FEASIBILITY OF COMPUTER-GENERATED TESTING VIA THE CATHODE RAY TUBE IN A BASIC CLOTHING CONSTRUCTION COURSE AT OKLAHOMA STATE UNIVERSITY

By

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1972

Submitted to the Faculty of the Graduate College
of the Oklahoma State University
in partial fulfillment of the requirements
for the Degree of
MASTER OF SCIENCE
July, 1974

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ACKNOWLEDGEMENTS

The writer expresses sincere appreciation to Dr. Grovalynn F. Sisler, Head, Department of Clothing, Textiles and Merchandising, for her encouragement, guidance and assistance during the course of this study and in preparation of this thesis. Appreciation is also extended to Dr. Donice H. Kelly and Dr. Richard Robl for their support and counsel during this study and in the preparation of this manuscript.

Special acknowledgement is expressed to Mrs. Regina Brinkerhoff for allowing her class to be used in this study. Her cooperation was appreciated greatly.

A very grateful acknowledgement is extended to Joseph L. Gray, systems programmer at the University Computer Center, for developing the computer program used in this study. Without his assistance and the cooperation of the University Computer Center staff, this study would not have been possible.

Special appreciation is extended to the writer's parents, Mr. and Mrs. Don L. Good, for their encouragement and understanding during the course of undergraduate and graduate study and during the preparation of this thesis. Thanks are extended to Mrs. Mildred Lee for her diligence in typing this manuscript.

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CHAPTER I

INTRODUCTION

The computer is now recognized as man's most versatile problem solver (24). After several years of experience with the traditional problems of record keeping, fiscal reporting and experimental design, computer scientists and educators are now focusing on the broad, perplexing problems of education. Whether to use the computer as an educational tool is a question which was appropriate and timely a decade ago, but it is no longer. "The pertinent and present question is how to provide for the optimization of computer applications to education" (25).

"The computer is incredibly fast, accurate and stupid. Man is unbelievably slow, inaccurate and brilliant. The marriage of the two is a force beyond calculation" (14). A primary objective of applying the computer to education is to assist instructors in individualizing instruction. A major premise of such instruction is that it allows each individual to progress at his own rate and to pursue his own style of learning.

Until recently, educators have basically taught their classes in the traditional manner and no one questioned whether students were reaching their potential. Now, both students and teachers have begun to evaluate the educational process. With the assistance of educational technology, educators are seeking new methods of instruction

and management and the computer should not be overlooked.

Record keeping, testing and test analysis are time-consuming duties of teachers. The vast high speed capabilities of the computer can relieve the teacher of these tasks, thus enabling him to spend more time improving and expanding instructional activities and personalizing instruction.

The purpose of this developmental study was to determine how the cathode ray tube computer terminal can be used successfully for computer-generated testing in the basic clothing construction course at Oklahoma State University.

Objectives of the Study

To adapt the current final examination in basic clothing construction for use on the computer.

To implement a computer program to generate tests via the cathode ray tube.

To compare student performance in a control and an experimental group.

To determine student attitudes toward computer-generated testing.

To determine the cost-effectiveness of using computer-generated testing via the cathode ray tube terminal.

Limitations of the Study

The study was limited to two methods of classroom testing: computer-generated testing and conventional testing. Subject matter was limited to selected concepts in basic clothing construction at Oklahoma State University. In addition, the participants were limited

to those students enrolled in basic clothing construction for spring semester, 1974.

Definition of Terms

Cathode ray tube -- "a television-like display device" (7).

Computer -- "a machine that performs numerical and logical manipulations, as directed by a human programmer" (36).

Computer-generated test -- a test in which the computer randomly selects questions from an item pool and presents them to the student.

Item pool -- a bank of test items stored on computer tape.

Programming -- "the procedures contributing to the development of a sequence of instructions for computer solutions of a problem; includes problem analysis, program design, coding and testing" (4).

CHAPTER II

REVIEW OF LITERATURE

One of the most dynamic problems confronting the American educational system at this time is coping with the information explosion. "The information explosion has resulted in more information being more quickly gathered, more minutely processed, more rapidly fused, more overwhelmingly difficult to synthesize" (35). In order for the educational system to function effectively, it must advance to discover workable and innovative methods of challenging students with the information explosion.

Computers in Education

During the 1960's the increasing growth rate of students caused educators to critically and constructively analyze the American educational system. Student/teacher interactions have traditionally played an invaluable role in education, ". . . but current efforts to provide them in higher education often fall short of the ideal" (10). Perhaps this failure was caused primarily by the terrific influx in the student population during the last decade. As former Commissioner of Education, Francis Keppel, has emphasized, quantity rose and quality fell (21). Though student enrollment has declined somewhat in the 1970's, the student/teacher ratio is still high and the information explosion must still be dealt with. With the small amount of time an instructor

can allot per student, the computer would seem to be a possible substitute to partially provide continuous feedback between the individual learner and the instructor.

Since 1955 three major stages in the application of computer technology to education have been evident.

1) Installation of the university computing service for mathematical and scientific problem solving.
2) Using electronic data processing systems in accounting, record-keeping and logistic control activities.
3) Using time-shared computers with on-line teletypewriters and cathode ray tube display equipment for supporting educators and learners in a wide range of intellectual processes (52).

To synthesize some of the thoughts of Lumsdaine (32), Atkinson and Wilson (3) there are at least three factors which precipitated the growth of computer usage in education. These are:

1) growth of an educational discipline called Educational Technology which is characterized by utilizing mechanical and technical tools and emphasis on the science of behavior.
2) the vast growth of the data processing industry.
3) increasing aid to education from the Federal Government.

These three factors continue to be important in the growth of computer usage in education.

Bushnell (13) stated,

> The challenging reality of individual differences, and exploding curriculum, and the pressure of time and numbers make the uses of modern information processing technology essential if the goal of education for all Americans is to be achieved.

The Carnegie Commission on Higher Education also supported computer use in education by recommending "a greater use of the new electronic technology as a supplement to and an alternative for traditional teaching" (40).

The versatility of the computer opens a virtually unlimited area of research on learning as well as the potential of programming for individual differences. No college of any size can ignore these challenges of education. Those who plan to live without a computer must do so knowing the economic and educational implications.

Terminal Configurations

When computers are used in education, the terminal is the communication link between student and computer. The function of the terminal is to present instructional materials and to record and transmit student responses to the central computer for analysis. Currently three different terminal configurations are being used for student terminals:

1) Simple terminal configurations consist of a teletype connected by phone wires or a touch pad to the central computer.
2) Intermediate terminal configurations include, in addition to the teletype, various audiovisual devices for optical projection and audio reproduction.
3) Complex terminal configurations include cathode ray tube, audio and film display, teletype and light pen. The student may respond via the teletype or the light pen (52).

Terminal configurations are not limited to these specifically defined terminals. Combinations of these terminal configurations are available from different companies.

The advantages of the cathode ray tube are 1) it can quickly generate graphic and print displays under computer control and 2) it allows the student to quickly respond to the stimulus display using a light pen, rather than forming his response on the typewriter. Besides the rapid display and light pen usage, another advantage of the cathode ray tube is its quiet operation. The typewriter terminal is rather

noisy and for that reason may be less suitable for educational applications.

Computer-Assisted Instruction

Because of the increased interest in and importance of the computer, and the apparent dissatisfaction with course content and instructional method, computers are sometimes used to teach concepts in the classroom. This application of the computer is referred to as computer-assisted instruction.

According to Zielinski (54), the computer system is "far superior to all systems of instruction," because in addition to its ability to control and present subject matter in a programmed sequence, it is able to receive student reaction during the process of learning and to utilize it simultaneously with the process.

Computer-assisted instruction is defined as

> a man-machine interaction in which the teaching function is accomplished by a computer system without intervention by a human instructor. Both training material and instructional logic are stored in computer memory (45).

Replacement of the instructor by the computer is not advocated by scientists or educators. Rather, the computer is a device to relieve the teacher of much generalized lecturing and to provide him with knowledge about each student's level of performance.

Computer-assisted instruction is an outgrowth of the programmed instruction of several years ago. Consequently, the four basic principles which define programmed instruction are also relevant to computer-assisted instruction:

1) The subject matter is systematically presented in small bits to the student.

2) The student becomes an active participant and constructs an answer to a question.
3) The student receives immediate feedback.
4) The student then continues at his own rate to the next frame (16).

Modes of Computer Usage

Before students begin to use the computer as a learning aid, programs must be developed for the specific concepts to be "taught" by the computer. A program consists of four steps:

1) An objective is prepared.
2) A criterion test is developed to test whether or not the objective is met.
3) Content is imbedded in the media as required to obtain the objective.
4) Material is tested and revised until the students achieve the objective (45).

After being programmed the computer, as used in computer-assisted instruction, has all the characteristics of the teaching machine.

Various teaching modes can be used within computer-assisted instruction. Perhaps the simplest and most recently identified modes were summarized by Bell (6). She described four modes: tutorial, inquiry, simulation and problem solving.

The tutorial mode presents original material to which the student responds. Upon response the computer branches to meet the student's needs. This mode of instruction not only provides for individual differences, but also supplies immediate feedback.

In the inquiry mode, the student attempts to solve a problem presented by the computer. A list of available assistance accompanies the problem, and the student may ask for help. The main task of the computer is to check solutions to the student's problems and give assistance when requested.

Still in the developmental stage is the simulation mode in which the computer is used to process information and solve problems. The computer displays an experiment with options for varying parameters. The student establishes specific parameters and the computer presents a solution.

Finally, the most complex mode of instruction is that of problem solving. A student given a problem may discuss the results with the computer. After reducing the problem to mathematical formulations, the computer receives and stores the formula. The student then enters the data and executes the formula while the computer provides the solution.

Research in Computer-Assisted Instruction

The field of computer-assisted instruction is not without research. In a study by International Business Machines (IBM) comparing the learning time of computer-assisted instruction with the conventional lecture class in statistics, research indicated that study time required to accumulate the specified amount of information was five times longer for conventional methods of teaching. This same study revealed that the midterm grade average for students involved in computer-assisted instruction was 36 percent higher than that of students learning from conventional methods (16).

In addition, a study by Suppes and Morningstar (50) indicated that student dropout rate was lower with computer-assisted instruction than with traditional teaching methods in a mathematics course. Indicative of the same trend, Morrison and Adams (37) reported that in the SUNY German course, more students finished the computer-assisted instruction

course than finished the regular class.

Mathis, Smith and Hansen (34) attempted to identify student attitudes toward computer-assisted instruction in a general psychology course. The researchers found attitudes became more positive the longer students were engaged in computer-assisted instruction, but the degree of positiveness depended on how successful their experiences had been. The study indicated that if students are exposed to relevant programs and are successful using them, then computer-assisted instruction proves to be a valid type of instruction. A similar study with similar results was conducted by Brown and Gilman (9) using ninth and tenth grade physics students.

Most educators do not advocate totally computerized classrooms, but the coupling of human interaction with computer-assisted instruction seems to be an effective, workable combination. Because computers have such a potential for individualizing instruction, more students will have the opportunity to achieve the success that is so desperately needed to proceed with a positive attitude toward learning.

Computer-Managed Instruction

Since use of computer-assisted instruction is still limited because of excessive cost, researchers are focusing their attention on a more feasible type of computer usage, that of computer-managed instruction. In computer-managed instruction, the computer is used to help the teacher administer and guide the instructional process; it does not provide the learning materials. "Computer-managed instruction includes all applications of computer supported analysis that aid the teacher in managing the instruction without actually doing the

teaching" (20).

Computer-managed instruction has five major functions:

1) data collection and dissemination;
2) monitoring of student progress and activities;
3) providing descriptive information for teacher usage in the diagnosis of needs;
4) test scoring; and
5) providing planning information for the teacher/class activities (8).

Attitudes of graduate students enrolled in Educational Research at Florida State University indicated that a majority of the students reacted positively to a computer-managed course. Fifty-five percent expressed a desire to enroll in another computer-managed course while only four percent responded "reluctantly" or "never" (17).

While individual instruction can exist without a computer, computer-managed instruction greatly increases the chances of meeting the needs of the student because of the complexity that is possible. Another very important characteristic of computer-managed instruction is the capability to recommend use of appropriate media best suited to each student's learning style (11).

There are four constituents of a computer-managed instruction system:

1) a file of student characteristics and performance,
2) a set of diagnostic examinations,
3) a set of instructional segments, and
4) a program that employs data on a student's characteristics to prescribe an appropriate instructional segment (26).

A goal of American education is not just to reach all students but also to provide them with capabilities, skills and relevant information necessary for pursuing the profession of their choice. Computer-managed instruction allows more time for the faculty member to interact individually with students on significant or difficult problems.

Test Construction

The purpose of education is to effect a change in students; the role of the teacher is that of change agent. In order to facilitate student behavioral change, the teacher must first define behavioral objectives. These are defined in such a way that the students understand what is expected of them. Throughout the course, teaching material and activities for the students are planned to facilitate the student achievement of the stated objectives.

During the course and at the end of the course instructors need to evaluate how well the objectives are being accomplished. Testing is one means of evaluation. Ahmann and Glock (1) defined a test as nothing more than a series of questions or tasks to which a student responds. There are many types of tests, but the type used in this study is an objective test consisting of multiple-choice and true-false test items. "An objective test item is one that can be scored in such a way that judgement is for all practical purposes eliminated when determining the correctness of a pupil's answer" (1).

True-False

True-false test items, although possibly the most popular type of objective items, have been subject to considerable criticism because of their weaknesses and the widespread use of poorly constructed items. One of the main weaknesses of a true-false test item is the fifty-fifty chance of guessing the correct response. Another serious limitation of a true-false test item is that many of them are concerned with only small, insignificant facts. Finally, the ambiguity of true-false test

items is a problem. Specific determiners like "always," "never," "some" and "primary" should be avoided in order to construct items that are absolutely true or false (1).

The merits of true-false test items, although few, should be considered as a reason for the popularity of the true-false items. Well constructed test items allow students to respond quickly. A less obvious advantage is that this is essentially a realistic task for the student. Every day he makes decisions as to whether statements are true or false. A third, but perhaps doubtful, advantage is that true-false test items are easy to construct. The number of poorly constructed true-false items proves that reliable true-false items are not easy to construct.

Ahmann and Glock (1) suggested the following guidelines for writing true-false test items.

1) When constructing a test item requiring a response of either 'true' or 'false' and only that, search for statements that are true or false without additional qualifications.
2) Avoid the use of specific determiners which make the answer obvious or ambiguous.
3) Try to keep the true-false test items reasonably short and restrict each to one central idea.
4) If true-false tests are used regularly, be certain that the percentage of test items requiring 'true' answers and hence the percentage of test items requiring a 'false' answer, are not relatively constant from test to test.

Multiple-Choice Tests

As with any test item, the instructor considers specific instructional objectives when constructing multiple-choice test items. The items consist of three parts, the stem, the foils or distractors and the keyed response. The stem is a direct question or incomplete

statement which is followed by a number of possible alternatives. One of these alternatives is the correct answer or keyed response; the other alternatives are undesired answers (33).

Although weaknesses of multiple-choice test items are relatively few, they are worth mentioning. Multiple-choice items are difficult to construct and suitable distractors are hard to find. Such distractors as "none of the above" or "not given" if used consistently are usually recognized by the student as being more often the wrong answer than the correct one. In addition, another weakness of a multiple-choice test item is the response time. Students are able to answer fewer multiple-choice items than true-false items within a given period of time (1).

Multiple-choice tests are the most flexible and versatile of all objective type examinations (33). A primary strength of multiple-choice test items is that they may be used to measure instructional objectives at all levels of the cognitive domain. The versatility of the multiple-choice test item is evident in its adaptability to all subject matter areas and all grade levels. Finally, the problem of subjective scoring which weakens short-answer test items is eliminated. Multiple-choice test items may be scored rapidly, accurately and objectively by class assistants or secretaries without jeopardizing the accuracy of the results.

The following guidelines, suggested by Ahmann and Glock (1), are helpful in constructing multiple-choice test items.

1) Select the distractors so that all of them are reasonably plausible and appealing to those pupils who do not possess the knowledge demanded by the item.
2) Vary the number of options included in the multiple-choice test item as needed, anticipating that ordinarily there will be at least three and not more than five.

3) If a multiple-choice test item requires a 'best' answer, make certain that one and only one is clearly the best.
4) Whenever convenient, design the multiple-choice test item so that the item stem includes as much of the item as possible.
5) Express the responses to a multiple-choice test item so that grammatical consistency is maintained.
6) Minimize the use of negative expressions in a multiple-choice test item.

Examinations produce a quantitative representation of how well the students are reaching the educational objectives defined by the instructor of the course. Before a test can be effective, careful consideration must be given to the content and construction of each test item. Each item must measure a specific educational objective.

Computer-Generated Testing

While educational systems await computer-assisted instruction to revolutionize teaching methods, a number of more manageable computer techniques are proving useful in dealing with large university classes. One of these is computer-generated testing. The computer allows for greater flexibility in the order and nature of the test items that can be administered than is possible with conventional paper-and-pencil tests (28).

As the emphasis in American education focuses more and more on individualizing instruction to meet each student's needs and complement his learning style, the instructor's duties have become insurmountable. Class record keeping, test production and grading, test analysis and student performance evaluation are among the most time-consuming and least-valued parts of an instructor's duties. Because these tasks are so time-consuming, many of them, such as test analysis, are overlooked by the instructor. Were the time available, many instructors would

come nearer to meeting these educational challenges.

According to Prosser and Jensen (42), "of the several inadequacies of large class instruction, the examination procedures are perhaps the most seriously deficient." Typically, true-false and multiple-choice questions comprise most of the examinations administered to large classes. The examinations are administered at one time only. Several days may elapse before the results of the test are available to the student, and often the only information provided to the student is the total percentage score, which has little effect in guiding his study.

Newsom (38) suggests that computer-generated testing deserves serious consideration. With the computer, we can realistically diagnose learner difficulties, analyze these problems and prescribe alternatives in solving the difficulties.

Item Banking and Selection

The first step in a test construction system is to develop an item bank which can be stored in "computer manipulable form" (30). Most test generating programs have a format for generating questions. One question banking system described by Buckley-Sharp (12) has five options for selecting questions from the pool.

1) by subject mnemonic classification
2) by department, or examination reference
3) by question analysis statistics
4) by specified text profile
5) by specific question reference

Dudley's (18) item selection system for a business curriculum is based on either instructional objectives or the level of difficulty of the question. After one or both of these criteria are specified by the instructor, the computer randomly selects the questions for a

particular test.

Another unique testing program requires statistical analysis on each question from previous testing. This information tailors the difficulty of test items administered to the ability of an individual student. Lord (31) suggested that the best measurement is obtained when a student knows about one-half of the test items administered. In order to tailor test items for students, if an incorrect response is given to an item, the next item should be an easier item. Likewise, if a correct response is given, the next item should be more difficult.

Epstein (19), who is with the Educational Testing Service, used the computer to select items for standardized mathematics tests. The computer provided a list of item characteristics. These items were retrieved from the pool and printed by traditional means. Each question was subject to approval or disapproval by the professional staff.

Still another method of item selection was used by Baker (5). The instructor sat at a terminal, typed in a key word and the item record was displayed. In order to get the item analysis on each item, another code word was typed in. This proved to be an excellent way for an instructor to maintain and revise the item bank.

The Question Pool Management System (QPMS) is an example of how the computer can aid in constructing test questions (15). This system depends on three parts of a multiple-choice question, the question stem, possible correct answers, and the distractors or incorrect answer.

The QPMS system permits an association of up to seven correct answers and seven distractors with each question. With this data base, the computer then randomly selects one correct answer and four

distractors. In addition, the QPMS program randomizes the arranagement of those five choices.

Testing Procedure

The computer-generated testing process usually consists of four steps: 1) developing a bank of test questions, 2) producing tests, 3) administering the tests and 4) scoring the tests. Developing the test question bank is initially very time-consuming. Fortunately, once developed, the question pools are rather permanent and easily revised.

Initially, computer-generated testing took the form of computer-generated repeatable testing. Dr. Donald D. Jensen of the University of Nebraska and Dr. Franklin Prosser from the University of Indiana are known for successfully implementing computer-generated repeatable testing into several psychology courses at Indiana University. Prosser and Jensen contended that repeatable testing encouraged the student to use diagnostic information and to restudy material which was not initially mastered (42). In addition, more frequent examinations may enhance learning. Usually, in a course with only two examinations, students study seriously or "cram" only in a short period immediately preceding each test. By increasing the frequency of tests the number of serious study sessions increases (22).

Jensen and Prosser (41) found students to be highly satisfied with the computer-generated repeatable testing method of instructional testing as indicated on a standard evaluation questionnaire. Student achievement appeared to be higher in computer tested sections than in those tested with conventional examinations. Mean scores for multiple-choice and fill-in questions were higher in the sections with

repeatable examinations.

Similar methods of testing have been investigated at other universities. Hammer and Henderson (23) from Washington State University asked students in Personnel Administration to rate their computer-generated repeatable testing program on a seven point scale from "much worse" to "much better" than other testing procedures. On the average students rated computer-generated repeatable testing "slightly better". There is a general trend toward higher grades with a distinct mode at the "B" grade level.

All available evidence suggests that computer-generated repeatable examinations are very promising as an educational innovation. "The main benefits are believed to be the increasing reliability of the tests, the rapid availability of results and the ease of production of numerous forms of the same test" (43).

Student attitudes were measured in a computer-generated testing study conducted by Wilkins (53) in a clothing selection class at Oklahoma State University. She administered computer printed tests which consisted of randomly selected items. Students answered on separate sheets which were hand-graded when they finished the test. Eighty-seven percent of the students preferred the computer-generated test to a teacher made test. Students thought the test was easy to read but they did not like the large size of the computer printout pages.

Salisnjak (46), Stodola (47), Libaw (27), Anderson (2) and others have developed systems which generate tests by printing out the test on computer paper. These studies are very similar in development and procedure to the studies described above, but often there are different outputs as a result of grading the examination. The system at

Pepperdine University (18) yields an output which has proved very useful. There are several options for the instructor to choose from. He may have the student's entire test showing the student's answers and the correct answers, or he may ask for only correct items or only incorrect items. Statistical analysis on the student's performance can be obtained as well as particular areas of course content with which the student may need help.

Most of the research conducted to this point deals with tests which are printed out by the computer requiring the students to mark their answers on mark sense cards. When the students complete the examination, the mark sense cards are fed into a card reader in order to get printed out test results and analysis. Now that this method of computer-generated testing has proved effective, educators must continue to search for methods to increase testing effectiveness.

The computer can also aid the instructor as an administrator of the test. Using the computer in this capacity saves both instructor and class time. "While the computer has significant potential for test administration, actual operational testing programs are very limited" (26).

Palmer (39) described one of the few test generation systems which allows the students to interact directly with the computer. Pennsylvania State University developed a computerized spelling course for post high school students who need to improve communication skills. Of particular interest to this study are the diagnostic pretest and posttest. The pretest presents 50 multiple choice sentences, one at a time, on a cathode ray tube computer terminal. Each sentence contains one blank. With a light pen, the student chooses the word he judges to

be correct from three possible spellings. No immediate feedback is presented since the pretest is used for diagnostic purposes. When the student has completed all 50 questions, his total errors are shown on the cathode ray tube screen.

If a student makes below 80 percent, the computer automatically branches him into one of five instructional segments. Upon completion of the instruction, the student is branched to a posttest which is similar to the pretest but consists of 100 questions rather than 50.

Advantages of Computer-Generated Testing

Systems which utilize computer-generated testing have the obvious advantage of minimizing book keeping duties of the instructor. After the initial item bank has been established, the instructor is freed of the mechanical aspects of test construction. Since the item bank is in a centralized location, many users can contribute questions and by revising and reviewing, eventually most of the items will be of high quality statistically.

Possibly the most significant advantage of computer-generated testing is its contribution to individualizing instruction. Since students may take the test whenever they are ready, computer-generated tests are tremendous support for a self-paced course. Another benefit which aids in individualization is that a different test can be generated for each student. The variation of the test items ranges from simply re-ordering the questions for each student, to prescribing test questions on the basis of learner characteristics.

Two additional advantages of computer-generated testing are immediate score feedback and use of the test for advanced standing

credit. In most computer-generated testing systems, especially those in which the student interacts with the computer terminal, student score feedback is provided immediately. The cathode ray tube simply flashes the number of questions which were correct and the percentage score onto the screen. Advanced standing examinations could be administered via the cathode ray tube computer terminal, thus relieving the instructor of this task. As more and more courses are offered for advanced standing credit, the computer might well be used in this capacity.

Disadvantages of Computer-Generated Testing

As with other technological advances, cost of computer-generated testing is the greatest disadvantage. It is difficult to cite costs of using computer-generated testing as there is limited data describing the cost analysis. Accounting systems of various universities vary so greatly that cost comparisons between the schools would be of little value. The Report of the President's Science Advisory Committee stated,

> Whether or not computer-assisted instruction using a computer becomes widely used is an educational and economical problem. Surely, however, the cost of trying it to find how it works is a legitimate educational expense (44).

Though the committee was speaking of computer-assisted instruction, it would seem that computer-generated testing could logically be included.

Denney (15) cited reluctance in teacher acceptance as an additional problem of implementing computer-generated testing. Rather than making a complete change overnight, innovations must allow the instructor to begin at his own level of professional skill and gradually improve his skills to apply the innovation. Enough time must be allowed to prepare quality instructional materials.

Teachers as well as students are often afraid that implementing the computer into education will dehumanize the learning process (52). Testing is actually a rather mechanical process and by utilizing computer-generated testing, the teacher allows himself more time to individualize instruction and provide for even closer interaction between himself and the students. Since studies indicate student acceptance of and even preference to computer-generated testing, the problem of dehumanization may not be a legitimate disadvantage to computer-generated testing.

All educational innovations begin with problems. But unless systems are implemented for research purposes, the problems cannot be solved and alternatives cannot be tried out. These studies indicate a need for additional research in computer-generated testing. Home economics has published virtually no research utilizing computer-generated testing. In order to maintain high educational standards, further research should be conducted in applications of educational technology.

CHAPTER III

DEVELOPMENT AND ADMINISTRATION OF THE TEST

The participants in the study were 50 students enrolled in a basic clothing construction class at Oklahoma State University in the spring semester of 1974. Basic clothing construction (CTM 1103) is a core course required of all students working toward a degree in clothing, textiles and merchandising. Students should enroll for the class during their first or second year but occasionally juniors and seniors are enrolled in the class.

The clothing construction class consisted of three sections which met once a week for a joint lecture and once a week for separate laboratories. In addition, each student was responsible for spending approximately two hours per week in the audiotutorial laboratory.

For this study, the class was divided into two groups. In order to have groups which were somewhat similar in amount of previous knowledge and skills in clothing construction, students were assigned to groups on the basis of their pretest scores. The scores were ranked from highest to lowest and students were placed so that the groups would have similar means on pretest scores (see Appendix A, p. 41). The experimental group consisted of 24 students with a mean pretest score of 59.47 percent while the control group contained 26 students with a mean pretest score of 56.76 percent. One student originally placed in the experimental group asked to be eliminated from the

experimental study because she was afraid the anxiety over the "new" method would affect her performance and thus her grade in the course. For the final examination, the control group took a regular paper-and-pencil test. The experimental group took a comparable test generated by the computer and presented on a cathode ray tube terminal.

The computer-generated testing process consisted of three steps: 1) developing pools of test items, 2) test generating and 3) scoring the tests. The second and third steps were managed by the computer, while the first step was done by the researcher in collaboration with the instructor in the course.

Developing Test Item Pool

For the final examination, a bank of test questions was developed. Test items were divided into 13 subject matter categories based on course objectives determined by the instructor. These items formed the data base from which the individual tests were prepared. This was a rather time-consuming step as two or three alternate items were developed for each item on the original test in order to assure adequate variation on the individual tests. Fortunately, once the item pool is developed, it remains rather permanent.

After developing the item pool, each item was keypunched onto cards. The question stem and alternatives were keypunched exactly as they would appear on the cathode ray tube screen. A "header" card containing the item number, right answer, category number and number of cards used for the item accompanied each item. This information was then stored on a computer disc for use in test generation.

Generation and Administration of the Tests

Most of the students in the class had not used a computer terminal before. One week prior to final examination week, the students were taken to the University Computer Center in order to become familiar with the cathode ray tube computer terminal. At that time students were given the opportunity to practice using the light pen to answer sample questions. In addition, students signed up for a convenient time during final week to take the examination.

When a student took the examination, she sat at the cathode ray tube terminal and typed in a code requesting the final examination. Upon receiving the code, the computer flashed instructions onto the screen, describing how to use the light pen. The next display instructed the student to indicate her student identification number by touching appropriate numbers on the screen from left to right. When the identification information was received, the student's name was flashed on the screen. This was to insure that the student gave the proper identification number so her score could be accurately recorded. At that time there was a delay of two or three seconds while the computer shuffled and randomly selected 100 items from the 13 different categories for the final examination.

After selecting the items, the computer flashed the first item on the screen. When the student touched an answer with the light pen, the next item was automatically displayed. Students also had the option of skipping forward or backward to particular items simply by touching the number of the desired item at the bottom of the screen. If an item had been answered already and the student went back to the item, the

student's present answer was displayed. The answer could then be changed by touching the desired answer.

When the student had completed the 100 items, she touched "STOP" with the light pen. The student's score on the test was then flashed onto the screen. Finally the student typed a statement requesting to exit the program.

Since student attitudes are very important when introducing any innovation in educational techniques, students were asked to fill out an attitude form upon completion of the final examination. The survey was made to determine disadvantages and advantages of the computer-generated final examination. A sample of the form used is included in Appendix B, p. 44.

The Computer Program

The computer program to generate tests via the cathode ray tube computer terminal was developed by Joseph L. Gray, systems programmer at the University Computer Center. In addition to student interaction with the terminal during testing, the program was designed to include several other capabilities valuable to the instructor. By simply running a small deck of computer cards through the card reader, the instructor could get several different printouts. One printout listed all of the questions in the item pool, names of all students in the class and their student identification numbers. For ease in recording grades, the computer printed out a list of all student identification numbers with the scores made on the final examination. In order to allow students to discuss their examinations with the instructor, one printout listed the items each student had on her test, the right

answer, and the answer the student chose. If the student left the item blank an N was printed for her answer. Also for use in item analysis of test items, the computer provided a printout listing each item number, how many times that item had been selected and how many times each alternative (A, B, C, D or E) was chosen.

The instructor had the ability to change the body of an item already stored on computer disc or to freeze certain items to prevent them from being selected for the examination. Later if the instructor chose to do so, the frozen questions could be "thawed" and made available to be selected for a test. The program also gave the instructor the ability to designate exactly how many items from each of the categories would appear on each test. Still other capabilities of the computer program exist but were not used in this study. These additional capabilities, such as record keeping for five test scores plus two other scores, could be utilized if the test generation program were implemented for a complete semester. This would greatly help the instructor because it would compute the final grade for each student.

Results of the Study

Student responses to the student attitude questionnaire are summarized in Table I. Of the 24 students completing the questionnaire, 21 (87.5 percent) preferred the computer-generated test to the paper-and-pencil test. Twenty-two (91.6 percent) students indicated that they preferred using the light pen to select answers rather than the keyboard.

TABLE I

SUMMARY OF RESPONSES TO THE STUDENT ATTITUDE FORM

Question	Number	Percent
Which do you prefer?		
- taking the test by computer	21	87.5
- taking the test with paper-and-pencil	3	12.5
Which do you prefer?		
- using the light pen to select answers	22	91.6
- using the keyboard to select answers	2	8.3

In response to the open end questions, seven students indicated that they thought taking the test by computer was faster than taking it with paper-and-pencil. Eight students listed "easier to read" as an advantage. The fact that the score was flashed up immediately upon completion of the examination was listed as an advantage by eight students, also. Four students preferred the computer-generated test because it allowed them to take the final examination at their own convenience. Elimination of the risk of cheating, interesting change of pace and a more comfortable environment were each listed by two students as an advantage of the computer-generated test. Another student indicated that the computer-generated test alleviated problems of correctly marking the optical mark reader cards used for the paper-and-pencil examinations.

Although seven students indicated no disadvantages to the computer-generated test, a few disadvantages were mentioned. Noise

in the testing area disturbed four students. The noise was due to other computer users working on a rather noisy typewriter terminal. Another disadvantage listed by four students was that they did not have all the test questions in front of them to refer to during the test. Though most students thought the computer-generated test took less time to complete, two students felt it took longer. Another student preferred the security of taking the final examination in a group.

Additional comments or suggestions listed by the students were that the computer-generated test was something to look forward to and that it would be excellent for use in self-paced courses. Others expressed a desire to take all tests via the computer terminal.

A t-test was used to compare performance of the control and experimental groups. The t-statistic was computed using final examination scores and differences between scores on the pretest and the final examination for the two groups. Results of the t-test on the final examination scores are presented in Table II. The t-statistic revealed no significant difference between the two groups.

Similar results were found when comparing differences between pretest and final examination scores. Means, variations and standard deviations for the two groups are very similar and the t-statistic indicates no significant differences (see Table III). These results seem to indicate that students were as successful on the computer-generated test as on the paper-and-pencil test.

Although one of the purposes of implementing computer-generated testing is to save time and expense, the initial development and implementation of a computer program requires a great deal of both time and money. The major expense was that of developing and testing the

TABLE II

STATISTICAL COMPARISON OF FINAL EXAMINATION SCORES FOR EXPERIMENTAL AND CONTROL GROUPS

Group[a]	Mean	Standard Deviation	Variance	Degrees of Freedom	t-value
1	78.19	11.61	134.73	48	0.24866*
2	78.96	10.04	100.74		

[a]Group 1 consisted of students who took the final examination as a paper-and-pencil test. Group 2 consisted of students who took the final examination as a computer-generated test.

*Nonsignificant.

TABLE III

STATISTICAL COMPARISON OF DIFFERENCES BETWEEN PRE-TEST AND FINAL EXAMINATION SCORES FOR EXPERIMENTAL AND CONTROL GROUPS

Group[a]	Mean	Standard Deviation	Variance	Degrees of Freedom	t-value
1	21.73	15.08	227.33	48	0.59354*
2	19.13	15.97	254.90		

[a]Group 1 consisted of students who took the final examination as a paper-and-pencil test. Group 2 consisted of students who took the final examination as a computer-generated test.

*Nonsignificant.

computer program. Several changes were made in the program before it was ready for student use. In order to save money, all of the keypunching was done by the researcher. A professional keypuncher could have been employed to decrease keypunching time but the cost would have increased.

Another sizeable expense was that of generating the tests. No specific representative cost per test could be concluded for this study. Dr. Robert D. Gumm, director of the University Computer Center, stated that experience with external users of the cathode ray tube computer terminal is very limited here at Oklahoma State University. "The existing accounting system for the cathode ray tube terminal needs to be re-evaluated and perhaps modified to give a more accurate charge for the resources used," according to Dr. Gumm. A realistic cost structure could consist of approximately $1.20 per hour for connect time plus two cents per second for CPU (Central Processor Unit) time. The test generation program used about 20-25 seconds of CPU time per test.

Dr. Gumm also provided cost figures which would be involved to install a cathode ray tube computer terminal in a building on campus such as the home economics building. The terminal would rent for $150 per month ($125 for the terminal plus $25 for the control unit). Cable to connect the terminal is four cents per foot, a one-time cost. If light pen capabilities are desired, an additional $25 per month would be charged. The cost of installing a cathode ray tube terminal is comparable to installation of a typewriter terminal. Advantages of the cathode ray tube seem to support installation of such a terminal.

CHAPTER IV

SUMMARY AND RECOMMENDATIONS

A study was conducted at Oklahoma State University to determine how the cathode ray tube computer terminal could be used successfully for computer-generated testing in a basic clothing construction course. The study was limited to the adaptation of the final examination for generation by the computer. Subject matter was limited to selected concepts from the basic clothing construction course.

The control group consisting of 26 students took the final examination as a regular paper-and-pencil test. The 24 students in the experimental group took the test via the cathode ray tube terminal. Test items for the computer-generated test were divided into 13 subject matter categories, keypunched and stored on computer disc. Number of questions from each category was specified by the instructor prior to the testing week. Students signed up for a convenient time to take the test during final week. When a student entered the code requesting the final examination, the computer shuffled and randomly selected 100 items including the specified number of items from each of the 13 categories. After completing the examination and logging out, the student's score was flashed on the screen. Students filled out an attitude questionnaire to determine advantages and disadvantages of the computer-generated test.

A majority of the students preferred computer-generated testing to paper-and-pencil testing because it was easy to read and their scores were immediately available at the end of the examination. Students preferred the light pen to the keyboard for responding to test items. In addition, many students indicated that it was faster to take the computer-generated test than the paper-and-pencil test.

Noise in the computer terminal area seemed to disturb a few students taking the computer-generated test. A typewriter terminal was in the same room and was rather noisy. In the future, arrangements could be made for a separate room for testing. A few students thought that it was a disadvantage not to have a copy of all the test items in front of them.

The t-test was used to analyze differences in performance of the control group and experimental group based on final examination scores and differences between pretest and final examination scores. Means, standard deviations, and variances were very similar and the t-statistic was not significant. Based on this analysis the conclusion could be drawn that computer-generated testing is at least as effective as paper-and-pencil testing.

Because of inexperience with external users of the cathode ray tube at the University Computer Center, no specific cost per test could be established. Feasibly, the cost should be $1.20 per hour for connect time in addition to two cents per second of computer processor unit time. Cost necessary to install a cathode ray tube computer terminal in the home economics building on campus was investigated and found to be approximately $150 per month.

Recommendations

1) If the cathode ray tube computer program is to be used in the future, the instructor should investigate possibilities of using the program for a number of tests throughout the semester in order to utilize the record keeping aspects of the computer program.
2) The present test generation program could be made more sophisticated by using the item analysis data to aid the computer to select items for each test. For example, the computer could be programmed to select a more difficult item if the previous item were answered correctly. Likewise, if an item were answered incorrectly, a less difficult item could be selected.
3) Other programs should be investigated to determine how items other than multiple-choice and true-false could be used for computer-generated testing. These programs should focus on decreasing the cost of generating tests by computer.
4) The feasibility of installing a computer terminal in the home economics building should be investigated. Support of instructors and willingness to develop item pools would be necessary to justify the expense of the terminal.
5) Study should be continued on administering the advanced standing examination as a computer-generated test. Additional items should be constructed for the item bank and test items should be analyzed statistically in order to insure test reliability.

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APPENDIX A

PRE-TEST SCORES, FINAL EXAMINATION SCORES AND DIFFERENCES FOR CONTROL AND EXPERIMENTAL GROUPS

Group I--Control

Paper-and-Pencil Test

Student	Pre-test Score	Posttest Score	Difference
1	88	91	3
2	84	90	6
3	79	92	13
4	76	69	-7
5	75	84	9
6	71	88	17
7	71	87	16
8	66	74	8
9	66	74	8
10	63	83	20
11	63	78	15
12	60	80	20
13	60	77	17
14	56	85	29
15	52	73	21
16	52	75	23
17	52	83	32
18	50	83	33
19	49	92	43
20	48	80	32
21	41	79	38
22	40	82	42
23	37	43	6
24	29	57	28
25	27	58	31
26	22	84	62

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Group II--Experimental

Computer-Generated Test

Student	Pre-test Score	Posttest Score	Difference
1	90	83	-7
2	83	84	1
3	82	90	8
4	80	85	5
5	78	85	7
6	77	95	18
7	74	88	14
8	72	71	-1
9	68	89	21
10	67	76	9
11	66	80	14
12	65	88	23
13	63	84	21
14	60	58	-2
15	58	79	21
16	56	83	27
17	52	63	11
18	50	68	18
19	43	66	23
20	41	70	29
21	40	83	43
22	39	90	51
23	34	65	31
24	10	72	62

APPENDIX B

STUDENT ATTITUDE FORM

STUDENT ATTITUDE FORM

1. Which do you prefer?

   ____ taking the test by computer

   ____ taking the test with paper-and-pencil

2. Which do you prefer?

   ____ using the light pen to select answers

   ____ using the keyboard to select answers

3. What do you consider the greatest advantage of taking the test on the computer terminal?

4. What do you consider the greatest disadvantage of taking the test on the computer terminal?

5. Please write down any other comments or suggestions you have concerning computer generated testing.

VITA

Linda K. Good

Candidate for the Degree of

Master of Science

Thesis: FEASIBILITY OF COMPUTER-GENERATED TESTING VIA THE CATHODE RAY TUBE IN A BASIC CLOTHING CONSTRUCTION COURSE AT OKLAHOMA STATE UNIVERSITY

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