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THE EFFECTIVENESS OF A MODIFIED CLASSROOM COMMUNICATOR IN THE STUDY OF LEARNING AND RETENTION

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THE EFFECTIVENESS OF A MODIFIED CLASSROOM COMMUNICATOR IN THE STUDY OF LEARNING AND RETENTION

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PREFACE

This dissertation is a report of a study conducted while the author was employed as an Educational Specialist at the Naval Air Technical Training Center, Norman, Oklahoma. The impetus for the study came from the availability of a modification of an experimental communication system designed for use as a classroom training aid. Since this research project was carried out in a military organization, it was necessary to enlist the help and cooperation of many people, both civilian and military personnel, much too numerous to name. However, acknowledgment of the assistance given by individuals who have made direct contributions to the many stages of this study should be made. Therefore, I wish to express my sincere appreciation to the following faculty members at the University of Oklahoma for their invaluable guidance and assistance in this study: to Dr. Henry Angelino, who served as chairman, to Dr. O. J. Rupiper and Dr. Alfred F. Glixman, for their constructive suggestions and direction concerning the design of the study and the statistical treatment of the data. Each gave liberally of his time and advice. Appreciation is also expressed to Dr. Gail Shannon and to Dr. Chester S. Williams for reading the manuscript.

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I am deeply grateful to my wife, Sue, for her continuous encouragement and help during all stages of the study.

Thanks and acknowledgment are made to Houghton-Mifflin Company, Boston, Massachusetts, for permission to quote a passage from page 86 of E. F. Lindquist's Design and Analysis of Experiments in Psychology and Education.

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THE EFFECTIVENESS OF A MODIFIED CLASSROOM COMMUNICATOR IN THE STUDY OF LEARNING AND RETENTION

CHAPTER I

INTRODUCTION

With the end of World War II, the need for scientific personnel to deal with the problems of technological warfare was amply demonstrated. During the tense, post-World War II years, the application of science and technology to purposes of war continued as progressively greater emphasis was given to basic research and urgent military projects in terms of a new concept of military power, a concept in which electronics, guided and ballistic missiles, rockets, atomic energy, and nuclear propulsion have played an increasingly important role. Because of the intensive military research in these fields of endeavor, the past decade has witnessed the development of a host of revolutionary weapon types, improved communication systems, nuclear-powered submarines, and new ordnance devices and equipment designed to meet the challenge and demands of modern technological warfare.

Background of the Problem

Since World War II the requirements of military defense and preparedness have increased in complexity, and the nature of weapons and equipment has become more and more technical in structure and function. As a result, military forces have been faced with the difficult task of matching the tremendous advances in technological warfare with sufficient numbers of enlisted personnel adequately trained in the use and maintenance of rapidly changing armament. Despite the establishment of training programs, the problem of keeping an adequate supply of trained personnel in the armed forces has been aggravated due to the loss each year of large numbers of trained technicians who leave the service to take jobs in industry.

An approach to the problem of maintaining a continuing supply of trained technicians that offers recruits an opportunity to pursue a desirable technical education is illustrated by the Training Program of the Naval Air Technical Training Command (NATTC). This Training Program was established in 1942 to train the Navy's new aviation technicians and to increase the proficiency of the older ones. The magnitude of the World War II training effort is conveyed by the fact that more than 360,000 technicians were graduated from the Training Command's Basic, Class (A) school which offered technical training in various aviation ratings. Fleet aviation activities were able to maintain a high degree of

combat efficiency through the services of these trained aviation technicians.

By the end of the war Naval Air Technical Training (NATT) had become established as an independent entity and a necessary adjunct of the Fleet. During the post-war period the NATTC, with headquarters at Memphis, Tennessee, has continued to assist the Fleet in maintaining a state of combat readiness by furnishing trained technicians to Fleet aviation activities. This task has been carried out with the help of the Airman Preparatory School which was established in 1945.

Since its inception the Preparatory School has performed a unique function in NATT. It has provided fundamental training in the basic knowledge and skills necessary for all aviation ratings, and has prepared trainees for entrance to the various Class (A) schools. The fundamental knowledge and skills refer to the body of learning derived from the study of Mathematics, Physics, Hand Tools, and Layout, and represent the common foundation needed by all trainees for the technical work of the Class (A) schools.

By offering training in the fundamentals required of all aviation technicians, the Airman Preparatory School has helped to narrow the gap created by the diverse and often inadequate backgrounds of the trainees, a serious problem encountered in the Class (A) schools during the war. Also, it has allowed a greater degree of acceleration and specialization in Class (A) school training, thus permitting a material reduction in

the training time of these schools, an important consideration in military training programs. These factors have contributed to the quality and effectiveness of NATT and have been instrumental in producing adequately trained technicians in a shorter period of time.

In July, 1956, the Preparatory School assumed a major role in the implementation of a new concept in technical training identified as the Selective Emergency Service Rate (SESR) Program. The SESR Program was established within the existing framework of the NATT Program to provide an even greater degree of specialization than previously attained, and to shorten the training time so that the trained personnel may be available to the Fleet for a longer period of utilization.

Under the SESR Program the Preparatory School, reduced from eight weeks to five weeks, continues to furnish preparatory training in the fundamental knowledge and skills required of all aviation technicians. Instead of offering one general curriculum, the Preparatory School, officially designated as the Aviation Fundamentals School, Preparatory, now provides intensive and specialized preparatory training specifically designed for three distinct areas or courses, operational-clerical, mechanical, and electrical-electronics.

After graduation from one of the Preparatory School courses, the trainees are transferred to one of the Class (A) schools corresponding to the area or course in which the pre-

paratory training was received. At Class (A) schools the trainees now receive intensive training in only one part, rather than in many parts of a specialized aviation rating, such as, ADJ (jet engine mechanics), ADR (reciprocating engine mechanics), ATR (aviation electronics-radar), or ATN (aviation electronics-navigation). Thus, the process of training as represented by the SESR Program produces trained specialists and skilled technicians in a shorter period of time and consequently, makes them available to the Fleet for a longer period of service.

During the fifteen years of its existence the NATTC has trained more than one half million aviation personnel. Since 1952 the Preparatory School, located at the Naval Air Technical Training Center, Norman, Oklahoma, has trained more than 72,000 men. Each year approximately 15,000 trainees graduate from the Preparatory School and receive specialized training at the Class (A) schools. These statistics indicate the important role of training in naval aviation, and the success with which the NATTC has been able to supply the Fleet with trained specialists and skilled technicians through the years.

Much of the success of the NATT Program may be attributed to the employment of improved methods of instruction particularly suited to mass training techniques, and to the judicious use of operational equipment and special training aids to increase the efficiency of instruction. Before such training aids are approved by the NATTC, their practical

usefulness to NATT is subjected to evaluation under actual training conditions. The present study is concerned with such an evaluation of a special training aid, the Modified Classroom Communicator, in terms of its possible contribution to NATT.

Need for the Study

NATT makes extensive use of training aids to facilitate the presentation and teaching of lecture material. The Modified Classroom Communicator is an experimental communication system specifically constructed for use in the NATTC as a potential training aid. It was designed to systematize the questioning procedure and to keep the instructor informed as to how well the major points of a lecture are being communicated to the trainees. In this study the communication system served as a group participation device to elicit responses from subjects. The responses referred to are the subjects' choices from among four possible answers to questions based on a series of lectures.

Before the Modified Classroom Communicator can be fully endorsed by the NATTC, its possible contributions to the intensive, accelerated program of mass technical training must be demonstrated. The present study was undertaken, therefore, to evaluate the training effectiveness of the experimental equipment in terms of its effect on the learning of lecture material in a practical, classroom situation. The research project was designed to furnish evidence, based on the results

of the study, to enable the NATTC to either accept or reject the Modified Classroom Communicator as a training aid.

Purpose of the Study

Specifically, this research project was planned to serve three purposes. The first, and main purpose of the study was to investigate the effectiveness of the Modified Classroom Communicator as a training aid to facilitate the learning and retention of lecture material. The method employed was that of encouraging the subjects to participate in the classroom proceedings by having them answer questions presented during the course of each lecture given using the Modified Classroom Communicator as a response medium.

The second purpose of the study was to investigate the effectiveness of special answer sheet techniques used as substitutes for the function performed by the Modified Classroom Communicator. The method used was that of encouraging the subjects to participate in the classroom proceedings by having them answer questions presented according to the group method. One group of subjects answered questions at the end of each lecture given. Another group of subjects answered questions during the course of each lecture given. Special answer sheets were employed by each group to record the responses.

The third purpose of the study was to acquire sufficient information regarding the efficacy of the Modified Classroom Communicator to warrant or preclude its endorsement in the

Naval Air Technical Training Command as a standard training aid.

Statement of the Research Hypotheses

The main problem in this study was concerned with the investigation of the effects of four methods designed to facilitate the learning and retention of selected lecture material. This problem involved the testing of the following hypotheses:

1. There are significant differences in the effectiveness of the four methods used in this study to facilitate the learning and retention of selected lecture material.

a. There are significant differences in the performance between the control group Method A, the experimental group Method B receiving questions at the end of each lecture and using answer sheets for responses, the experimental group Method C receiving questions during the course of each lecture and using answer sheets for responses, and the experimental group Method D receiving questions during the course of each lecture and using the Modified Classroom Communicator for responses, as measured by the mean scores of these groups on the posttest.

b. There are significant differences in the performance between the control group and the experimental groups as measured by the mean scores of these groups on the retention test.

CHAPTER II

THE DEVELOPMENT OF THE EXPERIMENTAL EQUIPMENT

The Classroom Communicator

For the past decade the Armed Forces have found it necessary and expedient to develop and use special training aids and devices, and to conduct appropriate research to evaluate the effectiveness of such equipment (10). During this period the U. S. Navy, through its Special Devices Center, has been particularly interested in the development of special types of equipment for use in group communication and mass training in connection with instructional films. The following summary from a report (5) of the planning, design, and construction of an experimental communication system illustrates the development of equipment suitable for use in group instruction and for research on the learning process, principally through the use of sound motion pictures.

In 1947, the Special Devices Center, Port Washington, Long Island, New York, requested the Instructional Film Research Program, The Pennsylvania State University, to develop an enlarged and improved version of its first experimental Classroom Communicator. The Special Devices Center furnished

specifications in the form of general functional requirements, and a planning committee consisting of psychologists, educators, engineers, and physicists was formed for the purpose of modifying and enlarging the list of original functional requirements as submitted by the Special Devices Center. It was believed that the equipment could be planned and built to do two things: (a) provide a means for recording and measuring the reactions of individuals in audiences; and (b) provide a means for improving, facilitating, or increasing the rate and effectiveness of learning. These functions were to be performed by the equipment under conditions of group instruction principally by means of sound motion pictures.

After many months of planning, the list of functional requirements was completed and used as a guide for designing and constructing the Classroom Communicator. The general requirements as formulated by the Planning Committee indicate that the proposed Classroom Communicator should be a system which will be useful both for research and instruction, that it shall be designed and constructed especially for the rapid and accurate testing, and recording of responses, of individuals in groups, and that the system shall make it possible to reinforce instruction and to facilitate learning. The components of the completed equipment are as follows:

The Response Stations. Forty individual response stations are located on the arm rests of the seats as shown in Fig. 1. These response stations are semi-private and contain

five piano-like keys. By means of these stations, the subjects may register their responses to a multiple-choice or true-false question and to attitude scales by pressing a selected key. The keys make it possible to select and register one answer or response among five alternatives (Figs. 2 and 3).

The Console. The Console houses most of the functional mechanisms of the system, including the relay panels, the power supplies, and commutators (Fig. 4). The Console has a large panel on which are mounted most of the controlling and indicating devices (Figs. 5 and 6).

Classroom Correct Answer Lights. The Correct Answer Lights are in the front of the room in clear view of the class, and are used to signal the correct answer to the group immediately after the end of the response period.

Total Score Indicators. The bank of 40 electromagnetically operated counters is arranged in a pattern which corresponds to the pattern of seats in the room. These counters accumulate and indicate total scores for each individual in the group.

The Film Analyzer. The Film Analyzer (6) is a device used in evaluating programs such as films. Although it was possible to build the Classroom Communicator and the Film Analyzer as two independent systems, it was deemed economical and expedient to construct the latter device for use in connection with the Classroom Communicator. The Film Analyzer has been

Fig. 1. Classroom Communicator system showing: Response Stations (bottom), Console (left), Film Analyzer printer (center), Total Score Indicator (right), and Classroom Correct Answer Lights (top center). Reproduced from Carpenter, Cannon, Eggleton, and John (5).

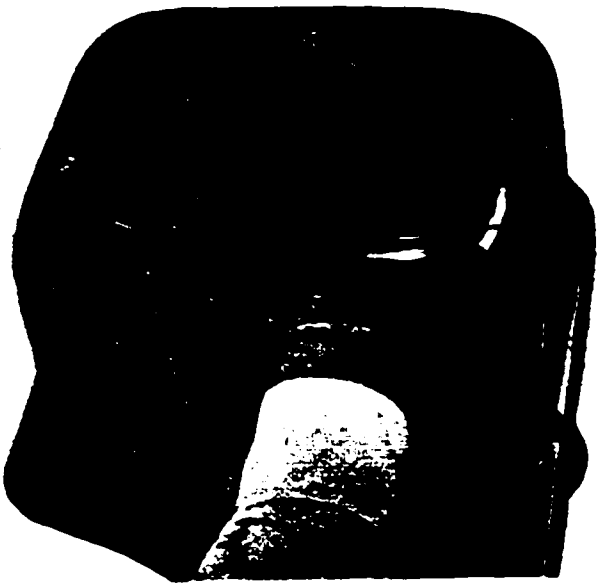

Fig. 2. Response Station with cover in place. Reproduced from Carpenter, Cannon, Eggleton, and John (5).

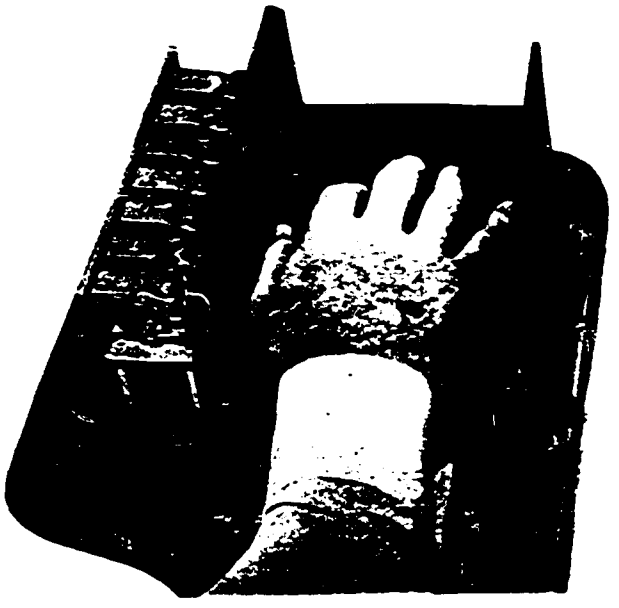

Fig. 3. Response Station with cover removed. Reproduced from Carpenter, Cannon, Eggleton, and John (5).

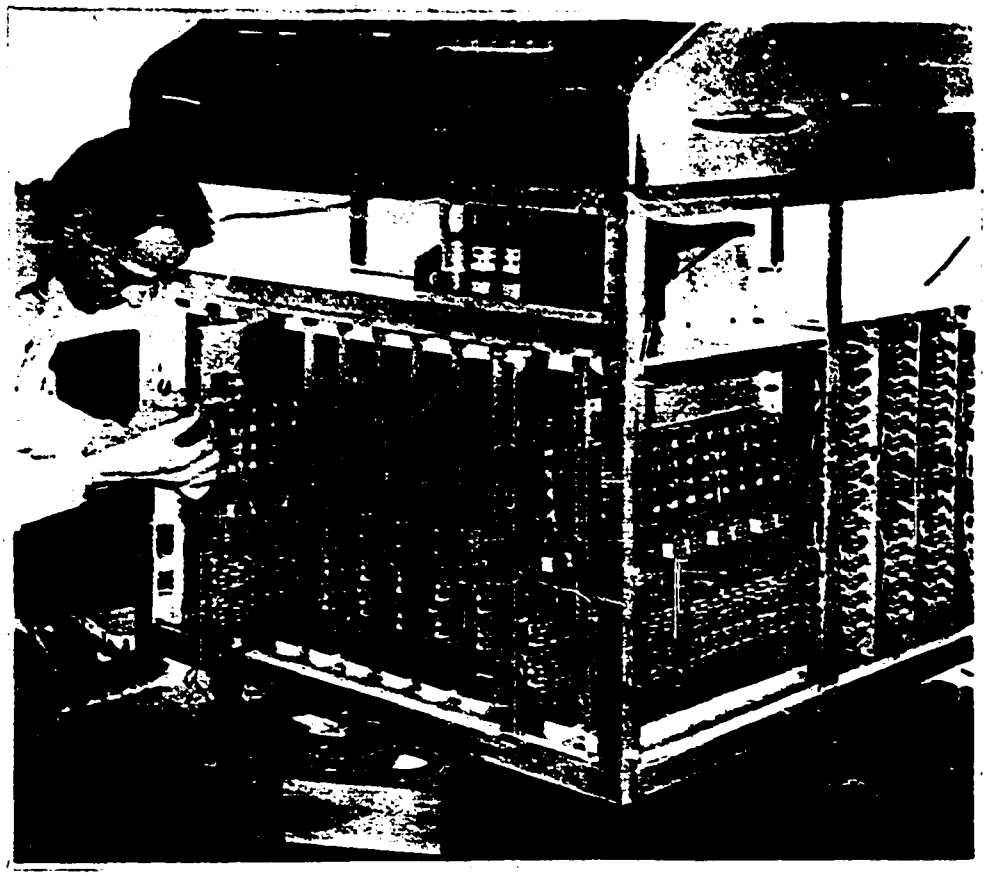

Fig. 4. Classroom Communicator console base with side panels removed showing relay counters (front) and memory relays (rear right). Reproduced from Carpenter, Cannon, Eggleton, and John (5).

1. Power switch, one control

2. Panel lights, one control

3. Response period controls, nine controls

    a. Manual response control, one
    b. Remote response control, one
    c. Automatic-manual, one
    d. Timer off-on, one
    e. Timer control: seconds, tens of seconds, minutes, and time after warning signal, four
    f. First response only, one

4. Correct answer controls, eleven controls

    a. Manual correct answer insertion, five
    b. Manual-automatic keycard, one
    c. Keycard press crank, one
    d. Item counter reset, one
    e. Keycard reset, one
    f. Multiple weights, one
    g. Correct answer lights, one

5. A-Vacant-B group switches, forty controls

6. Grid-light controls, seven controls

    a. Response scanning switches, six
    b. Master A-B group switch, one

7. Dial indicator controls, five controls

    a. Dial indicator off-on, one
    b. Counters off-on, one
    c. Recount, one
    d. Dials A-T-B upper and lower, two

Fig. 5. A list of the controls shown in Fig. 6. Reproduced from Carpenter, Cannon, Eggleton, and John (5).

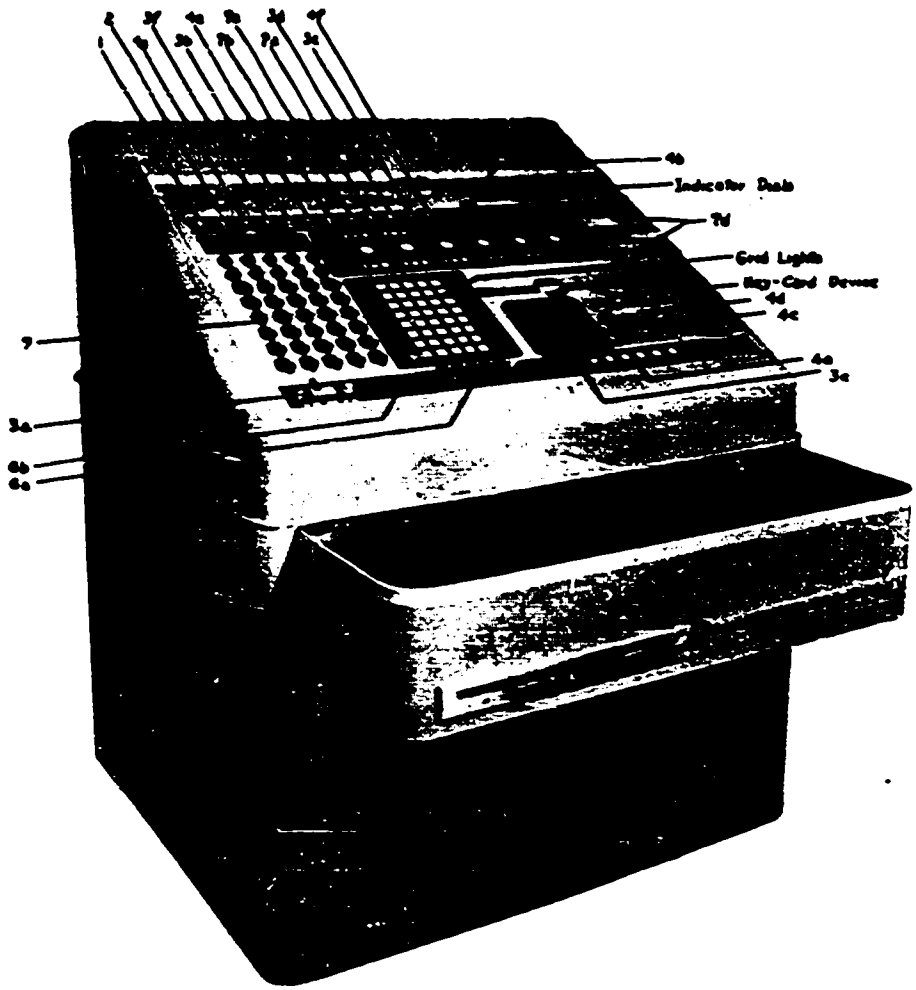

Fig. 6. The Classroom Communicator Console. Reproduced from Carpenter, Cannon, Eggleton, and John (5).

found most useful as a recorder since it is essentially a continuous recording polygraph which prints a record indicating which key was selected at each response station, along with time marks and film footage marks for use in analyzing films. The record produced by this device shows the answer or alternative selected, time required by each individual in a test situation to make a selection or decision, and the number of times the choice was changed before a final decision was made. In short, the Film Analyzer records the selection and timing of all responses made through the response stations of the Classroom Communicator.

The usefulness and value of the Classroom Communicator in mass communication and group instruction are indicated by the following performance characteristics:

1. The communication system gives immediate indication to an observer, instructor, or investigator of the distribution of correct and incorrect responses made by an individual or a group being tested.

2. The system registers, summates and presents the total test score for each individual of the group at the end of the test period.

3. The device provides for the insertion of correct answers for each test item either by the operator or by a prepunched correct answer card for as many as 100 items of a test.

4. The system provides a semi-private response station for each individual of a group of as many as 40 people. Each

response station has five keys which provide for a maximum of five alternative responses.

5. The device presents automatically and immediately after each response period is terminated the correct answer to a question, and this indication is clearly observable by the group through numbered correct answer lights.

6. The response stations prevent the possibilities of multiple answers to an item, for only one response from each station can be recorded at a time.

7. All dials on the console panel have been designed and illuminated, so that the system can be operated in a dark room. This illumination does not interfere with the projected qualities of a motion picture.

8. The system has a grid of lights operated by switches which permit the instructor to check on the kind of responses made by each individual.

9. The dial indicators provide the instructor or investigator with the number of responses to each alternative including omit.

10. By using the Film Analyzer in conjunction with the Classroom Communicator a complete record in symbols can be printed of every response made by each individual. Furthermore, since a record can be made of all response times, the system can be used for a variety of immediate or delayed response measurements.

Before the Classroom Communicator system was used as a

research tool, the equipment was subjected to a series of tests to evaluate its performance characteristics such as, for example, the situations in which the communication system might be employed and the demands made by the equipment both on the instructor and the students. When the tests were concluded, a program of experimentation was carried out with emphasis on instructional film research (11). Studies conducted under this program of research are cited in Chapter III.

With the termination of the Navy Research Contract on August 31, 1955, the Instructional Film Research Program as such ceased to exist. A new organization, the Instructional Research Program, was formed at The Pennsylvania State University to conduct research on some of the problems associated with instruction and to investigate the potentialities of closed-circuit television in university teaching (4; 10, p. 2). The attention given to the possibility of using television to extend the influence of university teaching is reflected by articles written on the subject of educational television (2, 3, 15, 18). These articles discuss the value of educational television in mass education, and suggest the need for careful planning and research in the use of this medium in view of the anticipated increase in the enrollments of colleges and universities without corresponding increases in the teaching staffs of these institutions. As technological advances in electronics are directed toward the solution

of technical problems in educational television, it is possible that communication systems, similar in function to the Classroom Communicator, will be designed and constructed for use with educational television.

The planners, designers, and builders of the experimental Classroom Communicator suggest that this equipment can serve several important and useful purposes (5, p. 30). The following purposes have specific implications for military mass training programs and, therefore, are particularly pertinent to the present study:

1. The Classroom Communicator system can be used for research on instructional and informational types of communication programs.

2. The Classroom Communicator can serve as a prototype for other models, simpler systems which may be needed to perform more limited functions such as, for example, those connected with mass training programs.

3. On the basis of the work done with this kind of equipment, a model can be developed, mass produced, and distributed for use in educational or training centers.

The Modified Classroom Communicator

The purposes enumerated above provided the stimulus for the design and construction of a Modified Classroom Communicator. This modification of the experimental model developed at The Pennsylvania State University was built by personnel at the Aviation Electronics School, NATTC, Memphis, Tennessee,

with material and parts that were available or could be produced at this school. This equipment was planned to meet the specific needs of NATT for a training aid designed to help naval aviation trainees learn technical material under mass training conditions. One study (20), and a replication, was conducted using the Modified Classroom Communicator. The results of this investigation are reported in Chapter III.

The major components of the Modified Classroom Communicator, shown in Fig. 7, are as follows:

The Response Stations. There are 36 individual, semi-private Response Stations that may be secured to the arm rest or some other convenient part of the chairs (Fig. 8). The open-end metal boxes contain four toggle switches that are used by the subjects to register their responses to multiple-choice or true-false questions. The switches make it possible to select and register one answer or response among four alternatives.

The Console Panel. The Response Stations are connected to 36 sets of lights on the Console Panel. The Console Lights are arranged in groups of four, with each group connected to a Response Station. The connections are made by means of cables, wires, and connecting plugs (Figs. 7 and 9). The Console Lights indicate to the instructor or investigator the correctness or incorrectness of the responses to each question.

There are no Total Score Indicators. However, the Console Panel provides space along each row of lights for the

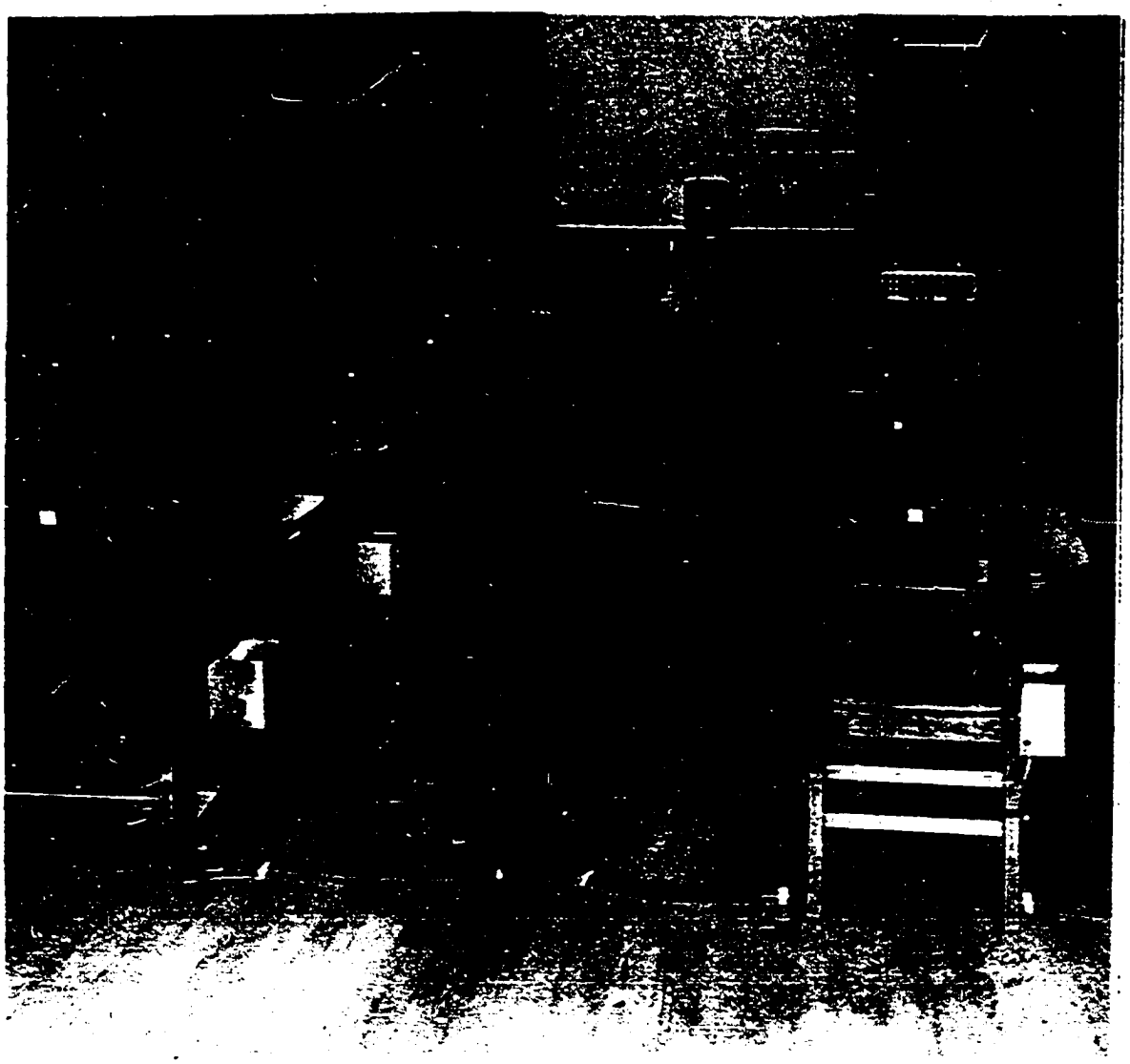

Fig. 7. The Modified Classroom Communicator system. Console (upper right), Response Stations (bottom). Cables secured to the floor extend from the rear of the Console to the Response Stations.

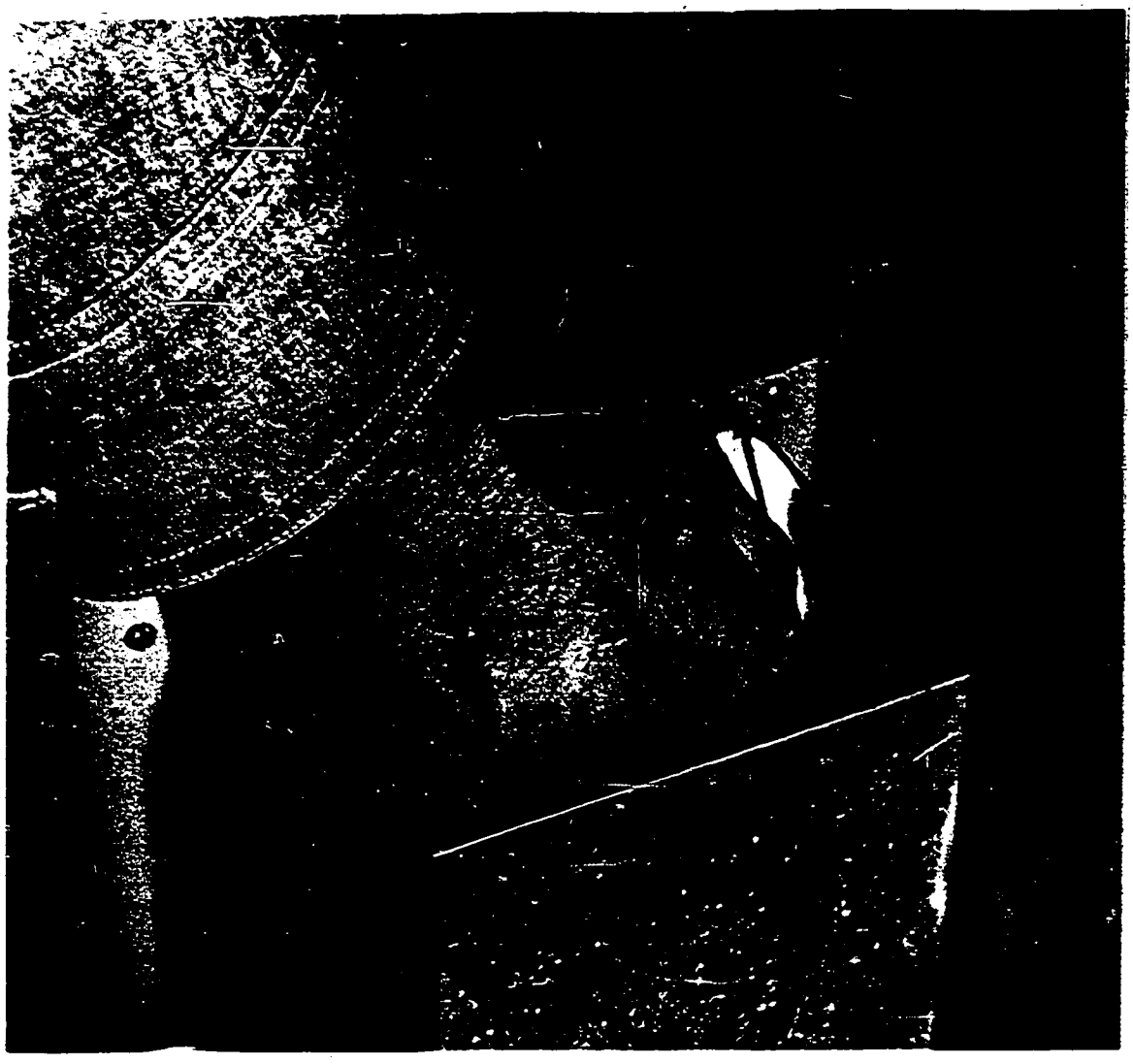

Fig. 8. Response Station with hand in operating position.

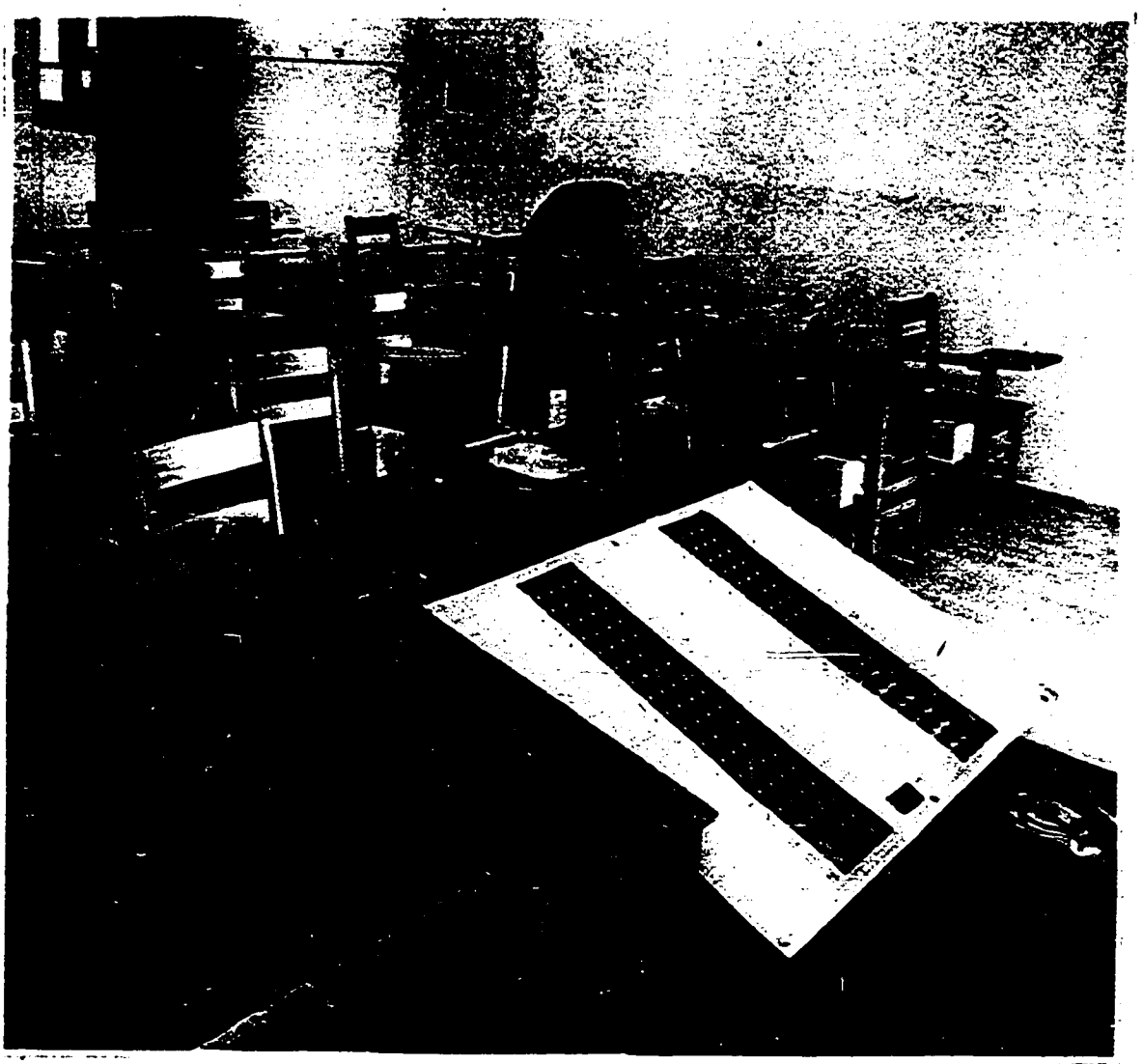

Fig. 9. The Modified Classroom Communicator Console Panel showing the two columns of Console Lights.

name of each subject and squares for each subject's individual scores. This is a manual operation that must be performed by the instructor or investigator. If more space is required for names and scores, a large, ruled form may be mounted over the Console Panel as shown in Fig. 9.

There are no Classroom Correct Answer Lights. The correct answer must be indicated by the instructor verbally or by some other appropriate means.

Equipment similar to the Film Analyzer is not available for use with the Modified Classroom Communicator. However, it is possible that the latter equipment can be adapted for use as an Analyzer should this need become apparent.

The major performance characteristics of the Modified Classroom Communicator are as follows:

1. The Console Panel Lights make it possible to operate the communication system in a darkened room. The green lights do not interfere with the presentation of questions by means of a projector, or the showing of instructional films.

2. The Console Panel Lights permit the instructor or investigator to check on the kind of responses made by each individual, and the number of responses made to each alternative, including omit.

3. The system gives immediate indication to an investigator, observer, or instructor of the distribution of correct and incorrect responses made by an individual or a group.

4. The system provides a means for recording the

correct and incorrect responses and the total test score for each individual at the end of the test period.

5. The system provides a semi-private response station for each individual of a group of as many as 36 people. Each Response Station has four toggle switches which provide for a maximum of four alternative responses.

6. The system provides a means for instructor-student intercommunication. During the course of a lecture the instructor can determine quickly, readily, and accurately whether or not the material he is presenting is understood by the students. The students, by using the Response Stations to signal the instructor when his presentation is not clear, can help the instructor make his teaching more meaningful. These things can be done with a minimum of interruption and interference with the normal proceedings of the classroom routine.

A comparison of the Classroom Communicator with the Modified Classroom Communicator reveals important differences and similarities between these two communicator systems. The major differences occur in the inherent complexity in design and construction, and in the constitution of the components of the respective systems. In addition, it is evident that the Modified Classroom Communicator is relatively uncomplicated in terms of operational characteristics and functionally much less versatile than its prototype.

The major similarities between the two communicator

systems are found in the basic functions performed by the equipment. Such functions include a technique for eliciting and recording the reactions of individuals in groups, a method for administering multiple-choice or true-false tests and making the results available directly after the conclusion of the test, and a means for enabling the instructor or experimenter to see immediately how each individual responds to each item in a test. These functions furnish the means for improving, facilitating, or increasing the rate and effectiveness of learning, and provide the basic ingredients needed for experimental research on the learning process, including the present study.

CHAPTER III

SURVEY OF RELATED RESEARCH

Research Using Experimental Equipment

The experimental Classroom Communicator constructed at The Pennsylvania State University was designed and developed to provide a means for conducting research on the learning process, principally through the use of instructional films. The Film Analyzer, designed for use in conjunction with the Classroom Communicator, has been most useful in evaluating instructional films and film scripts. Since it is a continuous recording polygraph, the Film Analyzer prints a record of the selections, time marks, and film footage marks made by means of the Response Stations of the Classroom Communicator.

One of the first studies to use the Classroom Communicator system for major research purposes was conducted by Twyford (22, 23) who attempted to determine whether profiles of learning, obtained from subjective ratings recorded on the Film Analyzer, would correlate highly enough with profiles of learning obtained from objective tests so that they could be considered as reliable measures of learning. A total of 276 high school and college students, randomly divided into seven

groups, participated in the experiment. Three groups of subjects were given instructions to indicate through the Response Stations of the Classroom Communicator when they were or were not learning during the showing of a film. Three other groups of subjects viewed the film and received a true-false test based on the factual content of the film to determine the amount of actual learning that occurred during the showing of the film. The seventh group, serving as the control group, was given the true-false test without seeing the film. The results of the study showed that the profiles of learning obtained from the subjective ratings were comparable to the profiles based on the objective tests. The conclusions drawn from Twyford's (23, pp. 14-17) investigation indicate that the subjects were able to judge for themselves when they were and were not learning during the showing of the film, and that audiences may be trained to rate learning from films.

Stover and Tear (21) conducted a study to determine whether two kinescopes (a series of Naval Reserve Training television programs recorded on film) were as effective for training as standard training films. A total of 25 film evaluation experts served as judges in this study. In the first phase of the experiment, a panel of 12 judges viewed the films and evaluated their teaching effectiveness in terms of a special rating form newly developed for such purposes. In the second phase of the experiment, a panel of 15 judges assumed the role of "average boots" and viewed the films to

determine which sections of the films were most effective and which were least effective in communicating information to the audience. Using the Film Analyzer equipment, the second panel of judges rated the kinescopes in the manner developed by Twyford (22) and evaluated the scenes they were viewing in terms of the amount of learning they judged would occur. Within the limitations of the methods used, Stover and Tear (21, p. 11) concluded that the kinescopes, as rated by both panels of judges, were at least as effective in the communication of information as the average of the training films that have been studied by the Instructional Film Research Program.

In an attempt to investigate the effects of the profile technique on learning, Fletcher (9) conducted a study using three versions of a film commentary, a profile version, a script writers' version, and a full version. A total of 204 naval trainees at the Bainbridge Naval Training Center, divided into four groups, served as subjects. One group of subjects was shown the full version. A second group of subjects was shown the profile version with 26 per cent of the material eliminated. The material in the profile version was eliminated by a panel of three judges using profiles obtained from a sample audience of 128 naval trainees who considered the eliminated material as either redundant or already known. A third group of subjects viewed the script writers' version with 11 per cent of the material eliminated by three script

writers without reference to the learning profiles, and the fourth group, serving as a control group, was not exposed to the film commentary. At the conclusion of the experiment a test composed of 50 multiple-choice questions based on the film commentary was administered to all subjects.

Instead of using the Film Analyzer equipment in this study, Fletcher used a series of potentiometers which were developed by Twyford to serve as special learning profile response stations. The results of the investigation showed that no significant differences in learning existed among the four groups used in the study. In effect, this evidence supports the findings reported by Twyford, that subjects are able to indicate through the profile technique when they are or are not learning.

A study conducted by Hirsch (13, 14) to ascertain whether knowledge of results would have a facilitating effect on learning of meaningful material represents an important use of the Classroom Communicator. Specifically, the study was undertaken to see if knowledge of results, provided by means of the Classroom Communicator, would influence test results based on factual material presented in selected sound motion pictures.

A total of 138 NROTC midshipmen at The Pennsylvania State University, divided into six groups of 23 subjects in each group, participated in the study. Through the use of the Latin-square design, all subjects were exposed to six

methods designed to give different degrees and presentations of knowledge of results. The methods were:

Method A. This was the Control Method. Knowledge of results was not given in any manner.

Method B. Subjects who selected the correct response were informed of this through a neon lamp which lighted up when the correct key was pressed. Subjects who did not press the correct key did not know which of the responses was the correct one.

Method C. This was the same as Method B, with the addition, however, that the Classroom Correct Answer Light informed all the subjects which response was correct regardless of the choice made.

Method D. This was the same as Method B. In addition, however, the question was repeated on the screen with all alternatives removed except the correct one.

Method E. This was the same as Method D, except that a second showing of the film was introduced at the end of the test.

Method F. This was a control for Method E. The subjects were shown the film, took the test without knowledge of results, and then saw the film the second time. The difference between Method E and Method F was that knowledge of results was not given to subjects in Method F.

The principal problem involved in the study was to determine which of the six methods produced the most amount

of learning as measured by retention of specific material taken from the films shown. In addition to this central problem, a secondary problem was investigated designed to determine whether the material would be retained better if knowledge of results was given in a meaningful way. This condition was satisfied by presenting to all the subjects both the question and its correct response. All subjects were given a pretest prior to the start of the study, a posttest immediately at the end of the experimental sessions, and a delayed posttest two weeks after the end of the last experimental session.

The results of the study showed a definite order of effectiveness for the methods used to provide knowledge of results. Method E was most effective followed by Method D and Method F, the control for Method E. Methods B and C were the least effective methods in comparison to the other methods except for Method A, the Control Method, in which knowledge of results was not given.

The results of the study suggest important implications for mass training programs. Some of the implications indicated by Hirsch (14, pp. 22-24) include:

1. Teaching methods which make provisions for giving knowledge of results have a facilitating effect on learning and retention of material. Thus a test, when used as an integral part of teaching methods to provide knowledge of results in addition to evaluating trainee progress, serves as an

effective teaching aid and a suitable technique for facilitating the learning and retention of material under conditions of mass training.

2. Knowledge of results, given item by item, aids the retention of learned material.

3. Knowledge of test results has a greater facilitating effect on learning when it is given in a meaningful manner as, for example, when each question and its correct answer are repeated, or when the material is presented a second time.

4. The Classroom Communicator is an effective training aid that can be used to minimize the one-way communication from instructor to trainee which usually exists in mass training situations. The Classroom Communicator makes possible a two-way interaction between the instructor and a number of trainees and, since one instructor is able to "hear the recitation" of an entire class at the same time, the communicator system furnishes the means for the active participation of a group of individuals in the learning process.

The Classroom Communicator served as the impetus for the design and construction of the Modified Classroom Communicator. This experimental equipment was built to provide a means for facilitating learning in the mass training program of Naval Air Technical Training. The investigation to evaluate the effectiveness of the Modified Classroom

Communicator as a classroom training aid was conducted by Mowry and Webb (20) at the Basic Aviation Electronics Technicians School, Memphis, Tennessee.

In the statement of the problem, Mowry and Webb (20, p. 30) point out that "Communication between an individual and a group is at best only partially reciprocal." This observation is true of most group teaching situations including the training program at the Naval Air Technical Training Center, Norman, Oklahoma. The teaching procedure observed at this training center provides opportunities for instructors to "check for understanding." Essentially, this is a question and answer period at which time the instructor asks questions about the key points of the material covered in the lesson guide and elicits answers from individual trainees in the conventional manner. Such a procedure permits the participation of only a few trainees during each question and answer period, and the understanding of only these few can be assessed for the amount of material presented in the lecture.

Of course, conventional multiple-choice tests are used to evaluate the progress and understanding of the trainees, but the course of study is so intensive and accelerated that usually a substantial amount of material is presented before tests are administered. Since an increase in the testing program would be prohibitive in time and effort, Mowry and Webb (20, p. 30) suggest that a training aid that would

provide the feedback information of the written examination without its limitations would serve an important function. The Modified Classroom Communicator appeared to meet the necessary requirements for such a training aid and, accordingly, two experiments were conducted with this equipment.

In the first experiment three classes were divided into lecture groups which were matched on the basis of the Navy Basic Battery Test scores (GCT, Arithmetic, and Mechanical Comprehension). A total of 145 trainees participated in the experiment. The control groups were instructed in the usual manner while the experimental groups used the Modified Classroom Communicator for a period of two weeks. By means of the Response Stations, the experimental groups responded to a series of questions projected on a screen. The questions, selected from a pool of test items submitted by instructors in the Electronics School, were based on the key points of the material taught during the experimental period and were projected throughout a lecture at the rate of four or five per hour. The instructor, by looking at the lights on the Console Panel, "checked the understanding" of each trainee in the group, indicated the correct answer for each question, and finally cleared up any misunderstandings. A regularly scheduled test was administered to all trainees at the end of the 15th week. The results of this test were subjected to analysis of covariance, using the Airman Preparatory School grades as initial scores. In addition, the scores

of 98 trainees from a sample of pre-experimental classes were treated in a similar manner.

The results of the first experiment showed no significant differences between the groups on the initial measure nor between the experimental and the control groups on the final measure. Differences between the pre-experimental and both the experimental and control groups on the final measure were significant beyond the .01 level of confidence.

The second experiment, undertaken several months later in a different unit of study during the 5th week of school, used unmatched sections. A total of 94 trainees were used as the experimental subjects while 281 trainees served as the control subjects. The 5th week test scores and the Airman Preparatory School grades were subjected to analysis of covariance. The results showed that differences in the 5th week test scores between classes using the Modified Classroom Communicator and the control classes were significant at the .03 level of confidence.

Instructors in both experiments were rotated between the experimental and control groups to avoid systematic bias resulting from differences in instructional ability. At the conclusion of each experiment, the instructors were interviewed and questionnaires were administered to both the instructors and the subjects to ascertain their attitudes concerning the use of the Modified Classroom Communicator. The responses to the questionnaire showed that the majority of

the trainees expressed favorable attitudes toward the use of the Modified Classroom Communicator. The instructors, however, were opposed to the use of this equipment because the time schedule did not permit the use of the Modified Classroom Communicator in addition to carrying out the normal classroom routine (20, p. 32).

Based on the outcome of the experiments, the following observations were made by the investigators (20, p. 33):

1. The results of the investigation indicated to a high degree of probability that the Modified Classroom Communicator can be used effectively to facilitate the learning of material presented in classroom lectures.

2. Students' attitudes suggest a favorable effect on two important variables, motivation and morale. Learning by the students was probably further facilitated by increased attention, active participation in the learning process, and the presentation of knowledge of results.

3. The conditions under which the investigation was carried out left much to be desired. Due to the frequent breakdown in the equipment, much time was spent in repairs. As a result the instructors expressed negative attitudes toward the use of the Modified Classroom Communicator.

4. Lack of time prevented the instructors from asking all the questions provided and in the manner prescribed in the experimental design in addition to teaching the material in the lesson guides.

Other Related Research

One of the difficulties associated with the use of instructional films concerns the lack of activity on the part of the viewers. There is a tendency for the audience to relax and to consider the film more entertaining than informative. Some attempts have been made to incorporate directly into instructional films a participation feature or technique, consisting of a series of questions or statements presented before, during, or after the presentation of the film. This procedure was designed to encourage the active participation of the viewing audience, that is, to stimulate the learners and to give them a more active approach to the learning of the material presented in a film. Training aids or devices, other than the film itself with the addition of the questions or statements, were not used. Two studies representing this type of research will be reported.

An exploratory study, reported by the Motion Picture Research Project, Yale University (27), was conducted to investigate the effects of two specific procedures on the learning of the content of instructional films. These procedures involved the introduction of questions into a film designed to arouse the curiosity of pupils' concerning the facts about to be presented, and to require the pupils to participate more actively during the presentation of the film. Approximately 600 sophomores and juniors from high schools in the vicinity of New Haven, Connecticut, were the subjects.

Questions, designed to increase the pupils' motivation to learn, were spliced into films and presented in titles before each unit of work. The purpose of these questions was to arouse the interest of the pupils in learning the material about to be presented, and to direct attention to the relevant aspects of what was to be shown. The participating questions, answered by the pupils at the end of each unit of work, were based on material that had just been presented. The purpose of these questions was to encourage the pupils to participate actively by answering the questions which were printed on a work sheet. After a short interval, the correct answer to each question was given on the screen.

The results of this study, reported in percentages of increase in correct answers on the posttest over the pretest, showed a definite order of effectiveness for the five versions used, with Motivating and Participation Questions being most effective, followed by Participation Questions, Factual Presentation Twice, Motivating Questions, and finally, Factual Presentation Only being least effective.

A study, similar to the one just reported, was carried out by Walter and Brenner (16, 25). In this study six different methods were used to present and teach a body of material based on factual information presented in two films, two control methods, and four experimental methods. One control method received no special treatment while the second control method viewed the films twice in succession. The experimental

methods employed a series of questions or statements spliced into the films at time intervals of approximately 32 or 64 seconds. The questions were designed to facilitate the learning of information just presented, while the statements were planned to reinforce the same information. Immediately after the showing of the films, tests based on the factual information given in the films were administered to the subjects. Four weeks later the same tests were administered to measure retention of learning.

The test scores of 1332 students, 111 boys and 111 girls from each of the six schools participating in the study, were used in the analysis of results. The results of the study showed that small differences existed among the different versions employed, and that a generally consistent order of effectiveness in the methods was lacking. Although only limited conclusions could be drawn from the results of this study, the evidence produced by this research project showed that, in general, questions and statements incorporated into instructional films are effective in facilitating learning of information presented in films. Furthermore, showing the film twice in succession was about as effective as the technique of inserting questions and statements into the film (25, p. 15).

The research cited in this chapter concerning the Classroom Communicator indicates that this equipment has been used in a variety of situations to conduct studies on the learning process. The work completed at The Pennsylvania State Uni-

versity, with its emphasis on instructional film research, employed the Classroom Communicator system as a device to record and measure the reactions of subjects. One important deviation from this pattern is represented by the study reported by Hirsch (13, 14). It is important to note that in this study the Classroom Communicator served not only as a device to record and measure responses, but also to provide a means of communication between the experimenter and the subjects. When used in this manner, the Classroom Communicator becomes a valuable device for encouraging the active participation of groups in the learning process.

Since the Classroom Communicator was designed primarily for use as a recording and measuring device in connection with instructional film research, studies to demonstrate the application of this communication system in learning material presented in classroom lectures are lacking.

The Modified Classroom Communicator, unlike its prototype, was designed for use primarily as an aid in classroom teaching and essentially as a recording device. Its most vital function is to furnish a means of communication between the instructor and the trainees in group teaching situations. The experiments reported by Mowry and Webb (20) have demonstrated that communication between the instructor and a group of trainees may be accomplished by presenting a series of questions based on lectures and having the trainees respond to these questions through the communicator system.

In this way the instructor can quickly assess the understanding of each individual in the group and, as necessary, clear up any misunderstandings. In view of the favorable trends shown in the experiments with the Modified Classroom Communicator, further research with this equipment appears definitely indicated.

CHAPTER IV

DESCRIPTION OF THE EXPERIMENT

The Equipment Used

The Modified Classroom Communicator. This electrical equipment is composed of a Console and 36 individual Response Stations. In the present study only 30 Response Stations were used to accommodate the size of the sections using the Modified Classroom Communicator. The Console Panel has two columns of lights, with 18 lights in each column arranged in rows of four. The Response Stations, open-end metal boxes containing four toggle switches, are connected to the Console by means of cables, wires, and plugs. When a toggle switch is in the on position a light on the Console Panel signals this occurrence. Through the use of this equipment, subjects can register their responses to true-false or multiple-choice questions. The Console Lights indicate the correctness or incorrectness of the responses.

The Overhead Projector. This is the Master Vu-Graph, a special type of transparency projector, used to project the questions on the screen. A projector of this type was available in each of the classrooms, and all instructors were

familiar with the function and operation of this projection equipment.

Projection Screen. A 96 x 96 beaded or semi-matte screen is recommended for use with the Overhead Projector.

Electric Timers. Each of the three classrooms assigned to one of the experimental methods used in this study was equipped with an electric timer, connected to the Overhead Projector, to insure uniformity in the exposure time of questions projected on the screen. The timers turned the projectors on and, at the end of 40 seconds, turned them off automatically.

The Materials Used

Answer Sheets. Answer sheets were used to record the subjects' responses to questions projected on the screen. The answer sheets contained columns for marking answers and for checking them against the correct answers. One group of subjects used one answer sheet during each experimental session, or a total of six answer sheets for each subject during the experimental day. Another group of subjects used two answer sheets during each experimental session, an original and a carbon copy, or a total of 12 answer sheets for each subject during the experimental day. Directions for the use of the answer sheets were printed on the forms (Appendix A).

Instructional Material. The instructional material selected for the study was a unit of instruction in the Funda-

mentals of D. C. Electricity (Appendix B). This unit of instruction was composed of six lectures, each 50 minutes in length, which served as an introduction to the study of electricity and electronics. This particular material was selected because it represented a relatively homogeneous block of work not found in other parts of the course. It served as the framework for the basic concepts, principles, and factual knowledge needed to introduce the trainees to the study of electricity and electronics, especially as this information applied to naval aviation. It also represented the foundation for the work to be undertaken in the specialized, Class (A) schools in the electronics field.

The instruction during the experimental day was based on standardized lesson guides which were in existence prior to the start of the study. A sample of a lesson guide and one of the lectures is presented in Appendix B. All subjects were exposed to the same instructional material and were taught in the approved Navy manner of teaching as prescribed by the lesson guides. The only deviation from the regular classroom routine occurred in terms of the conditions imposed by the experimental procedures.

The Tests Used

Unit Test Questions. The unit test questions were composed of 50 multiple-choice items prepared on transparencies for use with the Overhead Projector. These questions, based on the selected instructional material, were projected on the

Table 1

Lecture Titles and Number of Unit Test Questions Based on Each Lecture

Lecture Period	Lecture Title	Number of Questions
1	Atomic Structure	8
2	Static and Dynamic Electricity I	8
3	Static and Dynamic Electricity II	9
4	D. C. Voltage, Current, Resistance I	9
5	D. C. Voltage, Current, Resistance II	8
6	Conductors, Insulators, Resistors	8
	Total number of unit questions	50

screen at the rate of eight or nine questions either at the end of each lecture, or during the course of each lecture after a small unit of work was presented. Lecture periods, lecture titles of the instructional material, and the number of unit test questions based on each lecture are shown in Table 1.

Posttest. This multiple-choice test, composed of 50 questions based on the instructional material indicated in Table 1, was administered at the conclusion of the experimental day. Items used as unit test questions were not duplicated on the posttest. Samples of unit test and posttest questions are shown in Appendix C.

Delayed Retention Test. This composite test, composed of the unit test and posttest questions, was administered nine days after the end of the experimental day.

The questions used in the unit test and the posttest

were selected from a pool of questions submitted by the instructors in the Electrical-Electronics Course at the Naval Air Technical Training Center, Norman, Oklahoma. These tests were prepared in accordance with the principles and suggestions contained in Adkins (1). Prior to the start of the experiment, 400 trainees from the E/E Course participated in a study of test reliabilities. The coefficient of reliability computed by the Kuder-Richardson Formula 20 (12, p. 454), was .82 for the unit test, and .84 for the posttest. The coefficient of correlation between these two tests, determined by the Pearson r, was .94.

Testing Procedure. At the conclusion of the experimental day, the four groups of subjects participating in the study proceeded to the central test building where the posttest was administered from 3:00 P. M. to 4:00 P. M. under rigidly proctored conditions. Nine days later these same subjects were marched to the test building where the retention test was administered from 3:00 P. M. to 4:00 P. M. under the same conditions established for the posttest.

Selection of Subjects

A total of 833 naval trainees, randomly assigned to four methods groups to be described later, served as subjects in this research project. Group Method A consisted of 206 trainees, Group Method B contained 210 trainees, Group Method C had 212 trainees, and Group Method D contained 205 trainees. These trainees were undergoing a five week preparatory course

of instruction in the Electrical-Electronics Course at the Naval Air Technical Training Center, Norman, Oklahoma.

On each Monday during the eight weeks while the study was in progress, approximately 150 trainees were convened in the Electrical-Electronics Course. In accordance with the usual practice, these trainees were assigned alphabetically to sections containing up to 30 trainees per section. Each Monday during the course of the study, four sections of the convening class were randomly selected by means of a table of random numbers to participate in the study. In turn, these four sections of trainees were randomly assigned to one of the four group methods used in the study. In this way each of the convening sections of trainees had equal opportunity to participate in the experiment and to be assigned to one of the four methods groups.

During the first two weeks of school, the subjects received instruction in Mathematics, Mechanical Physics, Hand Tools, and Shop Work. The next two weeks were devoted to the study of D. C. Electricity and related subjects, while the fifth and final week was devoted to Air Familiarization, Fire Fighting, and Survival. On each Monday of the third week of school, during periods one through six, the subjects received instruction in the subject matter indicated in Table 1.

Selection of Instructors

From lists of eligible instructors in the Electrical-Electronics Course, two separate groups of instructors,

composed of 16 instructors in each group, were randomly selected by means of a table of random numbers to participate in the study. The first group of instructors was randomly assigned to eight teams consisting of two instructors per team. Each team of instructors was then randomly selected to teach during one of the eight practice periods. These practice periods were given during the second week of school when the section of trainees assigned to Method D received practice in the use of the Modified Classroom Communicator.

The second group of instructors, also randomly assigned to eight teams with two instructors per team, was selected to teach on Monday of the third week of school during the experimental day. Each week four teams of instructors from this second group were randomly assigned to teach one of the group methods used in the study.

Experimental Procedure

This study employed one control method and three experimental methods to encourage the subjects' participation in a series of question and answer periods. These methods were incorporated into the regular classroom teaching routine and were concerned with the presentation of questions which serve as an indication of the subjects' understanding of material presented in a series of six lectures during the experimental day. The methods, designed to facilitate the learning and retention of the lecture material, were as follows:

Method A. This was the control method. The usual Navy

classroom teaching routine was followed as prescribed by the standard lesson guides. At the end of each lecture questions were asked about the key points in the lesson and responses were elicited from individual trainees in the conventional manner.

Method B. The usual Navy classroom teaching routine was followed as prescribed by the standard lesson guides. At the end of each lecture given during the experimental day, either eight or nine multiple-choice questions were projected on the screen, one at a time. These questions were based on the material that had just been presented in the lecture and served as a review of the key points in the lecture. The subjects had 40 seconds in which to read each question, select an answer, and mark this answer on the special answer sheet provided. Once a response was made no changes were allowed. An electric timer was used to insure the proper exposure time for each question. In this method the subjects used two answer sheets, an original and a carbon copy, with spaces for 10 responses. At the end of 30 seconds an amber colored transparency was placed over the question to indicate that 10 seconds remained. After all the questions were presented and answered the subjects turned in their original answer sheets to the instructor. This procedure was included to encourage individuality in the subjects' responses. After the original answer sheets were collected, the same questions were again projected on the screen. As each question was presented, the

instructor indicated verbally the correct answer and briefly explained why that answer was the correct one. During this time the subjects checked and marked the answers on the copies of their answer sheets. At the end of the class period these answer sheets were also turned in to the instructor. The entire procedure was duplicated at the end of each of the six lectures given during the experimental day.

Method C. This method was essentially the same as Method B except that the questions were projected on the screen during the course of each lecture given during the experimental day, after a small unit of work was presented. The questions served to reinforce the key points that had just been presented. The subjects used only one answer sheet during each lecture period.

Method D. This method was identical to Method C except that the Modified Classroom Communicator was used for the responses.

The procedure for any one class, shown in summary form on the following page, was as follows:

1. Prior to starting school, the trainees in the convening class consisting of approximately 150 students were assigned alphabetically to sections containing up to 30 trainees per section. On Monday of the first week of school, four sections of the convening class were randomly selected and assigned by means of a table of random numbers to one of the four methods used in the study.

Summary of Procedure for any One Class

Procedure	Methods			
	A	B	C	D
Monday of the first week of school Four sections of trainees in the convening class randomly selected and assigned to methods groups.	x	x	x	x
Tuesday, Wednesday, Thursday, Friday of the second week of school Section of trainees assigned to Method D received practice in the use of the Modified Classroom Communicator				x
Monday of the third week of school Experimental Day Method A - Control Group The usual classroom routine was followed according to standard lesson guides	x			
Method B - Experimental Group Questions projected on the screen at the end of each lecture. Two answer sheets used for responses.		x		
Method C - Experimental Group Series of questions projected on the screen during the course of each lecture. One answer sheet used for responses.			x	
Method D - Experimental Group Series of questions projected on the screen during the course of each lecture. The Modified Classroom Communicator used for the responses.				x
Monday of the third week of school at conclusion of experimental day Posttest administered	x	x	x	x
Wednesday of the fourth week of school Delayed retention test administered	x	x	x	x

2. On Tuesday, Wednesday, Thursday, and Friday of the second week of school, the section of trainees previously assigned to Method D was given practice in the use of the Modified Classroom Communicator under actual classroom conditions. This practice was deemed necessary to allow the trainees to become familiar with the use of the experimental equipment, and to reduce the effect of novelty that might be present due to the use of such equipment. A total of 40 multiple-choice questions, prepared by the instructors to cover the material taught during the second week of school, were used in the four days of practice. The procedure for presenting and answering these questions was identical to that followed in Method D during the experimental day.

3. On Monday of the third week of school, the four sections of trainees selected to participate in the study took part in the experimental day proceedings according to the group method selected for each section.

4. On Monday of the third week of school, at the conclusion of the experimental day, the four groups of subjects participating in the experiment proceeded to the central test building where the posttest was administered from 3:00 P. M. to 4:00 P. M.

5. On Wednesday of the fourth week of school, the subjects who had taken the posttest nine days previously as indicated in number four above, gathered in the test building at 3:00 P. M. when the delayed retention test was given.

This procedure outlined above was duplicated for a total of eight convening classes during August and September, 1957.

CHAPTER V

STATISTICAL ANALYSIS

Method of Analysis

The primary statistical technique used to analyze the data presented in summary form in Table 2 was the analysis of variance. This method of analysis is useful and appropriate when it is necessary to study several groups of subjects simultaneously in a simple-randomized experiment similar to the present study. The application of analysis of variance is predicated on two major underlying assumptions. These assumptions as pointed out by Lindquist (17, p. 73) are: (a) that the treatment groups used in the study were selected at random from the same population and (b) that the variances between the groups of data obtained in the study are homogeneous.

The first assumption has been satisfied by the selection procedures described in Chapter IV. In order to determine whether the second assumption has been satisfied, the Hartley Test for Homogeneity of Variances was applied in the manner suggested by Walker and Lev (24, p. 192). The obtained F ratio values were 1.33 for the posttest and 1.56 for the

Table 2

Group Means and Standard Deviations on the Posttest and Retention Test by Methods

Methods	N	Posttest		Retention Test	
		M	S.D.	M	S.D.
Method A Control Group	206	38.75	6.30	76.39	12.66
Method B Experimental Group Answer sheet technique. Questions given at the end of lectures.	210	39.71	5.91	80.55	10.93
Method C Experimental Group Answer sheet technique. Questions given during the lectures.	212	40.10	5.47	80.83	10.08
Method D Experimental Group Use Modified Classroom Communicator. Questions given during lectures.	205	40.50	5.51	81.27	10.06
Total number of subjects	833				

retention test, with four k mean squares. The degrees of freedom varied from 205 for the largest variance to 211 for the smallest variance. The F ratios were referred to a special table (24, p. 462). It was found that these values exceeded the critical region of 1.00 thus making untenable the hypothesis of homogeneity of variances. As a result the second assumption apparently has not been satisfied.

Failure to satisfy the assumption of homogeneity of variances does not invalidate or preclude the use of analysis

of variance, however, since it has been indicated that strict homogeneity of variances is not an absolute criterion for the use and application of this method of analysis. This thought is expressed by Wert, Neidt, and Ahmann (26, p. 184), by Fisher (8), and by Lindquist (17). Fisher (8, pp. 124-125) indicates that the "assumption" of equality of two variances has been incorrectly stated since it actually refers to the hypothesis that the two samples are drawn from the same normal population and therefore, the *t* test, as a test of this hypothesis, is absolute and thus requires no assumption concerning the homogeneity of variances.

In discussing experimental situations in which there is a lack of homogeneity of variances in the treatment groups, Lindquist (17, p. 86) states:

> . . ., the heterogeneity must be quite extreme to be of any serious consequence. While statistical tests of heterogeneity of variance are available . . ., there will be relatively few situations in which any such test is required. In general, unless the heterogeneity of either form or variance is so extreme as to be readily apparent upon inspection of the data, the effect upon the *F*-distribution will probably be negligible. In general, when the heterogeneity in form or variance is "marked" but not "extreme," allowance may be made for this fact by setting a higher "apparent" level of significance for the tests of treatment effects than would otherwise be employed.

The distribution of scores of the subjects on the General Classification Test, the posttest, and the retention test are presented in Tables 7, 8, and 9 in Appendix D. The frequency distributions offer a tabular description of the groups of subjects used in the study.

Table 3

Analysis of Variance of the Scores Made by Four Groups of Subjects on the Posttest

Source of Variation	Sum of Squares	df	Variance	F
Between groups	345.2	3	115.1	3.4*
Within groups	28084.7	829	33.9	
Total	28429.9	832		

*Significant beyond the .05 level.

Analysis of Posttest Scores

The summary of the analysis of variance of the posttest scores is shown in Table 3. Reference to the F table reveals that the obtained F value of 3.4 exceeds the F value of 2.61 required for a statistically significant difference between the groups at the .05 level of confidence with 3 and 829 degrees of freedom. This indicates that the differences between the posttest means cannot be attributed to chance alone.

The next step in the analysis of variance was to compute the t test to check the significance of the specific differences between the means of the treatment groups. As suggested by Guilford (12, p. 263) and McNemar (19, p. 259), this procedure is required whenever a significant F ratio has been found. Accordingly, the t tests were computed and referred to the t table. The results, presented in Table 4, show that the differences in the means between Methods A and C, and

Table 4

Significance of Differences in Means on the Posttest Between Methods Groups

Methods Groups	Mean		$Mean_{diff}$	SE_{diff}	t
A-B	38.75	39.71	.96	.57	1.68
A-C	38.75	40.10	1.35	.57	2.37*
A-D	38.75	40.50	1.75	.57	3.07*
B-C	39.71	40.10	.39	.57	.69
B-D	39.71	40.50	.79	.57	1.39
C-D	40.10	40.50	.40	.57	.70

*Significant beyond the .05 level.

between Methods A and D are statistically significant beyond the .05 level, based on 829 degrees of freedom. All other comparisons failed to reach statistical significance.

Table 5

Analysis of Variance of the Scores Made by Four Groups of Subjects on the Retention Test

Source of Variation	Sum of Squares	df	Variance	F
Between groups	3181.2	3	1060.4	8.6*
Within groups	102660.9	829	123.8	
Total	105842.1	832		

*Significant beyond the .05 level.

Analysis of Retention Test Scores

The summary of the analysis of variance of the retention test scores is given in Table 5. The obtained F ratio of 8.6 exceeds the tabled value of 3.81 required for a statistically significant difference between the groups at the .05 level of confidence with 3 and 829 degrees of freedom. This indicates that the differences between the retention test means are not chance differences.

Table 6

Significance of Differences in Means on the Retention Test Between Methods Groups

Methods Groups	Mean		$Mean_{diff}$	SE_{diff}	t
A-B	76.39	80.55	4.16	1.09	3.81*
A-C	76.39	80.83	4.44	1.09	4.07*
A-D	76.39	81.27	4.88	1.09	4.48*
B-C	80.55	80.83	.28	1.08	.26
B-D	80.55	81.27	.72	1.09	.66
C-D	80.83	81.27	.44	1.09	.40

*Significant beyond the .05 level.

Following the procedure established in the analysis of the posttest scores, the t test was used to check the significance of the specific differences between the means of the methods groups. The t ratios were computed and entered in the table of t. The results, presented in Table 6, show

that the differences in the means between Methods A and B, between Methods A and C, and between Methods A and D, are all statistically significant beyond the .05 level, based on 829 degrees of freedom. The remaining three comparisons failed to attain statistical significance.

Interpretation of Results

The statistical analyses in the present study were based on the results of the posttest and the retention test administered to the four groups of subjects participating in the study. The analysis of variance was used first to determine the significance of differences in the achievement of the groups. The obtained F values were significant at or beyond the preselected .05 level of confidence and consequently, t tests were conducted to check the differences between specific methods groups.

Interpretation of posttest scores. The analysis of variance of the scores on the posttest are presented in Table 3. Examination of Table 3 indicates that statistically significant differences existed between the groups on the posttest scores with a probability beyond the .05 level. This means that the four groups of subjects differed significantly in achievement on the posttest.

The t ratios between specific methods groups on the post-test are given in Table 4. As shown in Table 4, experimental Method C which received the questions during the course of the lectures and used answer sheets for responses,

and experimental Method D which received the questions during the course of the lectures and used the Modified Classroom Communicator for responses differed significantly from the control Method A with a probability beyond the .05 level. These results may be interpreted to mean that Method C and Method D were more effective than Method A in facilitating the learning of the material presented in lectures during the experimental day.

Further examination of Table 4 shows that experimental Method B which received the questions at the end of the lectures and used answer sheets for responses did not differ significantly from Method A. Also, the three experimental methods showed no statistically significant differences when they were compared with each other.

Interpretation of retention test scores. The analysis of variance of the scores on the retention test are presented in Table 5. The results show that statistically significant differences existed between the groups on the retention test results with a probability beyond the .05 level. This means that the four groups of subjects differed significantly in performance on the retention test.

The t ratios computed to check the significance of the differences between specific methods groups on the retention test are shown in Table 6. Examination of Table 6 reveals that the three experimental groups, Method B, Method C, and Method D, although showing nonsignificant differences when

compared with each other, showed statistically significant differences when compared to the control group Method A with a probability beyond the .05 level. These results may be interpreted to mean that the three experimental methods were more effective than the control method in facilitating the retention of the material presented in lectures during the experimental day, at least within the time limits used in this study.

Discussion of the Results

In summarizing the findings of the statistical analyses, several salient features are revealed. The results of the analyses to compare the effectiveness of the specific methods groups, given in Tables 4 and 6, clearly indicate that the experimental methods were statistically superior to the control method in facilitating the learning and retention of the selected lecture material. One exception was found in that Method B was not statistically superior to the control method on the posttest.

The experimental methods, when compared to each other, did not show an ordering of statistical superiority either on the posttest or on the retention test. Thus the answer sheet technique and the Modified Classroom Communicator, when used as training aids to encourage groups of trainees to participate in a series of question and answer sessions will facilitate the learning and retention of lecture material.

The answer sheet techniques are essentially paper and pencil tests and, therefore, possess certain inherent limitations and disadvantages which are common to all written tests. The answer sheets must be distributed, collected, and perused by the instructor at some later time to evaluate the understanding of the trainees regarding the lecture material covered in the test. This process prevents immediate and direct communication between the instructor and the group of trainees.

It will be recalled that the Modified Classroom Communicator was designed to provide the instructor with the feedback information of the written test without its limitations and disadvantages. In performing this function the communication system permits the instructor to determine immediately, quickly, and accurately the level of understanding of each individual in the class on each question presented, and to clear up any misunderstandings as soon as they are discovered. In this way a means of direct communication is established between the instructor and each individual of a group of trainees. This advantage and characteristic of the Modified Classroom Communicator is sufficiently important to consider this communication system as being less cumbersome, more efficient, and more practical than the answer sheet methods, especially under conditions of mass technical training as found in the Naval Air Technical Training Command.

CHAPTER VI

SUMMARY AND CONCLUSIONS

The Naval Air Technical Training Command makes extensive use of training aids to facilitate the presentation of lecture material and to help trainees learn technical material under mass training conditions. Before training aids are accepted for use their training value must be demonstrated under practical classroom conditions.

Purpose of the Study. This study was undertaken to investigate the effectiveness of the Modified Classroom Communicator when used as a training aid to facilitate the learning and retention of material presented in a series of six lectures based on an Introduction to D. C. Electricity.

Equipment used. The Modified Classroom Communicator is an electrical device containing 36 individual, semi-private Response Stations connected to the Console. The Console contains two columns of lights with 18 sets of lights in each column arranged in rows of four, making a total of 36 sets of lights. The Response Stations contain four toggle switches which are used to make responses to either multiple-choice or true-false questions projected on the screen. The Console

Lights signal the correctness or incorrectness of these responses.

Methods used. Four group methods, one control and three experimental methods were used in this study. These methods were:

Method A. This was the control method. The usual Navy classroom teaching routine was followed as prescribed by the standard lesson guides.

Method B. In this method either eight or nine questions were projected on the screen at the end of each of the six lectures given during the experimental day. Special answer sheets were used for the subjects' responses.

Method C. In this method the questions were projected on the screen during the course of each lecture after a small unit of work had been presented. Special answer sheets were used for the subjects' responses.

Method D. This method was identical to Method C except that the Modified Classroom Communicator was used for the subjects' responses.

The subjects. The subjects were 833 naval trainees undergoing a five week preparatory course of instruction in the Electrical-Electronics Course at the Naval Air Technical Training Center, Norman, Oklahoma. The subjects were assigned by random to the four methods groups described above. Method A contained 206 subjects, Method B had 210 subjects, Method C had 212 subjects, while Method D had 205 subjects.

The instructors. Two groups of available instructors from the Electrical-Electronics Course were randomly selected to participate in the study. Each group of instructors, consisting of 16 instructors in each group, was assigned to eight teams with two instructors per team. Each week one team from the first group of instructors taught during the second week of school when the trainees assigned to Method D were given practice in the use of the Modified Classroom Communicator. Each week four teams of instructors from the second group of instructors were assigned to teach one of the methods used in the study.

The experimental procedure. Each Monday during the eight weeks of the study four sections of trainees in the convening class were randomly selected and assigned to one of the four methods used in the study. During the second week of school the trainees assigned to Method D were given four days of practice in the use of the Modified Classroom Communicator.

On each Monday of the third week of school during the course of the study the four sections of trainees selected to take part in the study participated in the experimental day proceedings in accordance with the group method assigned to each section.

At the conclusion of the experimental day all subjects participating in the study were given a posttest containing 50 multiple-choice questions based on the material presented

in the lectures given during the experimental day. Nine days later these subjects were given the delayed retention test composed of 100 multiple-choice questions.

The experimental procedure for one class outlined above was duplicated for a total of eight classes.

Statement of the hypotheses. The problem in this study involved the testing of the following hypotheses:

1. There are significant differences in the effectiveness of the four methods used in this study to facilitate the learning and retention of selected lecture material.

a. There are significant differences in the performance between the control group Method A, the experimental group Method B which received questions at the end of each lecture and used answer sheets for responses, the experimental group Method C which received questions during the course of each lecture and used answer sheets for responses, and the experimental group Method D which received questions during the course of each lecture and used the Modified Classroom Communicator for responses, as measured by the mean scores of these groups on the posttest.

b. There are significant differences in the performance between the control group and the experimental groups as measured by the mean scores of these groups on the retention test.

The statistical treatment. In order to test the above hypotheses the analysis of variance was applied to the data

obtained from the study to test the significance of the differences in the means between the groups on the posttest and the retention test, and t ratios were derived to check the significance of the differences in the means of specific methods groups. This analysis provides a means by which the effectiveness of one method could be compared with the effectiveness of any other method.

The results. The results of the analysis of variance of the posttest and the retention test scores are given in Tables 3 and 5. The F values of 3.4 for the posttest, and 8.6 for the retention test were significant beyond the .05 level of confidence.

As shown in Table 4, the t tests applied to the differences between the mean scores of the methods groups on the posttest yielded a t of 2.37 between Methods A and C, and a t of 3.07 between Methods A and D. These t values were significant beyond the .05 level. The remaining comparisons were statistically nonsignificant.

As shown in Table 6, the t tests applied to the differences between the mean scores of the methods groups on the retention test yielded a t of 3.81 between Methods A and B, a t of 4.07 between Methods A and C, and a t of 4.48 between Methods A and D. These t values were significant beyond the .05 level. The remaining comparisons were statistically nonsignificant.

The statistically significant differences revealed by the t tests occurred in the predicted direction as indicated in the hypotheses with one exception. The experimental Method B did not differ significantly from the control Method A in performance on the posttest. Based on the findings indicated in the results, the hypotheses as stated were accepte and confirmed with the one exception noted.

Conclusions. The principal conclusions indicated by the results of this study are as follows:

1. Learning and retention of lecture material can be facilitated when the Modified Classroom Communicator and the answer sheet technique are used to encourage groups of Navy trainees to respond to a series of questions based on lecture material.

2. Method B which used the answer sheet technique to encourage trainees to respond to questions presented at the end of lectures was not significantly better than the control method in facilitating the learning of lecture material as measured by the posttest.

3. Method C which used the answer sheet technique to encourage trainees to respond to questions presented during the course of lectures, and Method D which was identical to Method C except that the Modified Classroom Communicator was used for the responses to the questions, were significantly superior to the control method in facilitating the learning of lecture material as measured by the posttest.

4. All three experimental methods were significantly superior to the control method in facilitating the retention of lecture material as measured by the retention test.

5. Analysis of the differences between specific experimental methods groups revealed no statistically significant differences.

6. The largest differences in performance on both the posttest and the retention test occurred between the control method and Method D which used the Modified Classroom Communicator. This trend, together with other practical considerations, seems to indicate that the Modified Classroom Communicator may provide an effective and efficient technique for facilitating the learning and retention of technical material presented in lectures under mass training conditions.

Practical implications. The present investigation seems to support the following implications for mass training programs:

1. The answer sheet technique does not provide a convenient, efficient, or time saving method of checking the understanding of the trainees. The answer sheets must be distributed, collected, and perused by the instructor at some later time to evaluate the trainees' understanding of the material. This is a time consuming process.

2. The answer sheet technique does not provide a means for direct and immediate communication between the instructor and a group of trainees.

3. The Modified Classroom Communicator provides a convenient, efficient, and time saving method for encouraging trainees to respond to questions projected on the screen. By looking at the Console Panel Lights the instructor can determine quickly, accurately, and immediately the response made by each trainee to each question presented. Any areas of misunderstanding can be cleared up as soon as they occur.

4. Since the instructor can "listen" to the recitation of the whole class at one time, the Modified Classroom Communicator provides an efficient means for establishing direct communication between the instructor and a group of trainees. This makes possible the active participation of the entire class in the learning process.

5. This study has demonstrated that the Modified Classroom Communicator can be used reliably in practical and realistic learning situations under mass training conditions. In addition, this study has shown that the equipment can be used to conduct research on problems in learning.

6. The significant differences found between Method A and Method D on the posttest (a t of 3.07), and the retention test (a t of 4.48), seem to warrant the adoption of the Modified Classroom Communicator as a training aid in the Naval Air Technical Training Command. In a mass training program where large numbers of individuals must be trained in a minimum of time, the program of instruction should include techniques which can be demonstrated to facilitate learning of

technical material in an efficient manner. The Modified Classroom Communicator is one such technique.

Suggestions for further research. As suggested by Darley (7, p. 311), human learning is an important consideration in military training programs and research in this area should be on a continuing basis. The research project reported in the preceding pages has demonstrated the usefulness of the Modified Classroom Communicator not only as a training aid, but also as a tool of research. The results of this research project suggest that further research, even a program of research, to explore other practical problems in Naval Air Technical Training should be conducted.

One area of research would be concerned with an attempt to determine the different situations in which the Modified Classroom Communicator may be used, e. g., in situations involving problem solving, demonstration classes, or group discussion classes, and the manner in which the equipment could best be employed in these situations.

Another area of research would involve the use of the Modified Classroom Communicator with trainees of different achievement potentials to determine whether the use of this equipment will reveal different results with different kinds of learners, and under what conditions.

Still another area of research would involve the use of the Modified Classroom Communicator adapted as an Analyzer to determine what and how much instructional material could be

reduced or eliminated from the various phases of instruction without rendering the instruction ineffectual. This is an important consideration in military mass training programs since large amounts of material must be presented in short periods of time. If redundant material or material already known to the trainees could be safely eliminated, more time could be spent on new and difficult material. A program of continuous evaluation based on such an objective could be of considerable help in maintaining an effective technical training program.

In order to determine the long range effects of the Modified Classroom Communicator on learning and retention of lecture material, a research project extending over a period of one or two years should be carried out. The performance of the first year trainees could be compared with the performance of the second year trainees and checked against the achievement of control groups. Appropriate criterion measures could be employed as a basis for determining differences in the performance of the groups. In connection with such a longitudinal study the same instructors should be used so that relatively consistent instruction will prevail from class to class throughout the period of the experiment.

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APPENDIX A

SAMPLES OF ANSWER SHEETS

Name_____ Rate_____ Service No._____

Class_____ Section _____ Date _____

DIRECTIONS:

1. Use this form to record your answers to the questions projected on the screen.
2. After the question is projected on the screen write your answer in the column headed "Your Answer."
3. When you have finished answering all the questions turn your original answer sheet in to the instructor. Keep the carbon copy. Keep the carbon paper at your desk.
4. When the correct answer to each question is given write its number on your carbon copy in the column headed "Correct Answer."
5. If your answer is right, put a check mark in the column headed "Check here."
6. Put the number of correct answers in the space provided at the bottom of the form.
7. Turn your carbon copy in to the instructor at the end of the period.
8. You will have 40 seconds for each question.

Question Number	Your Answer	Correct Answer	Check Here
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			

Number Right Answers _____

Name_____ Rate_____ Service No. _____

Class _____ Section _____ Date _____

DIRECTIONS

1. Use this form to record your answer to the questions projected on the screen.
2. After the question is projected on the screen write your answer in the column headed "Your Answer."
3. When the correct answer is given write its number on your answer sheet in the column headed "Correct Answer."
4. If your answer is right, put a check mark in the column headed "Check here."
5. Put the number of correct answers in the space provided at the bottom of the form.
6. Turn your answer sheet in to the instructor at the end of the period.
7. You will have 40 seconds for each question.

Question Number	Your Answer	Correct Answer	Check Here
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			

Number Right Answers _____

APPENDIX B

SAMPLE OF INSTRUCTIONAL MATERIAL

NAVAL AIR TECHNICAL TRAINING CENTER
NORMAN, OKLAHOMA
AVIATION FUNDAMENTALS SCHOOL
(CLASS P)

ELECTRICAL-ELECTRONICS FUNDAMENTALS COURSE

LESSON GUIDE NO. 1

I TITLE: Atomic Structure

II OBJECTIVE: To present the names and characteristics of the parts of the atom in order to lay a foundation for the study of electricity

III TIME: 1 Hour

IV REFERENCES:
1. Modern Physics, Dull, Metcalf and Brooks, pages 5, 6, 91-105, 420-421, 562, 565
2. First Principles of Physics, Fuller, Brownlee and Baker, pages 2, 3, 22, 28, 36, 573, 574
3. Aviation Physics Study Guide and Workbook

V TRAINING AIDS:
1. Transparencies
   a. Definition of matter
   b. Definition of atom
   c. Atomic number, weight, and charge
   d. Hydrogen atom
   e. Helium atom
   f. Carbon atom
   g. Oxygen and hydrogen atom
   h. Atomic charge

VI TEACHING PROCEDURE:
A. Introduction
   1. Knowledge of the structure of atoms helps us to understand more about electricity.
   2. While each of the ninety (or more) elements has its own characteristic atomic structure, the atoms of all elements are composed of a few basic particles.
   3. Every atom is like a tiny solar system.
   4. It has been estimated that the energy that binds together the nuclear particles in only 1 gram of helium atoms would be sufficient to operate a 10 watt electric lamp continuously for 2200 years.
   5. Remember, our primary objective in this lesson is to lay the foundation for the study of electricity.

6. This lesson
   a. Title: Atomic Structure
   b. Objective: To present the names and characteristics of the parts of the atom in order to lay a foundation for the study of electricity.
   c. Breakdown of objective
      (1) What are the basic particles of an atom and where are they found?
      (2) How are atomic number and atomic weight determined?
      (3) What are positive and negative charges?

B. Presentation
   1. Definition of matter
      NOTE: Display transparency - Matter
      a. Matter is anything that occupies space and it is found in three states - solids, gases, and liquids.
      b. This is a review of the lesson on matter that was previously taught in the second lesson in physics.
   2. Composition of Matter
      NOTE: Display transparency - Oxygen-hydrogen atom
      a. Molecule
         (1) Definition
             A molecule is the smallest particle of a substance that has all the properties of that substance. (A substance is either an element or a compound)
         (2) Structure
             (a) A molecule is composed of one or more atoms linked together.
             (b) The means by which they are linked and the various forms they take are not important to this lesson.
                 NOTE: Have trainees note the picture of a molecule of water in their workbooks, page 30, problem 2.
      b. Atom
         NOTE: Display transparency - Definition of atom
         (1) Definition
             An atom is the smallest particle of an element that can combine with other atoms to form molecules.
         (2) Structure
             NOTE: Display transparency - H atom

(a) Nucleus
1. The atom of hydrogen is composed of a center part called the nucleus and one revolving particle (electron).
2. The nucleus contains almost all the weight of the atom.
3. In the case of the hydrogen atom, 1844/1845 of the weight is in the nucleus.

(b) Proton
1. The proton is a particle found in the nucleus. It has a plus (positive) charge.
2. The proton has been assigned the unit weight of 1. NOTE: This is a relative weight.

(c) Electron
1. The particle or particles that orbit around the nucleus are called electrons and have a negative (minus) charge.
2. The electron weight is 1/1845 as much as that of a proton. As you can see, the weight of an electron is insignificant.
NOTE: Display transparency Helium atom, and point out the electrons, protons, and neutrons.

NOTE: Display Experimental Questions A, B, C, D

c. Charge
NOTE: Display transparency - Atomic number, weight, and charge

(1) Positive charged atom
An atom containing a deficiency of planetary electrons (less electrons than protons) is positively charged.

(2) Negative charged atom
An atom containing an excess of electrons (more electrons than protons) is negatively charged.

(3) Neutral atom
An atom that has the same number of electrons as it does protons is in a neutral or unchanged state.

(4) The electrons found in outer orbits are comparatively easy to move or displace. Electrons may be forced completely away from an atom with an ease

that varies with the material.

d. Atomic number

NOTE: Display transparency - Carbon atom

(1) Definition

The atomic number of an atom is determined by the number of protons (or by the number of electrons if the atom is in a neutral state) found in the nucleus.

(2) Hydrogen, only having one proton, has an atomic number of one. Helium has an atomic number of two, etc.

e. Atomic weight

(1) Definition

The atomic weight is determined by the number of particles (protons plus neutrons) found in the nucleus of an atom.

(2) Since the neutron is assigned a unit weight of 1, all that is necessary to find atomic weight is to count the number of protons and neutrons.

NOTE: Remember, the weight of the electron is so small that it is not considered when determining atomic weight.

(3) Hydrogen has an atomic weight of one since it has only one particle (proton) in the nucleus.

(4) Helium has an atomic weight of 4 since there are 4 particles in the nucleus (2 protons and 2 neutrons).

NOTE: It is not necessary that atoms have an equal amount of protons and neutrons in its nucleus.

NOTE: Display Experimental Questions E, F, G, H
Omit Summarization (1) in experimental methods

C. Summarization

1. Check for understanding

a. Name the three particles of the atom.
Answer - a. Electron
b. Proton
c. Neutron

b. What is the structure of the atom?
Answer - The nucleus (center) and the electron orbit

c. What electrical charge does the electron have?
Answer - Negative charge

d. How do you find atomic weight?
Answer - Count number of protons plus neutrons
e. An atom has what kind of electrical charge if it has two protons and two electrons?
Answer - No charge (neutral)
f. An excess of electrons in an atom gives it what kind of electrical charge?
Answer - Negative charge

2. Conclusions
a. An atom is the smallest particle of an element that can combine with other atoms (particles) to form molecules.
b. Three basic particles are found in the atom.
(1) Electrons which orbit around in a center part called the nucleus
(2) Protons which are found in the nucleus
(3) Neutrons which are also found in the nucleus
c. An atom can be positively or negatively charged.
(1) A negatively charged atom has an excess of electrons
(2) A positively charged atom has a deficiency of electrons
d. Atomic number of the atom is the number of protons in the nucleus.

3. Review Key points
a. During this lesson "Atomic Structure" our objective was:
NOTE: Refer to objective chart
b. We accomplished this by discussing:
NOTE: Refer to breakdown of objective
(1) Basic parts of atom and where found
(2) Determination of atomic number and weight
(3) Positive and negative charges

VII STUDENT APPLICATION
Each trainee will solve appropriate classroom problems.

APPENDIX C

SAMPLES OF TEST QUESTIONS

SAMPLE OF UNIT TEST QUESTIONS

1. A positively charged atom has a/an

   (a) Excess of electrons
   (b) Deficiency of electrons
   (c) Deficiency or excess of electrons
   (d) Deficiency of protons

2. Which type of electrical charge is produced by an excess of electrons

   (a) Negative
   (b) Positive
   (c) Molecular
   (d) Neutral

3. The atomic weight of an atom is determined by the number of

   (a) Electrons in the orbit
   (b) Electrons and protons
   (c) Neutrons and protons
   (d) Neutrons, electrons, and protons

4. The three basic particles of the atom are

   (a) Neutron, proton, electron
   (b) Nucleus, orbit, electron
   (c) Nucleus, proton, electron
   (d) Nucleus, orbit, proton

5. The weight of a proton is equal to the weight of a/an

   (a) Electron
   (b) Atom
   (c) Positron
   (d) Neutron

SAMPLE OF POSTTEST QUESTIONS

1. Which of the following is the term for "electricity at rest"?

   (a) Dynamic
   (b) Current
   (c) Magnetic
   (d) Static

2. The size of a fixed resistor mainly determines the

   (a) Resistance
   (b) Cunductance
   (c) Capacity
   (d) Wattage

3. The types of non-metallic resistors are

   (a) Commonly called "wire-wound"
   (b) Fixed, variable, and tapped
   (c) Radial and axial
   (d) Grouped by size, wattage, and ohmic values

4. A neutral atom is one that has no

   (a) Apparent weight
   (b) Static charge
   (c) Atomic number
   (d) Electrical charge

5. In the experiment with the glass rod, some of the electrons were removed from the rod leaving a

   (a) Positively charged rag and rod
   (b) Positively charged rag
   (c) Positively charged rod
   (d) Neutral rod

APPENDIX D

FREQUENCY DISTRIBUTIONS OF SCORES

Table 7

Distribution of Scores of Subjects for the General Classification Test by Methods

Scores	Frequencies			
	Method A	Method B	Method C	Method D
76	1	0	0	0
75	0	2	0	1
74	0	0	2	0
73	1	1	1	2
72	1	2	1	1
71	2	0	1	2
70	5	6	7	7
69	2	3	2	3
68	8	2	9	2
67	6	8	10	8
66	11	9	12	11
65	6	6	11	4
64	5	13	6	13
63	11	6	7	5
62	12	16	18	9
61	17	15	13	11
60	14	17	11	13
59	12	14	13	15
58	15	7	12	7
57	10	15	17	21
56	5	13	5	14
55	14	18	13	16
54	8	5	4	7
53	8	7	8	7
52	9	8	10	5
51	3	6	1	5
50	4	2	4	2
49	2	1	1	3
48	4	3	2	2
47	6	2	3	3
46	1	1	1	3
45	2	0	1	0
44	0	0	3	1
43	1	1	1	2
42	0	1	2	0
Number	206	210	212	205
Mean	59.09	59.40	59.67	59.09
Median	58.98	59.06	59.46	58.30
S. D.	6.29	5.88	6.52	6.25

Table 8

Distribution of Scores of Subjects for the Posttest by Methods

Scores	Frequencies			
	Method A	Method B	Method C	Method D
48-50	7	11	10	15
45-47	38	42	37	40
42-44	38	43	46	44
39-41	32	31	51	43
36-38	27	38	32	24
33-35	25	21	17	19
30-32	24	8	9	13
27-29	8	10	4	3
24-26	4	4	4	3
21-23	1	2	2	0
18-20	2	0	0	1
Number	206	210	212	205
Mean	38.75	39.71	40.10	40.50
Median	39.63	40.63	40.75	40.99
S. D.	6.30	5.91	5.47	5.51
Sk	-.42	-.47	-.36	-.27

Table 9

Distribution of Scores of Subjects for the Retention Test by Methods

Scores	Frequencies			
	Method A	Method B	Method C	Method D
95-99	7	11	10	14
90-94	25	32	38	38
85-89	35	38	35	35
80-84	28	48	47	46
75-79	27	39	30	27
70-74	23	9	20	15
65-69	22	14	17	10
60-64	18	5	7	14
55-59	7	5	6	2
50-54	9	7	1	1
45-49	2	1	1	2
40-44	2	1	0	1
35-39	1	0	0	0
Number	206	210	212	205
Mean	76.39	80.55	80.83	81.27
Median	78.50	82.60	82.05	82.85
S. D.	12.59	10.93	10.08	10.66
Sk	-.38	-.56	-.36	-.44