B. S., Engelhart, M. D., Furst, E. J., Hill, W. H. and Krathwohl, D. R. 1956. Taxonomy of educational objectives. The classification of educational goals Handbook I: cognitive domain by a committee of college and university examiners. David McKay Company, Inc. New York.

Boocock, S. S. 1966. An experimental study of the learning effects of two games with simulated environments. The American Behavioral Science 10(2): 8.

Boocock, S. S. 1971. Games, instructions. Encyclopedia of Education 4: 109.

Braun, L. 1970. Digital computer as a general purpose simulator. Journal of Education Data Processing 7(3): 151.

Buffa, E. S. 1969. Modern Production Management. 3rd ed. p. 15. John Wiley and Sons, Inc. New York, New York.

Calder, E. M. C. 1967. Computer simulation of straight-line, bypass, and random-path cafeterias; evaluation of system effectiveness. Unpublished M. S. thesis. University of Wisconsin, Madison, Wisconsin.

Carroll, J. B. 1971. Problems of measurement related to the concept of learning for mastery. In "Mastery Learning." Ed. Block, J. H. P. 29. Holt, Rinehart and Winston, Inc. New York, New York.

Cherryholmes, C. H. 1966. Some current research of effectiveness of educational simulations: implications for alternative strategies. The American Behavioral Science 10(2): 4.

Creager, J. G. and Murray, D. R. 1971. The advantages and applications of modules. In "The Use of Modules in College Biology Teaching." Ed. Creager, J. G. and Murray, D. R. p. 9. Commission on Undergraduate Education in the Biological Sciences. Washington, D.C.

David, B. D. 1972. A model for decision making. Hospitals 46(15): 50.

Durben, J. N. 1970. Elements of inventory control. In "Production and Inventory Control Handbook." Ed. Greene, J. H. p. 14.3. McGraw-Hill Book Co. New York, New York.

English, C. S. 1974. Methodology for evaluation of audio-tutorial modules in the development of cognitive knowledge and intellectual skills in sensory evaluation of foods. Unpublished M. S. thesis, University of Tennessee, Knoxville, Tennessee.

Francis, J. B. 1972. Behavioral objectives and the teaching/learning process in nursing education. In "Proceedings of the Conference and Workshop on Behavioral Objectives." Ed. Hart, S. E. and Rott, R. K. p. 12. January 1971. School of Nursing, State University of New York at Buffalo. Buffalo, New York.

Hastings, G. R. 1972. Independent learning based on behavioral objectives. Journal of Education Research 65(9): 411.

Heinkel, O. A. 1970. Evaluation of simulation as a teaching device. Journal of Experimental Education 38(3): 32.

Hoover, H. M. 1967. Levels of conceptual understanding. Journal of Home Economics 59(2): 89.

Inbar, M. 1970. Participating in a simulation game. Journal of Applied Behavioral Science 6(2): 239.

Keller, F. S. 1968. Good-bye teacher . . . Journal of Applied Behavioral Analysis 1(1): 79.

Kibler, R. J., Barker, L. L. and Miles, D. T. 1970. "Behavioral Objectives and Instruction." Allyn and Bacon, Inc. Boston, Massachusetts.

Kibler, R. J., Cegala, D. J., Barker, L. L. and Miles, D. T. 1974. Objectives for Instruction and Evaluation." Allyn and Bacon, Inc. Boston, Massachusetts.

Knickrehm, M. E. 1966. Digital computer simulation in determining dining room seating capacity. Journal of American Dietetic Association 48(3): 199.

Knickrehm, M. E., Hoffman, T. R. and Donaldson, B. 1963. Digital computer simulations of a cageteria service line. Journal of American Dietetic Association 43(9): 203.

Kreutz, S. M. 1971. Organizing the components of curriculum. In "Proceedings of the Sixth Conference of College and University Faculties of Institution Management." Center for Tomorrow, Ohio State University, Columbus, Ohio, March 24-27, 1971.

Mager, R. F. 1962. "Preparing Instructional Objectives." Fearon Publishers. California.

Marshall, J. C. and Hales, L. W. 1972. "Essentials of Testing." Addison-Wesley Publishing Co. Boston, Massachusetts.

Matthews, M. E. and David, B. D. 1971. Evaluation of four hypothetical purchasing systems: effect of varying the number of entree selections in the hospital menu. Journal of American Dietetic Association 59(6): 575.

McClelland, W. A. 1970. Simulation: can it benefit vocational education? American Vocational Journal 45(6): 23.

McKenney, J. I. and Dill, W. R. 1966. Influences on learning in simulation games. The American Behavioral Science 10(2): 28.

McMillan, C. and Gonzalez, R. F. 1965. Systems and models. In "Systems Analysis: a Computer Approach to Decision Models." p. 1. Richard D. Irwin, Inc. Homewood, Illinois.

Meckley, R. F. 1970. Simulation in leadership training. American Vocational Journal 45(6): 26.

Meier, R. C., Newell, W. T. and Pazer, H. L. 1969. "Simulation in Business and Economics." Prentice-Hall, Inc. Englewood Cliffs, New Jersey.

Milton, O. 1972. "Alternatives to the Traditional." p. 66. Jossey-Bass, Inc. California.

Miller, D. W. and Starr, M. K. 1967. "The Structure of Human Decisions." Prentice-Hall, Inc. Englewood Cliffs, New Jersey.

Morrison, E. J. 1970. The use of behavioral objectives in instructional materials development. American Vocational Journal 45(2): 46.

Murray, D. L. 1971. The components of a module. In "The Use of Modules in College Biology Teaching." Ed. Creager, J. G. and Murray, D. R. p. 5. Commission on Undergraduate Education in the Biological Sciences. Washington, D.C.

Nagy, E. J. 1967. Optimum reorder quantity: a means of reducing inventory and controlling costs. Hospitals 41: 101.

Nee, T. R. 1971. Educational usage of computer. Clearing House 46(1): 63.

Ostenso, G. L., Moy, W. A. and Donaldson, B. 1965. Application to interactions of food systems: developing a generalized simulation. Journal of American Dietetic Association 46(5): 379.

Sarthory, J. A. and Wade, D. E. 1971. Simulating the acquisition and allocation of educational resources. Educational Technology 11(12): 58.

Siegel, S. 1956. "Nonparametric Statistics for the Behavioral Sciences." McGraw-Hill Book Co. New York, New York.

Starr, M. K. and Miller, D. W. 1962. Dynamic inventory problems under uncertainty. In "Invertory Control: theory and practice." p. 152. Prentice-Hall, Inc. Englewood Cliffs, New Jersey.

Stuck, D. L. and Manatt, R. P. 1970. A comparison of audio-tutorial and lecture methods of teaching. The Journal of Education Research 63(9): 414.

Tennyson, R. D. and Merrill, M. D. 1971. Hierarchical models in the development of a theory of instruction: a comparison of Bloom, Gagne and Merrill. Educational Technology 11(9): 27.

This, L. E. 1970. What is simulation? American Vocational Journal 45(6): 20.

Tinsley, W. V. and Sitton, M. 1967. Teaching intellectual aspects of home economics. Journal of Home Economics 59(2): 85.

Tuckman, B. W. and Edwards, K. J. 1971. A systems model for instructional design and management. Educational Technology 11(9): 21.

Ullery, J. W. 1971. Individualized instructional systems for vocational education. Educational Technology 11(3): 22.

Vance, G. R. 1968. Inventory simulations: concepts, implementation and benefits. Management Accounting 49: 43.

Vinacke, W. E. 1971. Problem-solving. Encyclopedia of Education 4: 219.

West, B. B., Wood, L. and Harger, V. F. 1966. "Food Service in Institutions." 4th ed. p. 399. John Wiley and Sons, New York New York.

Wight, O. W. 1970. Inventory control systems. In "Production and Inventory Control Handbook." Ed. Greene, J. H. p. 16.24. McGraw-Hill Book Co. New York, New York.

APPENDICES

APPENDIX A

Case Study #1

TO: Dietitian

FROM: Director

SUBJECT: Overstocking of vegetables

The storeroom manager reports that there is not any available storage space for all the vegetables which have come in today due to the large amounts still on hand. It seems that this problem has occurred several times in the past few months. Records also show that ordering costs have increased during this same period.

Will you simulate this situation for 30 days to see what is occurring and reduce these space requirements to a level to meet demands?

The following data have been compiled for your use:

1. Present inventory policy: Fixed-order-period.
2. Orders are placed every 2 days.
3. Lead time is 1 day.
4. Actual average daily demands are 3251 units.
5. Standard deviation is 163.
6. Order cost is $15.00.
7. Necessary data for each vegetable is found on the next page.

The final written report should state what the problems were, give procedures used to correct this situation and also be accompanied by the final computer printout showing these improvements.

Due November 5, 1973.

		Beginning Inventory	Forecasted Daily Demand	Reserve Stock	Actual Cost/Portion	Portions/ Purchase Unit	Cu. Ft./ Purchase Unit	Prob. of Selection
1.	Squash	100	40	10	.028	240	.60	.01
2.	Spinach	150	65	10	.032	180	1.26	.02
3.	Broccoli	300	150	10	.050	120	1.26	.04
4.	Carrots	500	250	20	.034	100	1.26	.07
5.	Cauliflower	600	295	20	.054	120	1.26	.09
6.	Wh. Corn	700	325	20	.040	100	.60	.11
7.	Lima Beans	700	360	20	.045	100	.60	.10
8.	Mix. Vegs.	900	455	35	.037	100	.60	.14
9.	Gr. Beans	1100	520	40	.042	150	1.26	.16
10.	Peas	1800	825	45	.033	100	.60	.26

APPENDIX B

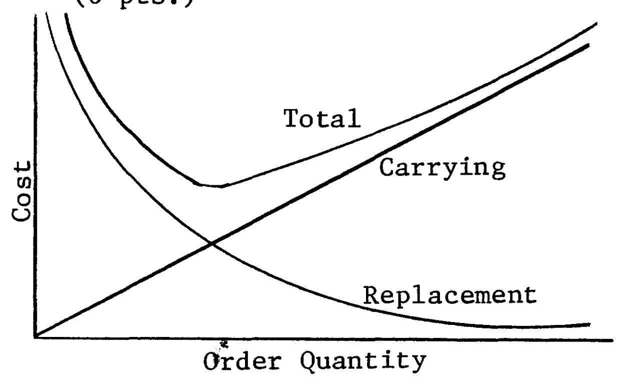
Pretest

1. What is an "inventory management system"? (4 pts.)

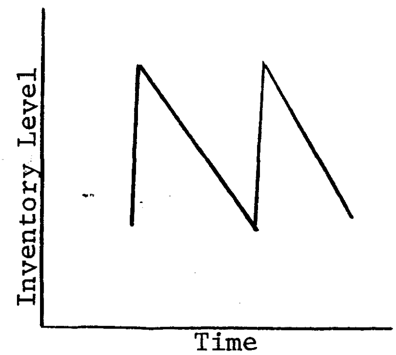
2. Compare the characteristics of an inventory management system with those of an inventory control system. (8 pts.)

3. Briefly define these inventory terms: (a) perpetual inventory, (b) lead time. (6 pts.)

4. What are the objectives of a food service procurement system? (6 pts.)



A



B

5. Using diagram A given above as a basis explain
   (a) the effects of an unreasonable order quantity on the associated costs of an item (4 pts.);

   (b) the relationship between the associated costs of an item and the determination of an optimum order quantity for that item. (10 pts.)

6. Using diagram B given above as a basis explain
   (a) the purpose of the economic order quantity model (4 pts.);
   (b) the reasons why this model cannot be used entirely in a food service situation as the only determinant of order quantities for items. (8 pts.)

7. If a food service ordering procedure for corn has a lead time of two days, a forecasted daily demand of 1500 units, a safety stock of 75 units and 3200 units are needed daily, what would be the resulting conditions to this inventory? Could they be improved? If so, how? (8 pts.)

8. The ordering clerk has provided you with the following information about squash. Read the information carefully and answer the questions at the end. (42 pts.)

   (a) Reorder quantity is 120 portions.

   (b) Ordered in 120 portions/purchase unit.

   (c) Orders are placed daily and delivered at the close of business.

   (d) Forecasted average daily demand is 196 portions.

   (e) Safety stock is 10 portions.

   (f) Beginning inventory is 400 portions.

   (g) There are no outstanding orders.

   (h) The average daily demand actually used is 190 portions.

   1. What is the reorder point for squash?

   2. On which day would the next order be placed?

   3. Could this ordering procedure be improved? If so, how?

   4. Is this problem an example of an inventory management or of an inventory control system?

Posttest and Retention Test

1. What is an "inventory control system"? (4 pts.)

2. Compare the characteristics of an inventory control system with those of an inventory management system. (8 pts.)

3. What is the purpose of using the economic order quantity model with inventories? (4 pts.)

4. How are the three associated costs (found for a specific item within an inventory) related to the determination of an optimum order quantity for that item? (10 pts.)

5. Explain why the characteristics of the economic order quantity theory are unrealistic as the only determinant of order quantities in a food service. (8 pts.)

6. How will an unreasonable reorder point for an item affect other items in the inventory and the associated costs of the inventory? (4 pts.)

7. Briefly define these inventory terms: (a) reorder point, (b) stock-out. (6 pts.)

8. If the forecasted average daily demand for an item is less than the actual daily demand for that item, what changes can be made in the system? (5 pts.)

9. What is the purpose of having safety stock for each item in a food service? (3 pts.)

10. What are the objectives of a food service procurement system? (6 pts.)

11. The ordering clerk has provided the following information to you about peas. Read the information carefully and answer the questions at the end. (42 pts.)

    (a) Purchase order is placed every Monday and delivered on the 10th day.

    (b) Average daily demand (forecasted) is 23 cans.

    (c) Peas are used daily.

    (d) Safety stock is 3 cans.

    (e) Another green vegetable is substituted for peas if a stock-out occurs.

11. (f) Beginning inventory (BI) is 69 cans.

(g) Perpetual inventory for peas for part of April including the actual daily demands for the vegetable follows:

BI is 69.

Date	Demand	Issues	Rec't	Bal.	Date	Demand	Issues	Rec't	Bal.
1	19	19	-	50	7	22	22	-	88
2	30	30	-	20	8	24	24	-	64
3	22	20	-	0	9	27	27	-	31
4	21	0	156	156	10	33	31	-	0
5	29	29	-	127	11	18	0	216	216
6	17	17	-	110	12	25			

1. If peas are to be ordered on Monday, April 9, what would be the order quantity?
2. What improvements could be made in this ordering procedure?
3. What is happening to the costs of the operation?
4. Is this an inventory management system or an inventory control system?

TABLE 15

CODES FOR THE TEST QUESTIONS ON PRETEST AND POSTTEST

Code	Pretest	Posttest
Q1	What is an "inventory management" system?	What is an "inventory control" system?
Q2	Compare the characteristics of an inventory management system with those of an inventory control system.	Same
Q3	Using diagram B given above as a basis explain the purpose of the economic order quantity model.	What is the purpose of using the economic order quantity model with inventories?
Q4	Using diagram A given above as a basis explain the relationship between the associated costs of an item and the determination of an optimum order quantity for that item.	How are the three associated costs (found for a specific item within an inventory) related to the determination of an optimum order quantity for that item.
Q5	Using diagram B given above as a basis explain the reasons why this model cannot be used entirely in a food service situation as the only determinant of order quantity for items.	Explain why the characteristics of the economic order quantity theory are unrealistic as the only determinants of order quantities in a food service.
Q6	Using diagram A given above as a basis explain the effect of an unreasonable order quantity on the associated costs of an item.	How will an unreasonable reorder point for an item affect other items in the inventory and the associated costs of the inventory?
Q7	What are the objectives of a food service procurement system?	Same
Q8	Briefly define these inventory terms: (a) perpetual inventory (b) lead time	Briefly define these inventory terms: (a) reorder (b) stock-out

TABLE 15 (continued)

Code	Pretest	Posttest
Q9	If a food service ordering procedure for corn has a lead time of two days, a forecasted daily demand of 1500 units, a safety stock of 75 units and 3200 units are needed daily what would be the resulting conditions to this inventory? Could they be improved? If so, how?	If the forecasted average daily demand for an item is less than the actual daily demand for that item, what changes can be made in the system? What is the purpose of having safety stock for each item in a food service?
Q10	Application Problem	Application Problem
Q11	Is this problem an example of an inventory management or of an inventory control system?	Is this an inventory management system or an inventory control system?

TABLE 16

PLACEMENT OF QUESTIONS WITHIN DIVISIONS

Recall of Knowledge DIV I Question Code #	Application of Knowledge DIV II Question Code #
1	6
2	9
3	10
4	
5	
7	
8	
11	

APPENDIX C

Student Information Sheet

Social Security No. ________________

Classification __________________ Age _________

Major _____________________ Have you had a previous major? ___________
What? ____________________________________

Instructions: Circle the correct answer or check in the blank, if provided.

1. Are you a transfer student? ________ From where?

2. Which of the following courses have you had or are presently taking? Check all that apply.

		When?	Quarter/Yr
FSA 3110 (3410)	Quantity Food Procurement Production and Service	_____	__________
FSA 4150 (4510)	Design and Layout of Food Service Systems	_____	__________
FSA 4130 (4520)	Food Systems Administration	_____	__________
FSA 3920	Survey of Dietetics	_____	__________
FSA 4140 (4540)	Food Systems Personnel Development	_____	__________
FSA 4410	Clinical Experience in Dietetics	_____	__________
FSA 4420	Clinical Experience in Dietetics	_____	__________
FSA 4430	Clinical Experience in Dietetics	_____	__________

3. Have you ever had any of these topics in a course? Check all that apply.

	Course?	Quarter/Yr
perpetual inventory	_____	__________
physical inventory	_____	__________

	Course?	Quarter/Yr
3. economic order quantity	_____	__________
fixed-order-period theory	_____	__________
fixed-order-quantity theory	_____	__________
computer programming	_____	__________
forecasting techniques	_____	__________

4. Do you or have you ever had a job involving food? ___________

5. Do you or did you have any contact with any of these food inventory procedures?

   ordering ________

   issuing _________

   receiving _______

6. Briefly describe your duties in each area checked.

7. What title position did or do you hold?

   How long did you or have you held the position(s) named?

APPENDIX D

Student Evaluation of Teaching Method

Social Security No. ______________ Quarter/Yr ___________________

Group you participated in: Lecture/traditional _______________

Module/simulation _________________

A. Please complete the form below.

1. If you were in the module/simulation group fill in these blanks:

   (a) How many times did you use the module? ___________

   (b) Did you complete the module the first time? __________

   (c) If not, why?

   (d) How long did you spend using the computer simulation? _______

2. If you were in the lecture/traditional group, fill in these blanks:

   (a) How long did you spend outside of class on this topic? _____

   (b) How did you spend this time? ______________

B. Please place a check beside the list of terms which best describe your reaction to each topic. If the list is inadequate then write your reaction in the provided spaces. Feel free to be frank and truthful but try to be constructive in your comments.

1. STRUCTURE OF TAPE:

   _____ Adequate length for content coverage; presented in an interesting manner. (+2)

   (+1) ____

   _____ Too long; presented in a boring manner. (0)

   (-1) ____

   _____ Inadequate length for content coverage but presented in an interesting manner. (-2)

   ____

2. STRUCTURE OF STUDY GUIDE OR LECTURE:

_____ Material and instructions presented in clear terms; adequate length; well organized. (+2)

(+1) ____

_____ Material and instructions presented in vague terms; material not well organized; too long. (0)

(-1) ____

_____ Material and instructions presented in vague terms; but well organized and of adequate length. (-2)

____

3. CONTENT OF STUDY GUIDE, LECTURE OR TAPE:

_____ Adequate coverage of topic; language used was easily understood. (+2)

(+1) ____

_____ Inadequate coverage of topic; language was vague, hard to understand. (0)

(-1) ____

_____ Inadequate coverage of topic but language was clear and easy to understand. (+2)

____

4. STATED OBJECTIVES FOR INVENTORY MANAGEMENT UNITS:

_____ Clearly worded so that you knew what was expected from you. (+2)

(+1) ____

_____ Objectives were not given. (0)

(-1) ____

_____ Not clearly worded; you did not know what was expected from you. (-2)

____

5. CASE STUDY OR CLASS PROBLEM:

_____ Instructions clearly presented; problem helped to explain inventory management principles. (+2)

(+1) ______________________________

_____ Busy work; problem was of no value to understanding inventory management principles. (0)

(-1) ______________________________

_____ Instructions vaguely presented but problem helped to explain inventory management principles. (-2)

____

6. INSTRUCTOR/STUDENT RAPPORT:

_____ Instructor was able, willing and available to answer questions. (+2)

(+1) ______________________________

_____ Instructor was not available to answer questions. (0)

(-1) ______________________________

_____ Instructor was available but unable to answer questions. (-2)

____

7. OVERALL REACTIONS TO TEACHING METHOD:

_____ Interesting. (+2)

(+1) ______________________________

_____ Waste of time. (0)

(-1) ______________________________

_____ Boring. (-2)

____

APPENDIX E

TABLE 17

INDIVIDUAL TEST SCORES FOR PRETESTS, POSTTESTS AND RETENTION TESTS

Class and Student	Pretest	Posttest	Retention Test
FSA 3110 Fall--Experimental			
1	31	42	40
2	37	51	53
3	26	38	24
4	23	24	33
5	17	40	34
FSA 3110 Fall--Control			
6	27	44	--
7	29	36	39
8	24	30	27
9	31	44	60
10	27	36	43
FSA 3110 Winter--Experimental			
11	21	59	35
12	22	87	62
13	21	54	37
14	18	64	69
15	19	43	--
16	34	77	56
17	18	57	--
18	21	32	--
19	30	68	65
FSA 3110 Winter--Control			
20	21	43	--
21	26	53	40
22	25	65	67
23	24	60	--
24	27	47	32
25	17	34	--
26	18	74	65
27	22	55	45

TABLE 17 (continued)

Class and Students	Pretest	Posttest	Retention Test
FSA 4130 Fall--Experimental			
28	21	44	34
29	21	35	31
30	21	42	32
31	37	41	33
32	30	42	37
33	29	34	--
34	20	50	--
35	25	45	35
36	31	34	38
37	19	46	36
38	23	45	39
39	26	49	50
FSA 4130 Fall--Control			
40	24	38	33
41	34	29	34
42	17	25	29
43	33	31	31
44	27	34	33
45	33	31	31
46	33	30	--
47	34	34	32
48	28	33	29
49	26	27	29
50	26	29	33
51	36	22	34
52	25	25	28

TABLE 18

QUESTION SCORES FOR ALL PRETESTS, POSTTESTS AND RETENTION TESTS

Class and Students	Pre	Post	Ret	Pre	Post	Ret	Pre	Post	Ret	Pre	Post	Ret	Pre	Post	Ret
FSA 3110 Fall Experimental															
		Q1			Q2			Q3			Q4			Q5	
1	0	0	0	0	2	0	0	0	0	2	5	0	0	1	1
2	4	0	0	0	2	0	2	0	0	0	1	5	0	1	1
3	0	2	0	0	2	0	0	0	0	0	3	0	0	0	0
4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	0	2	0	0	1	0	0	1	0	0	5	0	0	1	1
		Q6			Q7			Q8			Q9			Q10	
1	4	2	1	2	4	2	6	6	6	2	5	4	15	17	23
2	2	1	0	2	2	2	6	6	6	1	4	6	17	31	32
3	2	3	1	0	0	0	6	6	4	0	5	4	15	17	15
4	0	2	1	6	0	4	6	0	6	2	5	4	15	17	15
5	2	1	0	0	2	2	0	6	6	0	4	5	15	17	17
		Q11													
1	0	0	3												
2	3	3	0												
3	3	0	0												
4	0	0	3												
5	0	0	3												

TABLE 18 (continued)

Class and Students	Pre	Post	Ret	Pre	Post	Ret	Pre	Post	Ret	Pre	Post	Ret	Pre	Post	Ret
FSA 3110 Fall Control															
		Q1			Q2			Q3			Q4			Q5	
6	0	1	-	0	0	-	0	2	-	1	5	-	1	1	-
7	0	0	2	0	1	0	1	1	0	0	0	0	0	2	1
8	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1
9	0	2	1	0	1	0	0	2	1	2	6	4	2	1	3
10	0	1	0	0	1	0	0	0	1	0	0	0	0	0	0
		Q6			Q7			Q8			Q9			Q10	
6	1	2	-	4	2	-	3	6	-	0	4	-	17	21	-
7	2	2	2	4	2	4	3	6	6	1	5	5	15	17	19
8	0	1	0	2	2	2	6	3	3	0	4	4	15	17	17
9	2	1	3	4	6	4	6	6	6	0	4	4	15	15	31
10	0	1	4	4	2	4	6	6	6	0	5	4	17	17	21
		Q11													
6	0	0	-												
7	3	0	0												
8	0	3	0												
9	0	0	3												
10	0	3	3												

TABLE 18 (continued)

Class and Students	Pre	Post	Ret	Pre	Post	Ret	Pre	Post	Ret	Pre	Post	Ret	Pre	Post	Ret
FSA 3110 Winter Experimental															
		Q1			Q2			Q3			Q4			Q5	
11	0	2	1	1	2	1	0	2	1	0	2	0	0	4	1
12	0	2	2	0	5	2	0	2	4	0	10	4	0	8	4
13	0	2	0	0	2	1	0	0	1	0	2	0	1	2	1
14	0	4	2	1	3	5	0	0	4	0	5	5	0	1	0
15	0	0	-	0	0	-	0	0	-	0	0	-	1	2	-
16	0	2	2	0	6	3	1	4	1	1	10	0	0	4	1
17	0	2	-	0	4	-	0	2	-	0	2	-	0	0	-
18	0	0	-	0	0	-	0	0	-	0	0	-	0	0	-
19	0	2	1	0	2	4	0	2	0	0	4	5	0	2	2
		Q6			Q7			Q8			Q9			Q10	
11	0	4	4	2	6	0	3	6	6	0	6	4	15	22	17
12	0	4	0	4	6	4	3	6	3	0	7	8	15	34	28
13	0	2	3	0	2	2	0	6	6	0	6	5	17	30	18
14	0	4	3	2	6	6	0	6	6	0	4	5	15	31	30
15	0	2	-	0	2	-	0	6	-	0	5	-	15	26	-
16	1	3	4	4	4	6	3	6	6	2	8	7	19	30	23
17	0	4	-	0	4	-	0	6	-	0	4	-	15	26	-
18	0	3	-	2	2	-	1	3	-	0	5	-	15	19	-
19	0	2	1	2	2	6	3	6	6	2	8	8	23	35	29

TABLE 18 (continued)

Class and Students	Pre	Post	Ret	Pre	Post	Ret	Pre	Post	Ret	Pre	Post	Ret	Pre	Post	Ret
FSA 3110 Winter Experimental															
		Q11													
11	0	3	0												
12	0	3	3												
13	3	0	0												
14	0	0	3												
15	3	0	-												
16	3	0	3												
17	3	3	-												
18	3	0	-												
19	0	3	3												
FSA 3110 Winter Control															
		Q1			Q2			Q3			Q4			Q5	
20	0	0	-	0	2	-	0	2	-	0	0	-	0	2	-
21	0	2	2	0	5	1	0	2	0	2	0	0	0	1	2
22	0	4	2	0	2	2	0	4	3	0	4	4	1	0	1
23	2	2	-	0	4	-	0	2	-	0	2	-	0	3	-
24	2	0	0	0	0	0	0	1	0	0	3	0	0	1	1
25	0	0	-	0	0	-	0	0	-	0	0	-	0	0	-
26	0	2	2	0	5	2	0	4	4	0	5	4	0	2	2
27	0	2	0	0	3	2	0	1	0	0	0	0	0	1	1

TABLE 18 (continued)

Class and Students	Pre	Post	Ret	Pre	Post	Ret	Pre	Post	Ret	Pre	Post	Ret	Pre	Post	Ret
FSA 3110 Winter Control															
		Q6			Q7			Q8			Q9			Q10	
20	2	1	-	2	2	-	0	6	-	0	5	-	17	23	-
21	1	3	2	0	2	2	3	3	3	2	4	5	15	28	20
22	2	4	4	4	4	4	3	6	6	0	5	5	15	29	33
23	2	4	-	2	4	-	3	3	-	0	5	-	15	27	-
24	0	3	4	2	2	2	3	6	6	1	5	4	19	26	15
25	0	4	-	2	2	-	0	6	-	0	4	-	17	15	-
26	0	4	4	2	4	4	0	6	3	0	5	5	16	34	32
27	0	3	4	4	6	2	1	6	6	0	4	4	17	26	23
Fall 3110 Winter Control															
		Q11													
20	0	0	-												
21	3	3	3												
22	0	3	3												
23	0	3	-												
24	0	0	0												
25	0	3	-												
26	0	3	3												
27	0	3	3												

TABLE 18 (continued)

Class and Students	Pre	Post	Ret	Pre	Post	Ret	Pre	Post	Ret	Pre	Post	Ret	Pre	Post	Ret
FSA 4130 Fall Experimental															
		Q1			Q2			Q3			Q4			Q5	
28	0	0	0	0	0	0	0	2	1	0	1	0	1	2	0
29	0	1	0	0	1	0	0	0	0	4	0	0	0	1	1
30	0	1	0	0	4	0	0	0	1	1	5	0	0	1	0
31	0	2	0	2	0	0	1	1	0	0	0	0	1	1	1
32	0	2	0	0	2	0	0	2	0	0	0	0	1	0	0
33	0	1	-	0	0	-	0	0	-	0	0	-	1	1	-
34	0	2	-	0	1	-	0	1	-	0	0	-	0	3	-
35	0	1	0	1	2	0	2	0	1	0	3	0	0	1	1
36	2	0	0	1	0	0	2	0	0	0	0	0	0	2	3
37	0	2	0	0	1	0	1	1	0	0	0	0	1	0	1
38	0	2	2	1	1	0	0	0	0	0	0	0	1	2	0
39	2	2	0	0	1	1	0	0	0	0	2	4	0	0	0
FSA 4130 Fall Experimental															
		Q6			Q7			Q8			Q9			Q10	
28	0	2	0	2	2	2	3	6	6	0	5	4	15	24	18
29	0	1	1	0	0	2	0	6	6	2	5	4	15	17	17
30	2	1	1	0	2	2	3	6	6	0	5	4	15	17	18
31	0	1	2	0	0	0	3	6	6	0	6	5	17	21	16
32	0	2	2	4	2	4	6	6	6	4	6	4	15	17	18
33	4	3	-	0	0	-	3	6	-	2	5	-	19	15	-
34	0	4	-	2	4	-	2	6	-	1	8	-	15	21	-

TABLE 18 (continued)

Class and Students	Pre	Post	Ret	Pre	Post	Ret	Pre	Post	Ret	Pre	Post	Ret	Pre	Post	Ret
FSA 4130 Fall Experimental															
		Q6			Q7			Q8			Q9			Q10	
35	2	2	0	0	2	2	3	6	6	2	5	5	15	20	17
36	2	3	2	2	0	2	6	6	6	1	4	5	15	19	17
37	0	2	0	2	4	2	0	6	6	0	6	5	15	21	19
38	0	2	0	2	6	4	0	6	6	2	4	5	17	19	19
39	4	4	4	4	6	6	0	6	6	1	5	6	15	20	20
FSA 4130 Fall Experimental															
		Q11													
28	0	0	3												
29	0	3	0												
30	0	0	0												
31	3	3	3												
32	0	3	3												
33	0	3	-												
34	0	0	-												
35	0	3	3												
36	0	0	3												
37	0	3	3												
38	0	3	3												
39	0	3	3												

TABLE 18 (continued)

Class and Students	Pre	Post	Ret	Pre	Post	Ret	Pre	Post	Ret	Pre	Post	Ret	Pre	Post	Ret
FSA 4130 Fall Control															
		Q1			Q2			Q3			Q4			Q5	
40	0	0	0	0	0	0	0	0	0	0	2	0	1	1	0
41	2	0	0	0	0	0	1	0	1	6	0	2	0	0	1
42	0	1	0	0	0	0	0	1	1	0	0	0	0	0	1
43	2	0	0	0	0	0	0	0	0	0	0	0	1	0	0
44	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
45	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0
46	0	0	-	0	0	-	0	1	-	1	0	-	1	1	-
47	0	0	0	0	0	0	1	0	0	2	0	0	1	0	0
48	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0
49	0	2	1	0	0	0	0	0	0	0	0	0	0	0	0
50	0	0	0	0	0	0	0	0	0	2	0	0	0	0	1
51	0	0	0	1	0	0	0	0	1	2	0	0	0	0	0
52	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
Question Value	4	4	4	8	8	8	4	4	4	10	10	10	8	8	8
FSA 4130 Fall Control															
		Q6			Q7			Q8			Q9			Q10	
40	1	2	2	4	2	4	3	6	6	0	5	5	15	17	16
41	4	2	2	2	2	2	2	3	6	2	4	4	15	15	16
42	0	0	0	2	4	2	0	0	6	0	4	4	15	15	15
43	3	1	2	4	2	2	6	6	6	2	4	5	15	15	16
44	0	2	3	4	4	2	3	6	6	4	4	5	15	18	17
45	2	1	0	2	2	2	3	6	6	4	5	4	17	17	19

TABLE 18 (continued)

Class and Students	Pre	Post	Ret	Pre	Post	Ret	Pre	Post	Ret	Pre	Post	Ret	Pre	Post	Ret
FSA 4130 Fall Control															
		Q6			Q7			Q8			Q9			Q10	
46	2	1	-	2	0	-	3	6	-	4	6	-	17	15	-
47	2	1	0	4	4	4	3	6	6	2	5	5	19	15	17
48	2	1	0	0	0	2	3	6	6	4	4	4	15	19	16
49	0	0	0	4	0	2	3	6	6	2	4	5	17	15	15
50	2	2	2	0	0	2	3	3	6	2	5	5	17	19	17
51	2	0	2	2	0	2	3	0	6	4	4	4	19	15	19
52	2	0	1	0	0	2	3	3	4	0	4	5	17	17	16
Question Value	4	4	4	6	6	6	6	6	6	8	8	8	39	39	39
FSA 4130 Fall Control															
		Q11													
40	0	3	0												
41	0	3	0												
42	0	0	0												
43	0	3	0												
44	0	0	0												
45	3	0	0												
46	3	0	-												
47	0	3	0												
48	3	3	0												
49	0	0	0												
50	0	0	0												
51	3	3	0												
52	3	0	0												
Question Value	3	3	3												

TABLE 19

INDIVIDUAL DIVISION SCORES FOR PRETESTS, POSTTESTS AND RETENTION TESTS

Student	DIV I			DIV II		
	Pre	Post	Ret	Pre	Post	Ret
FSA 3110 Fall Experimental						
1	10	18	12	21	24	28
2	17	15	15	20	36	38
3	9	13	3	17	25	20
4	6	0	13	17	24	20
5	0	18	12	17	22	22
FSA 3110 Fall Control						
6	9	17	--	18	27	--
7	11	12	13	18	24	26
8	9	8	6	15	22	21
9	14	24	22	17	20	38
10	10	13	14	17	23	29
FSA 3110 Winter Experimental						
11	6	27	10	15	32	25
12	7	42	26	15	45	36
13	4	16	11	17	38	26
14	3	25	31	15	39	38
15	4	10	--	15	33	--
16	12	36	22	22	41	34
17	3	23	--	15	34	--
18	6	5	--	15	27	--
19	5	23	27	25	45	38
FSA 3110 Winter Control						
20	2	14	--	19	29	--
21	8	18	13	18	35	27
22	8	30	25	17	35	42
23	7	24	--	17	36	--
24	7	13	9	20	34	23
25	0	11	--	17	23	--
26	2	31	24	16	43	41
27	5	22	14	17	33	31

TABLE 19 (continued)

Student	DIV I			DIV II		
	Pre	Post	Ret	Pre	Post	Ret
FSA 4130 Fall Experimental						
28	6	13	12	15	31	22
29	4	12	9	17	23	22
30	4	19	9	17	23	23
31	10	13	10	17	28	23
32	11	17	13	19	25	24
33	4	11	--	25	23	--
34	4	17	--	16	33	--
35	6	18	10	19	27	25
36	13	7	11	18	27	27
37	4	17	12	15	29	24
38	4	20	15	19	25	24
39	6	20	20	20	29	30
FSA 4310 Fall Control						
40	8	14	10	16	24	23
41	13	8	12	21	21	22
42	2	6	10	15	19	19
43	13	11	8	20	20	23
44	8	10	8	19	24	25
45	10	8	8	23	23	23
46	10	8	--	23	22	--
47	11	13	10	23	21	22
48	7	9	9	21	24	20
49	7	8	9	19	19	20
50	5	3	9	21	26	24
51	9	3	9	25	19	25
52	6	4	6	19	21	22

TABLE 20

INDIVIDUAL RATINGS FOR PREVIOUS KNOWLEDGE OF INVENTORY MANAGEMENT PRINCIPLES AND ESTIMATED TIME SPENT IN LEARNING PROCESS

Student	Previous Knowledge	Time (hr)
FSA 3110 Fall (Experimental)		
1	2	18.00
2	3	9.25
3	2	10.41
4	3	5.00
5	2	2.50
FSA 3110 Fall (Control)		
6	2	1.00
7	3	1.83
8	2	2.33
9	2	2.81
10	3	2.33
FSA 3110 Winter (Experimental)		
11	3	13.92
12	0	19.92
13	3	7.75
14	3	20.45
15	0	16.66
16	3	9.33
17	2	9.83
18	2	16.25
19	3	24.50
FSA 3110 Winter (Control)		
20	2	6.83
21	3	3.83
22	2	2.33
23	3	.83
24	2	.83
25	3	3.83
26	2	15.83
27	3	3.83

TABLE 20 (Continued)

Student	Previous Knowledge	Time (hr)
FSA 4130 Fall (Experimental)		
28	3	10.83
29	3	3.83
30	3	4.00
31	3	14.66
32	3	3.83
33	3	-----
34	3	15.75
35	2	6.00
36	3	5.50
37	2	8.25
38	0	7.00
39	2	6.41
FSA 4130 Fall (Control)		
40	3	-----
41	3	-----
42	3	-----
43	3	-----
44	3	-----
45	3	-----
46	3	-----
47	3	-----
48	2	-----
49	3	-----
50	3	-----
51	3	-----
52	2	-----

TABLE 21

INDIVIDUAL RATINGS FOR DEGREE OF SATISFACTION WITH VARIOUS ASPECTS OF TEACHING METHOD USED

Student	Structure of Tape	Structure of Lecture	Content	Objectives	Case Study or Problems	Instructor Student Rapport	Overall Reaction
FSA 3110 Fall (Experimental)							
1	-1	2	2	1	-1	1	2
2	0	1	2	2	1	2	1
3	2	2	2	2	0	2	1
4	0	0	0	2	-2	1	0
5	1	-2	2	2	-2	0	1
FSA 3110 Fall (Control)							
6	-	2	2	-2	-	2	-2
7	-	2	2	2	2	2	2
8	-	2	2	2	-	2	2
9	-	2	-1	2	-	2	2
10	-	1	1	2	2	2	2
FSA 3110 Winter (Experimental)							
11	2	2	2	2	2	2	2
12	2	1	2	2	1	2	2
13	2	-2	2	2	1	2	2
14	-1	2	1	2	2	2	2
15	0	-2	2	2	1	2	1
16	2	2	2	2	2	1	2
17	1	2	2	-1	2	2	1
18	1	2	2	2	2	2	2
19	2	2	1	2	-	2	2

TABLE 21 (continued)

Student	Structure of Tape	Structure of Lecture	Content	Objectives	Case Study or Problem	Instructor Student Rapport	Overall Reaction
FSA 3110 Winter (Control)							
20	–	-1	2	2	2	2	2
21	–	-2	-2	-2	–	2	1
22	–	2	2	0	–	–	2
23	–	-2	-2	2	–	2	-2
24	–	2	-2	2	0	2	2
25	–	0	0	-2	–	–	-1
26	–	2	-2	1	–	-2	-2
27	–	1	-2	–	–	2	–
FSA 4130 Fall (Experimental)							
28	1	2	1	-2	-2	2	0
29	2	0	2	2	1	2	1
30	-2	1	2	2	-2	2	0
31	0	-2	–	-2	0	2	1
32	1	1	0	-2	0	2	1
33	–	–	–	–	–	–	–
34	2	-2	2	-2	1	2	2
35	-2	1	1	2	0	2	2
36	-1	2	1	2	2	2	2
37	-2	1	1	2	1	2	1
38	-1	2	2	2	1	2	2
39	2	2	2	2	-2	2	2

APPENDIX F

TABLE 22

MANN WHITNEY U-TEST VALUES FOR EFFECT OF TEACHING METHOD ON COGNITIVE LEARNING DETERMINED BY COMPARING DIFFERENCES BETWEEN TEST SCORES FOR EXPERIMENTAL AND CONTROL GROUPS

	U-Test Value	Probability
FSA 3110 Fall		
p-p N=10	15	n.s.
p-r N= 9	5	n.s.
FSA 3110 Winter		
p-p N=17	45	0.2
p-r N=11	10	n.s.
FSA 3110 Fall and Winter		
p-p N=27	106	n.s.
p-r N=20	37	n.s.
FSA 4130 Fall		
p-p N=25	146	0.01
p-r N=23	19	n.s.

Probabilities represent a one sided Mann Whitney U-Test level of significance for the experimental group.

n.s. = no significance beyond the 0.2 level.
p-p = posttest minus pretest scores.
p-r = posttest minus retention test scores.
N = total sample for experimental plus control groups.

TABLE 23

MANN WHITNEY U-TEST VALUES FOR EFFECT OF TEACHING METHOD ON COGNITIVE LEARNING DETERMINED BY COMPARING DIFFERENCES BETWEEN QUESTION SCORES FOR EXPERIMENTAL AND CONTROL GROUPS

	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11
FSA 3110 Fall p-p N=10	11	*19	7	15	**18	9	*19	11	6	**17	**8
FSA 3110 Fall p-r N= 9	7	6	11	6	7	2	9	10	9	4	13
FSA 3110 Winter p-p N=17	**45	33	26	**47	43	43	**48	40	***57	40	19
FSA 3110 Winter p-r N=11	12	14	15	8	4	11	17	15	12	9	17
FSA 3110 Fall and Winter p-p N=27	106	100	64	*117	**112	102	***124	99	**113	**113	52
FSA 3110 Fall and Winter p-r N=20	37	39	57	30	21	21	51	50	44	29	**61
FSA 4130 Fall p-p N=25	****122	****112	***83	114	***120	****128	****125	****118	****123	****130	***107
FSA 4130 Fall p-r N=23	24	30	47	48	53	44	53	38	41	43	****102

p-p = posttest minus pretest; p-r = posttest minus retention test; N = total sample for experimental plus control groups. * = 0.1, ** = 0.2, *** = 0.05, **** = 0.01 representing a one sided Mann Whitney U-Test level of significance for the experimental group.

TABLE 24

MANN WHITNEY U-TEST VALUES FOR EFFECT OF TEACHING METHOD ON COGNITIVE LEARNING DETERMINED BY COMPARING DIFFERENCES BETWEEN DIVISION SCORES FOR EXPERIMENTAL AND CONTROL GROUPS

	Division I	Division II
FSA 3110 Fall p-p N=10	11	14
FSA 3110 Fall p-r N= 9	6	4
FSA 3110 Winter p-p N=17	40	54***
FSA 3110 Winter p=r N=11	13	11
FSA 3110 Fall and Winter p-p N=27	97	118*
FSA 3110 Fall and Winter p-r N=20	41	32
FSA 4130 Fall p-p N=25	141****	140****
FSA 4130 Fall p-r N=23	23	34

p-p = posttest minus pretest scores.
p-r = posttest minus retention test scores.
N = total sample for experimental plus control groups.

**** = 0.01
*** = 0.05 represent a one sided Mann Whitney U-Test level
* = 0.1 of significance for the experimental group.

TABLE 25

MANN WHITNEY U-TEST VALUES FOR EFFECT OF QUARTER IN WHICH TEACHING METHOD WAS USED ON COGNITIVE LEARNING DETERMINED BY COMPARING DIFFERENCES BETWEEN TEST SCORES FOR BOTH FALL AND WINTER QUARTERS

	U-Test Values	Probability
FSA 3110 Exp p-p N=14	3	0.05
FSA 3110 Exp p-r N=11	24	n.s.
FSA 3110 Con p-p N=14	0	0.05
FSA 3110 Con p-r N=11	19	n.s.

Probability represents a one sided Mann Whitney U-Test level of significance for winter quarter.

n.s. = no significance beyond the 0.05 level.
Con = Control group.
Exp = Experimental group.
p-p = posttest minus pretest scores.
p-r = posttest minus retention test scores.
N = total sample for both fall and winter quarters.

TABLE 26

MANN WHITNEY U-TEST VALUES FOR EFFECT OF QUARTER IN WHICH TEACHING METHOD WAS USED ON COGNITIVE LEARNING DETERMINED BY COMPARING DIFFERENCES BETWEEN QUESTION SCORES FOR FSA 3110 CLASSES

	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11
Fall Con vs Winter Con p-p N=13	18	***8	*10	20	***10	4	**8	***8	16	****5	14
Fall Con vs Winter Con p-r N= 9	11	7	13	8	8	12	14	12	8	13	10
Fall Exp vs Winter Exp p-p N=14	*12	17	***10	19	*12	****2	*13	***7	****4	***7	22
Fall Exp vs Winter Exp p-r N=11	17	14	14	16	***F25	9	16	17	17	****F28	****F18

Con = Control group.
Exp = Experimental group.
p-p = posttest minus pretest scores.
p-r = posttest minus retention test scores.
N = total sample for experimental plus control tests.

**** = 0.01
*** = 0.05 represent a one sided Mann Whitney U-Test level of significance for the winter quarter.
* = 0.1

****F = 0.01
***F = 0.05 represent a one sided Mann Whitney U-Test level of significance for the fall quarter.

TABLE 27

MANN WHITNEY U-TEST VALUES FOR EFFECT OF QUARTER IN WHICH TEACHING METHOD WAS USED ON COGNITIVE LEARNING DETERMINED BY COMPARING DIFFERENCES BETWEEN DIVISION SCORES FOR FSA 3110 CLASSES

	Division I	Division II
Fall Exp. vs Winter Exp. p-p N=14	7***	1****
Fall Exp. vs Winter Exp. p-r N=11	19	28****F
Fall Con. vs Winter Con. p-p N=13	2****	3****
Fall Con. vs Winter Con. p-r N=9	20****F	17***F

Exp. = Experimental group.
Con. = Control group.
p-p = posttest minus pretest.
p-r = posttest minus retention test.
N = total sample for both fall and winter quarters.

**** = 0.01 represents a one sided Mann Whitney U-Test level
*** = 0.05 of significance for winter quarter.

****F = 0.01 represents a one sided Mann Whitney U-Test level
***F = 0.05 of significance for fall quarter.

TABLE 28

T-VALUES[a] FOR THE COMPARISON OF ACTUAL SCORES FROM POSTTEST WITH RETENTION TESTS USING WILCOXON MATCHED PAIRS

	FSA 4130		FSA 3110	
	Con N=12	Exp N=11	Con N=9	Exp N=11
Total	18.0	4.5***	16.5	11.5*
Q1	0.0	0.0***	9.0	0.0**
Q2	0.0	0.0**	5.0	13.0
Q3	2.5	6.0	11.5	13.5
Q4	1.5	2.0	3.0	6.0**
Q5	2.5	4.0	2.5	3.0
Q6	10.5	6.5	5.C	9.0*
Q7	9.0	6.0	0.0	3.0
Q8	0.0**	0.0	0.0	12.0
Q9	3.0	13.5	5.5	22.5
Q10	25.0	3.0*	13.5	8.5*
Q11	0.0**	2.5	1.5	8.0
DIV I	18.5	5.0***	3.0***	12.0
DIV II	19.5	8.0*	22.0	5.5***

a = total number (-) for determining level of significance for the one sided Wilcoxon Matched Pairs Test.
Con = Control group.
Exp = Experimental group.
N = Total sample for tests in that group.

* = 0.05
** = 0.025 Levels of significance for the "T" Value.
*** = 0.01

VITA

The author was born in Atlanta, Georgia August 4, 1940, where she attended elementary and secondary schools. She completed in 1962 a Bachelor of Science degree in Home Economics with a major in Experimental Foods at the University of Georgia, Athens. With the financial aid of a laboratory assistantship from the University of Georgia, she completed in August, 1963 a Master of Science degree with a major in Foods and Nutrition.

That September she began teaching foods and nutrition at Berry College in Rome, Georgia. Nine years later in 1972 she left Berry College as an assistant professor teaching not only the foods and nutrition courses but also the institutional management courses. Her work experience also included employment as a nutritionist for the Maternal and Infant Care Project at Grady Hospital in Atlanta, as a dietary consultant for a small nursing home in Rome, Georgia and as an assistant professor of foods, nutrition and institutional management at the University of Alabama, Tuscaloosa.

She received an Allied Health Traineeship Grant to enter the University of Tennessee, Knoxville, Tennessee in September 1972 to begin doctoral work in the Food Science, Nutrition and Food Systems Administration Department. She is married to Benny H. West and resides in Collinsville, Alabama.